THE MODEL FARM

GUIDELINES IN DEVELOPING A CONSOLIDATED AND MECHANIZED FARM FOR IRRIGATED RICE

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ABOUT THIS BOOK

This guidebook focuses on the development of a model farm with emphasis on providing a favorable environment for mechanized farm operations in irrigated rice production. The book presents a systematic guideline in transforming a typical farm area into a mechanized model rice farm. From land consolidation, land levelling, provision of access roads to establishment of irrigation and drainage facilities, we hoped that the intended users of this guide book such as our agricultural extension workers , service providers, and farmers, find it useful as learning material and valuable information on establishing a consolidated and mechanized model farm.

FOREWORD

When we talk about rice farming in the Philippines, we often depict it as traditional and old-fashioned due to the limited resources and access to mechanization. The backward condition is worsened by fragmented lands that hinder economies of scale in rice farming. One of the eight paradigms of the Department of Agriculture for food-leveling up Philippine agriculture is farm consolidation. It is highlighted to achieve economies of scale for crops that require mechanization and massive use of technology. Land consolidation can be implemented through block farming, trust farming, contract farming, or corporative farming, which will make farming more efficient; where modern technology is used, cost of production is reduced, and farm productivity and incomes are increased.

This guidebook chronicles experiences of our Rice Engineering and Mechanization Division (REMD) in developing small farm plots and turning them into sizable areas for rice production. It contains procedural information from land consolidation to provision of access roads and establishment of irrigation and drainage facilities which are all important factors in rice farming. It also includes lessons learned from the experiences in the development of a model farm to provide valuable guidance and information for our progressive farmers, extension workers, and policy makers in the journey of transforming typical small parcels into large consolidated areas appropriate for mechanization.

John C. de Leon
Executive Director, DA-PhilRice

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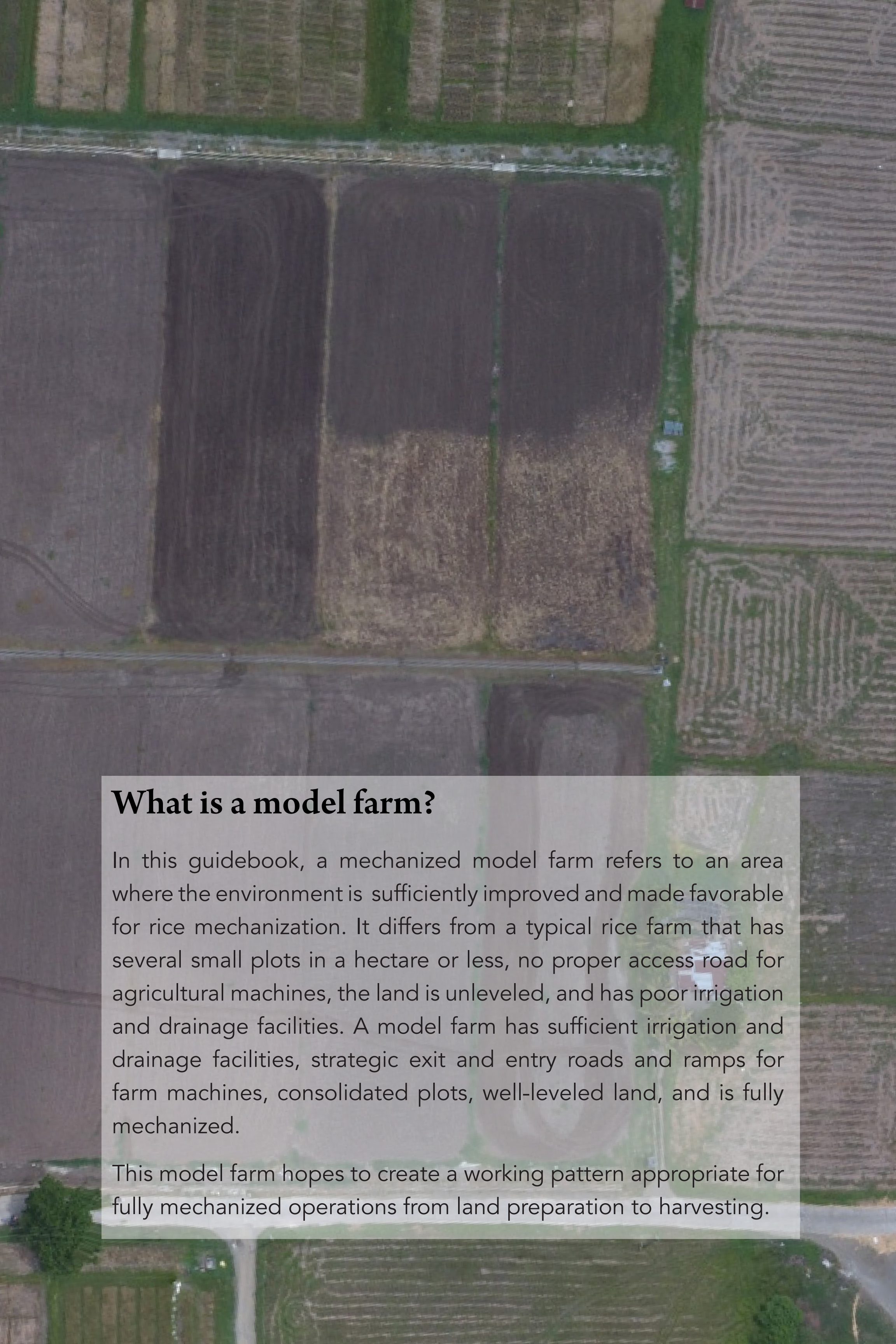
INTRODUCTION

Rice is one of the most important staple crops in Asian countries especially the Philippines. Our total farm area is 7.19 million hectares in 2012, which translates to an average land holding of 1.29 hectares. This land holding size has decreased from 2.84ha in 1980 due to the partitioning of land holdings from one generation of agricultural holders to their succeeding generations (PSA, 2015). Smaller land holding area results in greater use of chemical fertilizers, irrigation, and labor; thus, pulling down farm productivity. One way of reducing these inputs is through farm mechanization.

Farm mechanization is the process of using agricultural machines and equipment to greatly increase farm land and labor productivity. It involves all forms of power sources such as human power, animal draft power, and mechanical power depending on specific circumstances. In the Philippines, the level of farm mechanization has increased to 1.23hp/ha in 2011 from 0.52hp/ha in the 1990's, but is still way behind compared to other Asian countries such as Japan and South Korea with 4.11 and 4.10hp/ha, respectively (Official Gazette, 2013). Our country is still dominantly using human and animal technology. Only land preparation and threshing operations are mechanized.

To introduce efficient and effective local farm mechanization, the Rice Engineering and Mechanization Division (REMD) of PhilRice is working toward modern farm development. It is reshaping land parcels through land consolidation and improving infrastructures such as irrigation and drainage systems, access roads, and entry/exit ramps. Hence, this guide book documents the experiences of developing a fully mechanized and modernized rice farm in an irrigated lowland rice area.

The 4-ha REMD farm divided into 16 rectangular plots with $2378m^2$ area each.



What is a model farm?

In this guidebook, a mechanized model farm refers to an area where the environment is sufficiently improved and made favorable for rice mechanization. It differs from a typical rice farm that has several small plots in a hectare or less, no proper access road for agricultural machines, the land is unleveled, and has poor irrigation and drainage facilities. A model farm has sufficient irrigation and drainage facilities, strategic exit and entry roads and ramps for farm machines, consolidated plots, well-leveled land, and is fully mechanized.

This model farm hopes to create a working pattern appropriate for fully mechanized operations from land preparation to harvesting.

Benefits of mechanized farming

Farm mechanization has reshaped the world of agriculture especially in developed countries such as Japan and South Korea. Through mechanization, the use and improvement of farm inputs and infrastructures can be achieved efficiently and effectively. The Philippines is now realizing the importance of farm mechanization and its many advantages to be able to decently compete with neighboring ASEAN countries such as Vietnam and Thailand. Below are some of the benefits of mechanizing a farm:

- Timeliness of operations
- Precision of operations
- Improvement of work environment
- Enhancement of safety
- Reduction of drudgery of labor
- Reduction of loss of crops and inputs
- Increased productivity of land
- Increased economic returns to farmer
- Levelled up dignity of farmer
- Progress and prosperity in rural areas

Dry rotovation using the disc plow (left) and harrowing using the rotary tiller (right).

The laser-controlled bucket attached to a 4-wheel tractor drags the excess soil from high to lower points of the field.

LAND CONSOLIDATION

01 **Primary tillage**

02 **Secondary tillage**

03 **Construct dikes/bunds**

04 **Laser leveling**

I

Land Consolidation

Elmer G. Bautista, Katherine C. Villota, Myrwilliene C. Mariano, and Virsus L. Galdonez

Land consolidation is the process of restructuring small areas of land into a larger area to remove the undesirable effects of fragmentation. The advantages of land consolidation include increased land utilization by 6% and yield by 10% owing to bigger area harvested, and better water management due to well-leveled land. The field efficiency of a machine is also improved to at least 90% relative to fragmented and small plots.

In developing a fully mechanized farm for rice production in irrigated lowland conditions, the first step in selecting sites for land consolidation is to identify the soil and determine soil properties and characteristics. Once identified, conducting a topographic survey of the farm site that aims to determine the elevations of the area can proceed as to know whether it meets all the requirements. Other factors to consider include area of the farm, water supply, and drainage.

Procedure

1. **Conduct field survey.** Determine the size, elevation, arrangement, and number of field plots in the area. In addition, identify the locations of other structures such as irrigation and drainage canals and access road, which should also be considered in consolidating the area.

2. **Prepare plan and layout.** Land consolidation does not only mean combining small plots to form large ones. The arrangement of plots should also be considered. Plots should be regularly arranged to be easily accessed by the machines to be operated in the area, otherwise the plots should be restructured. Likewise, plot size and the regularity their shape

should be considered during planning. A rectangular plot with length three times longer than its width is the ideal shape and size to lessen headland turnings that restrict the machines' operational efficiency. At the REMD farm, 16 plots were formed from 32 plots, measuring ¼ of a hectare or 83m^2 x 28m^2 size. Each plot could be accessed through a road established on borders. Figure 1 shows the physical arrangement of the REMD farm before and after the execution of land consolidation.

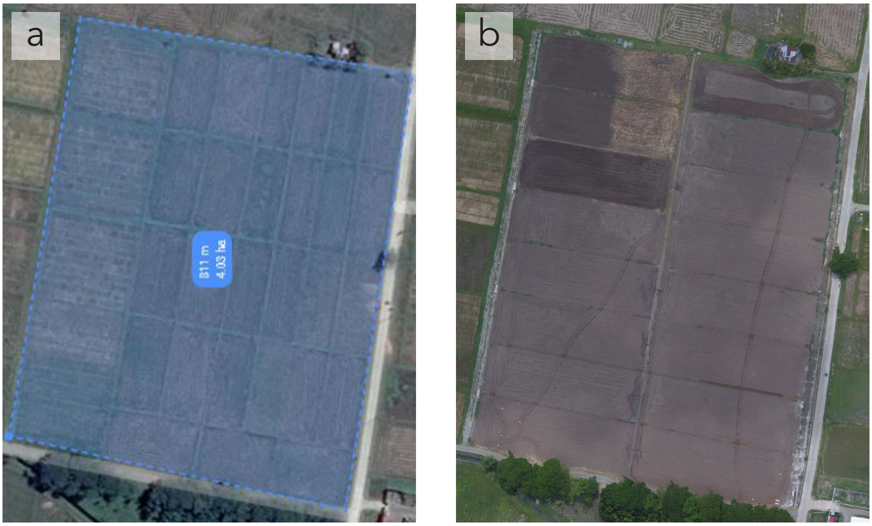


Figure 1. The arrangement of field plots at the 4-hectare REMD Farm (a) before and (b) after the execution of land consolidation.

3. **Plow the field.** Plow the small fields at least twice to prepare the area to a condition suitable for dry leveling. Existing bunds that would no longer be part of the bigger plots to be formed should also be plowed. A four-wheel tractor with a rotovator or disc plow could be used to plow the whole area and existing bunds (Figure 2a). It is best done after harvest as residual moisture in the previous crop is still available. When the field dries up or after a week or two without rain, plow the area again to achieve small soil clods suitable for dry leveling. During leveling, if the consolidated

plots have a relatively high difference in elevation, another round of plowing should be done on high spots (Figure 2b) to further level the field.

Figure 2. Plowing of the field before (a) and during laser leveling (b).

NOTE:

When farm plots with higher elevation are more than 15cm of the depth of cut of the implement, repetition of rotovation during laser-guided leveling is recommended to attain the desired standard difference in elevation of ±2cm. If done properly, the fields should not require further major leveling work for another 4 years.

4. **Construct the bunds to form the big plots.** Do this after the initial plowing while the soil still has moisture to be easily molded. Use markers with plastic twines as guide during bund establishment (Figure 3). The ideal size is 30cm x 30cm, well-compacted with no cracks. Though this could not be achieved during this period, the bunds could be improved before crop establishment, specifically during wetland preparation.

Figure 3. Establishing field bunds at the REMD farm.

5. **Determine the elevation of plots.** A topographic survey of each plot should be conducted to determine the low and high spots. First, measure the elevation at every 10-m distance using a laser transmitter and a measuring rod with a laser receiver. Record the readings on a grid map with a benchmark so that any point in the field could be checked back if the need arises.

   Next, determine the mean elevation of the field by taking the sum of all the readings and dividing by the number of readings taken. Subtract all the recorded elevations from the mean and prepare another grid map showing the difference between the mean height and the recorded height (Figure 4). Positive (+) height indicates that the area should be filled, while negative (-) height suggests that the site should be cut.

   For example, if the mean height is 2.0cm and the actual height is -5.5cm, then there is a low point of 3.5cm, which should be cut during leveling.

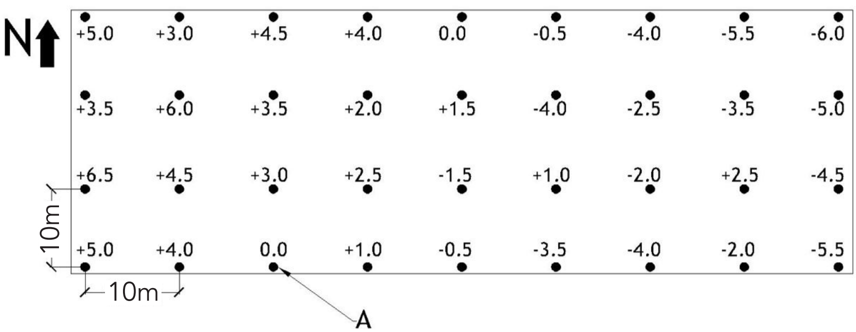


Figure 4. Sample grid map.

6. **Perform laser leveling.** In this activity, a laser-guided leveler will be used to dry-level the consolidated plots. Laser leveler moves the dry soil from the higher points of the field to the lower points using a four-wheel tractor with leveling bucket that automatically operates by means of a laser control system. This system consists of a laser transmitter, a laser receiver, an electrical control panel and a twin solenoid hydraulic control valve (Figure 5).

   The laser transmitter transmits a laser beam that is intercepted by the laser receiver mounted on the leveling bucket. The control panel mounted on the tractor interprets the signal from the receiver and opens and closes the hydraulic valve, which will raise or lower the bucket (IRRI, 2013).

Figure 5. Components of a laser-guided leveling equipment.

Using the second grid map (showing the computed elevation difference), identify a spot with an elevation equal to or near to zero then position the bucket on this spot (e.g. spot A on Figure 4). Set the laser receiver on the rod mounted on the leveling bucket to a height that would position the bucket's blade 1cm to 2cm above the soil surface. Once set, leveling operation could be started. Leveling should start from high spots (with - sign) to low spots (with + sign).

Stop the process when the bucket is no longer scraping the soil at any point within the plot. After leveling, re-survey the field. The plot is considered leveled when the elevation measurements are within -2cm to +2cm. Figure 6 shows the topography of a plot at the REMD farm before (a) and after (b) dry laser leveling while Figure 7 shows the actual condition of a laser-leveled field.

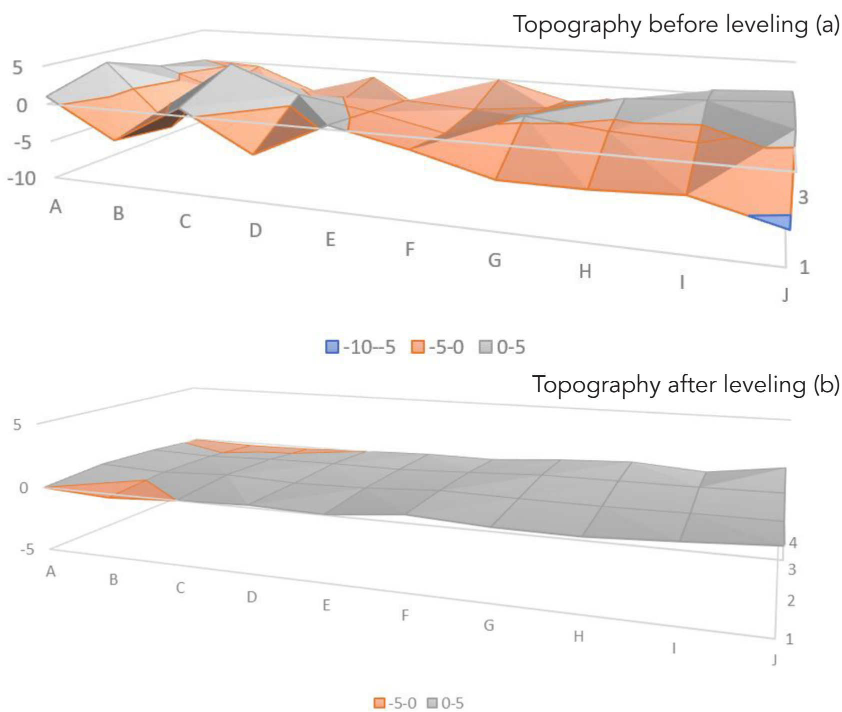


Figure 6. Topography of a plot at the REMD Farm before and after leveling.

Figure 7. Laser-leveled field.

Water discharge from a 4-inch water pump at the REMD farm.

ESTABLISHMENT OF IRRIGATION AND DRAINAGE FACILITIES

01 Field survey

02 Plan and layout

03 Design the irrigation canals

04 Construct other irrigation structures

05 Prepare drainage plan layout

06 Estimate peak flow

07 Design the drainage canal size

II Establishment of irrigation and drainage facilities

Kristine Samoy-Pascual, Alaissa T. Remocal, Lea S. Caguiat, and Arnold S. Juliano

Proper design and development of an irrigation and drainage system are very important to avoid excessive and deficient soil-water conditions during plant growth, and to allow effective control of drainage flows at the right time and condition. Good planning includes careful assessment based on appropriateness for the crops, scheme layout and possible implications the system may have on farm operations, access roads, and proximity to source of water. It should also be cost-effective in terms of materials, construction methods, operation, and maintenance in the long term.

A. Irrigation system

Establishing an irrigation system for rice involves important steps to come up with proper design and achieve the ultimate goal of raising crop productivity by providing effective water management through irrigation facilities. In the design and development, the following steps are recommended:

1. **Conduct field survey.** This involves inspection and evaluation on the physical, environmental, and farming conditions of the target area. Existing facilities such as source of water, canal system, and associated structures should be inventoried for proper planning. The information is necessary whether there is a need for rehabilitation of existing canals or construction of new irrigation facilities in the area. Other data such as soil texture, climate, cropping pattern, crops to be

planted, topography, stream and groundwater flows, and other hydrological characteristics of the area should be gathered and collected for planning and design purposes.

2. **Plan and layout.** For irrigation, select a method of irrigation that is best suited for the intended crops to grow. For example, the REMD farm considered surface irrigation as the most appropriate method of irrigation for a water-loving crop that is rice. Surface irrigation can include basin, border and furrow. The choice of these methods depends on land slope, soil texture, topography, crops, and farmer's preference. Other methods, such as micro-irrigation (i.e., sprinkler and drip irrigation), can also be used but these methods are expensive and need farm support in terms of maintenance and supply.

   In surface irrigation, the topography of the land must be considered whereby the slope and surface features that need correction by land leveling as well as the direction of irrigation are all important. Other factors, such as cost of construction, maintenance and flexibility for future automation, must also be taken into account. The design must cover the greatest area of influence to maximize the area to be irrigated, entailing the least cost of construction. Table 1 shows factors that guide selection for the delivery system of the surface irrigation used at REMD farm. In addition, a control gate at the opening of the canal can be installed to facilitate water distribution per block or turnout within the farm.

Table 1. Factors that guide selection for the delivery system of irrigation used at REMD farm.

	Pipe Irrigation	Concrete Canal	Earth Canal
Advantages	• High water-use efficiency • Virtually no or very minimal conveyance loss • Less space occupied • No soil erosion	• Minimal or no seepage and percolation loss • Better maintenance; easier to spot damages • Increased velocity of flow • Controls water logging • Medium irrigation and application efficiency • Easy to construct	• Low cost • Easy to construct
Disadvantages	• High investment cost • Difficult to locate leaks/ blockages • High maintenance cost • Needs high operating pressure	• Longer to construct • Evaporation loss • High cost	• Higher seepage or evaporation • Low velocity of flow • Easy to erode • Water logging • Poor maintenance • Low irrigation and application efficiency

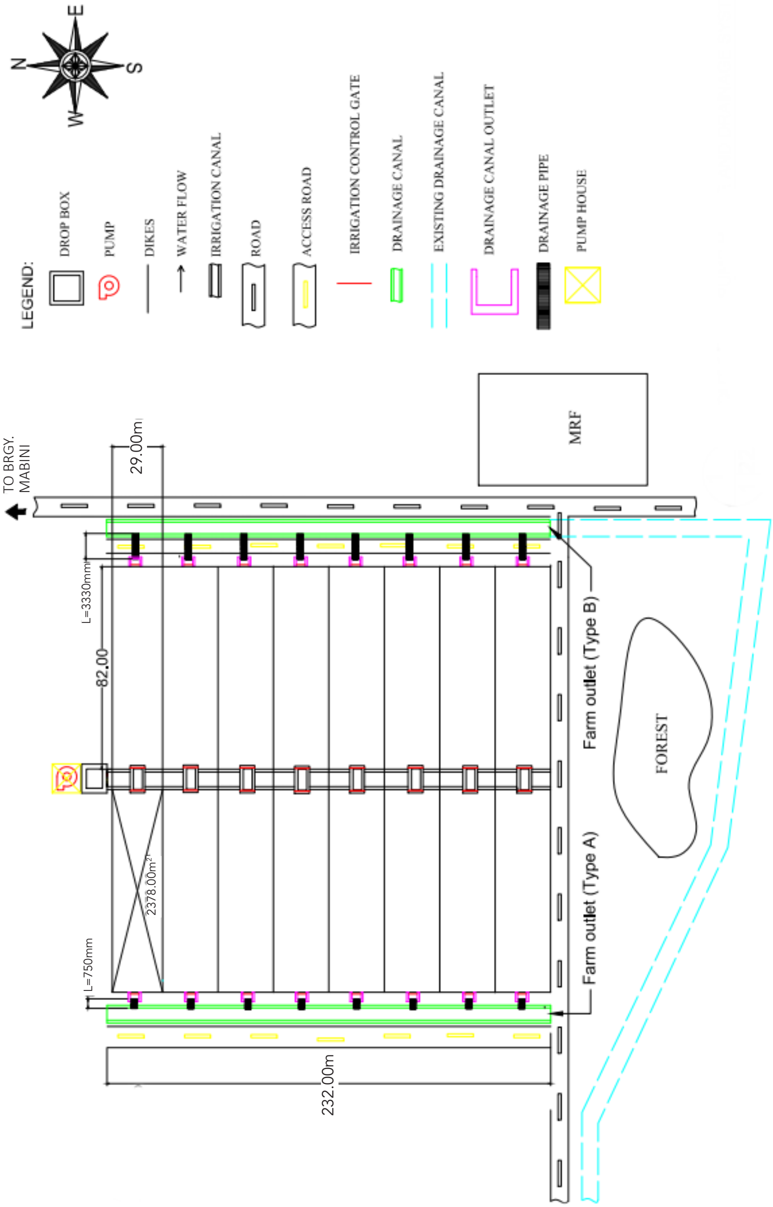


Figure 8. Sample layout of an irrigation and drainage system at REMD model farm.

3. **Design the irrigation canals.** The design of the channel involves selection of the channel alignment, size, and bottom slope. Whether the irrigation canal will serve as a main canal or farm ditch, the Philippine Agricultural Engineering Standards (PAES 217:2017) outlined procedures in determining the irrigation water requirement and calculating the design discharge. The design discharge for the main canal is equal to the diversion water requirement; that for the main farm ditch canal is equal to the farm water requirement (FWR).

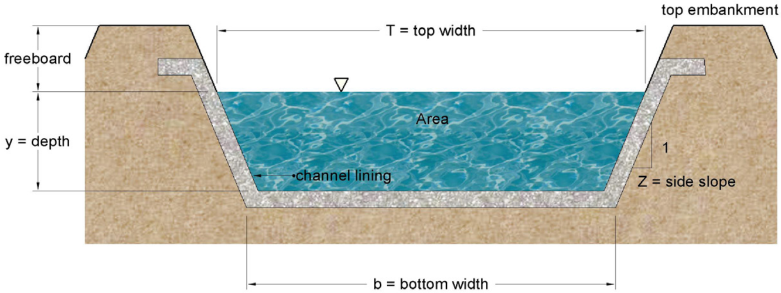
   At REMD farm, the design discharge was based on the FWR to be supplied by a pump irrigation as the source of water in the area. The estimated permissible minimum velocity was 0.6 m/s for the proposed lined canal (PAES 217:2017). The permissible velocity is the mean velocity at or below which the bottom and side of the channel will not erode. To obtain the best hydraulic section of the canal, the following PAES general formula was used:

$$Q=VA \qquad \text{Eq. 1}$$

   Where Q = Discharge, m^3/s
   V = Velocity, m/s
   A = Area, m^2

   Table 2 introduces the different formulas of computing the cross section of the open channel for the lined canal. At REMD farm, the cross section of a trapezoidal lined canal was used as shown in Figure 9. Generally, in lined canals, the recommended shapes for irrigation canals are trapezoidal and rectangular sections due to their stability and higher resistance to scouring (PAES 216:217)

Table 2. Formulas to determine canal section dimensions of the different open channels (PAES 216:217).



	Trapezoidal	Rectangular	Triangular	Circular
Area	$(b+zy)$	by	zy^2	$\frac{1}{8}(\theta-\sin\theta)d_0{}^2$
Wetted perimeter	$b+2y\sqrt{1+z^2}$	$b+2y$	$2y\sqrt{1+z^2}$	$\frac{1}{2}\theta d_0$
Hydraulic radius	$\frac{(b+zy)y}{b+2y\sqrt{1+z^2}}$	$\frac{by}{b+2y}$	$\frac{zy}{2\sqrt{1+z^2}}$	$\frac{1}{8}(1-\frac{\sin\theta}{\theta})d_0$
Top width	$b+2zy$	b	$2zy$	$\sin\frac{\theta}{2}d_0=$ $2\sqrt{y(d_0-y)}$
Hydraulic depth	$\frac{(b+zy)y}{b+2zy}$	y	$\frac{y}{z}$	$\left[\frac{\theta-\sin\theta}{\sin\frac{\theta}{2}}\right]\frac{d_0}{8}$

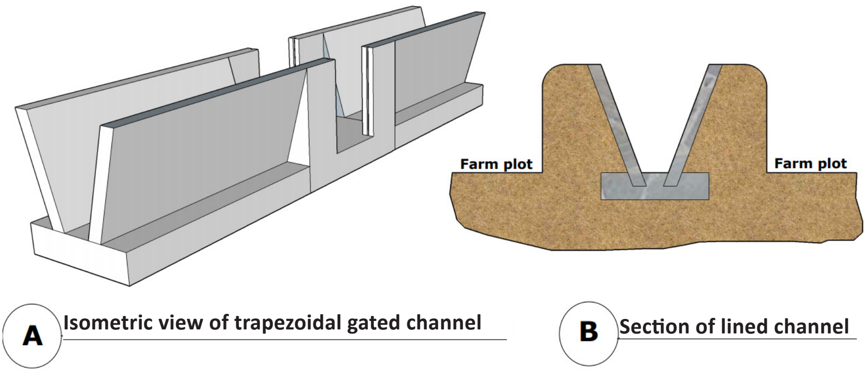


Figure 9. Cross section of the trapezoidal irrigation channel constructed at REMD farm.

4. **Construct other irrigation structures.** Depending on the area, the source of irrigation could be from rivers, reservoirs, and groundwater. At REMD farm, for example, there is already an existing groundwater source with a shallow tube well. The design and installation of a shallow tube well is detailed in PAES 231:217.

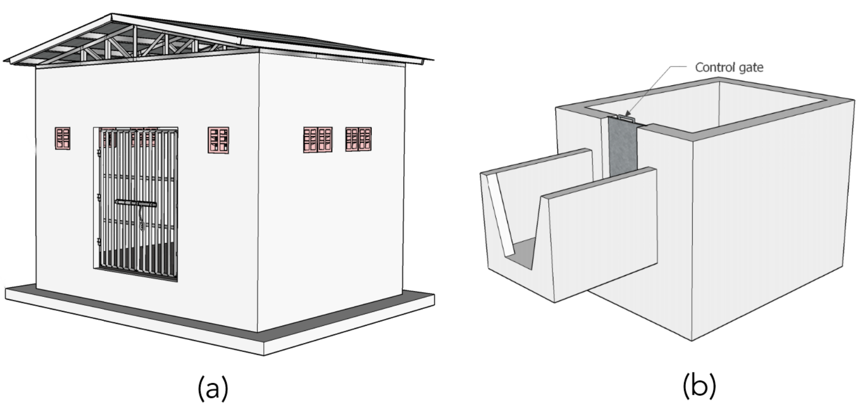


Figure 10. Irrigation structures such as (a) pump house or a (b) drop box at the pumping station found at REMD farm.

A pump house should also be constructed to provide shelter for the pumping station. At REMD farm, the pump house was designed to accommodate a rice hull gasifier engine-pump system as alternative to diesel engine pump to draw irrigation water from the tube well. In addition, a drop box was also constructed to temporarily collect and raise the upstream water level during pumping before diverting it to the farm ditch/lined canal.

B. Drainage system

Following the establishment of an irrigation system, the drainage facility should also be equally planned to remove excess water during runoff caused by heavy rainfall and facilitate terminal drainage near crop maturity. Coarse-textured soils that are naturally well-drained may not require artificial drainage. However, other soils such as those with heavy clay usually need artificial drainage. Generally, open drain is the least expensive and common method of drainage collector especially in rice production. This is usually done through artificial slope by means of land grading or leveling to develop a high to low gradient toward the open ditch.

One of the common forms is a surface drainage which includes both collection and disposal ditches that collect and remove surface water from a field or small land area. A drainage system could also be a subsurface whereby buried drains or pipes are installed within the soil profile to convey excess ground water through gravity toward the main drainage canal. Similar with irrigation design, the drainage system follows the same procedure as previously discussed in Section II (page 19).

1. **Prepare the layout of the drainage plan.** A layout or a map should be prepared to show the proposed location of the drainage system including other features such as access roads, farm boundaries and irrigation facilities that affect the design, construction, and maintenance of the planned improvements. At REMD farm, there was already an existing main drainage earth canal, and the land gradient was also identified. Thus, only the size of the cross section of the proposed lined canal was designed including the pipe drain to collect water from the field to the disposal system or the open-ditch main canal. Several pipe drains were designed to collect excess water from a small area or block and drain the water to the main ditch.

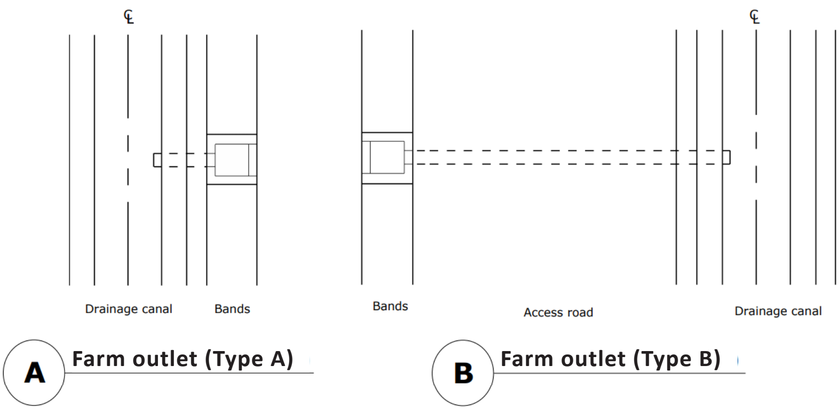


Figure 11. Drainage plan at REMD farm.

2. **Estimate the peak flow.** Any drainage installation should be designed according to the probability of occurrence of an expected peak discharge, which is related to the intensity and duration of rainfall events. The rate of removal is called the drainage coefficient. For surface drainage, the coefficient is usually expressed in terms of flow rate per unit of area, which varies with the size of the area. In estimating the peak discharge, the rational formula can be used (FAO,1998)

$$Q=CiA \qquad \text{Eq. 2}$$

Where Q = peak discharge, m^3/s
i = rainfall intensity for a critical period (m/s)
A = drainage area, m^2

The intensity for a critical period requires rainfall frequency analysis that determines the rainfall probability of a given intensity and duration equaled or exceeded. The results of the analysis are presented in curves showing the relationship of rainfall intensity of a given duration to the probable frequency of occurrence of said event. At REMD farm, we used 20-year rainfall data for the frequency analysis.

NOTE:

If there is no drainage map, produce a sketch layout showing any existing ditches, canals, and outlets including proposed drainage facilities along with the dominant direction of slope in the field.

3. **Design the size of the canal.** The size of the channel for a given design discharge can use the Equation 1 in Section II.3 (page 23). In addition, for a given hydraulic gradient (s), and channel roughness (n) the Manning equation in Equation 3 can also be used to determine the velocity (FAO, 1998). The determination of the optimum size based on the designed Q can be solved by iteration using selected cross section area listed in Table 3 and details are listed on PAES 216:217

$$V=\frac{R^{\frac{2}{3}}S^{\frac{1}{2}}}{n} \quad \text{Eq. 3}$$

Where
V = Velocity, m/s
R = Hydraulic radius (m)
S = Slope of the surface water
n = Roughness coefficient of the channel

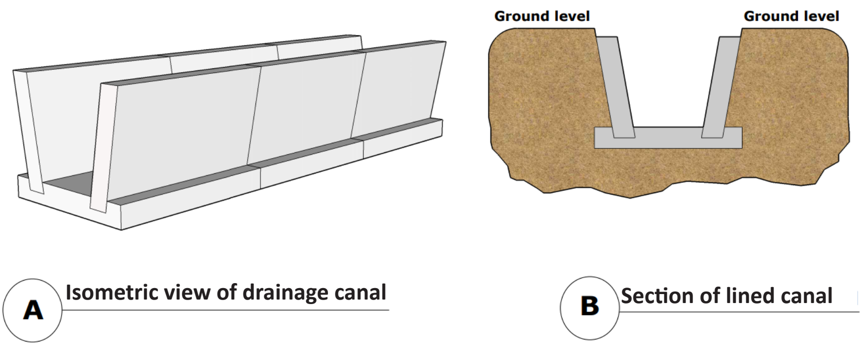


Figure 12. Cross section of the trapezoidal main ditch lined canal constructed at REMD farm.

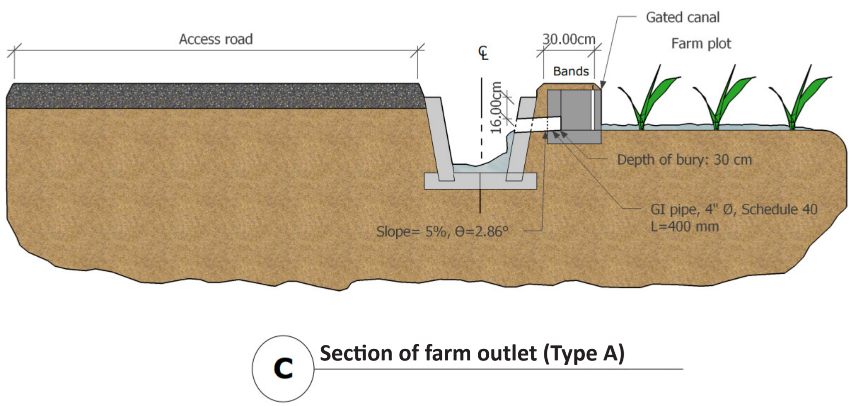


Figure 13. Cross section of the main concrete ditch showing the pipe drain at REMD farm.

Gravelling of access road at the REMD farm.

ESTABLISHMENT OF ACCESS ROAD AND RAMP

01 **Field survey and ocular inspection**

02 **Plan and layout**

03 **Determine sizes of access road and ramp**

III Establishment of access road and ramp

Katherine C. Villota, Myrwilline C. Mariano, Julius R. Waliwar, and Arnold S. Juliano

Access structures such as road, ramp, and bridge are complementary components of a mechanized farm. Efficient movement of machines and timeliness of operations are possible if these structures are available. Moreover, the recurring problem of destruction of bunds due to crossing of machines will be significantly reduced with proper exit and entry points. The procedures discussed below provide useful information in designing and constructing access road and ramp in the farm. Such procedures might apply only to specific farms but they illustrate and discuss the techniques and considerations involved in the establishment of these access structures.

Establishing the access road and ramp

1. **Conduct field survey and ocular inspection.** Field inspection determines the needed improvements in the area. Gather necessary information for planning and designing the structures. The needed information are briefly discussed below:

    - *Existing road.* If an access road is already available in the farm, determine its dimension and elevation to paddy field. This information is necessary in determining the embankment to be established or removed to achieve the recommended size and height of the road. Also, for its location which might be necessary in determining if additional road network is needed for the new layout of the farm.

- *Arrangement of field plots.* Arrangement of plots largely determines the location of the road and ramps to be constructed. If plots will be re-structured, one short length of each plot to be formed should be along the border as road and ramp are usually established on this portion of the farm. With this, the use of these structures for entry and exit point for each block is maximized.

- *Other farm components to be frequently accessed.* Identify components like the pump house that will need roadway for its accessibility. Though it is ideal to have a roadway in every border of the farm, this could reduce the production area and would require more budget.

- *Size of the farm.* Measure the size and determine the shape of the farm. This information is needed in preparing the farm layout and formulation of designs.

- *Size of bigger machines used in the farm.* This information is important in identifying the appropriate sizes of road and ramp to be established. Though this information may not be available during field inspection, it may be gathered from the farm workers.

2. **Prepare the plan and layout.** When all needed information is already available, plan the improvements to be done and components to be established. Prepare a farm layout which will serve as a general guide in developing the farm. A holistic planning and programming of activities should be done to avoid overlapping of activities which might affect the overall outcome and completion of the project. Figure 14 shows the

standard field size and arrangement in Japan (JICA, 1990). This layout was applied at REMD farm as shown in Figure 15.

The four-hectare rectangular farm is subdivided into 16 equally sized rectangular plots. These plots are regularly arranged on north and south side of the farm with irrigation canal at the center and drainage canal as borders. All borders are provided with one-lane gravel road and concrete ramps to easily access the plots and the pump house. In the previous layout, east and south road portions were not available and plots were irregularly arranged. Machine operators had no option but to work in the area in a plot-to-plot manner which frequently damaged the bunds.

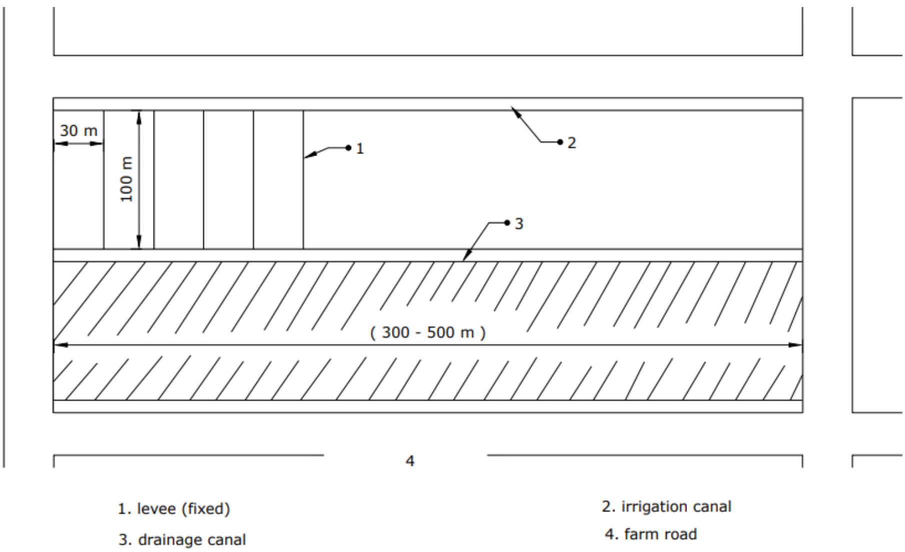


Figure 14. The standard field size and arrangement in Japan (JICA, 1990).

Figure 15. The improved layout of the REMD farm.

3. Determine the size of access road and ramp

3.1 *Access road.* The design of a farm road may vary from one-lane to two-lane with pavement materials from earth, gravel, bituminous to concrete. Among the designs, one-lane gravel road is the widely established and used design in many developed farms in the country largely due to its cheaper cost compared to concrete and asphalt. It is also considerably more stable than earth road. Generally, the road consists of a carriageway, shoulder, and ditch (Figure 16). Carriageway is intended for the safe and comfortable movement of vehicles. The minimum width of carriageway for two-lane road should be four meters, while it is 2m for a one-lane road.

The carriageway maximum slope for earth, gravel, and bituminous roads should be 3% while for concrete should be 1.5% from the center line toward the ditch. The shoulder that provides space for stopping outside of the traffic lanes should have minimum width of one meter and maximum 4% slope for both one- and two-lane roads. The minimum specifications for design and construction of farm roads are discussed in PAES 421:2009.

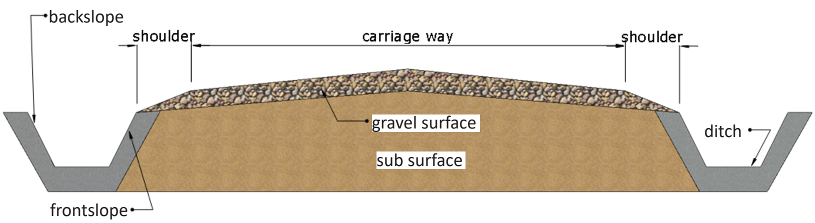


Figure 16. Cross section of road.

3.2 *Width of the access road.* In selecting size of the road, the main considerations are width and volume of machines that will simultaneously operate in the farm. The proposed width should provide more than 1-m allowance from the width of bigger machines (Table 3). At the REMD farm, a 90-hp tractor with two-meter implement will be used to dry-level the plots once every three years or when necessary. The other machines are 40-hp tractor and handtractor during land preparation, walk-behind transplanter during crop establishment, combine harvester and 4-wheeler truck during harvesting. This entails very low traffic situation throughout the period of rice production due to seasonal operation of machines. Hence, a one-lane gravel road was established at the borders of the farm. The width was based on the maximum width of a machine that would operate in the area to facilitate movement of two machines operating simultaneously.

Table 3. Recommended width of farm road based on tractor size (JICA, 1990).

Machine	Width
General	> 1m width from width of tractor and its implements
30hp Tractor	> 2.5m
40 ~ 80hp Tractor	> 3.0m
> 90hp Tractor	> 4.0m

3.3 *Height/thickness of road embankment.* The road embankment to be established will also depend on sizes of machines. The recommended height was 20-40cm relative to paddy field (JICA, 1990). Table 4 shows the recommended height of farm road to paddy field based on sizes of machines. This range is within the maximum 50cm height recommended in PAES 421:2009 for sites that do not necessitate high embankment like an area not prone to flooding. In calculating the quantity of embankment material to be used, additional 30% or more is recommended to consider the occurrence of ordinary compaction in the long term. The compaction may occur due to factors such as shrinkage of material used, moisture absorption from rainfall and having traffic passing over the road.

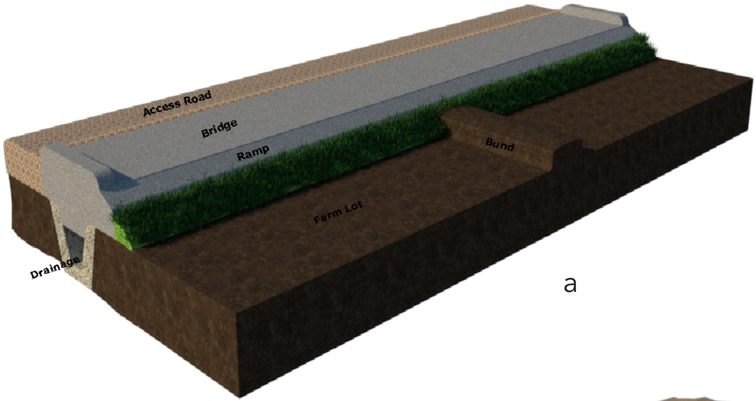
Table 4. Recommended height of farm road relative to paddy field based on sizes of machines (JICA, 1990).

Machine	Height, cm
Tractor	30
Combine harvester w/ 0.8 ~ 1.2m cutting width	< 20
Combine harvester w/ 1.2 ~ 3.5m cutting width	< 25
Combine harvester w/ 1.2 ~ 3.5m cutting width	< 40

At the REMD farm, graveling of access roads (Figure 17) was done in two succeeding dry seasons to achieve the recommended height of road to paddy field. Half of the estimated volume was applied in January 2019; the other half in March 2020. This was to ensure stability of the embankment by natural compaction especially for the newly established roads in the area since compaction equipment was not available and budget was limited. The minimum compaction requirement for earth road is 95% density; for gravel road, should be three complete passes of either roller, vibrator or compactor for each layer of embankment (PAES 421:2009).

Figure 17. Graveling of access road at the REMD Farm.

3.4 *Ramp and Bridge.* These are complementary structures to the farm road that allow easy access to the field plots. Bunds/levees would still be damaged during operation of machines if there were no ramps or bridges that connect the road to the paddy field. The establishment of ramp (Figure 18b) or combination of ramp and bridge (Figure 18a) depends on the availability of canal between road and paddy field. Basically, the establishment of ramp is to simply reinforce the portion of bund that will serve as entry and exit points of machines to and from the plots.



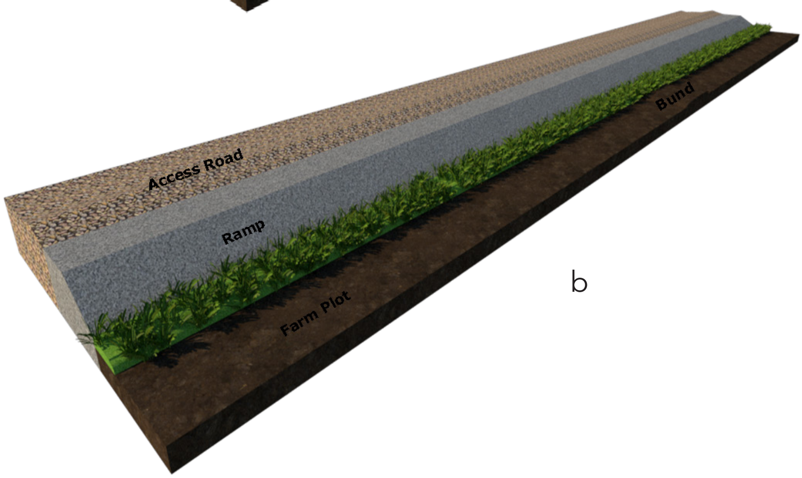


Figure 18. The design and arrangement of access structures at the REMD farm.

3.5 *Width and slope of ramp.* Like the access road, the width of ramp should be based on width of big machines that will operate in the field. At the REMD farm, an 8-m ramp is established strategically between two adjacent plots to provide more space for machines when moving through these plots (Figure 18a). For plots established on north side, a combination of ramp and bridge is provided since drainage canal is situated between access road and a plot

(Figure 18b). Plots on south side, on the other hand, are provided with ramp only since plots and access road are adjoining. The inclined surface of ramp should be less than 12% as recommended (JICA, 1990). To improve the traction of non-rubber tire machines, a rubber lining is provided on the inclined portion of the ramp (Figure 19).

Figure 19. The concrete ramp with rubber lining at the REMD Farm.

IV

Benefit-cost analysis of the establishment of the Model Farm

The economic feasibility of the project was evaluated using the benefit-cost ratio (BCR), payback period, and return of investment (ROI). Investment costs include the costs of civil works and materials in the establishment of irrigation and drainage facilities and accessories, access roads, and land consolidation. Table 5 shows the results of the economic analysis of the project.

The depreciation cost was calculated using the straight-line method with a 10% salvage value and a useful life span of 20 years. The interest on investment, insurance, and repair and maintenance were set at 10, 4, and 10% of the total investment cost, respectively. The cost of rice/seed production was estimated based on the actual cost and rate of seeds, fertilizers, fuel, herbicides and pesticides, machine rentals, and labors for two cropping seasons in 2019.

Three scenarios were used for the economic analysis of a four-hectare model farm after improvement. The first scenario is the area will be planted 100% for rice production, the second is for seed production, and the third is 50% rice production+50% seed production. In all scenarios, the BCR was greater than one which means that at the current discount rate (i.e., 20%), the benefits exceed the cost, and thus indicate that the project is viable. However, the payback period of scenario 1 (i.e., 37 years) is very long for the project to generate benefits to cover costs incurred in the investment.

The ROI is also very low, which indicates that the investment gain of the project is not favorable to their cost. This suggests that allocating solely the area for conventional or commercial paddy production is not worth the investment for substantial improvement in the irrigation and drainage facilities, access road, and land consolidation. While in scenario 2, allocating the model farm to 100% seed production resulted in a 2.1 BCR, 61.1% ROI, and 1.6 years payback period. Scenario 3 also gave promising results but lower in values at 1.5 BCR, 28.2% ROI, and 3.6 payback period.

The higher selling price of seeds resulted in higher net income compared to when the paddy is sold only as ordinary grains for milling. The economic analysis was made from the viewpoint of an investor or a progressive farmer who is willing and able to invest in a model farm. For ordinary farmers, the viewpoint will normally be different. Farmers will be interested more in the actual income they will likely earn as participant in the project, meaning how much cash they will earn from the project. Increasing crop yield and maximizing the area of production, and producing a high-value product will benefit the farmer.

Furthermore, aside from the financial benefits of having a model farm, opportunities for crop diversification can also be exploited to create other sources of income besides rice, and increase further the income due to a reliable source of irrigation and favorable biophysical farm conditions. Spillover effects such as ecological and aesthetics are also expected as an avenue in the promotion of agri-tourism and job generation.

Table 5. Economic analysis of the 4-ha REMD Farm.

Variables	Scenarios		
	Rice production	**Seed Production**	**50% Rice Production + 50% Seed Production**
Investment Cost , PhP			
Land consolidation	75,928.00	75,928.00	75,928.00
Irrigation	357,327.22	357,327.22	357,327.22
Drainage	897,196.21	897,196.21	897,196.21
Pump house & accessories	137,916.79	137,916.79	137,916.79
Access road	160,000.00	160,000.00	160,000.00
Entry/Exit ramps	182,922.34	182,922.34	182,922.34
Total	**1,811,290.56**	**1,811,290.56**	**1,811,290.56**
Fixed Cost (PhP/year)			
Depreciation	81,508.08	81,508.08	81,508.08
Interest on investment	181,129.06	181,129.06	181,129.06
Repair and maintenance	181,129.06	181,129.06	181,129.06
Insurance	72,451.62	72,451.62	72,451.62
Sub-Total	**516,217.81**	**516,217.81**	**516,217.81**

Table 5. *(continuation)*

Variables		Scenarios		
		Rice Production	**Seed Production**	**50% Rice Production + 50% Seed Production**
Variable Costs (PhP/year)				
Seeds		14,080.00	25,600.00	19,840.00
Fuel		18,320.00	18,320.00	18,320.00
Herbicide/pesticides		36,240.00	36,240.00	36,240.00
Fertilizers		43,136.00	43,136.00	43,136.00
Labor		112,176.00	259,776.00	259,776.00
Machine rentals		145,880.00	145,880.00	145,880.00
Sub-Total		**369,832.00**	**528,952.00**	**523,192.00**
Total Cost of Production	PhP/year	886,049.81	1,045,169.81	1,039,409.81
Total Production	PhP/year	934,800.00	2,164,800.00	1,549,800.00
Net Benefit	PhP/year	48,750.19	1,119,630.19	510,390.19
Payback period	**Year**	**37.15**	**1.62**	**3.55**
Benefit-cost ratio		**1.06**	**2.07**	**1.49**
Return of investment	**%**	**2.69**	**61.81**	**28.18**

The 4-ha REMD farm planted with rice during dry season 2019.

V

Lessons learned during the development of REMD farm

While the development of the REMD model farm did not involve several farmers owning fragmented parcels for land consolidation, and it did not take into account the social, political, and cultural dimensions in land consolidation that could stunt planning and development, we identified some lessons learned during the project implementation:

1. Proper coordination and planning of all activities must be established first before commencing a project. This basic and most important step should be done to avoid overlapping activities, mismatch design, and unnecessary delays in project implementation;

2. Time is always a significant factor for procurement of labor and supplies. It is important to prepare ahead of time the technical specifications, scope of work, and terms of reference to prevent delays. This is also to have sufficient time for alternative procurement approaches when public bidding fails;

3. Monitor the supplier/contractor's schedule of works to ensure all delivery demands and standards are met. Project engineers must be pro-active to have an on-site inspection to immediately rectify mistakes and preclude delays;

4. Consolidate and level the land first before establishing any infrastructures for their proper design and layout;

5. Establish the irrigation and drainage canals first before the access roads to prevent re-gravelling;

6. Cost must also be considered vis-a-vis the benefits that will accrue from investment in a modern, consolidated, and mechanized farm.

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NOTE

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We are a government corporate entity (Classification E) under the Department of Agriculture. We were created through Executive Order 1061 on 5 November 1985 (as amended) to help develop high-yielding and cost-reducing technologies so farmers can produce enough rice for all Filipinos.

With our "Rice-Secure Philippines" vision, we want the Filipino rice farmers and the Philippine rice industry to be competitive through research for development (R4D) work in our central and seven branch stations, including our satellite stations, collaborating with a network that comprises agencies strategically located nationwide.

We have the following certifications: ISO 9001:2015 (Quality Management), ISO 14001:2015 (Environmental Management), and ISO 45001:2018 (Occupational Health and Safety Assessment Series).

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