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Competitive Research Grant (CRG)

Sub-Project Completion Report

on

Improvement and Validation of BRRI Developed Head Feed Mini Combine Harvester

Project Duration

May 2016to September 2018

Farm Machinery and Postharvest Technology Division
Bangladesh Rice Research Institute (BRRI), Gazipur-1701

	Submitted to **Project Implementation Unit-BARC, NATP- 2** **Bangladesh Agricultural Research Council** **Farmgate, Dhaka-1215**	

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Improvement and Validation of BRRI Developed Head Feed Mini Combine Harvester
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Acronyms

BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BRRI	Bangladesh RiceResearch Institute
CRG	Competitive Research Grand
DAE	Department of Agricultural Extension
NATP	National Agricultural Technology Project
PPP	Public Private Partnarship

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Executive Summary

A study was aimed to modify, fabricate and test the performance of the BRRI developed prototype (version-1) of head feed mini combine harvester with locally available materials in Janata Engineering Workshop, Chuadanga under Public Private Partnership (PPP). BRRI provided engineering design, drawing, technical and financial support to improve and fabricate the machine. The second prototype of combine harvester was redesigned and fabricated according to the identified faults in the 1st prototype. The field test of 2nd prototype was conducted to find out the performance, efficiency, operation fault, etc. It was found that harvesting capacity and fuel consumption were 1.23~1.25 bigha/h and 3.84~3.96 l/h respectively. The improved combine harvester becomes appropriate in both dry and muddy fields with a plough pan up to 15-20 cm. The average harvest loss was 2.46% and off them the cutter bar, scattering and threshing losses were found to be 0.648, 0.373 and 1.327%respectively. A total offivedemonstrations-cum awareness programmes and 10 large scale validation tests of improved mini combine harvester (2nd version) were conducted to identify functional faults and create awareness among the end users. A total of 200 participants were participated (155 male and 45 female) in these programmes and observed the field performance of the combine harvester.

The user opinion survey was conducted to know the present condition, problems and to record farmer's reaction on harvest mechanization of during large scale validation test at farmers'fields and 126 participants participated in the survey. A semi-structured questionnaire was used for collecting information and statistical analysis of the collected data was carried out. The average cultivable area per farmer was 225 to 1239 decimal (1 decimal=40m^2). The survey indicated that 97.60% farmer used sickle and only 0.80% used combine harvester for harvesting. Threshing was mainly done using (49.21%) closed drum thresher and open drum thresher (26.20%), likewise 1 of 126 farmer would use head-feed combine harvester. In considerable amount(80.95%) of farmers had some kind of agricultural machinery, while the remaining (19.05%) did not have machines. Farmers agreed that harvesting was a labor-intensive method (35.71%), time consuming (28.57%) task. According to the respondents, the price of the machine identified as the main constraint (40.48%) and lack of easy credit system (21.43%)as second constraint to introduce machine for different agricultural operation. In the survey area most farmers (36.51%) identified the vital advantage of mechanized harvesting as lower labor requirement, while 21.43% of farmers said that a lower loss of rice. All farmers who participated in the survey expressed their need for machinery and mentioned agricultural credit with easy terms and conditions, subsidy for buying machinery and the ensuring of a fair market price for their produce. Therefore, this machine can also be used in agriculture in a number of ways, to increase productivity, mitigate labour shortage and reduce production cost.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:** Improvement and validation of BRRI developed head feed mini combine harvester
2. **Implementing organization:** Farm Machinery and Postharvest Technology Division, Bangladesh Rice Research Institute (BRRI)
3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):**

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4. **Sub-project budget (Tk):**
   - 4.1 **Total:** 29,91,170.00
   - 4.2 **Revised (if any):** N/A

5. **Duration of the sub-project:**
   - 5.1 Start date (based on LoA signed): 11 May 2017
   - 5.2 End date: 30 September 2018

6. Justification of undertaking the sub-project:

Farm Mechanization in rice aims to not only to reduce labour, inputs, human drudgery but also at improving farm productivity. Due to shortage of labour, scarcity of water and energy, the weed competition is going to be the major constraints to achieve higher production. Mechanization may be defined as the process of injecting power and machinery between man and materials in a production system. Mechanization as it relates to agriculture requires the study, manufacture, utilization, maintenance and repair of all tools, implements, machines, equipment and structures which will enable the farmer to raise the productivity of human labour economically. Esmay and Hall (1972) defined agricultural mechanization as the science application of mechanical aids for increased production, processing and storage of food with less drudgery and increased efficiency. The demand of cereals by the year 2030 has been projected to reach 43.82 million tons at an anticipated per capita income growth rate of 2% and 50.62 million tons at an income growth of 3 % (Baqui*et al.,*2007). This implies that the production of cereals will have to be increased by 2030 to the nation adequately. The farm sector accounts for more than 42.7% of national employment(Anonymous, Labour Force Survey, 2016), but only contributes about 14.1% to GDP in 2017-18(Anonymous, 2018). Scope for horizontal expansion of cultivable land is limited. To achieve the increased food production target has to go for vertical expansion of agricultural output over the current situation of its cultivable land. One of the most important means to boost up the vertical expansion of agricultural production is to adopt agricultural mechanization suitable for the Bangladeshi farmers. In order to increase the production and cropping intensity further, it has become necessary to mechanize certain farm operationslike transplanting, harvesting, processing. The cultivable land is being lost to development work such as road construction, housing, industry etc. To meet food needs, pressures are increasing to grow more food per unit of crop land. Farmers are producing large volumes of crops continuously throughout the year. They are always busy in doing many agricultural activities. Most of these operations are accomplished by human labor, traditional farm tools and implementswhich are slow and time consuming. Farmers face trouble in completing agricultural operations timely due to labor shortage, especially during the peak planting, harvesting and threshing periods.

Today's intensive agriculture leaves only a very limited time between harvesting of one crop and sowing/transplanting of the next one. Crops are susceptible to shattering if harvesting is delayed after maturity. Therefore, timely harvesting is very important. The most common traditional methods of harvesting is accomplished by using hand sickle (called *kachi*) in Bangladesh, which is quite tedious and labour intensive job. Due to shortage of labour, farmers are compelled to practice delayed harvesting, threshing, drying, winnowing, storing the produces results in yield loss, deteriorate grain quality and affecting market value. Sometimes, farmers incurred total loss of field crops due to natural disaster. Therefore, it is essential to introduce mechanical harvester, thresher and winnower to accomplish the rice and wheat postharvest activities timely.Mechanization of harvesting is only at the demonstration phase in Bangladesh. Thus harvesting is considered to be a major pain point in Bangladesh agriculture. During harvesting of Boro and Aus paddy, often rains and storms occurs causing considerable damage of standing crops. Therefore, rapid harvesting of crop allows extra days for land preparation and earlier

planting of the next crop. Thus the use of machines can help to harvest crop at the proper stage of maturity and reduce drudgery and operation time. Considering these, improved harvesting tools, equipment and combines are being demonstrated in the farmers field. Over the last decades, the government of Bangladesh and some private parties have experimented with a wide range of mechanized equipment. In particular harvesters from Europe, China, Japan and Korea have been imported and demonstrated by the various Agricultural Universities and Research Institutes. Based on the demonstrations and field trials, neither large, nor small harvesters are considered suitable for Bangladesh. A robust and simple harvester is considered to be the most suitable size for Bangladesh which yet to designed and fabricated through research and development activities.

BRRI developed power tiller mounted, self-propelled and power hand reapers may be used to harvest the crops timely with minimum field losses. It is estimated that about one-third of total labor will be saved when reaper is used for harvesting rice. However, reaper can't operate in wet/muddy soil and need skill operator to operate the machine. Frequent troubles during field operation, due to lack of skilled operator; discourage farmers to use reaper. In addition, the reaper machine doesn't have binding facilities and harvested crop laydown sometimes haphazardly on the field. The farmers have to thresh the harvested crop using close drum thresher and can't keep straw intact for better use. Moreover, farmers usually have given contact for cutting the field crop, carrying from field, threshing, cleaning and storing the paddy by manual labour as a package at higher unit cost. The farmers don't get benefit using reaper only cutting the paddy because labourer don't want work after machine cutting; sometimes wants more wages for the remaining activities after cutting. The head-feed combine harvester provides advantages to keep straw intact which can be used for another beneficial purpose. Therefore, a head-feed mini combine harvester may be the better alternative to existing harvesting machine in Bangladesh.

Currently, there are 50 rice reapers and 100 combined harvesters operating in Bangladesh (Wohab, 2012). The mechanization of rice harvesting has only reached 15% of the rice planting area. The use of mechanical harvesters in rice production can avoid losses of about 3% per season (Wohab, 2012). Over the long term, farmers in Bangladesh have been attempting to achieve modernization and mechanization. However, the rate of adoption of mechanical harvesters is still very low. There are several factors affecting the adoption of the mechanization of harvest and post harvest activity. To establish strategies for the successful mechanization of rice harvesting, it is necessary to assess the factors affecting the mechanization of these activities.It is estimated thatBangladesh would require approximately 30,000 harvesters, of the size chosen, to enable all the area cultivated to be harvestedmechanically. Currently, Bangladesh has less than 100 harvesters, of which less than 50 are in commercial operation. The remaining are with government and research institutions. Bangladesh went from less than 5% mechanized plowing, to over 95% mechanized plowing since last 15 years. However, at present mechanized harvesting is probably less than 1.0% in Bangladesh. It is expected that within 10 years, over 50% of the harvesting need to be mechanized to attaining sustainable rice cultivation in Bangladesh.

Moreover, it is found that rural labour force has started to shift from agricultural to industrial sector and service sector, creating an acute agricultural labour shortage during peak planting and

harvesting times. In case of occurrences of flood, drought and other natural disasters mechanization is the only option which can handle problems for land preparation, crop establishment, harvesting, threshing anddrying of different crops timely. Labor shortage is one of the main constraints to successful crop production. Presently, some farm machineries like weeders, threshers, power tillers and tractors have been in use in Bangladesh. Amongst the power-oriented implements, the power tiller holds a notable position. Farm machinery in Bangladesh needs a special consideration to landholding size and capability of the farmers to buy the machinery. A number of research institutes, Universities and Private Company in the country had invented, imported and also introduced a number of technologies in these fields. In the contemporary context,the mechanization of harvest and post harvest work has become very important in Bangladesh because of the high rate of labour. Literatures indicated that labour shipment occurs from rural to urban and industrial zones due to changes in the economy. Various research institutes (BRRI, BARI) and government institutes (BADC, DAE) have been working with modern harvesting machinery (hand reaper, power tiller operated reaper, self-propelled reaper and head feed combine harvester) and are trying to introduce these to farmers at subsidizing price in the range of 50 to 70% through a GoB project for popularizing those machines. As such, this study was undertaken with the following objectives

7. Sub-project goal:

Adoption of appropriate harvesting machinery at farmers level for attaining sustainable rice cultivation

8. Sub-project objective (s):

- To modify the existingBRRI developed combine harvester
- To test and evaluation of modified combine harvester at selected locations
- To validate the modified combine harvester to the end users

9. Implementing location (s):

Considering high cropping intensity, accessibility, scarcity of farm labor, rice-wheat-rice cropping pattern and soil type, the machines was validated at Chuadanga and Gazipur districts.

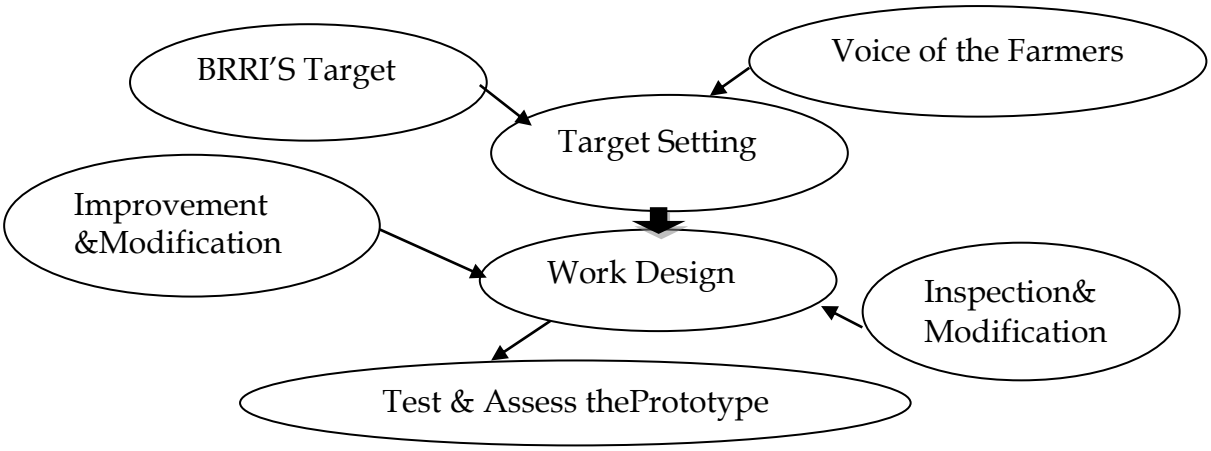
10. Methodology:

10.1 Head feed mini combine harvester:

Harvesting of paddy includes cutting, stacking, handling, threshing, cleaning and hauling of paddy. The goal of good harvesting methods is to maximize grain yield and to minimize grain damage and quality deterioration. Harvesting can be done manually using sickles and knives, or mechanically with the use of threshers or combine harvesters. Regardless of the method, a number of guidelines should be followed that will ensure that harvest losses are kept to a minimum and grain quality is preserved during harvest operations. The head feed combine is different from whole feed type combine where only the panicle is feed into the machine as a result straw remain intact but threshing capacity is lower than the whole feed type. In Bangladesh, straw is used to feed the cattle, as fuel for cooking and household other purposes. So it is necessary to develop a head feed combine harvester.

10.2Prototype development:

Bangladesh Rice Research Institute (BRRI) was developed a head feed combine harvester in 2016,but during field test some mechanical faults were identified. According to field test results the combine was modified and fabricated again to improve theprototype using locally available materials in the BRRI research workshop. After finalizing the prototype, multiplication was done in a local manufacturer's workshop as per per design, guidance and project financial help provided by BRRI through NATP – sub-project. After that, locally develop combine harvester was tested, evaluated and demonstrated in farmers' fields and collect farmers feedback. The process was continued until the perfection of the machine was achieved. A technical specification of improved combine harvester is given in Table 1 and its images are shown in Fig. 1.



Flow diagram of modifying process of the second prototype

10.2.1Development procedure:

The work aims to develop a mini combine harvester using locally available materials in the view of Public Private Partnership (PPP) approach between the Farm Machinery and Postharvest Technology Division, BRRI, Gazipur and Janata Engineering, Chuadanga. In total two versions of prototype were developed and performance tested in a farmer's field. According to the IRRI, combine harvester is called mini when cutting width is in between 120cm. The first version was developed by using GoB fund of BRRI, but modified and improved version (second) was done by funded of CRG, NATP-2 project. The preliminary test was conducted during the Aman/17 and Boro 2018 season.

10.1.2 First version(BRRI Combine Harvester):

BRRI has been working to develop the combine harvester since 2016. Series of works have been done continuously to fulfill the goals towards farmers' demand. The farmers' feedback was collected in three rice seasons before designing the 1st prototype and that information was used to finalize the second version. One of the major problem was that when straw thickness is more than one inch, some un-threshed panicles were observed at the lower layer of rice stalk in the 1st version (A). The major features, identified faults and necessary measures were mentioned as followed for 2nd version presented below during the development process (B).

10.2.3 A. Fault detected and removal process of BRRI head feed combine harvester (First Version)-*Mechanical fault*

Item of first version	Fault detected	Measure taken
✓ Wheel: Crawler type ✓ Engine: 20hp ✓ Gear: Chinese ✓ Power transmission system: locally made ✓ Lifting system: Hydraulic ✓ Starting system: Mechanical	✓ Working speed is low ✓ Gear system didn't work properly ✓ Power transmission problem ✓ Frequent break down in welding parts ✓ Cutting parts lifting is troublesome ✓ Un-threshed paddy due to threshing drum length ✓ Faulty design of cleaning blower ✓ Grain loss in different joint position due to improper welding	✓ New and high quality gear incorporated ✓ Threshing drum diameter increased (42 cm) ✓ Incorporated cyclone separator for paddy shifting ✓ Used lighter materials as per as possible

10.2.4 B. Problem solving and improving process of BRRI head feed combine harvester (First Version)- *Manufacturing fault*

Sl. No.	Problem	Improvement work/Implementation Status
1	The combine working speed was not up to mark (1.2~1.40km/h) at 1st gear position	New Chinese gear included and speed 1.50km/h
2	The weight of cutter part was too high	Using lighter materials to reduce the weight in cutting part
3	Low engine power	Incorporated new engine
4	The frame/base dimension was oversize so some space was un-used	Rearrange the engine, driver seat, bagging position to minimize the over size
5	Threshing drum length was small (61cm/24in) and some un-threshed grain remained	Included threshing table
6	The blower and cleaning sieve was large for cleaning the threshed grain	Incorporated the cyclone separator for cleaning
7	Grain breakage and loss was found	Grain loss minimized by improving some functional elements (blower and threshing table, etc.)
8	Others	Integrated dividers in front of the cutter bar

10.2.5 Some operational faultof BRRI head feed combine harvester (First Version)

- Sometimes straw clogged in the conveyer belt;
- Grain breakage was found in main outlet;
- Some un-threshed panicle was observed when rice stalk thickness was more than 1 inch
- The shuttering of grain was observed in the laid down crop during harvesting;

First prototype	**Field operation 1st prototype**
Fig. 1. BRRI developed head feed mini combine harvester (First version)	

10.2.6 Selection of manufacturing workshop:

The BRRI developed head feed mini combine harvester were developed and fabricated by the Janata Engineering under Public Private Partnership (PPP) approach. . For the improvement and financial support was provided from the CRG, NATP, Phase-II sub-project. The Janata Engineering has been selected for conducting research and improvement, a LoA was signed between the PI, Improvement and validation of BRRI developed head feed mini combine harvester(IVBDCH) project and proprietor, Janata Engineering, Chuadangha and Nayeem Engineering Workshop, Madan, Netrokona.

The main design considerations were:

- Feeding only the half portion of the crop (head feeding);
- Incorporate the crawler for moving both dry and wet fields;
- Small size is suitable for fragmented land and small fields;
- Additional power (32hp with self-starting) which can pass smoothly and easily;
- Compact structure, low height, stripping belt system;
- The major thrust was given to develop a combine harvester incorporating of multiple aspects, viz intake capacity of rice straw, use of local materials, reduction of drudgery, light weight, easy in travel control, flexible in turning

Design and fabrication:

The head feed combine was fabricated on the basis of locally available low cost materials considering easy fabrication process, simple disassembling and convenient for maintenance.

Farm Machinery and Postharvest Technology division provided design, technical and financial support to Janata Engineering, Chuadanga (Fig. 2-6) to fabricate the improved version of heed feed mini combine harvester using locally available materials under Public Private Partnership (PPP) approach. The literature review was done to know the working principle and fabrication procedure of different types of combine harvester, which helped to design and fabricate the combine harvester.The working speed and capacities for different functional elements (cutting part, conveyer, threshing, bagging part, base, and driving power) is very important for the development of a combine but in head feed combine the cutting and feeding part is very much complicated. The following standard parameters were considered:

- Rotational speed of the paddy conveyer star wheel is higher than the forward speed;
- Capacity of feeding table is to be same with the star wheel feeding;
- Optimum plant height should be ranging from 50 to 80cm;
- Cutting speed should be from 300–350rpm;

- Star wheel peripheral speed of 25~50% greater than the machine's forward speed;
- Inclination of grain conveyer is to be 35^0;
- Threshing drum speed is to be 550~600 rpm;
- Easy fabrication AutoCAD design software was used.

Again for easy fabrication, low cost, high capacity and minimum repair and maintenance were the major objectives of the prototype development and for this the following issues were considered:

- Use cutter bar from the reaper, which is found available found in local markets;
- Feeding table made by locally available heavy duty rubber;
- Locally available materials for the conveyer, belt pulley, etc.;
- Chinese engine, gearbox and crawler;
- Grain loss needed to be minimized by improving some of its functional elements (blower and thresher, etc.) and provision of dividers in front of the cutter bar.

10.2.9 The main functional elements of the machine are:

- Travelling mechanism;
- Platform/base;
- Cutting part with cutting head;
- Power system and transmission unit;
- Operative section/Driving system;
- Hydraulic system with pump assembly for controlling cutting parts up and down;
- Electric system;
- Bagging system with cleaning mechanism;
- Others (Seat assembly, indicator, safety protection).

10.3Field evaluation method:

The performance test of final version was conducted in the farmers' field for large scale validation. Finally, improved combine harvester was demonstrated to the farmers group in the project area for dissemination and adoptions of the technology. The performance parameters of harvesting machines were measured which included travel speed, working width, lost time and total required time. Before operating, crop conditions were recorded in terms of plant height, number of hill per unit area and grain moisture content. The paddy grain moisture content was determined by grain moisture meter (GMK 303 RS, Korea) at harvest time. To determine travel speed during operation and time required to traverse 30 m over harvesting was recorded by a stopwatch. This was repeated three times in each plot. Theoretical field capacity (Ct), effective field capacity (Ce), work capacity (Wc), and field efficiency (Fe) of harvesting machines obtained from following formulas (Hunt, 1995; Konaka, 2005):

$$C_t = \frac{\mathrm{W}\times\mathrm{S}}{10} \quad (1)$$

$$C_e = \frac{S\times W_e}{10} \quad (2)$$

$$W_c = \frac{1}{C_e} \quad (3)$$

$$F_e = \frac{T_e}{T_t} \times 100 \quad (4)$$

Where,

Ct : theoretical field capacity, (hah-1) Ce: effective field capacity, (hah-1)

W: working width, (m)
S: travel speed, (kmh-1)
Tt : total time, (h)
Te: useful time, (h)
Wc: work capacity, (hha-1)
Fe: field efficiency, (%).

10.4Harvest loss assessment procedure

In general, crop loss occurs from natural phenomena before harvest besides mechanical and physical parameters during harvesting. Combine harvesters accomplish reaping and threshing operations in a quick succession. Basically, harvest loss can be divided into quantitative and qualitative losses. Quantitative losses are as the result of shattering and losing of grain and non-threshed panicles during reaping and threshing. Whereas, qualitative losses are due to broken, husked and cracked grains from environmental and or mechanical impacts. The quantitative losses are measured in the study.

In combine harvesters, losses are observed at two main units i.e. cutting and threshing units. For this, the wooden frame was thrown out ahead and back sides of the combine and all grains and panicles inside it gathered and weighted. Then, weight percentage of harvesting loss computed by following formula (Pradham *et al.,* 1998)

$$HL = \frac{W_{gt} - W_{go}}{Y} \times 100 (5)$$

Where,

HL: harvest loss, (%)
Wgt: total harvest loss, (g/m^2)
Wgo: pre-harvest loss, (g/m^2)
Y: grain yield, (g/m^2)

In general, crop loss occurs from natural phenomena before harvest besides mechanical and physical parameters during harvesting. Loss could be attributed to harvest and threshing method, harvest time, type of variety and its physical properties, crop condition in terms of maturity, lodging and soil condition. In case of combine harvester, forward speed and cutting height may have an important role on harvesting losses because increase of forward speed increases the vibration of different operating units and feeding rate. And also increase of cutting height increases the shaking on the plant that increases the harvest loss. The grain moisture content may also have an effect on harvest loss due to the elastic conditions of high moisture content materials (Alizadeh and Allameh, 2013).

The combine requires a field with large enough area and flatness with qualified technicians to manage and service. There are many factors contributing to the performance of combine harvesters and they can be divided into machine and plant factors. Machine variables include combine forward speed, peripheral speeds of combine devices, and feeding rate. Moreover, the plant variables such as variety, moisture content and degree of maturity are considered as critical factors. The above mentioned factors affect directly on the grain losses, energy requirements, and efficiency, which in return, influence crop yield, and total operational cost. Therefore, care should be taken to operate the combines to minimize both losses because combine harvesters encounter problems with grain losses and frequent breakdowns (Bawatharani *et al.,* 2016).

The height at which the rice crop is cut at harvest plays a major role in determining the grain yield, which ensures optimum performance in terms of minimizing grain losses and optimizing

grain quality. When harvesting rice, the cutter bar is set as low as feasible to harvest as many of the panicles possible. In general, main stems are taller and produce more grains than primary tillers which in turn are taller and higher yielding than secondary tillers. Hence, adjustment of cutter bar height is an important loss control mechanism. Therefore, to optimize the grain harvest, the cutter bar should be set at optimum height. Further the length of cut crop is directly influenced by the bulk handling capacity of the threshing mechanism. Short crop results in less material and long crop with more material which will affect the overall capacity as well as composition of the grain mixture.

The loss of combine harvester is divided into natural loss (pre harvest loss), platform cutting loss (header loss), threshing loss, cleaning loss and the loss of body (Srivastava, Goering, and Rohrbach *et al*., 2006), of which the header losses caused by the cutter bar is considered to be important as the header unit is the component which hits the panicles in a vigorous manner. Therefore, the objectives of this study were to measure quantitative loss of grains from the header unit of combine harvester as affected by forward speed and cutting height and to assess the quality of the grains at different cutting heights.

After preparing the field, during the first path, combine adjustments were done precisely to reduce the loss amount and measure the real amount of it. Then the grain tank was emptied and the combine was driven at the beginning of the harvest place. Along the harvest path, a length of 10 m was specified with measuring tape and at the same time, the distance of the first crop row was measured and wrote down. Then the combine operator drove the machine with a constant speed and harvested the segregated 10 m. While harvesting a long tripal was placed at the back site of the combine to prevent losing the grains, in between the combine rear wheels and along the combine directionso that material comes out of the straw walkers and cleaning shoes pour on to the tripal. After the combine passed, grains and unthreshed panicles were separated and weighed.

Cutter bar loss

Grain lost due to rough handling and out of research of cutter bar is called cutter bar loss. The combine harvester was allowed to move forward for 50 m to attain a steady constant speed and it was suddenly stopped. The header unit was lifted up and the machine was moved back for about 2m. The quadrate with an area of 1 m^2 was placed in front of the parked machine and the grains and panicles were manually picked up. The panicles were then manually threshed and the cuter bar losses were determined by weighing the fallen grains and collected panicle grains.

Scattering Loss

Grain spread over the ground from cleaning/threshing unit and any other part of the machine is called scattering loss. In the field, a number of random quadrants are chosen of 1 square meters surface area each. After the harvesting procedure, all grains that are lying on the ground within the quadrants are collected. Following collection, the collected grain weighed carefully.

Threshing Loss

Grain lost over the straw rack in the form of unthreshed heads is called cylinder loss or header loss. And grain lost out the rear of the combine in the form of threshed grain is called separation loss. The cylinder loss and separation loss combinely known as threshing loss of the combine harvester. The threshed rice straw was collected from combine harvester on a long tripol. The

rice straw was separated and threshed grain was collected on tripol. The collected rice straw again threshed manually and collected grain.

10.5User opinion survey

Farmers'/machinery users opinion is needed to establish the mechanization guidelines, as well as details on their wishes and needs. A semi-structured draft questionnaire was prepared and pre-tested to refine the questionnaire for collecting necessary information. The questionnaire was supplied to farmers to get feedback on the harvesting, threshing, cleaning system and operation-related machinery and the associated problems. The questionnairewas finalized after incorporating the feedback of the farmers (Appendix 10). In the questionnaires, farmers provided relevant information on the harvesting systems what they are practicing for cutting, transporting, threshing, and cleaning. The total respondent was only 126. This interview focused on understanding the present condition and the scope of combine use in terms of harvesting machinery.The advantages and disadvantages of machinery operation related to the harvesting system were considered. Farmers' opinion regarding desire type of machine for harvesting were also considered. The improved mini combine harvester (2^{nd} version) was operated at least one hourbefore the participants during demonstration and validation programmes for better understanding the performance of combine harvester over traditional practice. Discussion session was arranged to collect participants reaction on the usefulness and drawbacks of the machine. Finally, the questionnaire was supplied to the participants requesting their opinion on machine performance. A statistical analysis of the collected data was carried out and presented in this report.

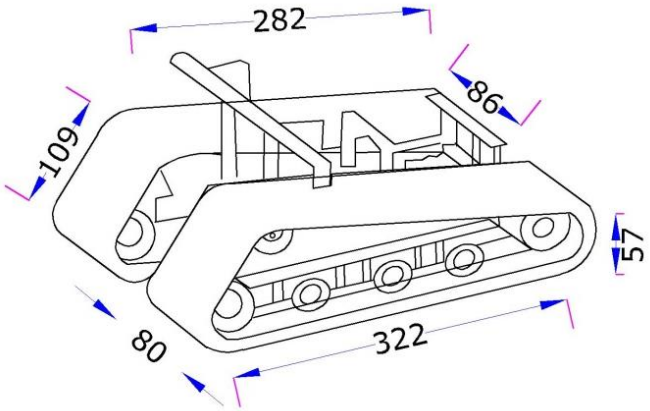
11 Results and discussion:

A series of work were done to finalize BRRI head feed mini combine harvester and measures were taken for further improvement**(Appendix 2-6).** Finally one prototype was furnished and fabricated in a local workshop. The performance of combine harvester such as quality of work, rate of work, trafficability, durability and so on was evaluated by its adaptability to the field and crop conditions which differ depending on the locations. The ultimate development outcomesare as follows:

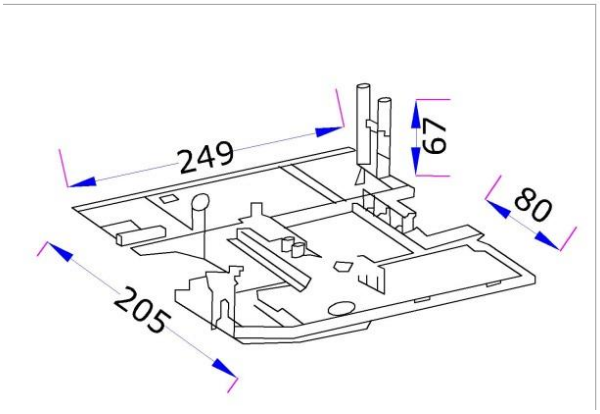
The second version of the mini combine harvester was redesigned to rectify the identified faults of 1^{st} prototype and fabricated at Janata Engineering workshop under PPP. The laboratory test of the second version of the prototype was carried out in Aman season, 2017. However, the detailed assessment was done in Boro 2018 season. Table 1 presents specification of head feed mini combine harvester.

Major parts of different functional elements

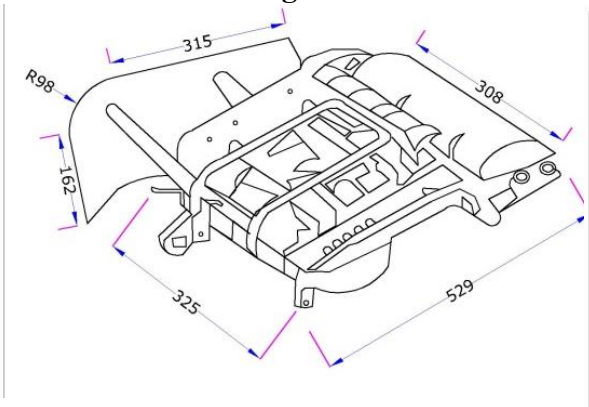
Cutting part ▪ Cutting blade (serrated blade) ▪ Cutting blade holder ▪ Cutter bar ▪ Cutting teeth ▪ Paddy separator and ▪ Hydraulic system	**Conveyer part** ▪ Conveyer cylinder ▪ Conveyer belt with peg ▪ Helical conveyer part-box type-remain closed
Threshing part ▪ Threshing drum with axial flow loop spiked ▪ Small thresher-threshing drum, drum shaft, peg tooth, stripper bar assembly	**Bagging part** ▪ Grain tank ▪ Conveyer panel ▪ Screw conveyer ▪ Bagging place
Driving system ▪ Crawler ▪ Differential shaft ▪ Gear arrangement ▪ Steering wheel ▪ Others control system	



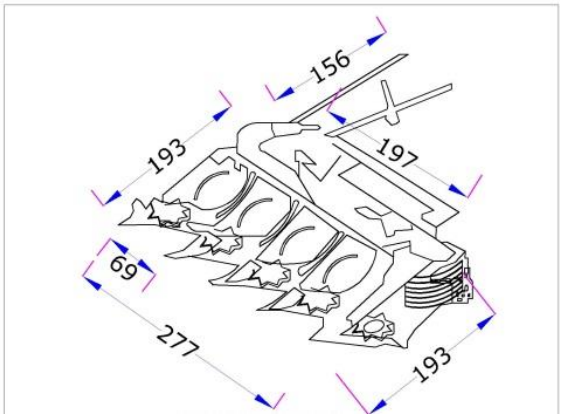
Travelling mechanization



Platform /base of the machine



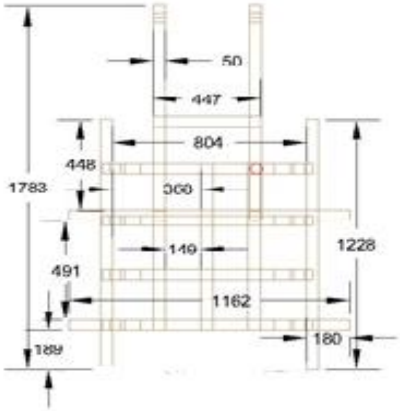
Threshing part



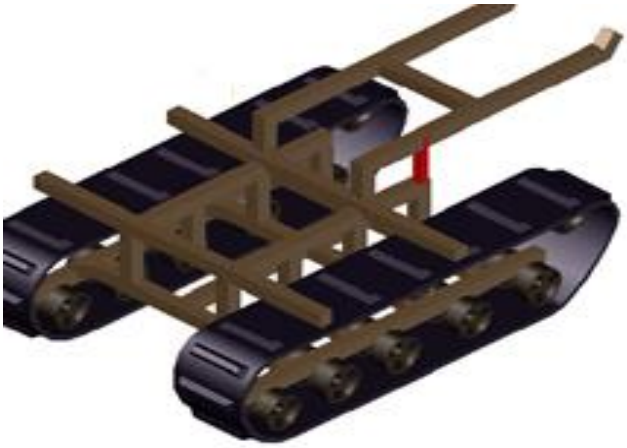
Cutting part

Note: All dimensions are in cm

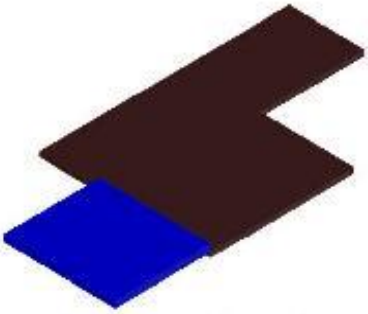
Fig.2. The main functional units of combine harvester



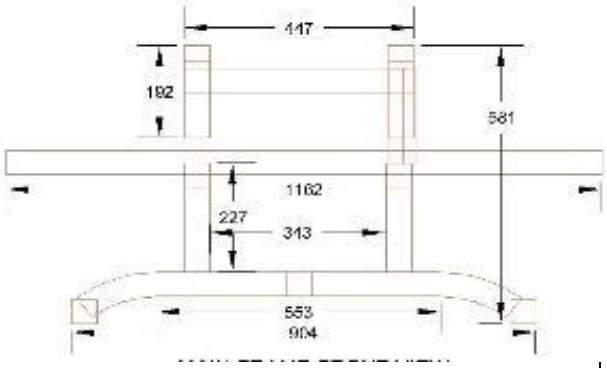
Top view dimension



Crawler with frame

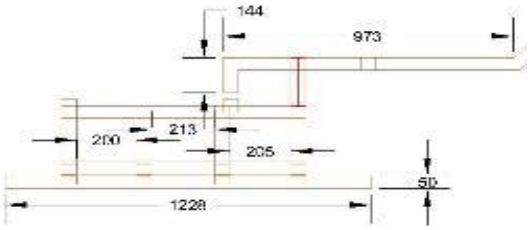


Isometric view-Flat form



Side view dimension

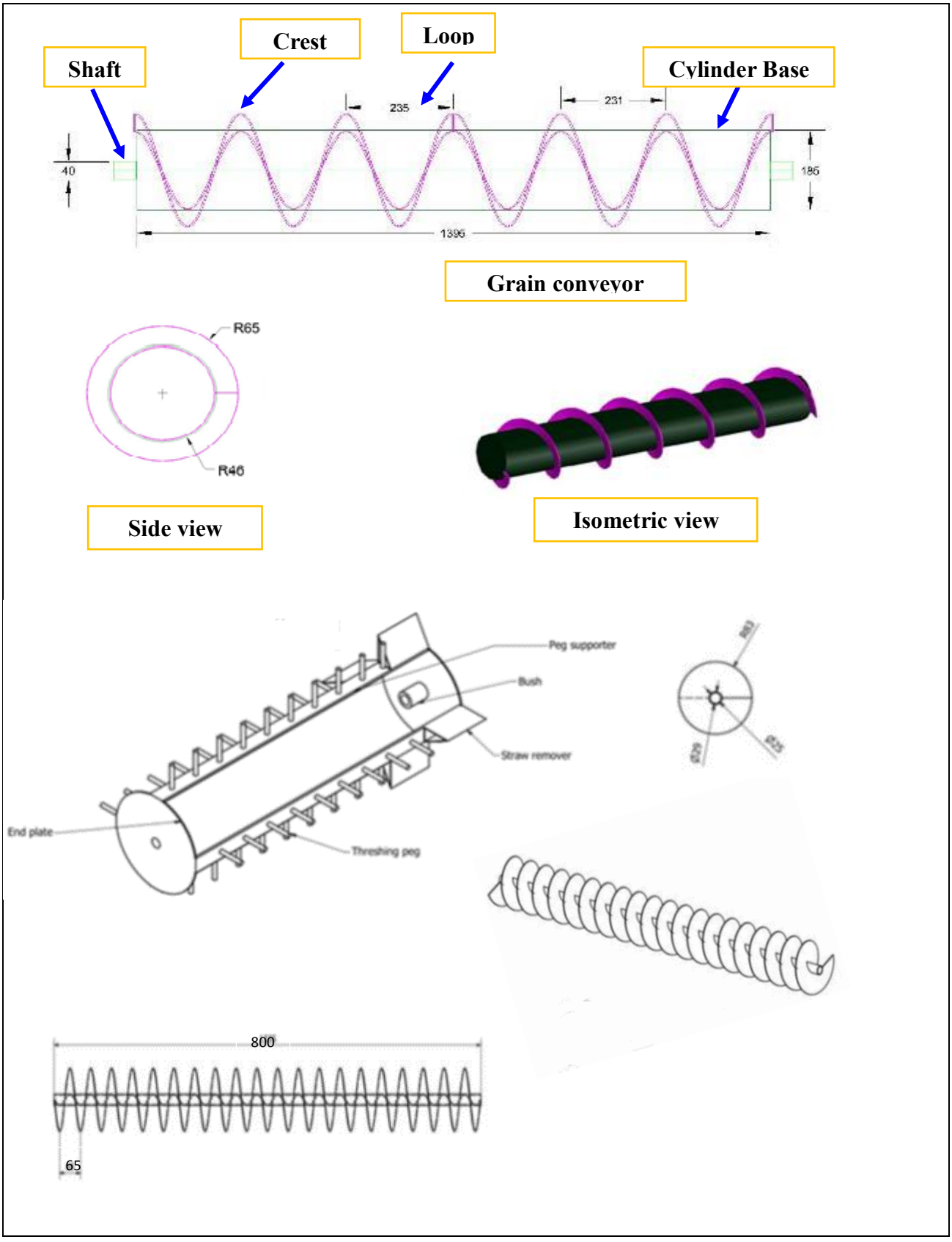
Isometric view



Front view dimension

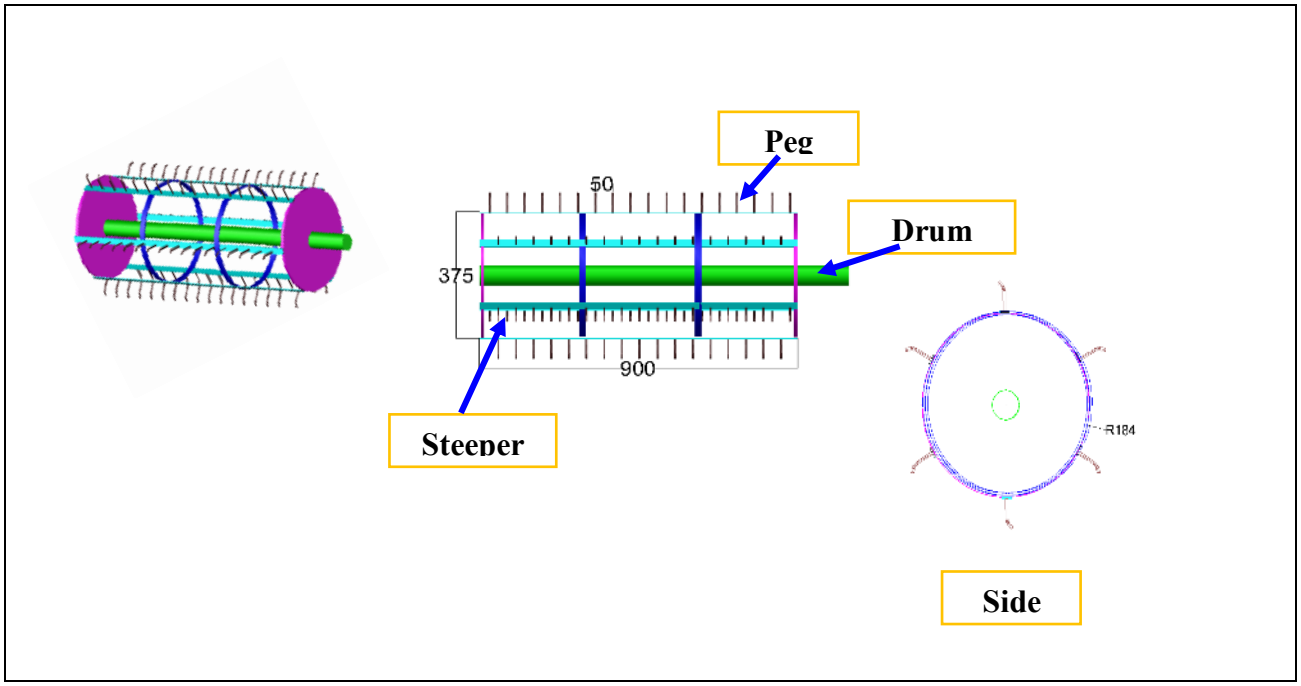
Note: All dimensions in cm

Fig. 3. Base of combine harvester



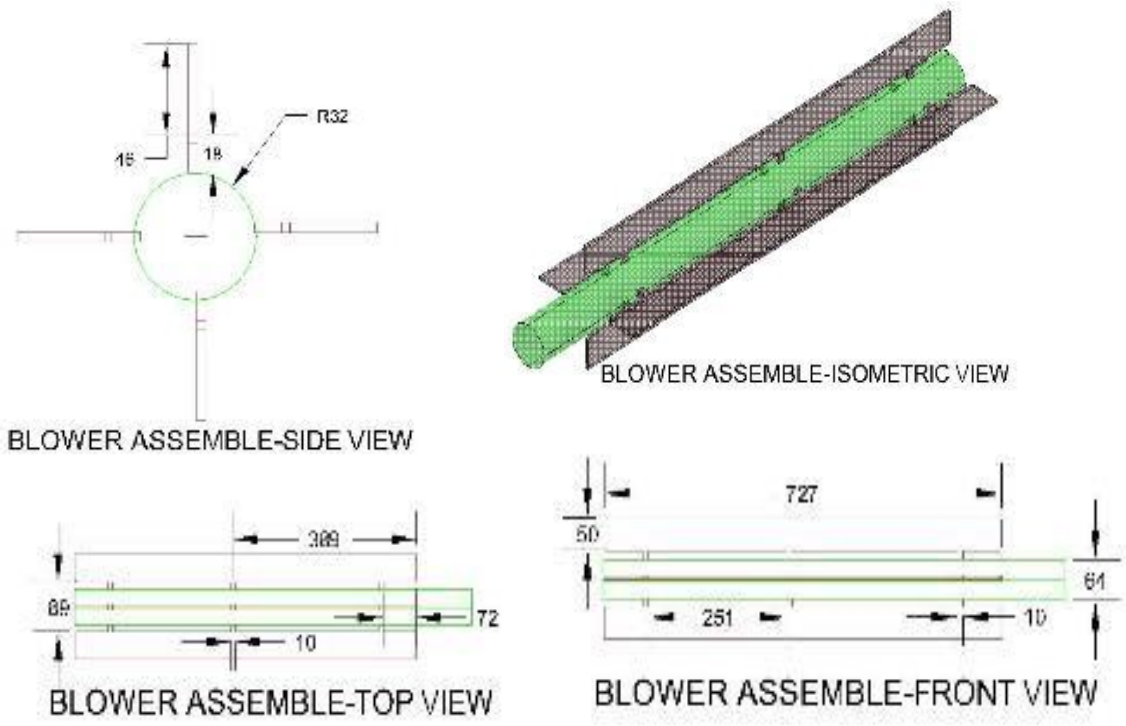
Note: All dimensions in cm

Fig. 4. Grain conveyor assembly



Note: All dimensions in cm

Fig. 5. Threshing part assembly



Note: All dimensions in cm

Fig. 6.Winnowing assembly

Table 1. Specification of designed combine harvester

Component		Specification
Feeding mechanism		Half-feeding
Dimension (Length*width*height)		262*120*134 cm
Harvesting mechanism		Cutting blade and two blades sliding cutting
Paddyconveying mechanism		Chain and star wheel
Threshing mechanism	Feeding	Head
	Feeding drum	Closed drum with axial flow loop
	Feeding drum (Length and diameter)	140 cm*46 cm
	Additional threshing drum type	Axial flow, spike tooth
Conveying mechanism of the threshed grain		Screw conveyer (Extendible transverse conveyer)
Type of concave screen		Grid type
Cleaning mechanism		Cyclone separator with blower
Bagging mechanism		Directly bagging
Engine	Type	Air cooling, four stroke, single cylinder, diesel engine
	Output/rpm, kw/rpm	23.87/2200 (Rated HP=32)
	Starting system	Auto and manual (Both)
	Fuel tank capacity, L	6
Traveling system	Crawler specification (width*pitch*No.of tooth)	40 cm*9 cm*46
	Ground clearance, cm	26
	Transmission	Hydrostatic transmission
Gear system (4 nos.)	Forward	1st gear, 2nd gear, 3rd gear
	Oil capacity	Engine 4 liter, Gearbox 8 liter
	Reverse	single
Power system		Hydro-static transmission (HST)
Grain unloading method		Manual
Overall dimension (L*W*H), cm		260*135*200
Cutting width		120 cm (4ft)
Type of cutter		Reciprocating type
Number of reaped row (Row to row distance: 20cm)		6
Minimum cutting height, cm		10
Type of cutter		Reciprocating type (two blades sliding cutting)
Minimum ground clearance, cm		20
Suitability in soil condition		Dry and wetland
Operators needed/manpower		3
Power transmission system		Chain sprocket/mechanical

	
Improved prototype (2nd Version)	**Field operation of 2nd Version**
Fig. 7. BRRI developed head feed mini combine harvester(2ndverson)	

11.1Test and evaluation:

The performance test of second version head feed mini combine harvester was conducted in different field (Dry and wet) conditions in Chuadanga. The identified problems and results were analysed and necessary actions were taken for further improvement. The improved combine harvester was tested on load and no-load conditions. Fine tuning and modification has been done of the second version combine harvester based on laboratory and field tests. Modification was carried out based on the performance of the laboratory and field tests until it became user friendly.

Afterwardsseveral field tests were conducted to evaluate the performance of second version combine harvester during Aman 2017 and Boro 2018 seasons in different fields of Chuadanga district. The following factors were considered to evaluate the performance of both load and no-load conditions. In no-load conditions the laboratory workshop test/ road test for verifying the joining/welding/ vibration/ balancing/ speed/ clogging/ alignment problems. The following factors were considered in field test:

- Harvesting area and harvesting time
- Walking speed
- Fuel consumption
- Field capacity

Table 2 shows the test results. The average walking speed was 1.37km/h and 1.25km/h in dry Aman 2017 and wet Boro 2018 season respectively. The working speed in Aman season was higherthan that of Boro season due to muddy field. Although working speed was low in Boro season but fuel consumption waslittle bit more due muddy field. The average fuel consumption was found 3.84 l/h in Aman season where as 3.96l/h was in Boro season. The average field capacity was 0.15ha/h (1.25bigha/h).

Table 2: **Field test data**
Place: Sorajganj, Chuadanga **Crop:** Rice **Season:** Aman 2017

Test no.	Duration of test (Working h)	Travel speed			Rate of work		Fuel consumption	
		Gear used	Speed		Area covered		l/h	l/ha
			(m/s)	(km/h)	(bigha/h)	(ha/h)		
1	3.0	1st	0.40	1.44	1.29	0.17	3.70	21.41
2	2.5	1st	0.38	1.37	1.23	0.16	3.50	21.32
3	4.0	1st	0.39	1.40	1.26	0.17	3.80	22.55
4	0.5	1st	0.34	1.22	1.10	0.15	4.20	28.59
5	0.30	1st	0.39	1.40	1.26	0.17	4.00	23.74
Average			**0.38**	**1.37**	**1.23**	**0.16**	**3.84**	**23.52**

Place: Sorajganj, Chuadanga**Crop:** Rice **Season:**Boro 2018

Test no.	Duration of test (Working h)	Travel speed			Rate of work		Fuel consumption	
		Gear used	Speed		Area covered		l/h	l/ha
			(m/s)	(km/h)	(bigha/h)	(ha/h)		
1	2.0	1st	0.30	1.08	0.97	0.13	4.20	32.41
2	2.0	1st	0.33	1.19	1.06	0.14	3.50	24.55
3	5.0	1st	0.40	1.44	1.29	0.17	3.80	21.99
4	2.5	1st	0.34	1.22	1.10	0.15	4.20	28.59
5	1.30	1st	0.37	1.33	1.19	0.16	4.12	25.78
Average			**0.35**	**1.25**	**1.12**	**0.15**	**3.96**	**26.66**

11.2 Problemidentified:
A limited scale interview was conducted during the validation test of developed combine harvester and opinions were collected from the participants,operators, farmers and machinery users regarding the overall performance of the machine. In general, they expressed their satisfaction about the machine performance making special reference to the following problems and comments:

- Grain breakage was found in main outlet;
- The shuttering of grain was observed in the laid down crop during harvesting;
- some straw was broken due to thresher loop

11.3Awareness and validation program:

A total of five demonstration-cum awareness and 10 validation programmes were conducted in presence of different categories of farmers, manufactures and operators. Total 160 farmers were trained directly on combine harvester operation. Four operators were also trained on operation and maintenance of combine harvester. Photographic views on awareness building program, validation activity and recording of farmers feedback are shown in the Appendix 6.Five demonstration-cum awareness building programmes and two large scale validation tests were conducted during Boro 2018 season and altogether 200 participants (166 male and 34 female) mostly machine operators attended in these programmes. Most of the participants were observed this type machine first time and became very curious about the use of combine harvester. The

participants expresses their satisfaction after observing the performance of the machine and they participated in user opinion survey.

In general, harvest loss could be attributed to harvest and threshing method, harvest time, type of variety and its physical properties, crop condition in terms of maturity, lodging and soil condition. Since cut crop is laid out on residuals from 24 to 48 hours depending on climate condition and then they are collected after moisture reduction and threshed later, therefore crop moisture reduction would lead to not only a rise in grain shattering during gathering and packing but also paddy would be exposed to environmental impacts that bring about cropqualitative loss in consequence. Table 3 shows the different losses of modified combine harvester. The average harvest loss was 2.46%. Off them the cutter bar, scattering and threshing loss were found to be 0.648, 0.373 and 1.327% respectively which is quite acceptable in terms of harvest loss.

Table 3. Harvest loss assessment for Combine harvester (10 m^2 area data)

Components	test III-i	test III-ii	test III-iii
A. Obtained Yield(OY)			
Obtained Wet weight, kg	5.40	6.00	6.00
Moisture content, %	23.8	23.8	23.6
OY, Adjusted weight, kg	**4.78**	**5.32**	**5.33**
Average		**5.14**	
B. Cutting loss			
Cutterbar loss weight, g	38.25	21.50	39.50
Cutter loss, %	**0.800**	**0.404**	**0.741**
Average		**0.648**	
Scattering loss			
Scattering loss			
Threshed grain weight, g	22.50	15.00	19.50
Scattering loss, %	**0.471**	**0.282**	**0.366**
Average		**0.373**	
C. Threshing loss			
1) Cylinder loss			
Cylinder loss weight, g	40.50	16.00	27.75
Cylinder loss, %	**0.847**	**0.301**	**0.521**
2) Separation loss			
Separation loss weight, g	40.00	40.50	38.00
Separation loss, %	**0.837**	**0.761**	**0.713**
Total threshing loss, %	**1.684**	**1.062**	**1.234**
Average		**1.327**	
Total harvesting loss, %	2.955	2.083	2.341
Average threshing loss, %		**2.460**	

11.4 User opinion survey:

11.4.1 Problems in harvesting:

About 35.71% of farmers opined that harvesting by sickle is a labor-intensive method (**Figure8**) while 28.57% of farmers expressed manual harvesting by sickle is time consuming. Of the respondents, 16.67% of farmers argued that manual harvesting by sickle affected the quantity of

crops due to shattering. However, 15.08% farmers considered that current cutting methods (sickle) resulted in a quality loss and 3.97% opinion has no alternatives.

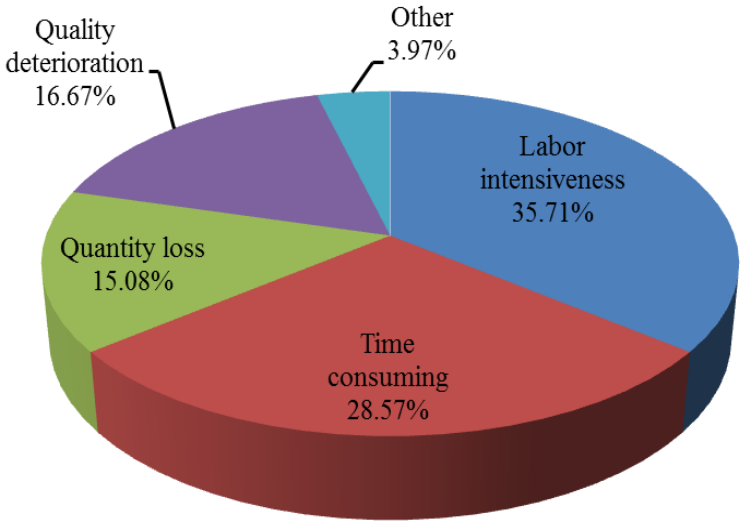


Figure8. Disadvantages of current cutting method (by sickle) of rice according to farmers' comments

11.4.2 Farmers' choice about mechanical harvesting:

Figure 9 shows the farmers' choice on the type of machinery. 63% farmers want partial mechanization because they worry about un-employment may occur; moreover, rest (37%) of them claimed full mechanization of rice harvesting is essential. The result indicated that 23.81% of farmers want to use reaper and thresher, while 14.29% of farmers are interested in head feed combine harvesters. 23.02% of farmers wanted a thresher and 5.56% of farmers desired a reaper. Only 0.79% farmers were interested in whole-feed combine, because its size made it impractical for their small fields, in contrary 26.19% farmers need winnower for cleaning rice after threshing.

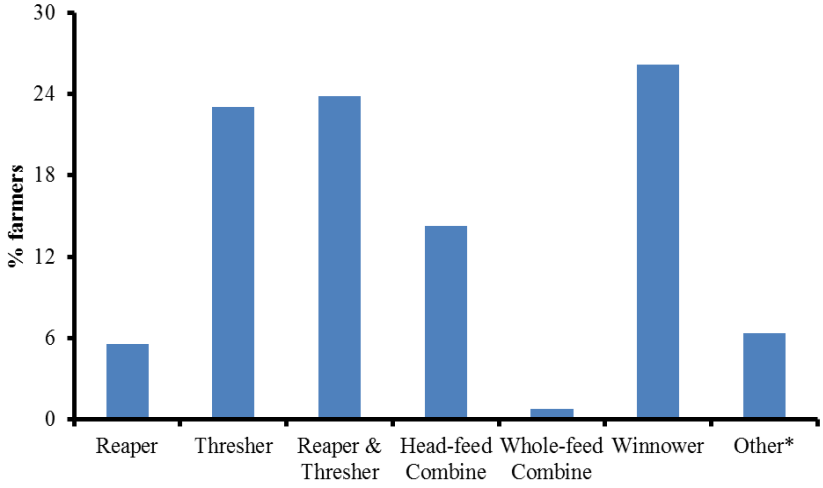


Figure9. Rates of farmers need to use machines for mechanization of rice harvesting system

11.4.3 Constraints of harvest mechanization:

Table 4 shows the survey results of constraints as expressed by the participants. Among the constraints to mechanization 40.48% of farmers identified that the main restriction as the price of the machine and 21.43% mention the information/awareness about machine, lack of credit facility

and lack of adequate government initiative is the main problem of mechanization. Other minor restrictions identified were poor condition of farm roads (6.35%) and small size of fields (5.56%).

Table 4. Factors affecting the use of machine(s) for rice harvesting from farmers

Factor/constraint	Farmer (%)	Rank	Remarks
Price of machine	40.48	1	Others: rental hire service, group of farmers
Information/ awareness about machine	21.43	2	
Lack of credit system and government initiative	21.43	2	
Poor farm road conditions	6.35	3	
Small size of fields	5.56	4	
Other	4.76	5	
Total	100		

11.4.4 Farmers' opinions about mechanized harvesting:

Table 5 shows that most farmers (36.51%) identified the vital advantage of mechanized harvesting as a lower labor requirement, while 21.43% of farmers said that lower loss of rice was another incentive for mechanizedharvesting. Only 15.87% of farmers identified low cost of harvesting as the main purpose of use harvester, moreover 14.29% farmers seems that harvesting machinery increase the social status and better livelihood of the farmers.

Table 5. Advantages of harvest mechanization from farmers (%)

Parameter	Ratio (%)	Rank	Remarks
Lower loss of rice	21.43	2	Others: Better livelihood, social status
Lower labor requirement	36.51	1	
Lower cost in harvest	15.87	3	
Save quality	11.90	5	
Other	14.29	4	
Total	100		

11.4.5 Farmer's perception for improved mechanized harvesting:

- Farmers expressed the opinion that they would benefit in different ways by introducing the harvesting machinery, as they would get extra time for doing off-farm work during the lean period as rice harvesting starts, neighboring farmers could borrow the machinery, and the new generation would show a greater interest in modern agriculture. It would also create an employment opportunity. Poor and marginal farmers who did not have the ability to purchase machinery could borrow to meet the requirements.
- In this interview, the similar needs of the farmers were disclosed in broad outlines. All farmers who participated in the interview expressed their need for machinery such as USG applicator, transplanter, harvester and weeder to increase crop productivity and cropping intensity. The main problems identified in buying and using such machinery was high price and small scale of land. As suggestions to resolve the various constraints hindering the rice productivity, all participant farmers mentioned agricultural credit with easy terms and conditions, subsidy for buying machinery and the ensuring of a fair market price for their rice.

- The participants urged the government to take effective initiatives via the local government or extension department to help the actual rice farmers to achieve greater rice productivity by using machinery. Finally, the participants mentioned that sustainable and field oriented suitable rice production technology needed to be introduced.

11.4.6Suggestion for formulating mechanized harvesting policy:

The following suggestions are made on mechanized harvesting policy based on field information.

- Farmers want to have capital intensive machine on subsidized price with an easy credit facility.
- Meetings, farmers' workshops, training, field days and demonstrations can promote farmers knowledge on the benefit of using the machine, and learn how to operate and maintain it.
- The establishment of farmer groups for harvesting service is also important. As larger fields are more productive, it is necessary to form cooperatives of small farms together.
- Development of entrepreneurship is urgently needed for providing custom hire service to the farmers.
- Research institute and extension agents can play a vital role by providing demonstration and training on the operation and maintenance of the modern machine which ultimately enhance the farm productivity through the adoption of farm machinery.

So, there is a broader avenue to introduce small to large machinery for enhancing the farm income in the study area. The key strategy in harvesting mechanization is to use machinery in every stage.

Figure 10 shows the adoption model of head-feed combine harvester.

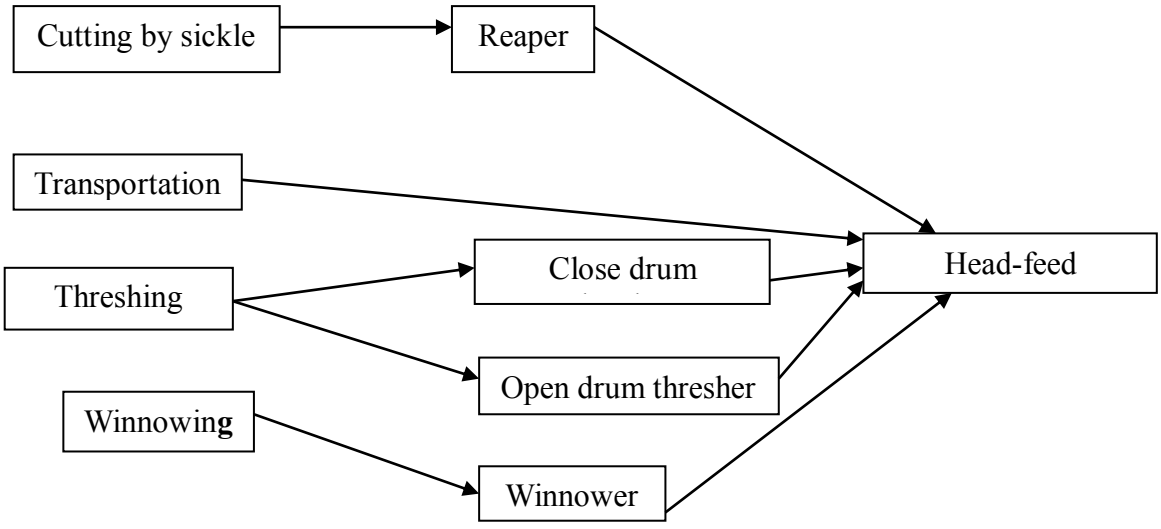


Figure10. Diagram for suggested harvest mechanization

12 Research highlight/findings:

- A prototype of head feed mini combine harvester was developedsuccessfully.
- The average harvest loss was 2.46%. Off them the cutter bar, scattering and threshing losses were found to be 0.648, 0.373 and 1.327% respectively.
- Capacity built-up of two local manufacturing workshops.
- The farmers opined that it is an easy and convenient way of harvesting paddy by combine harvester compared to the manual (sickle) system.
- Entrepreneurship should be developed to operate combine harvester on rental basis.

- Ensure quality spare parts and after sale-service for smooth operation of the machine.
- More Research and development is to be needed to get trouble free mini combine harvester at affordable cost available in a local workshop.
- Establish good linkage among the researcher, manufacturers, DAE personal and farmers for quick dissemination of the technology.
- More demonstration is required to popularize combine harvester in the field.
- Subsidy is needed for the sustainability of this technology in the farmer's field.

B. Implementation Position:

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment					
Laptop computer	1	60,000.0	1	60,000.0	
Scanner	1	10,000.0	1	10,000.0	
(b) Lab & field equipment					
Toolbox	2	30000.0	2	29200.0	
Tachometer	2	30000.0	2	30000.0	
Air Flow meter	1	8000.0	1	8000.0	
(c) Other capital items					

2. Establishment/renovation facilities: Not Applicable

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized: Not Applicable

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

C. Financial and physical progress :

Fig in Tk

Items of expenditure/activities	**Total approved budget**	**Fund received**	**Actual expenditure**	**Balance/ unspent**	**Physical progress (%)**	**Reasons for deviation**
A. Contractual staff salary	304170.00	294170.00	294170.00	0.00	100%	
B. Field research/lab expenses and supplies	1533000.00	1515419.00	1514102.00	1317.00	99.91%	
C. Operating expenses	530000.00	445412.00	444729.00	683.00	99.85%	
D. Vehicle hire and fuel, oil & maintenance	275000.00	258903.00	259513.00	0.00	100%	
E. Training/workshop/seminar etc.	0.00	0.00	0.00	0.00	-	
F. Publications and printing	130000.00	35500.00	35500.00	0.00	100%	
G. Miscellaneous	81000.00	77790.00	77790.00	0.00	100%	
H. Capital expenses	138000.00	140300.00	140300.00	0.00	100%	
Total	**2991170.0**	**2767494.00**	**2765494.00**	**2000.00**		

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
To modify the BRRI developed combine harvester	▪ Prototype was modified and preliminary field trial conducted ▪ Identified some mechanical faults ▪ Rectification of faults and finalized the prototype ▪ Improvement of gear system, working speed and cleaning system	A prototype of head feed mini combine harvester is available with better performance than that of previous one.	• Reduced turnaround time between two crops and increase cropping intensity. • Human drudgery and production cost will be reduced • Postharvest loss will be reduced.
To test and evaluation of modified combine harvester at selected locations	• • A total of fivedemonstrations – cum awareness programmes were conducted in the farmer's field during Aman 2017 and Boro 2018 seasons at Chuadanga and Gazipur.	• Total 200 progressive farmers, machine operators (M 155, F 45) were present in these demonstration cum training programme • The average field and fuel capacity was found 0.15 ha/h and 3.96 l/h respectively. • Machine price identified as the main constraint (40.48%) and lack of easy credit system (21.43%) as second constraint to introduce machine.	Farmers and machine operators became more confident to use and operate combine harvester.
To validate of the developed technology to the end users	• A total 10 validation programme was conducted at (Chuadanga 6, Netrakona 2 and Gazipur 2) farmers field • Evaluate the performance of machine • Farmers feedback were collected on machine's performance	• During validation test farmers opined thatthreshing was mainly done using closed drum thresher (49.21%) and open drum thresher (26.20%), likewise 1 of 126 farmer would use head-feed combine harvester. • Most farmers (36.51%) identified the vital advantage of mechanized harvesting as lower	An appropriate mini combine harvester will be available that will suitable for small farm holdings of Bangladesh.

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
		labor requirement, while 21.43% of farmers said that a lower loss of rice. • Operation manual was developed on field problem and troubleshooting mechanism of harvester.	

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	1		Operational manual
	1		Folder
Journal publication			
Information development			
Other publications, if any			

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity):

- An efficient mini combine harvester was successfully developed and thereby harvesting operations can be completed in time
- Production cost as well as postharvest losses will be reduced.
- The design of a prototype of head feed mini combine harvester was modified and fabricated through project support.
- 10 validation and 5 awareness training programmes were conducted with this final prototype of mini combine harvester.
- A printed research report and "User's Manual" of mini combine harvester has been published for farmers, extension workers and end users.

ii. Generation of new knowledge that help in developing more technology in future:

The field validation and demonstration progammes revealed that some improvements are necessary in the final prototype. The improvement works will be continued under revenue budget of BRRI. The minor faults can be rectified easily by the local manufacturers and farmers will get trouble free mini combine harvesters at affordable costs.

iii. Technology transferred that help increased agricultural productivity and farmers' income :

- The adoption of mini combine harvester in farmers field mitigate labour shortage at peak period of harvesting that ensure timely harvesting of paddy.
- Thereby, production cost and postharvest losses would be reduced and total productivity would be increase. This would also allow the land to be prepared for the subsequent crops quickly. The extra production will contribute in alleviating poverty of the end users.

iv. Policy Support:

- Provide financial support to local manufactures for collecting capital machinery and establish physical infrastructure of the workshop.
- Need back-up industry for research and development.
- Provide long term specialized training for mechanic, machine operator, manufactures, DAE personnel and researchers.
- Need subsidy and soft loan to farmers and enerpreners for purchasing farm machinery
- Establish jointresearch and manufacturing industry in collaboration with a renowned foreign industry.

G. Information regarding Desk and Field Monitoring:

i) Desk Monitoring (description & output of consultation meeting, monitoring workshops/seminars etc.):

The desk monitoring was done by Agricultural Engineering Section of Bangladesh Agricultural Research Council (BARC) and Project Implementation Unit (PIU), BARC, NATP Phase II on the basis of monthly progress report, quarterly, half-yearly and yearly report of each sub-project. PIU and Agricultural Engineering Section arranged day long review workshop on 15-16 May 2018 and 18 September 2018. The progress report of each sub-project was present and all PI and Co-PIs were present in these workshop. A threadbare discussion was done in the presence of expert pull member and all stakeholders.

ii) Field Monitoring (time & No. of visit, Team visit and output):

BRRI authority formed an internal monitoring committee to monitor NATP funded project. The internal monitoring committee of BRRI time to time monitor project activity at head quarter and farmers field as well. Director General and Directors also visited field demonstration of mini combine harvester at Jogitala, Dhirasharam and Taratpara of Gazipur districts. The BRRI authority and monitoring committee was given valuable suggestion to improve the performance of the harvester. Photographic views on performance evaluation are shown in Figs. presented in Appendix 1.

Monitoring team	Date(s) of visit	Total visit till date (No.)
Internal Monitoring	12/8/2017 & 05/03/2018	2
Field visit by BRRI expert pool	29/05/18	1
Others Visitors (Audit Team)	28/10/2017	1

I. Lesson Learned/Challenges (if any):

i) Rapid adoption of combine harvester is needed to minimize shortage of labour and high wages of labour during peak period of harvesting.
ii) The farmers opined that it is an easy and convenient way of harvesting paddy by combine harvester compared with the manual (sickle) system because machine accomplish cutting, threshing, cleaning and bagging at a time.
iii) Establish good linkage among the researcher, DAE personnel, manufacturers and farmers for successful extensive operation of the machine.
iv) Entrepreneurship should be developed to operate combine harvester on rental basis because purchasing capacity of farmers is low and one machine is not required for individual farmer to harvest his own land.
v) Ensure quality spare parts and after sale-service for smooth operation of the machine.
vi) The productivity of land and labour will be increased and create employment opportunity by engaging more people in machine operation, servicing, trading and fabricating machine, tools and accessories that contributing non-farm economy in rural areas.

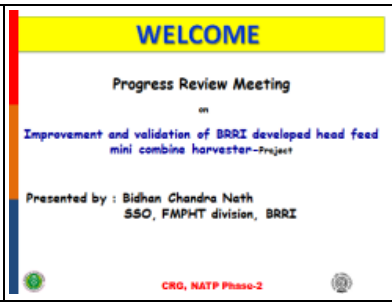
J. Challenges (if any):

There is no skilled manufacturing workshop/company in Bangladesh from where machine can be multiplied from engineering drawing, even from a prototype. There is also no facility to manufacture quality spare parts. Therefore, it's a big challenge to multiply quality machine from developed prototype of mini combine harvester and disseminate it to end users. In addition, skill mechanic is still absent for troubleshooting of combine harvester in the field.

Signature of the Principal Investigator
Date …….
Seal

Counter signature of the Head of the organization/authorized representative
Date ……..
Seal

Appendix 1: Project Monitoring Activities



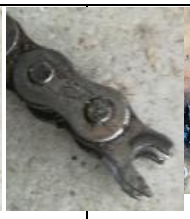
Planning and review meeting for modification of BRRI combine in FMPHT division	Monitoring and Evaluation meeti on CRG projects, BRRI

Appendix2: Field performance of 1st prototype

Performance test (no load condition)	Harvesting Aman/2017	Cleaning paddy

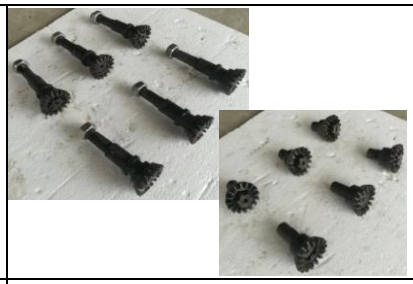
Harvesting Boro/18	Operation in wet field

Appendix 3: Frequently breakable parts (Chain, gripper, stripper belt, gear, etc.)



Chain	Gipper	Belt	Gear

Appendix 4: Different parts of combine harvester

		
Different sizes nut and bolt	Fabricated small parts	Nut and gear
		
Gear	Star wheel	Reapig bled
		
Stripper belt sylender	Stripper belt	Star wheel cover
		
Gear box	Cutting head	Crawler base

Appendix 5: Manufacturing of different parts at local workshop

		
Setting the stripper belt	Reaping part	
		
Assembling the cutter part	Threshing part	
		
Observe the work progress	Ptich length	Measured stripper belt speed
		
Measured the threshing drum rpm	Measured the cutting bled rpm	Obsevation the self starting system

Appendix 6: Awareness program, validation activity and farmers feedback collection

Field demonstration/awareness Program

Validation program

Farmers opinion/feedback collection

Operation in wet field

Operation in dry field

Straw row

Farmer observation

MoA people

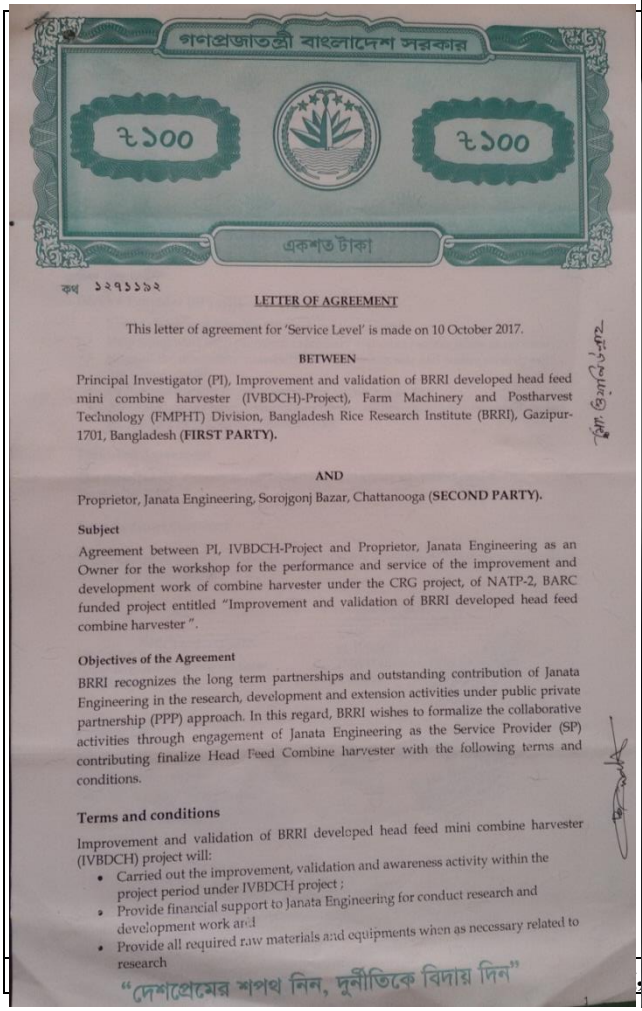
Cleaning grain

Appendix 7: Available combine harvester in Bangladesh

Glory model

Head feed (Dedong)

Appendix 8: LoA with local manufacturingworkshop



গণপ্রজাতন্ত্রী বাংলাদেশ সরকার

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LETTER OF AGREEMENT

This letter of agreement for 'Service Level' is made on 10 October 2017.

BETWEEN

Principal Investigator (PI), Improvement and validation of BRRI developed head feed mini combine harvester (IVBDCH)-Project), Farm Machinery and Postharvest Technology (FMPHT) Division, Bangladesh Rice Research Institute (BRRI), Gazipur-1701, Bangladesh **(FIRST PARTY).**

AND

Proprietor, Janata Engineering, Sorojgonj Bazar, Chattanooga **(SECOND PARTY).**

Subject

Agreement between PI, IVBDCH-Project and Proprietor, Janata Engineering as an Owner for the workshop for the performance and service of the improvement and development work of combine harvester under the CRG project, of NATP-2, BARC funded project entitled "Improvement and validation of BRRI developed head feed combine harvester ".

Objectives of the Agreement

BRRI recognizes the long term partnerships and outstanding contribution of Janata Engineering in the research, development and extension activities under public private partnership (PPP) approach. In this regard, BRRI wishes to formalize the collaborative activities through engagement of Janata Engineering as the Service Provider (SP) contributing finalize Head Feed Combine harvester with the following terms and conditions.

Terms and conditions

Improvement and validation of BRRI developed head feed mini combine harvester (IVBDCH) project will:

- Carried out the improvement, validation and awareness activity within the project period under IVBDCH project ;
- Provide financial support to Janata Engineering for conduct research and development work and
- Provide all required raw materials and equipments when as necessary related to research

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Service Provider (SP) will

- Provide labor and other facilities related to research;
- Help using workshop premises, machinery and others works when as necessary;
- Keep all the machinery, materials and equipments safe and ensure security with full responsibility;
- Fully assist to conduct field trials in the farmer's field and
- All related costs (labour, workshop charge, welding charge, the overhead charge, etc.) should be placed on letterhead pad.

Period of Agreement

The period of the agreement will be for twelve months (10 October 2017 to 30 September 2018).

Termination of contract

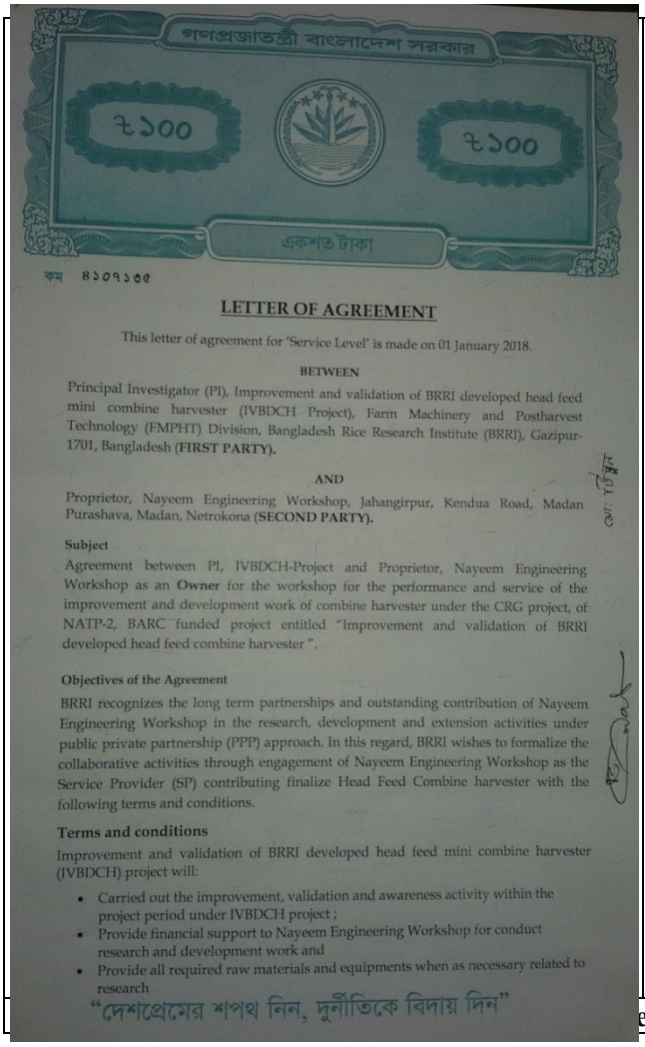
If the workshop Proprietor fails to meet the above any clause of the agreement will be terminated automatically.

Proprietor
Janata Engineering, Sorojgonj Bazar, Chuadanga

PI, IVBDCH Project
FMPHT division, BRRI
Gazipur

Witness
Name:
Address:

Witness
Name:
Address: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LETTER OF AGREEMENT

This letter of agreement for 'Service Level' is made on 01 January 2018.

BETWEEN

Principal Investigator (PI), Improvement and validation of BRRI developed head feed mini combine harvester (IVBDCH Project), Farm Machinery and Postharvest Technology (FMPHT) Division, Bangladesh Rice Research Institute (BRRI), Gazipur-1701, Bangladesh **(FIRST PARTY).**

AND

Proprietor, Nayeem Engineering Workshop, Jahangirpur, Kendua Road, Madan Purashava, Madan, Netrokona **(SECOND PARTY).**

Subject

Agreement between PI, IVBDCH-Project and Proprietor, Nayeem Engineering Workshop as an **Owner** for the workshop for the performance and service of the improvement and development work of combine harvester under the CRG project, of NATP-2, BARC funded project entitled "Improvement and validation of BRRI developed head feed combine harvester ".

Objectives of the Agreement

BRRI recognizes the long term partnerships and outstanding contribution of Nayeem Engineering Workshop in the research, development and extension activities under public private partnership (PPP) approach. In this regard, BRRI wishes to formalize the collaborative activities through engagement of Nayeem Engineering Workshop as the Service Provider (SP) contributing finalize Head Feed Combine harvester with the following terms and conditions.

Terms and conditions

Improvement and validation of BRRI developed head feed mini combine harvester (IVBDCH) project will:

- Carried out the improvement, validation and awareness activity within the project period under IVBDCH project ;
- Provide financial support to Nayeem Engineering Workshop for conduct research and development work and
- Provide all required raw materials and equipments when as necessary related to research

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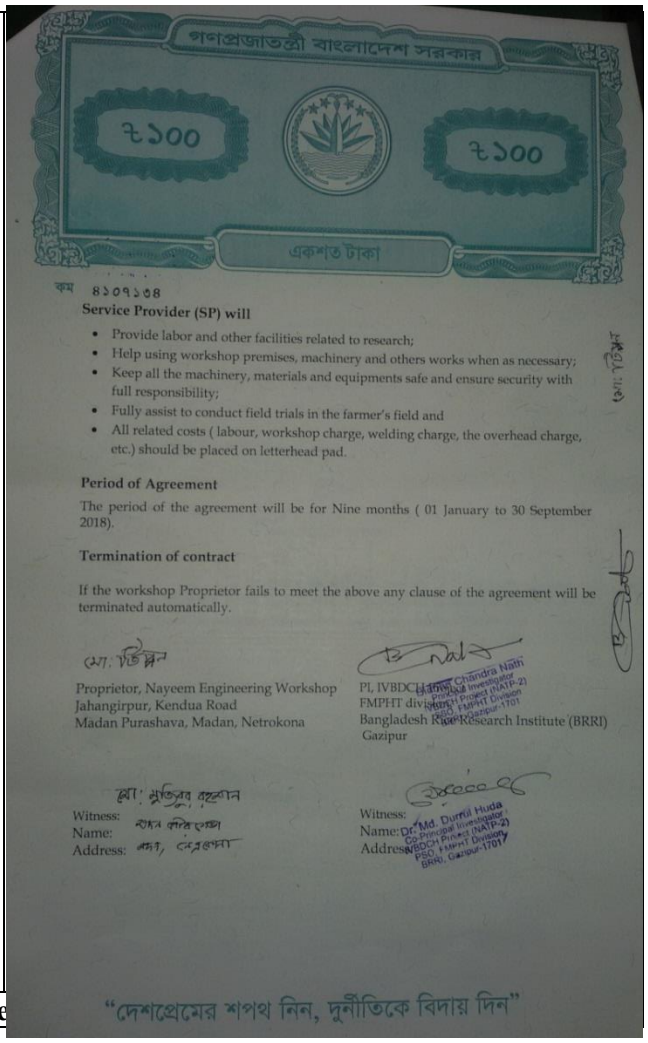
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Service Provider (SP) will

- Provide labor and other facilities related to research;
- Help using workshop premises, machinery and others works when as necessary;
- Keep all the machinery, materials and equipments safe and ensure security with full responsibility;
- Fully assist to conduct field trials in the farmer's field and
- All related costs (labour, workshop charge, welding charge, the overhead charge, etc.) should be placed on letterhead pad.

Period of Agreement

The period of the agreement will be for Nine months (01 January to 30 September 2018).

Termination of contract

If the workshop Proprietor fails to meet the above any clause of the agreement will be terminated automatically.

Proprietor, Nayeem Engineering Workshop
Jahangirpur, Kendua Road
Madan Purashava, Madan, Netrokona

PI, IVBDCH-Project
FMPHT division
Bangladesh Rice Research Institute (BRRI)
Gazipur

Witness:
Name:
Address:

Witness:
Name:
Address:

"দেশপ্রেমের শপথ নিন, দুর্নীতিকে বিদায় দিন"

Appendix 9: Publication of booklet and leaflet

Appendix 10:Opinion collection questionnaires

Questionnaire
For rice harvesting mechanization

Name of participatory of survey:
Address:

Amount of cultivable land/ farm size (decimal):

1. *How do you cut the rice?*
   a) Head-feed Combine b) Whole-feed Combine c)Reaper d) sickle
   e) Others (write down).....

2. *Which do you think the Disadvantage of your current cutting method of rice?*
   a) Labor intensiveness b) Time consuming c) Quantity loss d) Quality deterioration
   e) Others.....

3. *What kind of machine/tools do you use for threshing of rice?*
   a) Head-feed Combine b) Whole-feed Combine c) Head-feed Thresher
   d) Close drum Thresher e) Open drum Thresher f) Paddle Thresher
   g) Others (write down).....

4. *Which do you think the Disadvantage of your current threshing method of rice?*
   a) Labor intensiveness b) Time consuming c) Quantity loss d) Quality deterioration
   e) Others.....

5. *How do you use for cleaning the rice?*
   a) Winnower b) Kula c) Kula with Electric fan
   d) Others (write down).....

6. *Do you have any kind of machines for harvesting rice? (yes, no)*
7. *If you have some machines, which do you use to harvest the rice?*
   a) Head-feed Combine b) Whole-feed Combine c) Head-feed Thresher
   d) Whole-feed Thresher e) Reaper f) Binder
   g) Other machine (write down).....

8. *Do you want to do mechanization for rice harvesting? (yes, no)*

9. *If you want introduce some machines, what kind of machine do you want to harvest with?*
   a) Reaper b) Thresher c) Reaper & Thresher d) Head-feed Combine e) whole-feed Combine
   f) Others (write down).....

10. *What is the restriction to introduce the machine(s) for harvesting rice?*
   a) Price of machine b) Poor farm road condition c) Small size of the field
   d) Others (write down).....

11. *Which do you think the most important point for mechanization in harvesting?*
   a) Lower loss of rice b) Lower requirement of labor c) Lower cost in harvest
   d) Others (write down).....

12. *In spite of that you want to buy combine for highest performance, if the expensive price is the main obstacle, then are you willing to buy it with your neighbor for common use? <In this case, you may have to concern about removing ridges as borders.>* (yes no)

13. *How do you carry the cutting rice to threshing filed and disadvantage of carrying method?*
   (Write down).....

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