Project ID: 307

Competitive Research Grant

Sub-Project Completion Report

on

Improvement of Coconut Harvesting and Dehusking Machine

Project Duration

May 2017 to September 2018

Farm Machinery and Postharvest Process Engineering Division
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur-1701

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

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Project Implementation Unit
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Bangladesh Agricultural Research Council (BARC)
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Acronyms

FMPE: Farm Machinery and Postharvest Process Engineering Division

BARI: Bangladesh Agricultural Research Institute

HRC: Horticultural Research Centre

MS: Mild steel

SS: Stainless steel

m: Meter

SWG: Standard Wire Gauge

Ø: Diameter

φ:Phase

kg: kilogram

h: Hour

BCR: Benefit Cost Ratio

Tk.: Taka

BEP: Break Even Point

RARS: Regional Agricultural Research Station

RCC: Reinforced Cement Concrete

BBS: Bangladesh Bureau of Statistics

Nut: Coconut

DAE: Department of Agricultural Extension

L: Length

W: Width

H: Height

D: Diameter

T: Teeth

cm: centimeter

mm: millimeter

hp: Horse power

rpm: Revolution per minute

Table of Contents

List of Tables

List of Figures

Executive Summary

A base line survey was conducted on coconut production, harvesting, dehusking and packaging at six coconut growing districts such as Barishal, Noakhali, Khulna, Bagerhat, Patuakhali, and Pirojpur to generate baseline data which would help in developing improved coconut climbing and dehusking devices. One upazila from each district was purposively selected based on the existence of primary and secondary coconut markets. Primary data were collected from randomly selected 180 farmers, 24 Beparis/Paikers, 26 retailers and 9 wholesalers. The majority of the farmers (68.34%), traders (60.35%) and retailers (54.16%) had primary levels of education. Average experience of coconut Beparis/Paikers was 11.60 years which was ranged from 9 to 19 years. All farmers, traders and retailers sold coconuts in round the year. The highest and the lowest number of coconut tree cultivation of each family were found to be 37.2 and 16.7 in Noakhali and Patuakali respectively. Average height, girth of bottom and top, and grip numbers of the coconut tree were 10.32 m, 1.10 m, 0.78 m and 26.42 numbers per meter respectively. Farmers harvested coconuts in summer and winter in average 289 and 192numbers respectively. The highest yield of coconut was found in summer than that of winter whereas selling price of the coconut was vise-versa. Farmers harvested coconut by manual practice. There was no mechanical device used for harvesting of coconut in study areas. Average climbing speed of the skilled operator in manual practice was 0.4 m/s and harvesting including cleaning cost was 40 Tk per tree whereas 0.11 m/s speed and 25Tk per tree of improved climber. Ninety one percent farmers sold coconuts with husk and 9% farmers sold coconuts without husk. The most of the farmers used *Dha* for dehusking the coconut and other farmers used *Sarasi* and *Khanti*. Retailers sold 66% coconut with husk and 34% coconut without husk. Forty seven percent traders dehusked coconut using *Khanti*, 37% traders using *Sarasi*and 16% traders using *Dha*. Hundred percent trader of Khulna dehusked coconuts using *Khanti.*Dehusking capacities of *Dha, Sarasi*and*Khanti* varied from 20 to 25 nuts/h, 43 to 75 nuts/h and 100 to 175 nut/h respectively. Improved coconut tree climber and coconut dehusking machines were designed and fabricated with stainless steel of sheet, shaft, angle bar, flat bar, pipe, rod, chain sprocket, nut boltetcat Farm Machinery and postharvest Process Engineering Division. Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. The overall dimensions of the climber and dehusker were 1070×100×Ø10 mm and 920×750×1120 mm respectively. The main functional parts of the climber were left and right handle, foot holder, tree holder, wire etc. Main working parts of the dehusker were rotating blade roller, motor, chain sprocket. The weights of the climber and dehusker were 9 and 258 kg respectively. The prices of the climber and dehusker were Tk. 8800.00 and Tk. 100000.00 respectively. The payback period of the climber was 25 days. The benefit cost ratio of the climber was 1.60. The average capacity of dehusker was 309 nuts per hour at the speed of 25 rpm. The breakage percentage of coconut was found to be 3-6. The dehusking cost of the dehusker was found to be 0.28 Tk./nut. The payback period of the dehusker was 116 days and benefit cost ratio was 1.25. Therefore, coconut dehusk by the dehusker could be profitable to traders when the annual use of the dehusker exceeds 775 hours. Feedback from coconut growers and traders are very positive and encouraging response to motivate towards machine use. Improved technologies are safety, economic, women and environment friendly and make scope to generate employment.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: Improvement of Coconut Harvesting and Dehusking Machine
2. Implementing organization: Bangladesh Agricultural Research Institute
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: 1500000.00
   4.2 Revised (if any):
5. Duration of the sub-project:
   5.1 Start date (based on LoA signed): 9 May 2017
   5.2 End date: 30 September 2018

6. Justification of undertaking the sub-project:

Coconut (*Cocos nucifera*L.) is very popular and common fruits in Bangladesh. Coconut produced about 0.41 million tons in Bangladesh (BBS, 2018). Coconuts are cultivated more or less all over the country. Unfortunately, despite its mass distribution and wide spread around the world, coconut harvesting is still done without proper safety measures which can lead to serious injuries. It is very difficult to climb on coconut tree manually due to the constant cylindrical structure and single trunk. It is very hard to learn the necessary skills to climb coconut trees. Now a day, different types of coconut harvesting methods are held with the human in other countries of the world like India, Malaysia, and Sri Lanka. Edacheri*et al.,* (2011) reportedthat at present there are mainly two types of coconut tree climbing devices are available in Indian market. The two types are sitting type climbing device and standing type climbing device. Hariskrishna*et al.,*(2013)reported thatmost of these climbing robots are capable of climbing regular structures like poles, walls, domes etc. But a very few are capable of climbing trees, main reason being irregular surface and variation of diameter with length. It also requires greater agility and high maneuverability to be used as a product. Also the bark of some trees may not be strong enough to bear the weight of the climbing device, hence conventional climbing robots cannot be used for tree climbing applications. If a person wants to climb a coconut tree manually climbing person has to put his hands close to each other on

the back of the trunk, and pull one foot in front of the other one in front of the climbing person on the tree. By keeping pressure on the trunk with the balls of the climbing person's feet and toes, walk up alternating moving feet and hands. Technically it seems to be the easiest to learn but requires good balance and arm strength (Jeff Jepson, 2000). In Bangladesh, coconut growers know how to cultivate the coconut but they can harvest coconut mainly by climbing on tree which is very risky. As the coconut trees are very tall so injuries associated with coconut tree climbing, particularly falling from coconut trees is common phenomena. In traditional method climbing of a coconut tree is time consuming and labour dependence. People who employed for coconut tree climbing suffer musculoskeletal disorders. Due to the risk involved very less people are coming forward to climb on coconut trees. On the other hand, husk of coconut is removed for getting nut and shell as raw materials in coconut oil industries and for edible purposes at household level. Husking is done manually by sharp iron in oil industries and retail markets in our country. The work is hard and required high skill and strength. Now a days, labour crisis is acute as most of rural people go to urban area for getting better wage in different industry. So, the use of agricultural machinery will be mitigating the labour crisis. Time based demand of coconut harvesting and processing machines came from farmers level through different regional research stations of BARI. An automated machine for coconut dehusking and crown removal has been developed for the small scale farm holders in the agricultural and rural areas in India. The operation of the machine is simple and the maintenance of the machine is also not expensive. The capacity of the machine is on an average of 210 nuts per hour. Introducing this machine in the farm areas can reduce the risk involved in the use of spikes in dehusking the coconut and also eliminates the skilled manpower required for dehusking the coconuts. The machine can also be integrated along with the further processing steps of the nuts such as the production of copra (Venkataramanan et al. 2014). A power operated coconut dehusking machine operated 1 hp electric motor. It consists of main parts like frame, electric motor, speed reduction unit and dehusking unit. Single person is required for operating the dehusker. Average time required for dehusking a coconut was found to be 25 second, and the machine can dehusk 120-150 coconuts per hour (Jacob and Kumar, 2012). A power operated coconut de-shelling machine was designed and developed which consists of cutter with belt drive. Average de-shelling efficiency and capacity are 90% and 195 coconuts per hour. H. Mdakhir*et al.,* (2016) has been designed and developed a mechanical coconut dehusking machine which consisted of a petrol powered engine, hydraulic system, gears, chains, rollers with sharp spikes, mesh guard, speed controller and frame. The dehusking rate was estimated at 250 – 300 nuts an hour or 7 – 10 seconds per nut. Now, both the coconut climber and coconut dehusker are urgently need of the time in our country. At our policy level, it is given thrust to develop improved machine for coconut harvesting and dehusking. BARI has developed coconut tree climber and dehusker but their capacity and efficiency are comparatively lower. Breakage percentage of coconut using by BARI coconut dehusker is 5-10 percent that is higher. Imported climber was modified by BARI do not climb all diameters of coconut tree. There is a lot of scope to improve the machines efficiency. Due to lack of facility and money, progress of the machine is slow. On the basis of baseline survey information, the study was undertaken to improve a BARI manual climber and power coconut husking machine which were help the user to climb coconut tree easily and safely, and also dehusked coconut was useful for the people who is having large coconut cultivation as well as residents who is having less coconut trees.

7. Sub-project goal: Enhances risk free coconut harvesting and processing machine

8. Sub-project objective (s):
   i) To conduct the baseline survey on present status of harvesting and dehusking practices of coconut in selected major coconut growing areas of Bangladesh
   ii) To improve coconut climber &dehusker, and evaluate the performance of climber and dehusker along with economic feasibility
   iii) To conduct training of climber and dehusker at users level in the project areas.

9. Implementing location (s):
   Barishal, Noakhali, Patuakhali, Bagerhat, Khulna andPirojpur

10. Methodology in brief
    Site selection: The following six upazila were selected under six districts for survey data collection.

District	**Upazilla**
Barishal	Banaripara
Noakhali	Sadar(Maijdi)
Patuakhali	Dumki
Khulna	Fultala
Bagerhat	Sadar
Pirojpur	Nesarabad (Swarupkati)

Preparation of survey questionnaire
Survey questionnaire was developed by incorporating indicators for fulfilling the study objectives. The draft questionnaire was modified with the help of Agricultural Economics Division, BARI, Joydebpur, Gazipur.

Pre-test of questionnaires: Pre-test of questionnaires was conducted at Fultala, Khulna on 9 August 2017 (Fig.1). Questionnaires were modified as per pre-test information.

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Fig. 1 Trader interviewed through questionnaires at Fultala, Khulna

Survey and secondary data collection:
Different teams of trained enumerators and scientists of the project collected primary data from selected farmers and traders (retailers, wholesaler, Paiker) using structured questionnaire through personal interview during 16 August 2017 to 20 September 2017. Secondary data were also collected from journal papers, reports and internet etc.

Guideline to enumerators for fill up the questionnaire

The informal training program was conducted with the enumerators for fill up the surveyquestionnaire properly at FMPE seminar room, BARI, Gazipuron 10 September 2017 after modification of the pretest of questionnaire (Fig. 2).

Fig.2 Conducted informal training program of enumerators

Description of baseline survey data collection of six selected upazila:

Fultalaupazila, Khulna

The study was conducted at Fultalaupazilaunder Khulna district and neighboring area. Farmers, *Bapari/Paikers*, retailers and wholesaler were interviewed through respective questionnaire during 16-17 August 2017 (Fig. 3-4).

Fig.3 Data collected from farmers

Fig.4 Data collected from retailer

Banaripara upazila, Barishal

The survey study was conducted at Banaripara upzila under Barishal district. Farmers, *Bapari/Paikers* and retailer were interviewed through respective questionnaire during 6-7 September 2017 (Fig.5-7). There was no wholesaler found in this area.

Fig.5 Data collected from farmer

Fig.6 Data collected from farmer cum *bepari*


Fig. 7 Measurement physical parameters of coconut tree

BagerhatSadar

The survey data on practice of coconut harvesting and dehusking status of farmers, traders and retailers was collected at Bagerhat during 17-18 September 2017 (Fig. 8-11). Labour got scratched hands, legc and chest during climbing on and climbing down from the tree (Fig.9-10). Farmers and traders used *Khant*i for removal husk from the coconut (Fig. 12-13).

Fig. 8 Traditional practice of climbing of coconut tree

Fig. 9 Scratched of hands during climbing of coconut

Fig. 10 Scratched of during climbing of coconut tree

Fig. 11 Data collection from retailers

Fig. 12 Farmers and traders used sharp iron tool for removing of coconut husk

Fig. 13 Farmers and traders dehusked using sharp iron tool

Noakhalisadar (Maijdi)

The data on coconut harvesting and dehusking status was collected from farmers, traders and retailers at Maijdi17-18 September 2017 (Fig. 14-15). Traders used *Khanti* for dehusking the coconut (Fig. 16).

Fig. 14 Measurement physical parameters of coconut tree

Fig. 15 Data collected from farmer

Fig. 16 Dehusked coconut by using sharp iron tool (*Khanti)*

Nesarabad (Swarupkati), Pirojpur

The data on coconut harvesting and dehusking status of farmers, traders and retailers was collected during 17-18 September 2017. Labour got scratched of hands during climbing of coconut tree (Fig. 17). Traders used *Khanti* for dehusking the coconut. Labour got pained arms, knee and backbone of the body during dehusking the coconut by *Khanti* (Fig.18). They packed dehusked coconut into the plastic sack for long distance transportation (Fig. 19). Operators felt pain in the knees and back due to working back and posture.

Fig. 17 Scratched of hands during climbing of coconut tree

Fig. 18 Farmers and traders dehusked coconut using sharp iron tool (*Khanti*)

Fig. 19 Traders packed the coconut in poly sack for selling distance market

Dumki, Patuakhali

The data on coconut harvesting and dehusking status of farmers, traders and retailers was collected during 19-20 September 2017 (Fig. 20). Labour got scratched of hands during climbing of coconut tree (Fig. 21).

Fig. 20 Traditional practice of climbing of coconut tree

Fig. 21 Scratchedof hands during climbing of coconut tree in traditional

Present status of coconut harvesting and dehusking tools in traditional practices of selected project sites are shown in Table 1.

Table 1 Status of traditional coconut harvesting and dehusking tools at different districts

Sl. No.	Upazila Name	District Name	Harvesting practice and tool name	Dehusking practice and tool name
1	Banaripara	Barishal	Manually,and *Dha*	Farmers and traders did not dehusk coconut for selling but farmers dehusk coconut with *Dha*for their own consumption.
2	NoakhaliSadar (Maijdi)	Noakhali	Manually,and *Dha*	Farmers and traders did not dehusk coconut for selling but farmers dehusk coconut with *Dha* for their own consumption. Traders used *Khanti.*
3	Dumki	Patuakhali	Manually,and *Dha*	Farmers and traders did not dehusk coconut for selling but farmers dehusk coconut with *Dha* for their own consumption.
4	Fultala	Khulna	Manually,and *Dha*	Traders dehusked coconuts using *Sarasi* for selling.
5	Bagerhat Sadar	Bagerhat	Manually,and *Dha*	Traders dehusked of coconut using sharp iron tool (*Khanti*) for selling.
6	Nesarabad (Swarupkati)	Pirojpur	Manually,and *Dha*	Traders dehusked coconut using sharp iron tool (*Khanti*) for selling .

Design considerations of the coconut tree climber

- Safety measures should be maintained
- It should be portable
- Fabrication cost should be minimum

The improvement of standing type coconut tree climber was fabricated with locally available materials at the workshop of Farm Machinery and Postharvest Process Engineering Division of Bangladesh Agricultural Research Institute (BARI), Gazipur during 2016-2017. The materials used for fabrication of different parts of the climber were stainless steel, SS rod, nut-bolt, rubber and other small parts. Different views of the coconut tree climber are presented in Fig. 22. Fabrication materials and major component of coconut tree climber with specifications are shown in Table 2.

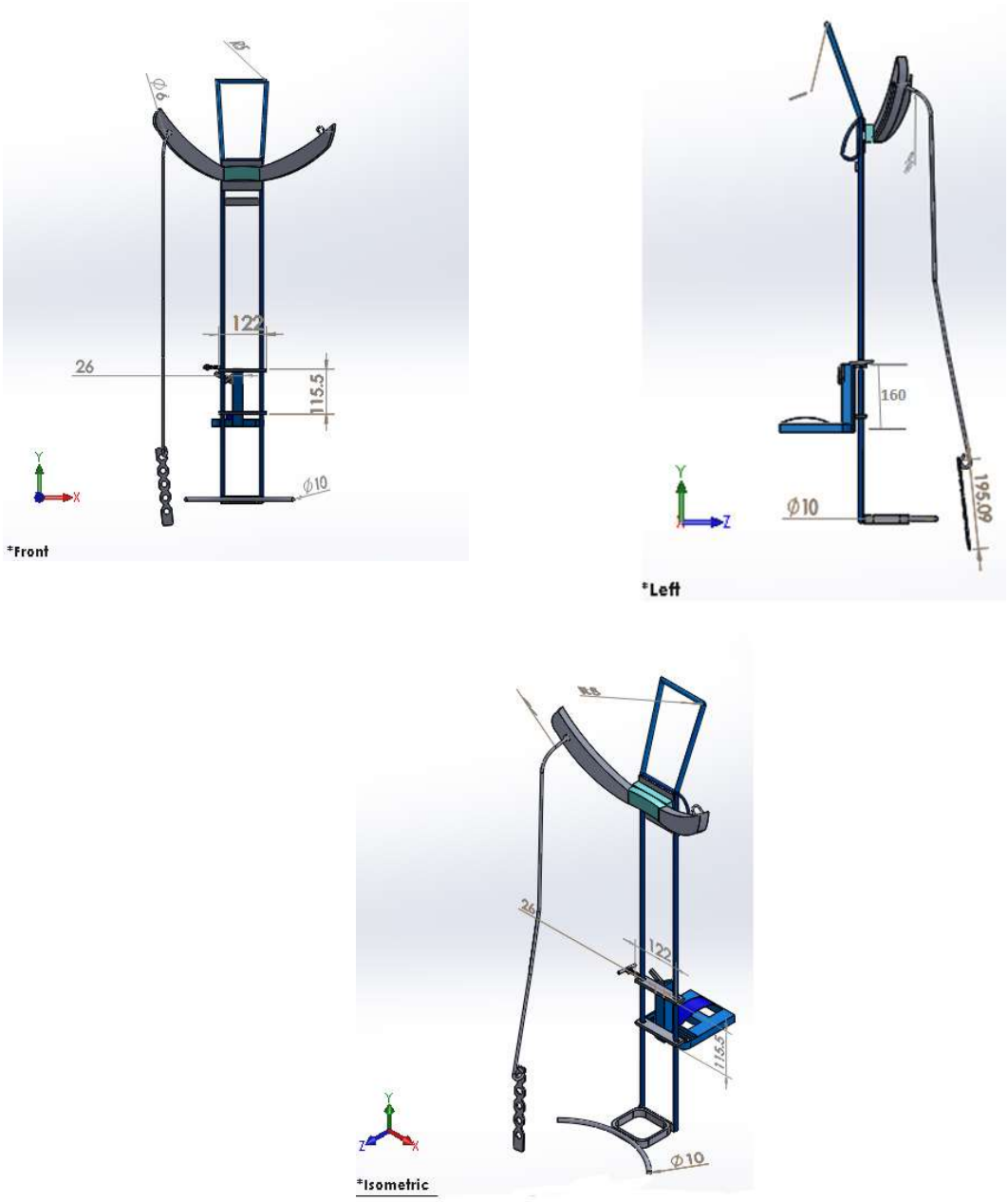

Fig. 22 Different views of coconut tree climber

Table 2. Specifications of different parts of coconut tree climber

Sl. No.	Name of the parts	Existing climber		Improved climber	
		Specification	Materials	Specification	Materials
1	Left main frame,((L×W×D) mm	1080×100×Ø10	Stainless Steel	1070×100×Ø10	Stainless Steel
2	Right main frame, ((L×W×D) mm	1030×100×Ø10	Stainless Steel	1030×100× Ø10	Stainless Steel
3	Left foot holder, (L×W× H) mm	150×130×180,4	MS flat bar and angle bar	150×130×160, 4	Stainless Steel
4	Right foot holder, (L×W× H) mm	155×130×330	MS flat bar, angle bar	150×130×330	Stainless Steel
5	Left handle, (L×W×D) mm	220×130 × Ø10	Stainless Steel	200×140 × Ø10	Stainless Steel
6	Right handle,(L×W×D) mm	100×130 × Ø10	Stainless Steel	110 ×135× Ø 10	Stainless Steel
7	Tree holder,(L×D) mm	345×Ø10	MS rod	360×Ø10	MS rod
6	Left wire, (L×D) mm	2133.6 × Ø6	Stainless Steel	1900× Ø6	Stainless Steel
8	Right wire, (L×D) mm	2133.6 × Ø 6	Stainless Steel	1900× Ø6	Stainless Steel
9	Rubber tier (L×W×T) mm	680×35×20	Rubber	520×60×20	Rubber
10	U clamp, (L×D) mm	80×45×Ø5	Mild Steel	50×30×Ø5	Stainless Steel
11	Girth control bar, (L×W×T) mm	-	-	200×27×3	Stainless Steel
12	Weight of the machine (left part)	4.9 kg	-	4.40	-
13	Weight of the machine (right part)	4.8kg	-	4.63	-

*L=length, W=Width and D=Diameter

Description of the climber

The machine is standing type manual operated coconut tree climber (Fig. 23). It consisted into two parts. One part is used in left leg and another part is in right leg. The parts of the machine are independently movable and positionable along the coconut tree trunk. The tree gripping section of the machine consisted of stainless steel wire and rubber tires. The functional parts of the machine were left and right handle, foot holder, tree holder, wire etc. The dimension of the climber is 1070×100×Ø10 mm. One person can easily operate this machine. The total weight of the machine is 9 kg.

Fig 23. Photographic view of coconut tree climber

Working Principle

Coconut tree climber has mainly two assemblies of similar fabrication. The user has maintained these two assemblies simultaneously by using hands and legs to climb on different size and shape of coconut tree. The user has to stand and operate the device. Initially the steel wire of both the assembles has to be looped with the tree and to be locked. One person can

stand by placing foot on both assemblies and has to hold on the handles. As the user raise the assembly by foot and by hand the steel wire will get loosen and when he push back with foot after reaching to a particular height it is got tighten. By this process the user can climb the tree easily. The descending the tree is exactly the reverse procedure. The machine works on the body weight and the steel rope wire and got adjusted as per diameter of the tree by the force applied by the user towards gravity.

Performance test of the climber

Laboratory test

The performance of coconut tree climber was evaluated at Horticultural Research Centre coconut orchard of BARI, Gazipur during 2017 (Fig. 24). Climbing time, height of coconut tree, girth of coconut tree and grip number and pressure of the operator was measured by stethoscope and aneroid sphygmomanometer made in Japan.

Fig. 24 Performance test of the climber at HRC orchard, Gazipur

Field test

The performance of the climber was evaluated in Regional Research Station, Rahmatpur, Barishal in February 2018 (Fig. 25). Climbing time, height of coconut tree, girth of coconut tree and grip number and blood pressure of the operators (before and after climbing) was measured by stethoscope and aneroid sphygmomanometer made in Japan.

Fig. 25 Performance test of the coconut tree climber at Barishal

Economic analysis

Price estimation for fabrication of coconut tree climber

The fabrication price of the climber was calculated including cost of materials, labour, overhead, incidental expenses and manufacturing profit (Appendix-I).

Operation cost estimation of coconut tree climber

Economic analysis of the coconut tree climber was done. Cost analysis included the operating cost of the machine. Operating cost of the machine included the fixed cost and variable cost. Fixed of the machine is included capital consumption. Variable costs included labour, and repair and maintenance. The price of the machine is Tk 8800 only and machine life is 5 years having working duration 250 days per year. One labour was required for operating the machine. Labour wage is 500 Tk/day.

Fixed cost

Fixed cost of the machine included annual depreciation, interest on investment. Capital consumption included depreciation and interest.

i) **Capital consumption (CC)**

$$CC = (P - S)CRF + S \times i \quad \text{----------} \quad (1)$$

where

P=Purchase price, Tk

S=Salvage value, Tk (10% of purchase value of the machine)

CRF= Capital recovery factor

$$CRF = \frac{i(1+i)^L}{(1+i)^L - 1} \quad \text{----------} \quad (2)$$

where,

i= Rate of interest

L=Life of machine, yr

Total fixed cost per year

$$FC = CC + T \quad \text{----------} \quad (3)$$

Variable Cost

In calculation of variable cost, the following relations were assumed

i) Labour cost per hour, L_b=Tk man-h^{-1}

ii) Repair and maintenance (R&M) cost per year =1.0% of purchase price of the machine

Total variable cost

$$VC = L_b + R\&M \quad \text{----------} \quad (4)$$

Annual cost/operating cost

$$AC = FC + VC \quad \text{----------} \quad (5)$$

Design of the coconut dehusker

The mechanical coconut dehusker was designed with following consideration

i. The capacity of the machine should be 300-400 nuts per hour

ii. It should be portable (for easy movement)

iii. Fabrication cost should be minimum as possible

iv. Power transmission system should be easy

v. Minimum power should be used

A power coconut dehusker was designed and fabricated with the local raw materials at Farm Machinery and Postharvest Process Engineering Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur in 2017. It was made of GI pipe, MS spike, MS blades, MS angle bar, MS shaft, MS sheet, MS plate, motor, belt-pulley, chain sprocket, gear reducer, pinion etc.

Main working parts of the machine were rotating spike roller, blade; motor, chain sprocket. Front view, top and side views and photographic view of the previous coconut dehusker (Fig. 26 and 27) respectively. Front view, top and side views and isometric view of the improved prototype of dehusker (Fig. 28 and 29) respectively. Photographic view of the improved coconut dehusker is shown (Fig. 30). Specifications of the improved coconut dehusker are presented in Table 3.

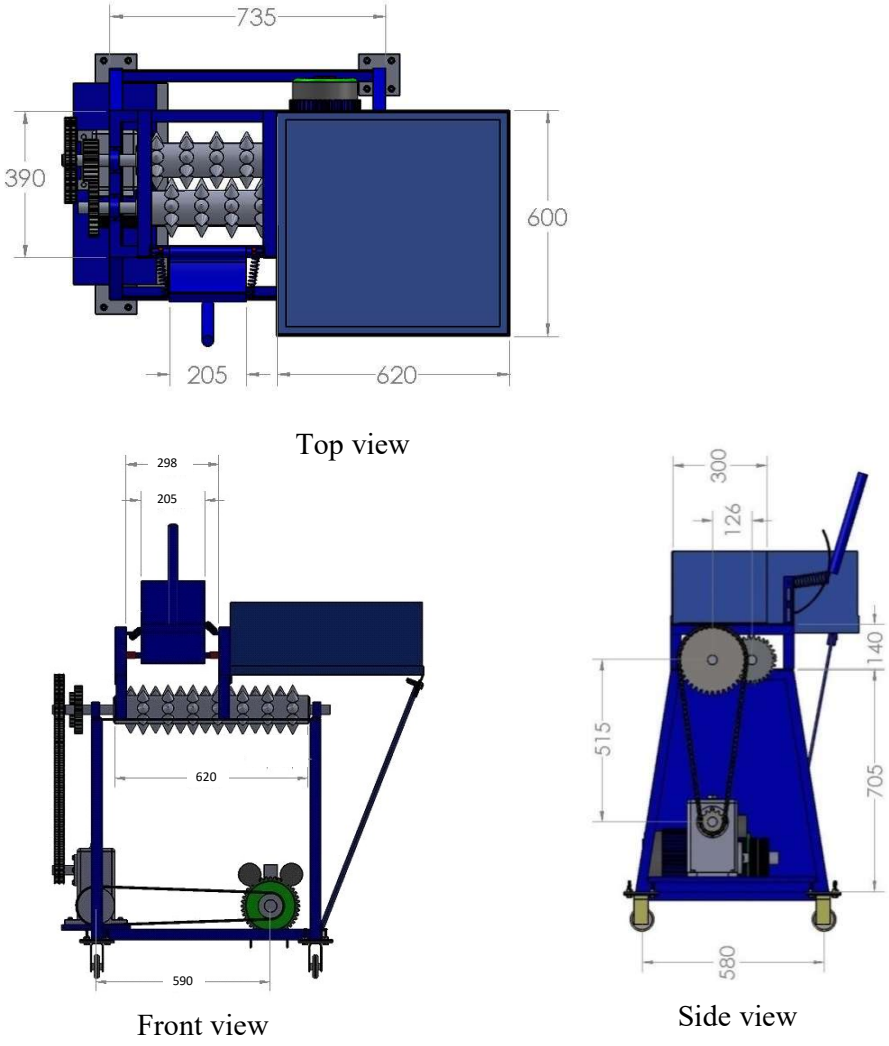

Fig. 26 Views of the previous coconut dehusker

Fig. 27 Previous coconut dehusker

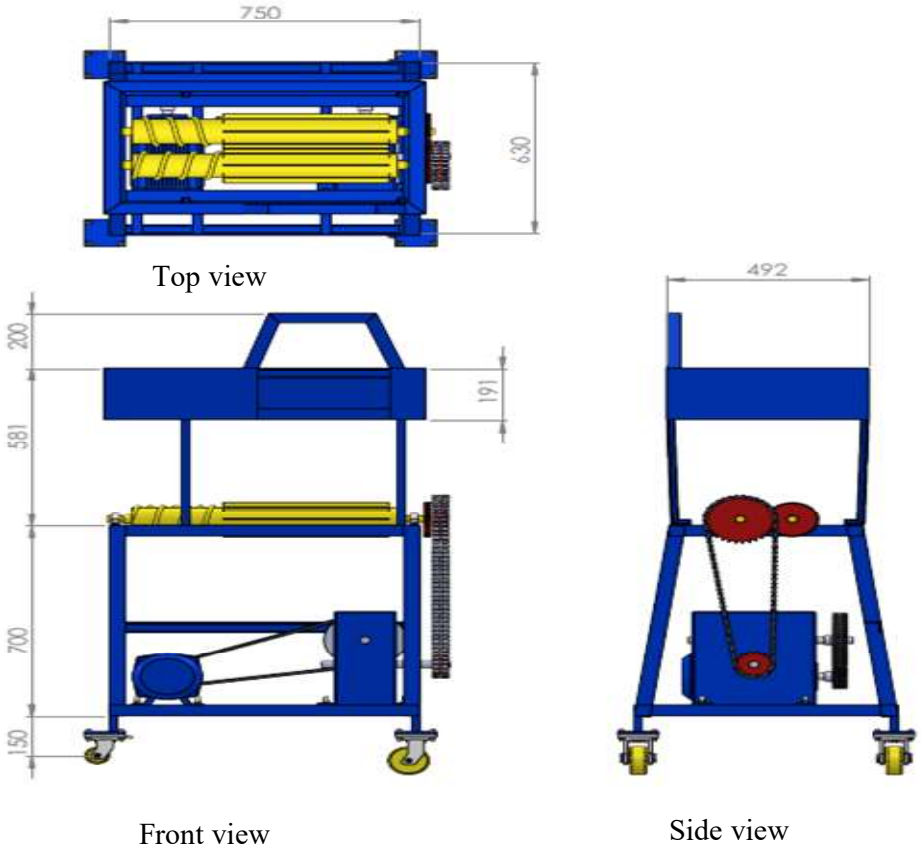

Fig. 28 Views of the improved coconut dehusker

Fig. 29 Isometric view of the improved coconut dehusker

Fig. 30 Photographic viewof theimproved coconut dehusker

Table 3 Specification of different parts of improved coconut dehusker

Sl. No.	Name of the parts	Specification	Materials
	Overall size of dehusker, mm	920×750×1120	
1	**Main frame**		
	Angle, mm	38.10×38.10×3.20	SS
2	**Roller with blade**		
	Pipe, mm	90 Ø	SS
	Shaft, mm	31 Ø	SS
	Angle for blade, mm	(25.4×25.4×3.2)x 406.4x 16 pcs	SS
	Rod, mm	8.0 Ø,9.6 Ø	SS
	Jam nut, mm	150	
3	**Power transmission**		
	Bearing	6206	
	Nut bolt	16 pcs	SS
	Motor, hp	3 hp,1450 rpm, 1φ	
	Gear reducer	10:1	
	Belt, mm	550	
	Pulley, mm	200	
	Pulley	750	
	Chain	428, double	SS
	Sprocket	28 T	SS
	Sprocket	14 T	SS
	Spur gear	24 T	
	Motor base plate, mm	228.6x254 x 6.0 x 1 pcs	
	Gear reducer base plate, mm	254x203.2 x 6.0 x1 pcs	
4	**Input tray and cover**		
	Sheet,SWG	18	SS
	Flat bar, mm	25.4, 508 x 2 pcs, 203.2 x 1pc	SS
	Angle, mm	19.10 x19.1x3.2 25.4x25.4 x 3.2, (38.1×38.1×3.2)	SS
	Spring	125 mm	MS
5	**Delivery tray**		
	Sheet, mm	(406.4×965.2)x 1pc	SS
6	**Accessories**		
	Wheel, mm	100	Nylon
	Base plate, mm	101.6x101.6 x6 x 4 pcs	MS
	Electrode	10	
7	**Electric system**		
	Wire, mm	1000	
	Push Switch	1pc	
	Two pin plug	1pc	

Working principle

The machine has to be placed on plain surface, open space and shady place. The motor has to be started by means of OFF-ON switch, machine is running. Later one operator has to be placed one by one coconut between the two rollers and immediately press the coconut upper surface by lever. Coconut is dehusked action of two spike/blade roller those are rotating opposite direction. The husk is drained out in the basket through delivery path.

Measurement of coconut size

For performance evaluation of the dehusker, there are three classified of the coconut on the basis of coconut size. Length, diameter and periphery of coconut were measured by measuring tape (Table 4).

Table 4 Measurement of coconut size for testing the coconut dehusker

Parameters	Dimension		
	Length (L), cm	Periphery, cm	Diameter(D), cm
Large			
R_1	27	58	18.47
R_2	23	61	19.42
R_3	22	54	17.19
	24.00	**57.67**	**18.36**
Medium			
R_1	21	56	17.83
R_2	22	55	17.51
R_3	24	53	16.87
	22.33	**54.67**	**17.40**
Small			
R_1	20	50	15.92
R_2	21	51	16.24
R_3	22	48	15.28
	21.00	**49.67**	**15.81**

Performance test of the coconut dehusker

Laboratory test

Coconut was purchased from RARS, Barishal. The performance of coconut dehusker was evaluated with three different sizes of coconut at FMPE workshop of BARI, Gazipur during 06 May 2018 (Fig. 31). Speed of roller, dehusking time, number of coconut, breakage coconut number, and coconut size was measured. The speed of the roller was measured by tachometer (Dual Digital tachometer, DT-2268, Japan). Voltage and ampere of electricity were measured with volt meter/ammeter.

Fig. 31 Performance test of dehusker at BARI, Gazipur

Field test

Coconut was harvested from orchard of RARS, Barishal. The performance of coconut dehusker was evaluated with three different sizes of coconut at Regional Agricultural Research Station, Rahmatpur, Barishal13 May during 2018 (Fig.32). Speed of roller, dehusking time, number of coconut, breakage coconut number, and coconut size was measured. The speed of the roller was measured by tachometer (Dual Digital tachometer, DT-2268, Japan).

Fig. 32 Field performance test of dehusker at RARS, Barishal

Economic analysis

Price estimation for fabrication of coconut dehusker

The fabrication price of the coconut dehusker was calculated including cost of materials, labour, overhead, Incidental expenses and manufacturing profit (Appendix- II).

Operation cost estimation of coconut dehusker

Economic analysis of the coconut dehusker was done. Cost analysis included the operating cost of the machine. Operating cost of the machine included the fixed cost and variable cost. Fixed of the machine is included capital consumption and shelter. Variable costs included labour, electricity, materials, repair &maintenance. The price of the machine is Tk100000.00 only and machine life is 7 years having working duration 300 days per year. Two labours was required for operating the machine. Labour wage is 500 Tk/day.

Fixed cost

Fixed cost of the machine included annual depreciation, interest on investment. Capital consumption included depreciation and interest.

i) Capital consumption (CC)

$$CC = (P - S)CRF + S \times i \quad \text{----------(6)}$$

Where, P=Purchase price, Tk
S=Salvage value, Tk
CRF= Capital recovery factor

$$CRF = \frac{i(1+i)^L}{(1+i)^L - 1} \quad \text{----------(7)}$$

where, i= Rate of interest

L=Life of machine, yr

ii) **Shelter,** T=3.0% of purchase price of the machine, Tk

Total fixed cost per year

$$FC = CC + T \quad \text{---------- (8)}$$

Variable Cost

In calculation of variable cost, the following relations were assumed

ii) Labour cost per hour, L_b=Tk man-h^{-1}

iii) Repair and maintenance (R&M) cost per year =3.5% of purchase price of the machine

Total variable cost

$$VC = L_b + E + R\&M \quad \text{----------} \quad (9)$$

Annual cost/operating cost

$$AC = FC + VC \text{----------(10)}$$

Training program conducted at project site

Two batches of training program on introduction and use of improved coconut tree climber and coconut dehusker among the coconut growers and traders were conducted at Dattabari, Noakhali on 26 September 2018 (Fig. 33) and at Begerhat on 30 September 2018 (Fig. 34). In total 24 participants (19 males and 5 female) joint in the training program. Principal investigator of the sub-project, DAE personnel and BARI regional personnel presented in the program.

Fig. 33 Training on coconut climber and dehusker conducted at Noakhali

Fig. 34 Training on coconut climber and dehusker conducted at Bagerhat

11. Results and discussion:

A Brief Profile of the Respondents

Farmer: The average age of the respondent farmers was estimated at 47.89 years which was ranged from 46.15 to 50.46 years. Majority of the farmers were primary (68.34%) followed by

secondary (14.45%), higher secondary (12.00%), and degree and above (8.66%) levels of education. Average family members of farmers were found to be 5.42 and average number of coconut trees of farmer was 28.42 which were ranged from 23 to 37.2. Amongst the farmers, the highest cultivation of coconut tree was found in Noakhali (37.2) and the lowest in Dumki, Patuakhali (Table 5).

Table 5. Brief profile of the sample coconut farmers in the study areas

Sl.No.	Profile	Banaripara	Noakhali	Dumki	Fultala	Bagerhat	Nesarabad	All area
1	Age (year)	47.43	48.76	46.33	46.15	48.23	50.46	47.89
2	Level of education (%)	-	-	-	-	-	-	
	a. Illiterate	66.67	73.33	90.00	66.67	46.67	66.67	68.34
	b. Primary	13.33	6.67	10.00	16.67	20.00	20.00	14.45
	c. Secondary	10.00	6.67	-	10.00	23.33	10.00	12.00
	d. Higher secondary	10.00	13.33	-	6.66	10.00	3.33	8.66
	e.Degree and above							
3	Numbers of family member (No.)	5.60	6.15	5.0	5.0	5.23	5.53	5.42
4	Numbers of coconut tree for each family (No.)	25	37.2	16.70	23	36	32.56	28.42

Traders: The average age of the coconut *Beparis/Paikers* of the study areas were at about 37.80 years. Majority of the traders were primary (60.35%) followed by higher secondary (14.48%), secondary (5.16%), and degree and above (3.33%) levels of education. Average experience of coconut traders was 11.60 years which was ranged from 9 to 19 years (Table 6).

Table 6. Brief profile of the respondent coconut Beparis/Paikers in the study areas

Sl.No.	Profile	Banaripara	Noakhali	Fultala	Bagerhat	Nesarabad	All area (mean)
1	Age (year)	49.00	46.00	37	51	43.8	37.80
2	Level of education (%)						
	a. Illiterate	-	-	-	-	-	-
	b. Primary	66.67	83.33	75	57.14	80.00	60.35
	c. Secondary	-	16.67	-	14.29	-	5.16
	d. Higher secondary	33.33	-	25	28.57	-	14.48
	e.Degree and above	-	-	-		20.00	3.33
3	Experience on coconut business (year)	10.67	9.00	14.25	19.29	16.4	11.60

The average age of the respondent retailers in the study areas were 43.24 years which was ranged from at 18 and 60 years. Majority of the retailers were educated at primary (54.16%) followed by secondary (22.5%) and higher secondary (20.00%). All retailers were sold coconut in round the year in all study areas (Table 7).

Information on coconut tree parameters cultivated by farmers in different locations is shown in Table 8. Farmers of all study upazila cultivated local variety of coconut. Average coconut tree height was observed 10.32 m and the tallest coconut tree (14.15 m) was found at Banaripara upzila and the shortest coconut tree (7.93m) at Dumki, Patuakhali. Average girths of bottom

and top were observed 1.1 m and 0.78 m respectively. The bottom girth of trunk was higher than that of girth of top. Average grip number of trunk was found to be 27 per meter and the maximum grip was 35 per meter at Bagerhat and the minimum was 12 at Banaripara, Barishal.

Table 7. Brief profile of the respondent coconut retailers in the study areas

Sl.No.	Profile	Banaripara	Noakhali	Dumki	Fultala	Bagerhat	Nesarabad	All area (mean)
1	Age (year)	45.83	52.00	18.00	41.40	60.00	42.25	43.24
2	Level of education (%)							
	a. Illiterate	-	-	-	-	-	-	
	b. Primary	50.00	80.00	-	80	40	75	54.16
	c. Secondary	50.00	-	-	20	40	25	22.50
	d. Higher secondary	-		100.00	-	20	-	20.00
	e. Degree and above	-	-	-	-	-	-	
3	Percentage of retailers who sold coconut in round the year	100	100	100	100	100	100	100

Average production of coconut per year in summer and winter seasons of farmers was found to be 289 and 192 respectively. It observed that coconut production in summer season was higher than that of winter season due to temperature effects and long period of summer season. It also revealed that selling prices of coconut in winter season (Tk.19.00) was higher than that of summer season (Tk.14.77) because of lower production of coconut in winter season and higher consumer demand.

Table 8. Physical parameters of coconut tree and production in different locations (Farmers)

Locations.	Variety	Height of tree, m	Girth, m		Grips number, No./m	Production (coconut/season)		Price of coconut, Tk	
			Bottom	Top		Summer season	Winter season	Summer season	Winter season
Banaripara	Local	14.15	0.94	0.72	11.63	405.83	266.00	14.93	20.57
Noakhali	Local	9.00	1.23	0.98	21.52	369.55	244.71	13.42	18.97
Dumki	Local	7.93	1.05	0.73	34.37	239.33	163.17	17.97	22.30
Fultala	Local	9.21	1.20	0.79	23.31	217.56	157.03	16.95	18.75
Bagerhat	Local	11.41	1.11	0.78	35.33	131.43	76.53	11.93	14.43
Nesarabad	Local	10.20	1.09	0.67	32.37	369.55	244.71	13.42	18.97
Mean		**10.32**	**1.10**	**0.78**	**26.42**	**288.88**	**192.03**	**14.77**	**19.00**

Status of traditional climbing practice on coconut tree and its performance in different locations is shown in Table 9. Hundred percent coconuts were harvested from coconut tree by traditional practice (manual) in all project sites. Climbing speed in manual practice (labour) was found to be 0.4 m/sec and maximum speed was 0.82 m/sec at Fultala, Khulna due to a boy was climbed a tree very speedy just like monkey and minimum was 0.28 m/sec at Banaripara and Noakhali. Average harvesting capacity of labour was found to be 61 nuts/h. Average climbing and descending time including cleaning of coconut tree for labour was recorded 20.23 minutes and average labour wage was estimated 40 Tk for doing these works. There was negligible dropping loss of coconut. It might be due to fall the coconut on hard place like RCC floor. Otherwise there was no loss of coconut during harvesting.

Information on traditional dehusking practice of coconut in different locations (farmers) is shown in Table 10. Ninety one percent farmersof selected project sites sold coconuts with husk and nine percent farmers sold coconuts without husk.Somebody dehusked coconut using local made tools (*Dha, Sarasi, Khanti*) for their own consumption and selling purpose.

Table 9. Status of climbing practice on coconut tree in different locations

Locations.	Climbing practice, (%)		Climbing speed, m/sec	Harvesting capacity of labour, nut/h	Climbing and descending time including cleaning, min	Cost of climbing and descending, including cleaning, Tk./tree	Dropping loss of coconut. %
	Manual	Machine					
Banaripara	100	-	0.28	60	20.57	40.50	0
Noakhali	100	-	0.28	52	21.65	44.68	0
Dumki	100	-	0.32	54	10.00	65.00	0
Fultala	100	-	0.82	72	24.78	32.34	0.5
Bagerhat	100	-	0.31	72	25.77	31.57	0
Nesarabad	100	-	0.37	56	18.63	25.73	0
Mean	**100**		**0.40**	**61**	**20.23**	**40.00**	**0.08**

Table 10. Information on traditional dehusking practice of coconut in different locations (farmers)

Locations.	% of farmers who dehusk and undehusk of coconut		% of farmers dehusked coconut using different tool			Dehusking capacity of tool, nut/h		
	Dehusk	Undehusk	Dha	Sarasi	Khonti	Dha	Sarasi	Khonti
Banaripara	0	100	90	6.67	3.33	25	120	180
Noakhali	0	100	100	-	-	20	-	-
Dumki	0	100	-	-	-	-	-	-
Fultala	3	97	27	3	-	25	100	
Bagerhat	0	100	30	-	7	20	-	200
Nesarabad	50	50	20	-	80	20		144
Mean	**8.83**	**91.17**	**53.40**	**4.84**	**30.11**	**22.00**	**110.00**	**174.67**

Average capacities of dha, sarasi, khanti were found to be 22, 110 and 175 nuts/h respectively.Averagelives of *Dha, Sarasi, Khanti* were found to be 5.22, 5 and 7 years respectively. Average prices of *Dha, Sarasi, Khanti* were found to be Taka 320, 500 and 600 respectively.

Table 11. Information on traditional dehusking practice of coconut in different locations (contd)

Locations.	Price of tool, Tk			Tool life, yr		
	Dha	*Sarasi*	*Khonti*	*Dha*	*Sarasi*	*Khanti*
Banaripara	350	400	750	5	5	8
Noakhali	450	-	-	4	-	-
Dumki	-	-	-	-	-	-
Fultala	300	600		5	5	-
Bagerhat	250	-	350	6	-	6
Nesarabad	250		700	6	-	7
Mean	**320.0**	**500.00**	**600.00**	**5.20**	**5.00**	**7.00**

Information on buying and selling of coconut status of retailer in different locations is shown in Table 12. Retailers sold 66% coconut with husk and 34% coconut without husk. They sold more coconuts in summer season than that of winter season and coconut selling price was higher in winter season that that of coconut in summer season. It revealed that retailers sold coconut without husk round the year.

Information on buying coconut status of traders in different locationsis shown in Table 13. Traders bought 40% coconut from farmers' orchard and 60% coconut from local market. They bought more coconuts in summer season than that of coconut in winter season and coconut purchase prices was higher in winter season than that of coconut in summer season.

Table 12. Information on buying and selling of coconut status of retailer in different locations

Locations	Selling season				Which types coconut sold, %	
	Winter		Summer		With husk	Without husk
	Quantity, No./yr	Unit price, Tk.	Quantity, No./yr	Unit price, Tk.		
Banaripara	2383	25	3950	17.5	70	30
Noakhali	3480	20	7500	13.8	100	
Dumki	1300	26	1800	19	100	-
Fultala	924	19.4	1620	17.6	50	50
Bagerhat	480	18.2	1296	12.2	-	100
Nesarabad	10750	25	13500	18	75	25
Mean	**3220**	**22**	**4944**	**16**	**66**	**34**

Table 13. Information on buying coconut status of traders in different locations

Locations	Buying from		Summer season		Winter season	
	Farmers orchard/	Local market	Quantity of coconut, No/yr	Unit price, Tk.	Quantity of coconut, No/yr	Unit price, Tk.
Banaripara	50	50	13333	22	18000	18
Noakhali	40	60	22600	17.8	44740	13
Fultala	75	25	61980	12.75	125900	12.25
Bagerhat	14	86	87657	15	158971	12
Nesarabad	20	80	37800	21.8	118600	17.8
	40	**60**	**44674**	**17.87**	**93242.2**	**14.61**

Information on traditional dehusking practice of coconut in different locations (Bepari/Paiker) is shown in Table 14 & 15. Forty seven percent traders of selected project sites dehusked coconut using *Kanti,* 37% traders using *Sarasi* and 16% traders using *Dha*. It observed that 100 trader of Fultala, Khulna dehusked coconuts using *Kanti*. Dehusking capacities of Dha, *Sarasi* and *Kanti* varied from 20 to 25 nuts/h, 43 to 75 nuts/h and 100 to 160 nut/h respectively. Prices of *Dha, Sarasi*and*Kanti* varied from Taka 250 to 300, 450 to 600 and 900 to 1000 respectively. On the other hand, tools lives of *Dha, Sarasi*and*Khanti* varied from 3 to 4 yrs, 5 to 6 yrs and 8 to 10 yrs respectively. Dehusking cost of coconut using *Kanti* was found to be 0.63 Tk./nut.

Table 14. Information on traditional dehusking practice of coconut in locations (Bepari/Paiker)

Locations.	Percentage of traders who dehusk and undehusk coconut		% of traders using different dehusking tool,			Capacity of operator, nut/h		
	Dehusk	undehusk	Dha	Sarasi	Khonti	Dha	Sarasi	Khonti
Banaripara	20	80	40	40	20	20	43	125
Noakhali	20	80	20	60	20	25	75	160
Fultala	25	75		25	75	-	60	150
Bagerhat	20	80	20	60	20	20	60	150
Nesarabad	50	50	--	-	100	-	-	100
Mean	**27**	**73**	**16**	**37**	**47**	**13**	**47.6**	**137**

Table 15. Information on traditional dehusking practice of coconut in different locations (Bepari/Paiker)

Locations.	Price of tool, Tk			Tool life, yr			Dehusking cost, Tk/nut
	Dha	Sarasi	Khonti	Dha	Sarasi	Khonti	
Banaripara	250	600	900	4	6	10	0.60
Noakhali	300	500	1000	3	5	8	0.75
Fultala	-	450	1000	-	5	7	0.75
Bagerhat	200	500	900	4	5	8	0.35
Nesarabad	-	-	1000	-	-	8	0.70
Mean	**150**	**410**	**960**	**2.2**	**4.2**	**8.2**	**0.63**

Performance test of coconut tree climber

Performance of coconut tree climber was evaluated at HRC coconut orchard, BARI, Gazipur (Table 16). The average speed of the operator for climbing upthe tree was found to be 6.12 m/min and 6.29 m/min for climbing down. Speed of climbing on the tree was slower than that of climbing down. But speeds of climbing up and down were slower than those of traditional practice. It revealed that climbing of traditional practice was faster but risky practice for operator whereas climbing of improved mechanical climber was safety and free of risk for operator. It was observed that upper blood pressure of the operators increased by 10 mmHg during climbing on the tree. After descending from the tree, blood pressure of operator became normal position within half an hour.

Table16 Performance evaluation of coconut tree climber at HRC coconut orchard, BARI, Gazipur

Operator age (year)	Operator weight (kg)	Blood pressure (mmHg) of operators		Height of the tree (m)	Time (minute)		Speed (m/min)	
		Before climbing up	After climbing down		Climbing up	Climbing down	Climbing up	Climbing down
30	56	120/80	130/100	10.00	2.50	2.39	4.00	4.18
30	56	110/80	120/80	10.06	3.09	2.09	3.25	4.81
42	62	150/110	160/130	12.5	2.25	1.55	5.55	8.06
40	59	140/120	150/130	8.84	1.25	1.13	7.07	7.82
25	52	120/80	130/80	8.90	0.83	1.35	10.72	6.59
					Average speed		**6.12**	**6.29**

Field performance test of coconut tree climber was conducted at RARS Rahmatpur, Barishal (Table 17 & 18). The average speed of the operator for climbing up of the tree was found to be 2.10 m/min and 3.38 m/min for climbing down those were lower speed than those of estimated speed of HRC, BARI, Gazipur. It might be due to unskilled operator of Barishal region. Speed of climbing up the tree was slower than that of climbing down. It was observed that blood pressure of the operators increased in climbing on the tree.

Table 17. Performance evaluation of coconut tree climber at inBarishal

Operator age (Year)	Operator weight(kg)	Height of tree, meter	No of grip at every meter of the tree	Time (minute)		
				Climbing up tree	Climbing down	cleaning and harvesting
30	60	11.16	24	6.00	4.23	3.52
27	56	8.25	28	4.28	2.11	3.00
27	55	8.00	26	3.33	2.40	2.00
42	62	9.00	26	4.00	2.45	2.50

Table 18. Performance evaluation of coconut tree climber inBarishal

Operator age (Year)	Harvested coconut, no	Blood pressure (mmHg)		Speed (m/min)	
		before climbing up	after climbing down	Climbing up	Climbing down
30	5	110/70	130/90	1.86	2.64
27	6	120/70	120/90	1.92	3.91
27	9	110/70	120/80	2.40	3.33
42	11	120/90	130/90	2.25	3.67
				2.10	**3.38**

Performance test of coconut tree climber was conducted at BARI, Gazipur (Table 19 & 20). The average speed of the operator for climbing up of the tree was found to be 6.36 m/min and 7.43 m/min for climbing down. The highest speed of the operator for climbing on the tree was found than those of the previous trials at HRC, BARI, Gazipur and RARS, Barishal. It might be due to skilled operators and improvement of climber. It was observed that blood pressure of the operators increased in climbing on the tree. The most of the cases before climbing on a tree and after climbing down from a tree, in both manual and mechanical operation blood pressure were varied from 10-20 mmHg of systolic and diastolic pressure. It is quite normal for every person because blood pressure of every people literally increased after hard physical work. Sometimes blood pressure showed little bit high value due to fear of height and use of new machine for the first time. Considering above problems the following measure were taken to improve the performance of the machine--Improvement of wire adjustable facility by adding girth control bar at the end point of the wire which facilitate to climb both thin and thick parts of the coconut tree. Changing the position of wire so that it can remain upward direction which makesclimbing operation effectively. It was observed that the person who climbs on a tree for the first time was taken more time to climb on and climbing down from the tree.

Table 19. Performanceevaluation of improved coconut tree climber

Operator age (year)	Operator weight (kg)	Height of tree, meter	No of grip per meter	Time (minute)		
				Climbing up tree	Climbing down	Cleaning and harvesting
27	56	7.31	22	1.28	1.10	3.00
42	62	9.15	24	1.30	1.11	3.00
42	62	8.00	26	1.26	1.08	2.50
37.00	**60.00**	**8.15**	**24.00**	**1.28**	**1.10**	**2.83**

But after climbing several numbers of trees it is noticeable that it required less time than first time because of removing fear of climbing and able to know how to operate the machine. The coconut tree climber was improved step by step through different trials.

Table 20.Performance evaluation of improved coconut tree climber

Operator age (year)	Harvested coconut, no.	Blood pressure (mmHg)		Speed (m/min)	
		before climbing up	after climbing down	Climbing up	Climbing down
27	8	110/80	130/90	5.71	6.64
42	11	110/80	120/80	7.04	8.24
42	7	120/90	130/100	6.34	7.40

	Average speed	**6.36**	**7.43**

Harvesting cost of coconut climber

The harvesting cost of coconut climber are shown in Table 21. Profitability analysis revealed that the method of coconut climber incurred fixed and variable costs. The lion share of cost was estimated for variable cost for the method. Fixed cost included two cost items namely capital consumption and shelter, whereas variable cost included labour and R & M. The harvesting cost of the climber was found to be 25 Tk./tree. It was also found that payback period of the climber was 25 days. It was also estimated that benefit cost ratio was 0.60. BCR of the climber was very low but improved climber is a safe and risk free tool. In traditional practice, working person got scratched at the hands and chest.

Table 21. Coconut harvesting cost of coconut climber

Sl.No.	Items	Cost
1	Capital consumption (CC), Tk./yr	2026.85
	Fixed cost Tk./yr	2026.85
	Fixed cost Tk./h	1.01
2	**Variable cost**	
	a) Labour, Tk/h	75
	b) Repair and maintenance, Tk/h	0.15
3	Total operating cost, Tk/h	75.15
4	Total cost (1+3), Tk/h	76.16
5	Capacity of climber, trees/h	3
6	Harvesting cost, Tk/tree(4/5)	25.39

Payback period of coconut tree climber

Total fixed cost=2026.85Tk/yr,

Yearly use of the machine = 250 days = 250 daysx 8 hours =2000 h

Fixed cost = Tk/h= 1.01, Variable cost Tk/h= 75.16

Total cost, Tk/h= 76.16, Harvesting cost, Tk/tree = 25.00

Manual harvesting cost, Tk/tree = 40, Net profit, Tk/tree = 15

Profit per hour = 15 Tk/tree x 3 tree/h = 45 Tk/ h

Profit per days = 45 Tk/ h x 8 h/days =360 Tk/ day

Payback period of coconut tree climber= Price of the climbing machine/ Profit per days=8800

(Tk/360 Tk/days= 25 days, BCR= profit/ cost=40/25=1.60

Performance test of coconut dehusker

Performance test of the dehusker was evaluated with three sizes of coconut at FMPE Division, BARI, Gazipur on 06 May 2018 (Table 22). The capacity of the coconut dehusker was ranged from 288-328 nuts per hour at roller speed of 25 rpm. It was observed that capacity of dehusker increased with decreased the size of coconuts. The breakage percentage of coconut was found to be 5. Capacity of coconut dehusker was 120-150 coconuts per hour (Jacob and Kumar, 2012).

Table 22 Performance test of coconut dehusker at FMPE workshop

Sl. No.	Parameters	Size		
		Large	Medium	Small
1	Quantity of coconut	20	20	20
2	Dehusking time, sec	250	230	219
3	No. of breakage coconut	1	1	1
4	No. of good coconut	19	18	19
5	RPM of roller	27	27	27
6	Voltage without load	218V	218V	218V
7	Voltage with load	210 V	210 V	210 V
8	Ampere	11.20 A	11.20 A	11.20 A
9	Capacity, nuts/h	288	313	328
				Av. = 310

- Large(Length x periphery x diameter): 24x58x18 cm, Medium(Length x periphery x diameter): 22x54x17 cm, Small(Length x periphery x diameter): 21x50x16 cm

Performance test of the dehusker was evaluated with three sizes of coconut at RARS, Rahamatpur, Barishal on 13 May 2018 (Table 23). The capacity of the coconut dehusker was ranged from 262-336 nuts per hour at roller speed of 28 rpm. It was observed that capacity of dehusker increased with decreased the size of coconuts. The breakage percentage of coconut was found to be 3-6 that was higher than that of the laboratory test. It might be due to feeding barrier of dehusker. The average capacities of dehusker for laboratory and field test were 309 and 310 that was similar. Chief Scientific Officer, Scientists and staffs of Regional Agricultural Research Station, Rhamatpur, Barishal expressed their opinions that the coconut dehusker performance was satisfactory and it fulfilled our coconut traders demands for coconut growing areas. Ultimately, technology indirectly influenced the production of coconut of the project areas.

Table 23 Performance test of coconut dehusker at RARS, Rahamatpur, Barishal

Sl. No.	Parameters	Size		
		Large	Medium	Small
1	Quantity of coconut	30	30	30
2	Dehusking time, sec	412	353	321
3	No. of breakage coconut	1	1	1
4	No. of good coconut	27	27	27
5	RPM of roller	28	28	28
6	Voltage without load	224	224	224
7	Voltage with load	219 V	219 V	219 V
8	Ampere	12.18 A	12.18 A	12.18 A
9	Capacity, nuts/h	262.14	305.95	336.45
				Av = 309

Dehusking cost of coconut dehusker

The dehusking cost of coconut dehusker are shown in Table 24. Profitability analysis revealed that the method of coconut dehusking incurred fixed and variable costs. The lion share of cost was estimated for variable cost for the method. Fixed cost included two cost items namely capital consumption and shelter, whereas variable cost included labour, electricity, and R & M. The dehusking cost of the dehusker was found to be 0.28 Tk./nut. It was also found that payback period of the dehusker was 116 days. It was also estimated that benefit cost ratio was 1.25.

Table 24. Dehusking cost of the dehusker

Cost item	Taka
Fixed cost (FC)	
1. Capital consumption (CC), Tk./yr	23133.00
2. Shelter (T), Tk/yr	500.00
Sub-total , Tk./yr	**23633.00**
Tk./h	**10.00**
Variable cost (VC)	
Labour, Tk./h	63.00
Electricity,Tk./h	13.00
R&M, Tk./h	1.50
Lubricant, Tk/h	0.60
Sub-total	**78.00**
Total cost (FC+VC), Tk/h	**88.00**
Capacity of the machine, nuts/h	309
Dehusking cost (Total cost/capacity), Tk./nuts	0.28

Payback period of the dehusker

Total fixed cost, Tk./yr =23633.00

Yearly use of the plant=300 days= 300 daysx8 h/day=2400h

Fixed cost, Tk./h =10.00,

Variable cost, Tk./h=78.00

Total cost, Tk./h=88.00

Capacity of the dehusker, kg/h=309

Dehusking cost by dehusker, Tk./nut=0.28

Manual dehusking cost, Tk./nut=0.63,

Net profit, Tk./nut=0.35

Profit per hour= 0.35 Tk./nut x 309 nuts/h=108 Tk./h

Profit per day=108Tk./h x 8 h/day=864Tk./day

Payback period of the plant =price of the dehusker /profit per day

=100000Tk./864 Tk./days=116 days

Benefit cost ratio (BCR):
=Net profit/cost=0.35/0.28=1.25

Break-even point of dehusker

Figure 35 shows the break-even point (BEP) of coconut dehusker. Break-even point was calculated including fixed cost and variable cost. Fixed cost included two cost items namely capital consumption and shelter, whereas variable cost included labour, electricity, and R & M. The net return of dehusking coconut was 0.35Tk./nut. It was observed that BEP of the dehusker was 775 hours per year. Therefore, coconut dehusk by the dehusker could be profitable to traders when the annual use of the dehusker exceeds 775 h.

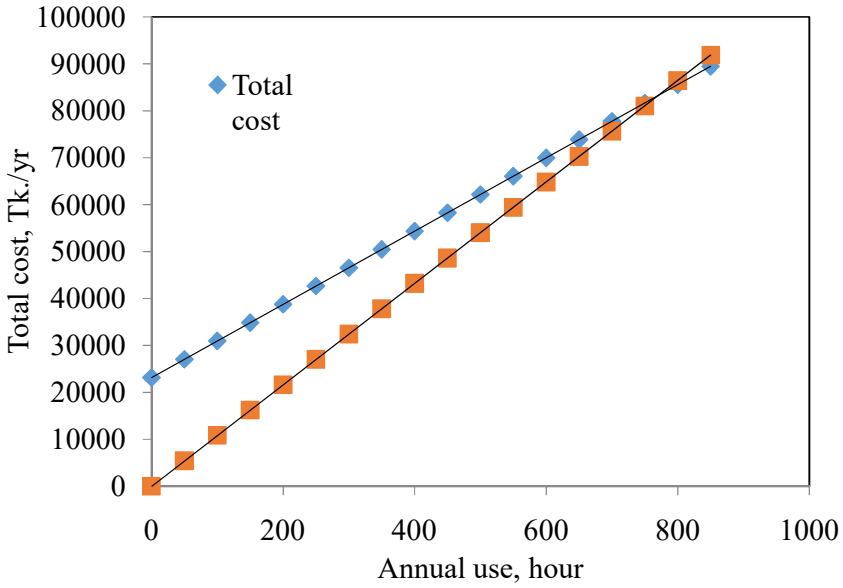

Fig. 35 Break-even point of coconut dehusker

Training program

Two batches (12 trainees per batch) training program for whole day were done on 26 September 2018 and 30 September 2018. All participant became happy and surprised to see the coconut climber and dehusker. Innovation of climber and dehusker showed better performance. Participant of Noakhali expressed their views that machines are good but higher capacity machine and multi-huskingcatagories machine is needed. Climber should be made simple, more safety and easy handling. Dehusker should be made with five options for removing husk from the coconut. In Noakhali. traders remove coconut husk in five categories such as full husk, half husk, one third husk, full husk with remaining of head husk and only upper layer of coconut. Improved dehusker can remove only full husk from coconut. Participants of Begerhat expressed their views that they showed positive interest to use the machine. The machine is suitable for our area but higher capacity machine and less breakage of coconut dehusker should be made.

A study was conducted at six coconut growing districts such as Barishal, Noakhali, Khulna, Bagerhat,Patuakhali, and Pirojpur. Average height, bottom girth, top girth and grip numbers of the coconut tree were 10.32 m, 1.10 m, 0.78 m and 26.42 numbers per meter respectively. Ninety one percent farmers sold coconuts with husk and 9% farmers sold coconuts without husk. The most of the farmers used *Dha* for dehusking the coconut and other farmers used *Sarasi* and *Khanti*. Retailers sold 66% coconut with husk and 34% coconut without husk. Forty seven percent traders dehusked coconut using *Khanti*, 37% traders using *Sarasi*and 16% traders using *Dha*. Dehusking capacities of *Khanti* varied from 100 to 160 nut/h respectively. Improved coconut tree climber and coconut dehusking machines were designed and fabricated with locally available materials at FMPE Division. Bangladesh Agricultural Research Institute, Gazipur. The dehusking cost of the dehusker was found to be 0.28 Tk./nut. Climber and dehusker can save 38% harvesting cost and 57% dehusking cost compared to the traditional practice respectively. The payback period of the climber and dehusker were 25 days and 116 days respectively. The average capacities of climber and dehusker were 3trees/ h and 309 nuts/h respectively. The breakage percentage of coconut reduced. Benefit cost ratios of climber and dehusker were 1.60 and 1.25 respectively. Manual harvesting practice was faster than that

of improved climber but improved climber is a safe and risk free tool. The prices of the climber and dehusker were Tk. 8800.00 and Tk. 100000.00 respectively. Coconut dehusker could be profitable to traders.

12. Research highlight/findings (Bullet point – max 10 nos.):

- There was no mechanical device used for harvesting of coconut. Ninety-one percent farmers sold coconuts with husk and 9% farmers sold coconuts without husk. Retailers sold 66% coconut with husk and 34% coconut without husk.
- Forty-seven percent traders dehusked coconut using *Khanti*, 37% traders using *Sarasi*and 16% traders using *Dha*.
- Dehusking capacities of *Dha, Sarasi*and*Khanti* varied from 20 to 25 nuts/h, 43 to 75 nuts/h and 100 to 160 nut/h respectively.
- Improved coconut tree climber and coconut dehusking machine were designed and fabricated with locally available materials.
- Average climbing speed of the skilled operator in manual practice was 0.4 m/s and harvesting including cleaning cost was 40 Tk per tree.
- The average capacity of dehusker was 309 nuts per hour at the speed of 25 rpm. The breakage percentage of coconut was found to be 3-6.
- The dehusking cost of the dehusker was found to be 0.28 Tk./nut. The payback period of the dehusker was 116 days and benefit cost ratio was 1.25.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Laser Printer (#1) Laptop (#1) Digital Camera (#1)	105000	Laser Printer (#1) Laptop (#1) Digital Camera (#1)	102924	100% achievement
(b) Lab &field equipment	Tachometer (#1) Multimeter (#1) Platform Balance (#1) Stethoscope (#2) Helmet (#2) Apron (#4)	59000	Tachometer (#1) Multimeter (#1) Platform Balance (#1) Stethoscope (#2) Helmet (#2) Apron (#4)	57900	100% achievement
(c) Other capital items (Furniture)	Almirah(#1) File cabinet (#1) Visitor chair (#2)	52000	Almirah(#1) File cabinet (#1) Visitor chair (#2)	51300	100% achievement

2. Establishment/renovation facilities:N/A

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

3. Training/study tour/ seminar/workshop/conference organized:

Description	Number of participant			Duration (Days)	Remarks
	Male	Female	Total		
(a) Training	19	5	24	2	Two batches training were organized. Twelve participants for each batch for whole day
(b) Workshop					

C. Financial and physical progress

Fig in Tk

Items of expenditure	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	294970	294970	294970	0	100.00	
B. Field research/lab expenses and supplies	532656	515569	518014	-2445	97.25	Bought necessary research goods
C. Operating expenses	170944	153407	152579	828	89.26	It is an actual expenditure
D. Vehicle hire and fuel, oil & maintenance	97305	103428	103335	93	106.00	It is an actual expenditure
E. Training/workshop/seminar etc.	75000	74500	73600	900	98.13	It is an actual expenditure
F. Publications and printing	75000	10000	10000	0	13.33	PCR printing and binding expenditure did not sent to me
G. Miscellaneous	42001	18519	15895	2624	37.84	It is an actual expenditure
H. Capital expenses	212124	212124	212124	0	100.00	

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)**
i) To conduct the baseline survey on present status of harvesting and dehusking practices of coconut in selected major coconut growing areas of Bangladesh	➢ Site selection, preparation of questionnaires, pre-test and base line survey, data process	• Average height, bottom girth and top girth of the coconut tree were 10.32 m, 1.10 m and 0.78 m respectively. • Traditionally, a skilled labour climbed up coconut tree at average speed of 0.40 m/s. • Farmers and traders used to local made *Dha, Sarasi*and *Kanti*fordehusking of coconuts.	• The following parameters would be used for designing the new mechanical climber. • Local made tools would be helped making mechanical dehusker.
ii) To improve coconut climber &dehusker, and evaluate the performance of climber and dehusker	➢ Design and drawing of the coconut climber tree and dehusker ➢ Coconut tree climber and dehusker were	• Fabricated improved coconut dehusker and safety coconut tree climber. • The capacity of the	• Coconut dehusker can save time, money and reduce drudgery and dependency of

along with economic feasibility	fabricated ➢ Laboratory and field performance tests were evaluated at Gazipur and Barishal.	dehusker was 309 nuts/h. • Dehusker can save 57% cost and 50% time compared to the traditional practice	labour. • It generates employment
iii) To conduct training and demonstration of climber and dehusker at users level in the project areas.	➢ Training program were conducted at Noakhali and Bagherhat	• Trained up 24participants (19 males and 5 female) • Message the technologieswere published in two local newspapers. • Both the male and female aquired knowledge on the technologies	• It increases the production of coconut and reduce postharvest loss. • It makes awareness among female on use the machine

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 booklet	-	**01**	নারিকেল গাছে উঠার যন্ত্র ও নারিকেলের ছোবড়া ছাড়ানো যন্ত্রের পরিচিতি ও ব্যবহার নির্দেশিকাManual of introduction and use of coconut tree climber and coconut dehuker)
Journal publication	01	**01**	Development of a low cost coconut tree climber for small farmers in Bangladesh. International Journal of Engineering Research & Technology (IJERT). (3):242-248. Development and performance evaluation of coconut dehukser,
Information development			
Other publications, if any (News paper)	-	**02**	নারিকেলের ছোবড়া ছাড়ানো বৈজ্ঞানিক যন্ত্রের উদ্ভাবন, দৈনিক সচিত্র, নোয়াখালি, ২৭ সেপ্টেম্বর, ২০১৮ (Development of mechanical coconut dehuske, Daily SachitraNoakhali, 27 September2018) বাগেরহাটে নারিকেল গাছে ওঠা ও ছোবড়া ছাড়ানো যন্ত্রের ব্যবহার প্রশিক্ষণ, দৈনিক খবর, ১ অক্টোবর ২০১৮(Training of use of coconut tree climber and coconut dehusker at , Daily Khaber, 1 October 2018)

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

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

Developed an improved coconut mechanical dehusker and coconut tree climber

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

New knowledge on cutting blades and their gaps; girth control bars and number of grip of tree per meter and operating parameters has been developed that will help the development of precision dehusker and tree climber in future

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

Farmers, traders and manufacturers have been trained on operation, fabrication and repair of the developed dehusker and climber. It will increase production, reduce drudgery and cost of dehusking and cleaning. Finally, it will increase farmer's and trader's income

iv. Policy Support

Encourage local manufacturing of the precision dehusker and climber (technological support, training support, provision of subsidy, soft loans, etc.)

G. Information regarding Desk and Field Monitoring

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

Description	Output
Consultation meeting with manufacturers	Some design parameters outline was achieved from knowledge sharing meeting among manufacturers and PI and Co-PI for improving the machine
Consultation meeting with scientists and technicians	Some design and performance parameters outline were achieved from knowledge sharing meeting among scientists, technicians and PI & Co-PI for fine tuning the machine

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

Time	No. of visit	Team visit	Output
10,11and 18 January 2018	3	Professor and students, BSAMUR Agril. University, Gazipur	• Under graduate students and professor observed the machine. They were very happy to see the operation of the machine
30.1.2018	1	Professor and students, BAU, Mymensingh	• Good research technology for traders and farmers MS/under graduate students of BAU observed the machine
1 February 2018	1	Director (Oil seed) with monitoring team	• Monitoring team made by Director research satisfied on the research progress
14 March 2018	1	Director (PIU) BARC along with his team jointly visited	• Coconut climber and coconut dehusker are well designed • Overall machines performance is satisfactory • Some minor modifications of the machines should be done before dissemination

H. Lesson Learned/Challenges (if any)

i) For successful and timely completion of any sub-project, allocation of fund and resources availability to be ensured

ii) To achieve any successes/visible output in any agricultural sub-project, minimum time duration of the project should be 3 years

I. Challenges (if any)

A tree climber is a new tool in our study area. A skill man need for climbing up coconut tree. It is not properly use in rainy season due to trunk is slippery. Coconut dehusker is not economically feasible in household level.

Signature of the Principal Investigator
Date ……..

Seal

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

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Appendix I Price estimation of coconut tree climber

Sl. No.	Items	Dimensions	Total amount	Unit price, Tk	Total price, Tk
	Main frame				
1	Left Main frame,(L×W×D) mm	1070×100×Ø10mm			
	Right Main frame, ((L×W×D) mm	1030×100× Ø10mm			
	SS rod	10mm, 3/8"	8kg	260	2080
	Foot holder				
2	Left foot holder, (L×W× H) mm	150×132×160mm			
	Right foot holder, (L×W× H) mm	150×127×330mm			
	SS flat bar	3/4"× 1/8"	3kg	260	780
	SS angle bar	1×1×3/16"	1kg	260	260
3	Tree holder,(L×D) mm	360×Ø10mm			
	SS deform rod	10mm, 3/8"	0.5kg	255	127.5
4	U clamp, (L×D) mm	50×30×Ø5mm			
	SS threated rod	1/4"	0.6kg	200	120
	SS U clamp		4 pcs	50	200
5	Wire	1900× Ø6mm			
	SS wire	1/4"	16 ft	110	1760
6	Rubber tier (L×W×T) mm	520×60×20mm			
	Rubber	2"× 1"	2 pcs	200	400
7	Safety belt	5 ft	1 pcs	150	150
8	Nut bolt SS	3/8"	7 pcs	40	280
9	Girth control bar(L×W×T) mm	200×27×3			
	SS flat bar	3/4"× 1/8"	0.28kg	260	73
A	Material cost				6103
B	Labour (10% of A)				610.3
C	Incidental expenses (10% of A)				610.3
D	Total cost (A+B+C)				7323.6
E	Manufacturer profit (20% of D)				1464.72
	Total price				**8788.32**

Equivalent to 8800.00

Appendix II Price estimation of coconut dehusker

Sl. No.	Parts name	Specification	Quantity	Unit price, Tk	Total Price, Tk.
1	**Main frame**				
	SS angle		30	200	6000
2	**Roller with blade**			0	0
	SS pipe	90 mmØ	4	600	2400
	SS shaft	31 mmØ	6	200	1200
	SS angle for blade	(2.54×2.54×0.32 cm)x 40.64cmx 16 pcs	8	200	1600
	SS rod	0.8 cmØ,0.96 cm Ø	1	230	230
	Jam nut	6"	2	100	200
3	**Power transmition**			0	0
	Bearing	6206	4	500	2000
	Nut bolt		2	240	480
	Motor	3 hp,1450 rpm, 1φ	1	10000	10000
	Gear reducer	10:01	1	7000	7000
	Belt	B-55	2	300	600
	Pulley	8"	1	400	400
	Pulley	3"	1	200	200
	SS Chain	428, double	58	200	11600
	SS Sprocket	28 T	1	2000	2000
	SS Sprocket	14 T	1	600	600
	Spur gear	24 T	2	800	1600
	Motor base plate	22.86x25.4 cmx 0.6cm x 1 pcs	2.74	90	246.375
	Gear reducer base plate	25.4x20.32 cmx0.6 cmx1 pcs	2.43	90	219
4	**Input tray and cover**			0	0
	SS sheet (18 SWG)		40	250	10000
	MS flat bar		0.76	60	45.6
	SS angle		10	200	2000
	Spring	5"	1	200	200
5	**Delivery tray**			0	0
	SS sheet	(40.64×96.52 cm)x 1pc	5	250	1250
6	**Accessories**			0	0
	Wheel	4"	2	500	1000
		3"	2	300	600
	base plate	10.16x10.16 cmx0.6 cmx 4 pcs	1.95	100	195
	Nut bolt		16	15	240
	Electrode	10	2	1500	3000
				0	0
7	**Electric system**			0	0
	Wire		20	40	800
	Push Switch			100	100
	Two pin plug			100	100
	A	Total material cost			68105.98
	B	Labour (10% of A)			6810.598
	C	Overhead cost (power consumption ,machine depreciation, house rent,etc) etc) (25% of B)			1702.65
	D	Incidental expenses (10% of A			6810.598
	E	Total cost	(A+B+C+D)		83429.82
	F	Manufacturer profit (20% of E)			16685.96
		Total price			**100116**

Equivalent to 100,000.00

Expert comments/suggestions

SN	Title of the CRG Sub-project and PI/Presenter	Comments & Suggestions	Solution
1	ID 307: Improvement of Coconut Harvesting and Dehusking Machine **PI/Presenter:** Dr. Md. Nurul Amin SSO, FMPE Division, BARI	i. Farmer's feedback.	Included in result and discussion
		ii. Cost analysis and payback time of the machine.	Incorporated in methodology and result & discussion
		iii. Blood Pressure (BP) of the climber before and after climbing the coconut tree.	Included in Table 14 and 15 (BP varied from 120/80 to 130/100)
		iv. The time required for climber to become BP in normal position.	Mentioned in result and discussion
		v. Quantification of the improvement of the activity through machine/normal climber.	Include in Table2 Reduce weight of left and right part of climber from 4.9-4.40 kg and 4.8-4.63 kg respectively Reduce size of left main frame from 1080 mm to 1070 mm.