# Diffusion and Utilization of UPLB Corn Mechanization Technologies in Masbate Province

*Rossana Marie C. Amongo[1], Kevin F. Yaptenco[2], Ronaldo B. Saludes[3], Maria Victoria L. Larona[4], Fernando O. Paras, Jr.[3], Rosa B. De los Reyes[5], Marion Lux Y. Castro[5], Erwin P. Quilloy[5,], Jose D. De Ramos[6], Ronel S. Pangan[7], Victor A. Rodulfo, Jr.[7], Mark Daniel G. Estrada[8], and Ronnie C. Valencia[8]*

[1]Associate Professor 6, Institute of Agricultural Engineering, and Director, Center for Agri-Fisheries and Biosystems Mechanization, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, 4031, College, Laguna, Philippines

[2]Professor 2, Institute of Agricultural Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, 4031, College, Laguna, Philippines

[3]Associate Professor, Institute of Agricultural Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, 4031, College, Laguna, Philippines

[4]University Researcher II, Center for Agri-Fisheries and Biosystems Mechanization, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, 4031, College, Laguna, Philippines; (Author for correspondence; email: mllarona@up.edu.ph; mariavictorialarona@yahoo.com; Tel.: +63 49 536 8745)

[5]Assistant Professors, Institute of Agricultural Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, 4031, College, Laguna, Philippines

[6]University Extension Specialist III, Center for Agri-Fisheries and Biosystems Mechanization, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, 4031, College, Laguna, Philippines

[7]Engineer, Center for Agri-Fisheries and Biosystems Mechanization, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, 4031, College, Laguna, Philippines

[8]University Research Associate I, Center for Agri-Fisheries and Biosystems Mechanization, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, 4031, College, Laguna, Philippines

## ABSTRACT

*A project on diffusion and utilization of UPLB Corn Mechanization Technologies (CMTs) and knowledge systems was implemented by the Center for Agri-Fisheries and Biosystems Mechanization (BIOMECH) and the Institute of Agricultural Engineering (IAE), UP Los Baños in Masbate. It was funded by the National Agriculture and Fisheries Education System-Commission on Higher Education (NAFES-CHED). Ten different CMTs developed, designed and/or modified by UPLB were diffused in the area for adoption and utilization. The study employed community participatory extension including capability building, with the goal of increasing farmer's crop and labor productivity. A survey was conducted to determine farmers' insights on the use of each CMTs using the Likert scale. Results showed farmers' favorable response on technology adoption and utilization in Mandaon, Masbate. The benefit cost ratio of the utilization of nine CMTs were greater than 1.0 indicating economic viability of the technologies. For the sprinkle irrigation system, the BCR is less than 1.0 due to the high initial cost of the system. This may however be increased by utilizing the system for high value annual crops or fruit trees production. The project empowered all the stakeholders through continuous improvement of extension strategies, the realization of the farmers-beneficiaries for the establishment of machinery custom hiring services enterprise, model farm and machinery training center; and strengthening the research, development and extension capability of the project implementing institutions.*

*Keywords: diffusion and utilization, agricultural mechanization technologies, participatory extension strategies*

# INTRODUCTION

The Philippines is an agricultural country where abundant agricultural raw materials are produced for food, feed, and industrial applications. About 32% (9.671M has) of the total land area of 29.817 million hectares is under intensive cultivation, where 51% and 44% are arable and permanent croplands, respectively. In 2014, the major agricultural land utilization by area harvested is devoted to palay, corn, sugarcane, mango, tobacco, cassava and onions (BAS, 2014). Corn is the second major staple food of Filipinos while vegetables serve a large part of their diet.

Of the more than 100 M population of Filipinos with 2.96% growth rate in 2014 (NSCB, 2014), about 86% lives in the rural areas. Seventy-five percent (75%) of them depend on agriculture for employment and income. Although about 31% of the employment share comes from agriculture (BAS, 2014), many Filipinos remain unemployed or underemployed.

The crops subsector has increased its gross value by about 14.52% more than the 2013 level (BAS, 2014). The increase in values may be attributed to the purposive campaign of the government to attain food security and sustainability. In the corn industry, the area harvested in 2015 was 2.562 million hectares with a total production of 7.518 MMT or roughly 2.93 MT/ha. A high opportunity to increase corn yield can be achieved through the introduction of CMTs making farm operations more efficient and lessen postharvest losses.

The use of modern agricultural mechanization technologies on production and post-production systems will, among others, enable the agricultural sector to fully utilize farm products and by-products; cultivate lands, swamplands and other non-arable lands on a sustained basis; intensify and diversify farming systems which will, in turn, generate employment; conserve or even earn foreign currencies through local manufacturing and export of these technologies; reduce or minimize postharvest losses; increase the value added to farm products through secondary and tertiary processing; reduce pressures in the environment that would in turn achieve food security.

The project focused on the diffusion and utilization of CMTs in a corn-based farming system with the integration innovative technologies for vegetable production. The selection of the project site was based on key corn-producing areas in the country. The introduction of CMTs in the area also integrated the diffusion of knowledge systems through capability building in the form of training on the operation and repair and maintenance, demonstration of the technologies and continuous monitoring and evaluation of the project. Other expected outputs of the project are to enhance the capability of the Provincial Institute for Agriculture and Fisheries (PIAFs), Local Government Units (LGUs), and collaborating State Universities and Colleges (SUCs); publications; technology innovations for crop production-postproduction-processing (value adding)-marketing system; and small to medium enterprises.

# OBJECTIVES

The general objective of the project was to enhance productivity of a corn-based farming community through the introduction, diffusion, and utilization of corn mechanization and innovative technologies for food security. Specifically, the project aimed to:

1. Determine the level of mechanization in Masbate for the establishment of a pilot area by diffusing and utilizing corn mechanization and innovative technologies for corn -based farming system;
2. Demonstrate the use of corn mechanization and innovative technologies to enhance productivity of a corn-based farming system;
3. Enhance the capability of the stakeholders for the utilization of selected corn mechanization and innovative technologies focusing on corn-based farming system;
4. Assess farmers' perceptions on technology adoption and utilization; and
5. Demonstrate the economic viability of the CMTs technologies.

# METHODOLOGY

## Conceptual Framework

The project employed community participatory and collaborative approaches for the diffusion and utilization of CMTs. Collection of baseline information, farmers' knowledge and cultural practices lead to the identification of collaborators and stakeholders. The needs and design assessment was conducted to determine the farmers' mechanization requirement and establish the current farm practices. Dissemination of information on CMTs and knowledge systems were also done for better appreciation of the project. The experts' knowledge and the acquired knowledge systems of the beneficiaries were integrated to develop an effective extension agenda.

The diffusion of technology and knowledge systems were undertaken through technology packaging, demonstration, and Training on the Operations, Repair and Maintenance of the CMTs. Perception survey was conducted to initially identify project impacts and farmers' insights on technology adoption and utilization. Learnt knowledge anchored the creation of an enterprise geared toward increasing farmers' income, improved crop based systems for food production, attain self-sufficiency and food security. Strategies and innovations to achieve the project outputs and outcomes were designed through continuous mentoring, implementing participatory applied research and extension, and monitoring and evaluation of impacts and outcomes. Coordinated institutional, technical and social and marketing supports were also considered for the stakeholders to ensure proper project implementation and the achievement of deliverables and outcomes (Figure 1).

Benefit cost analysis was employed to determine project viability. The tangible benefits were identified from use of CMTs with and without project scenarios.

**Needs and Design Assessment**

The basic unit of the applied/action research project was implemented in a farmers' association in Mandaon, Masbate. The project team started with the creation of awareness among the target beneficiaries and stakeholders through the coordination with Dr. Emilio B. Espinosa, Sr. Memorial State College of Agriculture and Technology (DEBESMSCAT), the partner Provincial Institute of Agri-Fisheries present in the area.

A needs and design assessment (NADA), was conducted to collect baseline/benchmark information from the stakeholders. Results of the NADA served as bases for the selection of the farmers' group as project collaborators, and for the design, development and/or modifications of the ten different corn mechanization technologies (CMTs) for the area.

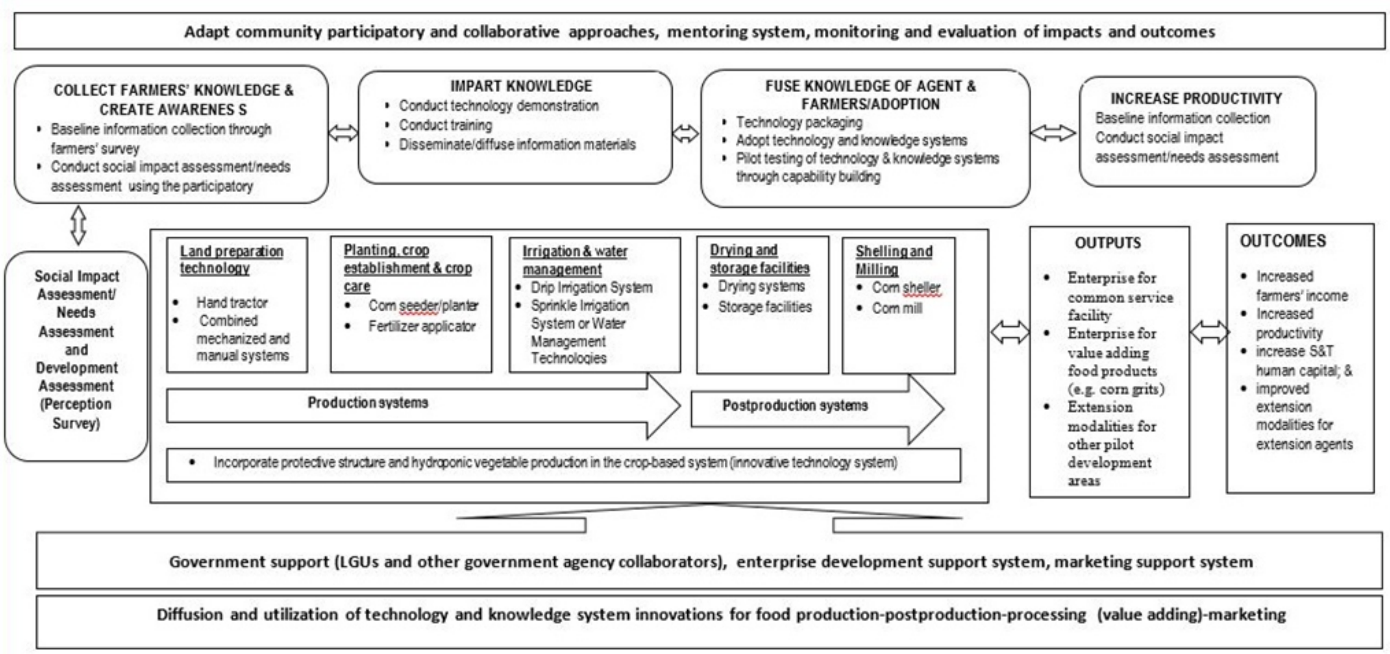


Figure 1. Conceptual framework of the project

**Sampling procedure and survey**

Ninety-five (95) corn farmer-respondents were surveyed from six (6) towns of Masbate using the stratified sampling technique. The towns were randomly selected based from the corn production area categorized as low, medium and high production area. The NADA helped identify the mechanization needs of the corn farmers in Masbate and the possible socio-economic impacts of the project and the development plans suitable in the project site. Monitoring and evaluation mechanisms were formulated to document the possible impacts and outcomes of the project.

**Data processing and analysis**

Data processing and analysis were done using the Microsoft Excel to generate tables, frequencies and graphs. The level of mechanization based on utilization of the different sources of power was computed per farm operation of corn production-postproduction systems (Equation 1), This equation was based on the study of Del Rosario, et al, 1991 and Amongo et al., 2013.

The UPLB developed and designed CMTs were diffused to the project site and knowledge systems were imparted to the farmer beneficiaries, collaborators and other stakeholders through pilot area demonstration and training on the operation and maintenance (ORM) of the ten UPLB-designed and developed CMTs. After each training, perception survey for the CMT was also conducted using a structured questionnaire to determine the general perception of the training participants and/or project beneficiaries on the CMTs and innovative technology introduced. The technology perception parameters included: applicability/compatibility in the area; willingness to use and try in the farm; learning ability to operate; ease of operation; comparative advantage to existing practice; degree of technology complexity; teaching ability of the trainees to other farmer-users; technology is recommendable to other farmers; and trial ability of the CMT in the farm within a given time frame. The technology perception parameter score for each technology was computed using Equation 2.

## RESULTS AND DISCUSSION

**Establishment of the Pilot Area Development Site**

The province of Masbate was selected as the project site using a five-point criterion, which included: (1) a corn producing area with existing Provincial Institute of Agriculture and Fisheries (PIAF); (2) has a low yield level of corn production; (3) has low level of mechanization; (4) marginalized province, considered as poor province, and (5) high percentage of population living in poverty.

**General description of the project site**

Masbate is a corn producing province and with existing PIAF, the Dr. Emilio B. Espinosa Sr., Memorial State College of Agriculture and Technology (DEBESMSCAT). Of the total land area of

$$\text{Level of Mechanization (utilization, \%)} = \frac{\text{No. of farmer using type of technology or source of power} \times 100\%}{\text{Total number of respondents}} \text{ per operation} \qquad \textit{Equation 1}$$

(Source: Del Rosario, et al, 1991 and Amongo et al., 2013)

where the sources of power considered were manual system, man-animal system and man-machine system

$$\textbf{Technology perception parameter scores} = \frac{(n_a*5) + (n_b*4) + (n_c*3) + (n_d*2) + (n_e*1)}{n_a + n_b + n_c + n_d + n_e} \qquad \textit{Equation 2}$$

where:
a is the highest rating (Strongly Agree, Very easy, Very Simple or Immediately)
b is the second highest rating (Agree, Easy, Simple, or After the current season)
c is the third highest rating (Neutral, Moderate, Moderate, or After two seasons)
e is the fourth highest rating (Disagree, Hard, Complex, or Wait and see)
d is the lowest rating (Strongly Disagree, Very Hard, Very Complex, or Never)
$n_i$ is the number of respondents responding to the 5 Likert scale of each perception parameter

21,566.75 hectares, the province is utilizing around 14,850.15 hectares for corn production with 13,539.15 hectares planted to white corn variety and 1,311 hectares for yellow corn variety (OPA, Masbate, 2014). The white corn variety is predominantly planted in the province since white corn is a staple food for Masbateños. In spite of the large area planted to corn (68.86 % of the total land area), however, the province has a low yield level for corn production. In 2014, the Office of the Provincial Agriculturist (OPA) noted that the average corn yield was only around 2.94MT/ha with the lowest yield of 1.1 MT/ha and highest yield of 4.0 MT/ha. Masbate is considered as one of the marginalized provinces in the country. It ranked 10$^{th}$ as the poorest provinces in the Philippines. Moreover, high percentage of its population is living in poverty. Around 44.2% of the total population of 892,000 (POPCEN, 2015) is living in poverty.

The project intervention is envisioned that corn farmers in the project site will increase their crop and labor productivity and the enterprises can be created to serve as source of additional income for farmer beneficiaries.

**Selection of the Project Beneficiary**

The Lantangan People's Organization (LAPO) in Brgy. Lantangan, Mandaon Masbate was selected out of three possible sites, as the farmers' group partner for project implementation, in coordination with the Mandaon Municipal Agricultural Office, DEBESMSCAT, and the farmers' organization itself. It is an Agrarian Reform Beneficiaries Organization (ARBO) under the Agrarian Reform Community (ARC) implemented by the Department of Agrarian Reform (DAR). LAPO is an ARC within a corn cluster area that has 328 Agrarian Reform Beneficiaries (ARBs) and composing of 180 members (dar.gov.ph). The major criteria in the selection of the project site were: (1) accessibility of the site for the technologies; (2) availability of water source for the installation of the water management technologies; (3) peace and order situation in the site; and (4) provision for machinery shed for the safety and security of the machinery.

**Needs and Design Assessment (NADA)**

The needs and design assessment (NADA) was undertaken to establish the farmers socio-demographic profile and identify the technology needs and gaps of the specific site or community in relation to the utilization and adoption of corn mechanization technologies. The baseline information collection determined the current agricultural activities, cultural practices and available technologies among 95 corn farmer respondents in Masbate (Table 1). The information served as bases to identify and design or modify existing technologies and processes applicable to the area. It also served as indicators for matching available technologies for the project beneficiaries.

The NADA was conducted to gather data through survey of 95 corn farmer respondents, focus group discussions, and interviews with key informants and collaborators. Table 2 summarized some of the significant socio-demographic farmers' profile. The age of corn farmer respondents ranged from 24 to 77 years old with an average age of 50 years old. Majority of the respondents (89.47%) planted corn as their main crop while 73.68% also plant other crops (mostly rice, cassava, coconut, and sweet potato). Table 3 presents the area planted, topography of farms, and irrigation management utilized by farmer-respondents. Majority of the farmers practice the corn-corn cropping system.

Through the survey and other data collection strategies, the project established the socio-demographic information, existing agricultural

Table 1. Composition of sample municipalities and corresponding number of respondents, Masbate, 2016

| SAMPLE MUNICIPALITIES OF MASBATE | NO. OF RESPONDENTS |
|---|---|
| Mandaon | 19 |
| Uson | 27 |
| Aroroy | 8 |
| Masbate City | 17 |
| Baleno | 12 |
| Milagros | 12 |
| **TOTAL** | **95** |

practices including the level of agricultural mechanization, marketing and credit system, problems and issues on the general agricultural system of Masbate. Results showed that the province had a low level of mechanization. Almost all farm operations were either performed manually or with the aid of animal draft. Planting and fertilizer application were done by manually using their bare hands. Harvesting was done manually using the "picked and dehusked in the field" method. Drying operation was done through sundrying while shelling operation was done manually with the aid of hand tools. Storage practice was through manual means. In field transport was either done manually or through the use of animal. Milling operation was done by machines which were located far from the farms in the town proper. Few farmers practiced manual milling using native stone mills. Transport system from farm to market was through the common public utility vehicles such as jeepneys, tricycles and motorcycles (Figure 2). The NADA also revealed important information as to the farm operations that the farmers would like to mechanize (Figure 3). The information became the basis for the modification and introduction of corn mechanization technologies to be introduced in the area.

Table 3. Corn farm information, Masbate, 2016.

| CORN FARM INFORMATION | PERCENTAGE OF RESPONDENTS (%) |
|---|---|
| Area planted 1st cropping season (ha) | |
| 0.25-1.0 | 80.00 |
| 1.1-2.0 | 14.00 |
| 2.1-10.0 | 4.00 |
| 20 | 1.00 |
| Area Planted – 2nd cropping season (ha) | |
| 0.25-1.0 | 54.00 |
| 1.1-2.0 | 5.00 |
| 2.1-10.0 | 3.00 |
| Area Planted – 3rd cropping season (ha) | |
| 0.25-2.0 | 3.16 |
| Topography | |
| Hilly lands | 49.00 |
| Upland plains | 40.00 |
| Flooded plains | 6.00 |
| Lowland corn after rice | 5.00 |
| Irrigation Management | |
| Rainfed | 91.00 |
| Free flowing water resource NIA/Communal | 5.00 |
| Irrigation System | 4.00 |

Marketing of farm produce could either be in the form of wet corn on cob, dried corn on cob, wet corn kernels or dried corn kernels. Table 4 presents some significant marketing information about farmers' marketing practices. It shows that majority of them are producers and not processors leaving less opportunity for value adding activities for their crops.

Table 2. Summary of some socio-demographic information of corn farmer-respondents, Masbate, 2016

| CORN FARMER - RESPONDENTS INFORMATION | PERCENTAGE OF RESPONDENTS (%) |
|---|---|
| Gender: | |
| Male | 66 |
| Female | 34 |
| Age of farmers (Aveg. - 50 years old) | |
| 20-30 | 8.42 |
| 31-40 | 11.58 |
| 41-50 | 30.53 |
| 51-60 | 30.53 |
| 61+ | 18.95 |
| Literacy (able to read and write) | 100.00 |
| Education: | |
| Elementary | 23.16 |
| High School Graduate | 15.79 |
| Main source of income as farming | 78.00 |
| Main crop (corn) | 89.47 |
| Other crops | 73.68 |
| Income from other sources (household members) | 27.37 |
| Income as farm hired labors | 23.16 |
| Other sources | 28.42 |
| Gross income range (PhP): | |
| Less than 20,000 | 43.00 |
| 20,000 – 50,000 | 36.00 |

Table 4. Marketing of corn harvest, Masbate, 2016.

| MARKETING DISTRIBUTION | PERCENTAGE OF RESPONDENTS (%) |
|---|---|
| Sold to traders | 86.00 |
| Cooperative | 4.00 |
| Other cooperatives | 4.00 |
| Other corn traders | 3.00 |
| NFA | 3.00 |
| Delivered to traders | 81.00 |
| Pick up by traders | 17.00 |
| Delivered to and picked up by traders | 2.00 |

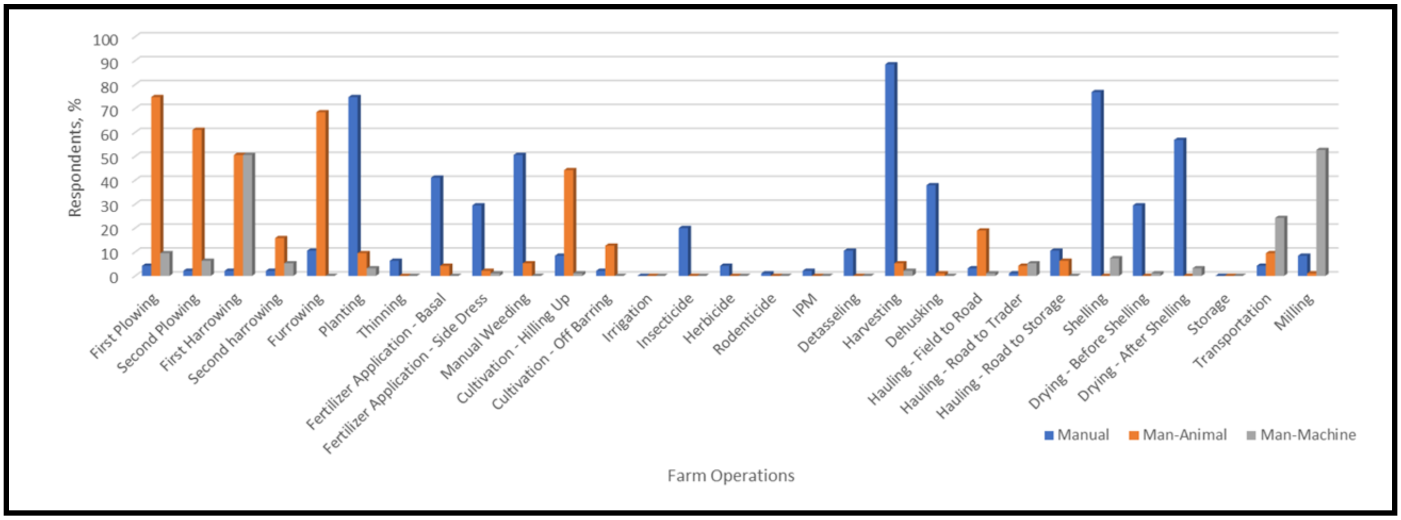


Figure 2. Level of mechanization based on the utilization of different power sources in corn production and post-production operations, Masbate, 2016.

**Computation of the level of mechanization in terms of utilization of different sources of power (Adapted from Del Rosario et al., 1991, and Amongo, et al., 2013)*

## Demonstration of the utilization of corn mechanization and innovative technologies in corn-based farming system

**<u>Modification and design of existing corn mechanization technologies applicable to Masbate condition</u>**

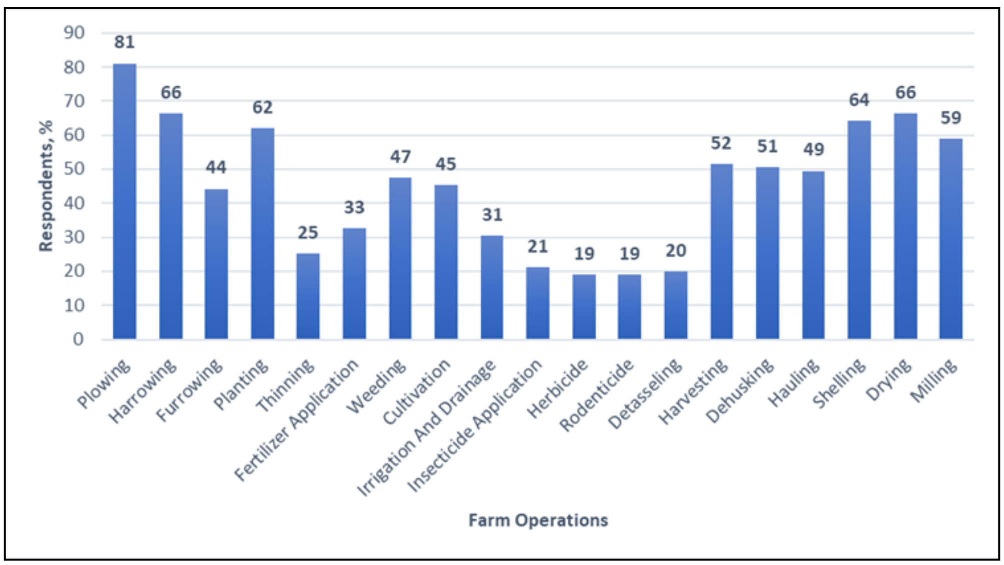


Figure 3. Farm operations that corn farmer respondents' would like to mechanize.

The 10 CMTs and innovative technologies were introduced in the project site using results of NADA. Some of the CMTs were modified to suit the existing conditions. The introduction, demonstration of the technologies provided opportunities to increase crop and labor productivity through increased efficiencies in the farm operations. The efficiencies as a result of the introduction of the CMTs were presented in the discussion of the benefit cost analysis.

### *Land Preparation and Transport Operation*

The UPLB Upland Hand Tractor with brake differential steering mechanism attached with implements such as the two-bottom disc plow, tooth harrow, and transport trailer was designed (Paras, 2005). It was fabricated tested and fine-tuned before it was brought and introduced in Masbate. The cage wheels were designed to maximize traction and aid in the land preparation as it also cultivates portion of the land during actual operation. Cage wheels for plowing are replaced by regular tires for transport operations (Figure 4a). The tooth harrow is used after primary tillage to break soil clumps and clean the field of unwanted materials. A trailer was made to allow transport operation and to maximize the utilization of the tractor. It could be used to transport farmers' goods and products more easily to and from the farm.

***Corn-crop establishment***

A two-wheel tractor mounted corn planter was designed for the site. The IRRI PT-5 Power Tiller, serves as the prime mover. The walk-behind two-wheel tractor is simple in construction, light in weight and easy to maneuver because of an idler clutch and throttle for controlling engine speed, for easy operation. It is powered by a 5-hp engine, and weighs about 88 kg without the engine. It requires one person to operate and has a field capacity of one hectare per day. The corn planter, a cell-type metering device made of engineering plastic, was designed as an attachment to the tractor. It has inrow hill spacing that can be adjusted by means of sprocket combinations between the ground wheel and metering device. It can discharge 1-3 seeds per hill and has an adjustable row spacing of 750mm (Figure 4b).

***Corn-crop care operation***

In Lantangan, Mandaon, Masbate, corn farmers commonly apply solid fertilizers using bare hands by broadcasting in the field or applying in bands along the furrows during planting operation. An average of 5.92 bags or approximately 6 bags (300 kilograms) of basal fertilizer is applied for a hectare of corn farm. This is being done manually and about 7.38 man-days are required for basal fertilizer application. Based from NADA, 32.63 % of the farmer respondents would like to mechanize fertilizer application.

The introduction of the automated fertilizer applicator in tandem with corn planter in the project area will aide in the precise application of fertilizers. It is designed to dispense the exact amount of basal fertilizer for every planted seed. This will in turn lessen the costs, and time spent in applying fertilizer, which could be diverted to other farm activities.

The automated fertilizer applicator (Figure 4b) was designed to work with the corn planter. It has the following features: a stepper motor to give precise application rate; equipped with infra-red sensor that only drops fertilizer granules along with the seed; meter the fertilizer granules in exact amount; the hopper assembly is made of stainless steel to avoid corrosion; and the metering device is made of engineering plastics for light weight and corrosion resistant.

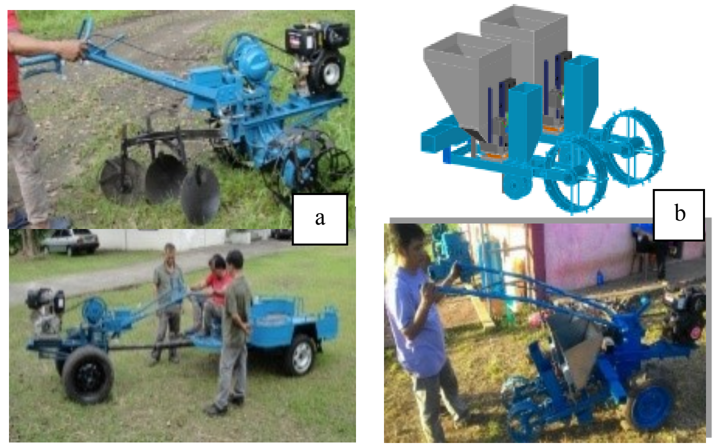


Figure 4. The UPLB Hand tractor with disc plow and trailer (4a); and the Two-Wheel Tractor Mounted Corn Planter with Automated Fertilizer Applicator (4b).

***Irrigation and water management technologies for corn-based farming system***

Two types of irrigation systems were introduced and installed in the site to demonstrate the advantage of available water for crop production. Initial field trial was conducted to demonstrate yield improvement and to test the adaptability of the drip irrigation system (DIS) and the sprinkler irrigation system (SIS) (Figure 5). Although, it requires high initial costs to install these systems, it can be compensated

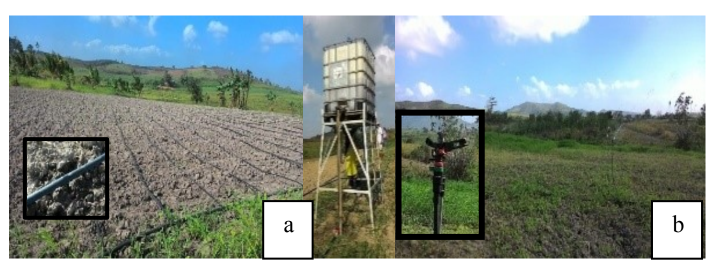


Figure 5. The a) Drip Irrigation System (DIS) and b) Sprinkler Irrigation System installed in the project site.

by its higher application efficiency. The use of cheaper materials could also reduce the initial investment and make it affordable to farmers.

The DIS is a lightweight and movable drip irrigation system. It is equipped with a top drip pressure-compensating and anti-siphon thin-walled dripline making it applicable to areas with varied topography and allowing longer laterals with high uniformity. It has a required pressure of 4-25 psi and discharge rate of 1.6 lph. The water from the spring well in the selected area was elevated to the 1000L tank using direct coupled gasoline engine and pump.

The SIS is a high impact sprinkler irrigation system with a riser (Figure 6b). The heavy-duty plastic materials provided resistance to corrosion, chemicals and UV radiation, which can be used for several years. It is applicable to areas with varied topography and designed for irrigation of field edges. It has a required pressure of 20-40 psi provided by a booster pump. It has a discharge rate of 450 lph and a wetted perimeter of 22 meters. The irrigation systems were designed for the production of high value crops such as tomatoes, lettuce, cabbage, etc. for additional income to farmers.

***Drying Technologies for Corn***

There are no available mechanical dryers in the project site. Farmers depend on the sun for drying operation. Farmers plant and harvest their product during dry months to reduce the possibility of spoilage. Such practice limits their capability to plant and harvest during the wet seasons. The availability of a mechanical grain dryer will enable farmers to plant 2 to 3 cropping per year and avoid product spoilage during the wet months.

The UPLB Flatbed dryer with 2-ton batch capacity was identified as the appropriate drying system for the project site; a biomass furnace was used as the heat source with dry corn cob as the fuel. The corn cob was readily available in the area. The original design of the dryer used wooden framing and plywood walls for the drying bed and plenum; the version installed at the project site was modified to be collapsible and constructed from steel sheet for ease in assembly and transport. The fan used to push

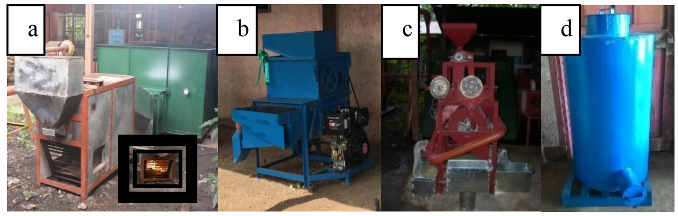


Figure 6. The UPLB Post Production Technologies brought to the project site:
UPLB Modified Flatbed Dryer (a), AMDP Two Drum Corn Sheller (b); AMDP Mini- Corn Mill (c); and Metal Grain Silo (d)

heated air through the drying bed was driven by a 5-Hp diesel engine (Figure 6a).

***Shelling and Milling Technologies***

The introduction of the appropriate corn shelling and milling system in the project site will enable farmers to avail of the benefits of good quality grains and grits, less operating cost and increased efficiency resulting to less losses. The AMDP Corn Sheller (Figure 6b) was identified as the sheller design in Masbate. It is constructed from locally available materials; a non-crushing type (shelled cobs are kept whole), versatile (can shell corn for seed purposes); and suitable for all sizes of corn ears (AMDP Corn Sheller leaflet, undated).

The AMDP Mini Corn Mill (Figure 6c) has the following features: compact and mobile; can mill flour and grits (very fine to coarse grind); adaptable to electric motor or single cylinder engine as power source; and with provisions for cleaning, sifting and dehulling. The design of the mill component was based on the commercial pin mill model because of its ease of operation, potential for local manufacturing, low power requirement and comparably high capacity per unit power requirement. The milling capacity ranges from 30 to 150 kg/hr for products ranging from very fine to coarse grind, respectively. The power consumption ranges from 4 to 1.38 kW for milling very fine to coarse grind.

The original AMDP Mini Corn Mill was modified by changing the grit separator from the oscillating rack into a rotating drum to make the machine more portable and compact for easy transport. The rotary also drum minimizes the vibration and lessen noise during operation.

*Grain Silos Storage Systems*

The NADA and literature search determined the small metal silos as suitable for home and on-farm storage for small volumes of corn grain in the area. A major concern of survey respondents was marketing of their product. They encountered difficulty in identifying buyers which further resulted to product deterioration due to lack of storage facilities. Some farmers also need cash immediately after the harvest period to settle immediate financial needs (e.g. debts and/or procure household supplies). The combination of mechanical dryers and on-farm storage technology is expected to help resolve this problem.

For small farmers and associations, the most appropriate storage method appears to be hermetic storage. This technology minimizes or eliminates the need for chemical control of insect pests and keeps the moisture content of grain at a stable level. The use of flexible bags and cocoons made from special materials has been tested and found effective. However, they are not entirely proof against rodents and some insect pests. Furthermore, availability of this technology may be limited in remote areas of the Philippines. Small metal silos that are hermetically sealed are more readily available since these can be fabricated from commonly available materials, are easy to assemble using simple tools and equipment, and require only basic metalworking skills to operate and maintain. Manuals produced by the UN FAO are provided for free online which have complete working drawings for fabricating various sizes of the grain silos.

To demonstrate the technology to farmers, only the smallest silo design was selected for fabrication with a capacity of 100 kg of dried shelled corn. GI sheets were used for the various parts of the silo. Welds were painted with primer including the outer surface of the silo was for protection against corrosion (Figure 6d).

***Innovation technologies for corn-based cropping system***

A 100 $m^2$ quonset style greenhouse (5 meters width x 20 meters length x 3.5 meters height) was constructed by using galvanized iron (G.I) pipes as structural frame and UV-resistant polyethylene (PE) film as covering material. Figure 8 shows the actual structure in the project site. It is covered with superfine net outside and equipped with a shading net inside. It also has an ante room used to prevent insects from entering the main structure. It was designed to withstand Typhoon Signal No. 3.

A run-to waste hydroponic system was constructed inside the plastic greenhouse. This hydroponics system requires less maintenance and repair. Irrigation water /nutrient solution is stored in elevated tanks and is supplied to the growing beds by gravity (Figure 7). The growing beds were lined with a geomembrane to prevent leaching of nutrient solution. Vermicompost is used as a growing medium for the crops. Four growing beds (15 m long x 0.5 m wide) were laid out to about 1-2% sloping for effective irrigation.

**Enhancing the capability of the stakeholders**

Capability building in the form of training on the operation, repair and maintenance of the technologies were undertaken. Training lectures/modules for the 10 CMTs brought to the area were prepared and provided to the trainees. The modules served as guide of the operator on how to operate the CMTs, know the requirements for efficient corn production and postproduction operations, perform repairs and

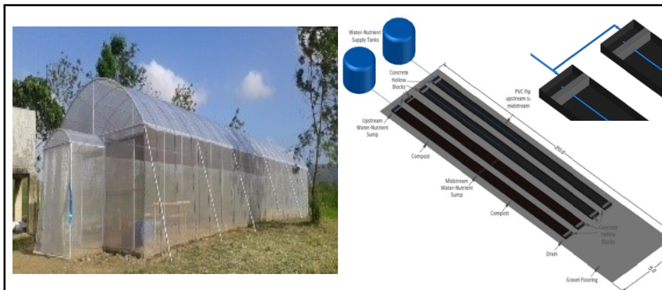

Figure 7. The Protective Structure (Greenhouse) and the Nutrient Delivery System installed at the project site in Lantangan, Mandaon, Masbate.

conduct maintenance jobs. The training activities were coordinated with DEBESMSCAT, LAPO, DAR, and LGU-Mandaon. The activities included the actual training, demonstration of the CMTs and hands-on operation by the participants were conducted. A total of 449 participants, whereby most of them attended more than 1 training (240 of which were farmers) for the 10 CMTs the training on the Basic Operation, Repair and Maintenance (ORM). The 10 trainings were conducted in December 2016 and January 2017 in Mandaon, Masbate (Table 5).

Table 5. Summary of the 10 Training on the Operations, Repair and Maintenance of the CMTs introduced and diffused in Brgy. Lantangan, Mandaon, Masbate, 2016-2017

| CORN MECHANIZATION TECHNOLOGIES (CMTs) | NUMBER OF TRAINEES | NUMBER OF FARMERS | DATE CONDUCTED |
|---|---|---|---|
| Upland Hand Tractor | 52 | 26 | Jan 26, 2017 |
| Corn Planter | 46 | 25 | Dec 9, 2016 |
| Automated Fertilizer Applicator | 52 | 26 | Jan 26, 2017 |
| Drip Irrigation System | 25 | 13 | Jan 24, 2017 |
| Sprinkler Irrigation System | 25 | 13 | Jan 24, 2017 |
| Corn Sheller | 64 | 31 | Dec 13, 2016 |
| Corn Mill | 64 | 31 | Dec 13, 2016 |
| Dryer | 48 | 31 | Dec 12, 2016 |
| Grain Silo | 48 | 31 | Dec 12, 2016 |
| Protective Structure & Hydroponics | 25 | 13 | Jan 24, 2017 |
| **TOTAL** | **449** | **240** | |

Table 6. Technology perception parameters scores* of the ten Corn Mechanization Technologies, Masbate, 2016-2017.

| TECHNOLOGY PERCEPTION PARAMETERS | CORN MECHANIZATION TECHNOLOGIES | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | UPLB Upland Hand Tractor with Brake Differential Steering n=33 | Two-wheel Tractor Mounted Corn Planter n=21 | Automated Two-wheel Tractor Mounted Fertilizer Applicator n=29 | Drip Irrigation System n=9 | Sprinkler Irrigation System n=9 | UPLB Flat-bed Dryer n=28 | AMDP Two-Drum Corn Sheller n=22 | AMDP Mini Corn Mill n=20 | Metal Grain Silo n=20 | Hydroponic Vegetable Production and Greenhouse Protective Structure n=9 |
| **LEVEL OF ACCEPTANCE/AGREEMENT** | | | | | | | | | | |
| Applicability or Compatibility in the area | 4.33 | 4.14 | 4.28 | 4.11 | 4.11 | 4.36 | 4.90 | 4.77 | 4.75 | 4.11 |
| Willingness to try | 4.24 | 4.43 | 4.41 | 4.33 | 4.33 | 4.79 | 4.90 | 4.77 | 4.60 | 3.89 |
| Comparative advantage to the existing practice | 4.27 | 4.05 | 4.34 | 3.78 | 3.78 | 4.75 | 4.75 | 4.59 | 4.60 | 4.22 |
| Teaching ability | 4.15 | 4.29 | 4.07 | 3.89 | 3.89 | 4.39 | 4.50 | 4.14 | 4.60 | 3.22 |
| Recommendability | 4.24 | 4.05 | 4.21 | 4.00 | 4.00 | 4.54 | 4.85 | 4.36 | 4.65 | 3.56 |
| Willingness to utilize | 4.15 | 4.38 | 4.34 | 4.11 | 4.11 | ND | ND | ND | ND | 4.00 |
| **LEVEL OF EASE** | | | | | | | | | | |
| Learning Ability | 3.48 | 3.48 | 3.62 | 3.33 | 3.33 | 3.54 | 3.55 | 3.59 | 4.20 | 3.44 |
| Ease of Operation | 3.64 | 3.48 | 3.48 | 3.33 | 3.33 | 3.93 | 3.75 | 3.68 | 4.26 | 3.11 |
| **LEVEL OF TECHNOLOGY COMPLEXITY** | | | | | | | | | | |
| Degree of Technology complexity | 3.52 | 3.57 | 3.41 | 3.11 | 3.11 | 3.75 | 3.80 | 3.64 | 4.25 | 3.56 |
| **TRIAL USE OF TECHNOLOGY WITHIN A GIVEN TIMEFRAME** | | | | | | | | | | |
| Trial ability | 3.85 | 4.29 | 4.00 | 3.22 | 3.22 | 4.15 | 4.35 | 4.09 | 4.45 | 2.78 |
| Trial ability for custom hiring | 4.00 | 3.71 | 3.93 | 2.44 | 2.44 | 4.44 | 4.40 | 4.05 | 4.35 | 3.33 |

Note: 5 highest score; *ND=no data; n= number of respondents in the perception survey*

Table 7. Savings/Benefits from use of CMTs "With" and "Without" project scenarios.

| PARAMETERS | UPLB UPLAND HAND TRACTOR | CORN PLANTER & AUTOMATED FERTILIZER APPLICATOR | DRIP IRRIG. SYSTEM | SPRINKLER IRRIG. SYSTEM | UPLB FLATBED DRYER | AMDP CORN SHELLER | AMDP MINI CORN MILL | METAL GRAIN SILO | GREEN HOUSE |
|---|---|---|---|---|---|---|---|---|---|
| Operating Costs/ Losses "Without" the Project (Php per year | 552,227.7 | 236,040.0 | 0 (Rainfed) | 0 (Rainfed) | 202,440.00 | 262,843.8 | 135,000.00 | 11,856.00 | 7,512.00 |
| Operating Costs "With" Project (Php per year) | 203,332.5 | 86,550.0 | 191,318.00 | 88,265.00 | 114,438.00 | 53,000.00 | 79,620.00 | 7,626.30 | 115,406.40 |
| **Savings / Benefits with Project (Php per Year)** | **348, 895.2** | **149,490.0** | **239,781.00 (add'l income from high-value crops)** | **5,321.00 (add'l income from corn)** | **208,002.00** | **209,843.8** | **135,000.00** | **24,279.83** | **234,864.00 (add'l income from high-value crops)** |

Table 8. Simple economic analysis for the different CMTs.

| ECONOMIC PARAMETERS | UPLB UPLAND HAND TRACTOR | CORN PLANTER & AUTOMATED FERTILIZER APPLICATOR | DRIP IRRIG. SYSTEM | SPRINKLER IRRIG. SYSTEM | UPLB FLATBED DRYER | AMDP CORN SHELLER | AMDP MINI CORN MILL | METAL GRAIN SILO | GREEN HOUSE |
|---|---|---|---|---|---|---|---|---|---|
| Initial Cost (Php) | 174,500.00 | 114,000.00 | 317,400.00 | 278,640.00 | 218,000.00 | 100,000.00 | 120,000.00 | 50, 670.00 | 319,600.00 |
| Fixed Cost (Php per year) | 49,732.50 | 22,230.00 | 80,937.00 | 71,053.00 | 42,510.00 | 19,500.00 | 23,400.00 | 5, 802.30 | 46,342.00 |
| Total Variable Cost (Php per year) | 153,600.00 | 64,320.00 | 110,381.00 | 17,212.00 | 41,040.00 | 33,500.00 | 56,220.00 | 1,824.00 | 69,064.40 |
| Benefits (Php per year) | 348, 895.22 | 149,490.00 | 239,781.00 | 5,321.00 | 208,002.00 | 90,000.00 | 135,000.00 | 24,279.83 | 234,864.00 |
| Payback Period (year) | 1.20 | 1.98 | 1.30 | 61.80 | 1.75 | 2.43 | 2.44 | 0.01 | 2.68 |
| Break Even Point | 4.00 ha/yr | 13.39 ha/yr | 2.5 ha/yr | negative | 17.15 ha/yr | 106000 kg of corn grain | 31848 kg of corn grain | 9.77 Php/kg | 328.23 kg/yr |
| **Benefit Cost Ratio** | **1.42** | **1.39** | **1.95** | **0.30** | **1.78** | **1.04** | **1.12** | **4.35** | **1.94** |

## Assessment of the farmers' perceptions on technology adoption and utilization

After each CMT training, perception survey based on identified technology perception parameters, for the different CMTs was conducted. The survey aimed to determine the general perception of the training participants on technology adoption and utilization in the site. These parameters included: applicability or compatibility in the area; willingness to try; comparative advantage to the existing practice; teaching ability; technology is recommendable to other farmers; willingness to utilize; learning ability; ease of operation; technology complexity; trial ability; and trial ability for custom hiring. The technology perception parameter scores for the 10 CMTs were computed using 5-level Likert scale (Table 6).

These perception survey results provided designers with information for possible technology improvements. Table 6 shows that the higher the score means favorable or positive perception of the farmers on the CMT. Generally, most of the 10 CMTs had higher scores, except for the light-shaded values where technology perception parameters were lower than 4.0 but still higher than 3.00. While the dark-shaded values represent the technology with lower than 3.00 score, for the trial ability (2.78) of the hydroponic and greenhouse system, and for and trial ability for custom hiring of the drip irrigation system (2.44) and sprinkler irrigation system (2.44). The results showed that farmers tend to

**Table 9. Tangible benefits in the utilization of the different CMTs.**

| TRADITIONAL FARM OPERATIONS (based on NADA) | CORN MECHANIZATION TECHNOLOGIES (CMTs) | TANGIBLE BENEFITS |
|---|---|---|
| Plowing:<br>24.06 man-days/ha | Upland Hand Tractor<br>1 ha/day (8 h operation) | • Drudgery in tillage operation is minimized; Better control of degree of soil pulverization; Farmers' productivity is improved, with more time for other farm activities;<br>• Hand Tractor primemover has multiple use for the farm (eg. irrigation, drying, transport);<br>• Transport operations are easier with the trailer attachment. |
| Planting:<br>7.76 man-days/ha<br>Fertilizer Application (Basal):<br>7.38 man-days/ha<br>(Side Dress): 5.20 man-days/ha | Corn Planter with Automated Fertilizer Applicator<br><br>1 ha/day (8 h operation) | • Precise and exact amount of seeds and fertilizer application realizing costs, labor and time savings;<br>• Increase planting and fertilizer application efficiencies;<br>• Lessen drudgery of planting and fertilizer application;<br>• Lessen health risk from direct contact in applying fertilizers; |
| Irrigation:<br>Rainfed | Drip Irrigation System<br>1.6 lph will be operated for 5 hours per irrigation application | • Increased production – though increase in cropping intensity and better control of water to obtain higher yields;<br>• Change in product – through the use of high value crops |
| Irrigation:<br>Rainfed | Sprinkler Irrigation System<br>450 lph will be operated for 18 hours per irrigation application | • Increased production – though increase in cropping intensity and better control of water to obtain higher yields;<br>• Crop/Product diversification – through the planting of high value crops as an added source of income |
| Shelling:<br>Manual Shelling<br>10.7 kg person / h | Corn Sheller<br>1 ton/h | • Increase shelling efficiency;<br>• Reduction of post-harvest losses due to the efficiency of the machine;<br>• Lessen hand injury during shelling operation;<br>• Increased value of the produce |
| Drying:<br>Solar Drying | Flatbed Dryer<br>2 ton capacity per batch (8 h operation) | • On-demand drying is available which will prevent spoilage if performed immediately after harvesting and shelling; improved quality of grain compared to sun-dried corn; Less labor input;<br>• Drying temperature can be controlled –less cracked grains;<br>• Dried corn can be stored for a longer period of time; Corn cobs can be utilized for fuel – no extra fuel cost |
| Storage:<br>Stored in sacks | Grain Silo<br>180-kg capacity | • Less pressure on farmers to sell grain immediately;<br>• Improved bargaining power when negotiating with buyers;<br>• Reduced need for chemical fumigation against insect pests;<br>• Increased protection against rodents, birds and other animals;<br>• Less vulnerability to poor weather conditions |
| Milling:<br>Private Corn Mills | Corn Mill<br>100 kg/h | • Lessen post-harvest losses due to the efficiency of the machine;<br>• Savings from the cost of milling services from private corn mills;<br>• Increase value of corn produce |
| Traditional Vegetable Farming | Innovative technologies:<br>Greenhouse & Hydroponic Vegetable Gardening | • Improved marketable quality of high value crops by reducing/eliminating damaging effects of soil-borne diseases, pest, weather, nutrient deficiency and water stress;<br>• Year-round production allows farmers to take advantage of seasonality of crops and higher selling prices;<br>• Increased plant density results to higher yield per unit area; higher water productivity promotes water conservation |

perceive simple technologies like the metal grain silo to be more acceptable, easier to use and less complicated.

**Benefit cost analysis of the CMTs**

For the benefit and costs analysis of the various CMTs and innovative technologies diffused in the project area, basic information and cultural practices as determined in the NADA were used. The analysis used operational costs or losses, "with" and "without" project scenarios to compute for the savings or benefits of each technology (Table 7). In the "without" project scenario, the operational costs refer to the price of using the traditional corn production practices in Masbate. This includes manual or man-animal labor and losses incurred in post-harvest handling. While in the scenario "with" the project, the operational costs refer to the price of using the CMTs. The benefits from this scenario were realized from the savings of fares in transportation, seeds, and fertilizers. The reduced losses due to the efficiencies of CMTs, the additional incomes from high-value crops, and the advantage of selling the produce at higher prices during periods of low availability also added to the benefits.

The benefit-cost ratio (BCR) for CMTs were all greater than 1.0 except for the sprinkler irrigation system. Moreover, all of the CMTs had payback period less than 2.50 years except the sprinkler irrigation system (61.80 years). In general, the results indicated that the introduction of CMTs is economically viable (Table 8). The sprinkler irrigation system is not feasible when used in corn production alone due to high investment cost. The benefit-cost ratio may be increased by using the system for high value annual crop or fruit trees production.

Table 9 provides the projected tangible benefits for the utilization of the different CMTs. This also details the information on the machine efficiencies, labor and crop productivity of the introduced CMTs compared to the traditional farm practices employed by the corn farmers in the project site.

# CONCLUSIONS

The UPLB-CLSU NAFES CHED Subprogram selected the province of Masbate as the project site, primarily because of the low corn productivity, high population level living below poverty line, and the presence of a Provincial Institute Agricultural and Fisheries (PIAF), namely the Dr. Emilio B. Espinosa Memorial Sr., Memorial State College of Agriculture and Technology (DEBESMSCAT). It was targeted that such criteria would bring about significant impacts and realizable outputs and outcomes towards increasing corn productivity and addressing food security through the utilization and diffusion of corn mechanization technologies (CMTs) and innovative technology.

The conduct of the NADA aided in determining status and existing production practices, the mechanization gaps, the appropriate mechanization interventions and specific plans for the area. The level of mechanization in Masbate is generally low. Most of the operations were predominantly done by manual means. Only few operations such as first harrowing (50.53%), transport (24.21%) and milling (52.63%) utilizes man-machine systems.

The conduct of the capability building activities, including project awareness dissemination, training on the ORM, demonstration and hands-on operation of the CMTs, and conduct of the perception survey served as guide for project's plans. The actual demonstration of the CMTs enhanced the appreciation and capability of the farmer-users. Thus, the farmer beneficiaries would like to mechanize all the farming operations particularly on plowing, harrowing, planting, drying and shelling operations as indicated by the perception survey.

It can be inferred from the perception survey results that simple and functional technology like the metal grain silo tend to be more acceptable and perceived as easy to use. Meanwhile, technologies like the automated fertilizer applicator, drip irrigation system and sprinkler irrigation system, and greenhouse system which can be viewed as 'high-tech' systems, prospective users may tend to perceive the technology as complex or difficult to use. In general, however, farmers/respondents showed favorable response for the technology adoption and utilization using identified perception parameters implying their willingness to adopt the technologies in Mandaon, Masbate. Moreover, the BCR of more than 1.0 for all CMTs indicated that the introduction of CMTs is economically viable

Immediate outcomes and impacts of the UPLB-CLSU NAFES-CHED project as discussed with all the stakeholder include significant outcomes as follows:

1. Empowerment of project team, together with other stakeholders, whereby the spirit and essence of collaboration, team work and diffusion of knowledge were strengthened for a common good.
2. Strengthening the farmers' organization through possible improvement in farm operations by utilizing the new technologies, establishment of the common service facility, and the LAPO center as a corn mechanization training center.
3. Enhancement of the DEBESMSCAT research training and extension activities since the demonstration farm can serve as training ground for their faculty and students.
4. Establishment of custom hiring services for the 10 CMTs to be managed by LAPO in coordination with UPLB-BIOMECH.
5. The model farm would serve as demonstration farms for students, faculty of DEBESMSCAT and other stakeholders, for research, instruction and extension purposes.
6. The project identified other mechanization technologies (e.g. peanut sheller) which can be introduced in the area by UPLB-BIOMECH.
7. Establishment of the model farm as training center for the corn mechanization technologies in the community and nearby towns of Masbate in coordination with other stakeholders, which include DAR, DEBESMSCAT, BIOMECH-UPLB, among others.

## RECOMMENDATIONS

Given the knowledge systems acquired from the project, possible replication of the project can be done in other sites of Masbate through the project demonstration farm in Brgy. Lantangan, Mandaon, Masbate, and even in other provinces with low corn productivity and high incidence of population living in poverty. For project sustainability, it is recommended that UPLB-BIOMECH continue the project implementation and address other technology needs of other crops (e.g. peanut sheller) in the area. UPLB-BIOMECH shall continue monitoring and evaluation activities and provide technical assistance in the pilot area in Mandaon, Masbate, in coordination with DEBESMSCAT, DARPO and LAPO. Such activities would aid in further assessing project and continue the provision of technical support to the various stakeholders in the project site for sustainability and to ensure land, labor and crop productivity for food security in the area.

Moreover, with the overall results of the project, follow-up training and demonstrations are needed to educate the farmers on the functionality and show evidences that would highlight the benefits of the high-tech systems technologies on water management and greenhouse structure. This should also be done for the other technologies which had higher perception scores. Continuous monitoring and evaluation is needed to assess the immediate impacts of the project.

## ACKNOWLEDGEMENT

The authors would like to acknowledge the CHED-NAFES for funding the project; CLSU project monitoring team and IAE & BIOMECH, CEAT, UPLB for the project support; and LAPO, DAR, DEBESMSCAT for serving as project partners.

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