



Manual for Laser Land Leveling



J F Rickman



National Agricultural Technology Project
Indian Council of Agricultural Research
Rice-Wheat Consortium for the Indo-Gangetic Plains



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The initial support from the Asian Development Bank and International Fund for Agricultural Development provided the groundwork for establishment of the RWC in 1994 and formalizing the collaborations between the NARS, IARCs and ARIs. The NARS-driven strategic ecoregional research initiatives with financial support from the Governments of the Netherlands, Sweden, Switzerland, Australia and the US Agency for International Development and the World Bank have grown over the years into a dynamic agenda of resource conservation technologies appropriate to different transects of the Indo-Gangetic Plains. The on-going successes in scaling-up resource conservation technologies for enhancing productivity and sustainability of the rice-wheat systems are beginning to create a revolution and favourably benefit large areas and more numbers of farm families.

Cover pictures:

Top left: Checking the laser transmitter and receiver communication for actual field survey

Bottom left: Conducting a detailed topographic survey with a laser system

Bottom right: Receiver mounted on the mast on a scraper bucket, hitched to a tractor, in alignment with the transmitter (laser unit)

Background: A diffused view of a laser leveled field

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DPS Marg, Pusa Campus, New Delhi 110 012, India
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Author

J F Rickman International Rice Research Institute, Los Baños, Philippines

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Manual for Laser Land Leveling

I. Introduction

Unevenness of the soil surface has a major impact on the germination, stand and yield of crops through nutrient water interaction and salt and soil moisture distribution pattern. Land leveling is a precursor to good agronomic, soil and crop management practices. Resource conserving technologies perform better on well-leveled and laid-out fields. Farmers recognize this and therefore devote considerable attention and resources in leveling their fields properly. However, traditional methods of leveling land are not only more cumbersome and time-consuming but more expensive as well. Very often most rice farmers level their fields under ponded water conditions. The others dry level their fields and check level by ponding water. Thus in the process of having good leveling in fields, a considerable amount of water is wasted. It is a common knowledge that most of the farmers apply irrigation water until all the parcels are fully wetted and covered with a thin sheet of water. Studies have indicated that a significant (20-25%) amount of irrigation water is lost during its application at the farm due to poor farm designing and unevenness of the fields. This problem is more pronounced in the case of rice fields. Unevenness of fields leads to inefficient use of irrigation water and also delays tillage and crop establishment options. Fields that are not level have uneven crop stands, increased weed burdens and uneven maturing of crops. All these factors tend to contribute to reduced yield and grain quality which reduce the potential farmgate income.

Effective land leveling is meant to optimise water-use efficiency, improve crop establishment, reduce the irrigation time and effort required to manage crop. The *Manual for*

Laser Land Leveling seeks to explain the benefits of land leveling in fields, particularly rice fields, and help develop skills of farmers and operators in using laser technology to achieve a level field surface. It is also intended to enable the users to identify and understand the working of the various components of a laser-controlled land leveling system; undertake a topographic survey using a laser system; set up and use a laser-controlled leveling system and troubleshoot a laser-controlled leveling system. It is hoped that the users (farmers and service providers) will find this manual useful in adopting this important resource conserving technology as a precursor to several other improved agronomic, soil and crop management practices.

II. Why Laser-level Land?

Benefits of Land Leveling

Effective land leveling reduces the work in crop establishment and crop management, and increases the yield and quality. Level land improves water coverage that

- Improves crop establishment
- Reduces weed problems
- Improves uniformity of crop maturity
- Decreases the time to complete tasks
- Reduces the amount of water required for land preparation

Yield

Research has shown a large increase in rice yield due to good field leveling. The following table shows the results of land leveling experiments conducted in Cambodia between 1996 and 1999.

Table 1. Results of land leveling experiments conducted by CIAP in Cambodia, 1996-1999

Year	Rice Yield ($t \text{ ha}^{-1}$)	
	Leveled fields	Unleveled fields
1996	3.40	2.67
1997	2.27	1.46
1998	2.72	2.36
1999 (CARDI)	2.34	2.00
Average	2.72	2.19

The above table shows that, for the same rice varieties and the same fertilizer input, the average increase in crop yield was 24% or 530 kg ha^{-1} .

In two experiments conducted at different localities, a strong correlation was found between the levelness of the land and crop yield. This correlation is shown in Fig. 1.

Weed Control

Land leveling increases yield. A large part of this increase is due to improved weed control. Improved water coverage from better land leveling reduces weeds by up to 40%. This reduction in weeds results in less time for crop weeding. A reduction from 21 to 5 labor-days per hectare is achieved. This represents a reduction of up to 16 person-days per hectare



Fig.2. Manual weeding operation.

- a 75% decrease in the labor required for weeding.

Farm Operation

Land leveling makes possible the use of larger fields. Larger fields increase the farming area (Fig. 3) and improve operational efficiency. Increasing field sizes from 0.1 hectare to 0.5 hectare increases the farming area by between 5% and 7%. This increase in farming area gives the farmer the option to reshape the farming area that can reduce operating time by 10% to 15%.

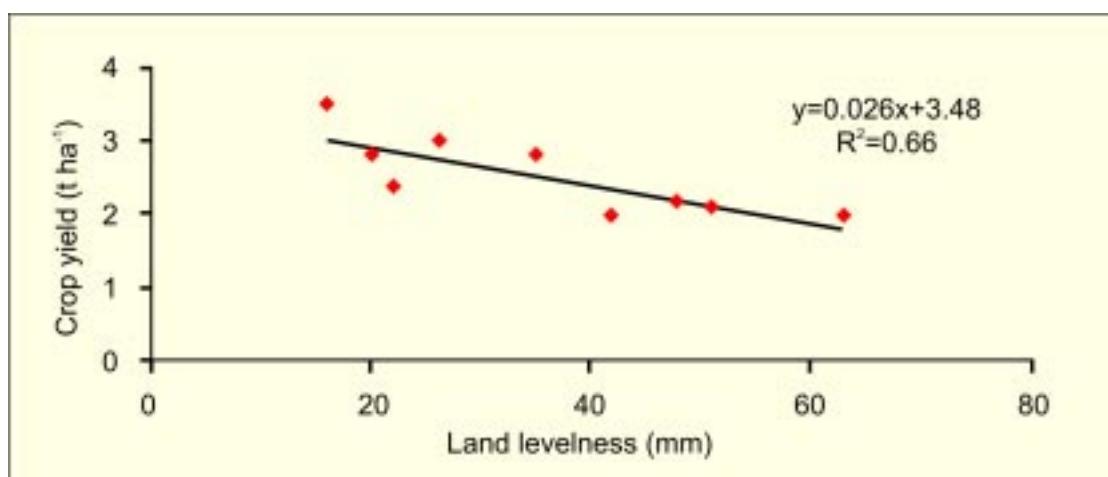


Fig.1. Graph showing correlation between the levelness of the land and crop yield.



Fig.3. Larger fields increase the farming area.

Seeding Practices

Leveling reduces the time taken for planting, for transplanting and for direct seeding. Land leveling provides greater opportunity to use direct seeding. The possible reduction in labor by changing from transplanting to direct seeding is approximately 30 person-days per hectare.

Efficiency of Water Use

Rice farmers using animals or 2-wheel tractors rely on water to accumulate in the field before starting land preparation. The average difference in height between the highest and lowest portions of rice fields in Asia is 160 mm. This means that in an unleveled field an extra 80 mm to 100mm of water must be stored in the field to give complete water coverage. This is nearly an extra 10% of the total water requirement to grow the crop. Land leveling



Fig.4. Land leveling terraces fields allowing water in the higher fields to be used in the lower fields.

effectively terraces fields allowing water in the higher fields to be used in the lower fields (Fig. 4) for land preparation, plant establishment and irrigation.

Economics of Land Leveling

The initial cost of land leveling using contractors and machinery is high. The costs vary according to the topography, the shape of the field and the equipment used. The table below shows a cost comparison for leveling one hectare of land using animals and machines.

Table 2. The time and cost comparison for land leveling in Cambodia

	Animal leveling board	2-wheel tractor blade	4-wheel tractor
Purchase price (\$)	500	1000	12,000
Time (days)	12	7	0.5
Operating cost (\$/ha)			
Labor	15.00	9.00	2.50
Fuel & oil		22.00	32.50
Repairs		5.00	7.50
Pumping cost	6.00	6.00	
Fixed cost (\$/ha)			
Depreciation cost	12.00	4.00	7.50
Total cost (\$/ha)	33.00	46.00	50.00

The above table shows that the total cost of leveling one hectare of land using tractors is between \$ 45 and \$ 50. This cost varies with the volume of soil to be moved and the soil type. Studies over many sites have shown that the actual cost ranges from \$ 3 to \$ 5 per 10 mm of soil moved per hectare. Contractors charge between \$ 30 and \$ 100 per hectare.

As the sophistication of the equipment increases, so does the capital cost. A 2-meter drag bucket costs \$ 1,000 to manufacture locally. A laser-controlled system will cost between \$ 3,500 and \$ 10,000 to buy. However, using more sophisticated equipment increases the area that can be leveled each day.

The application of additional fertilizer, especially phosphate, is necessary in areas from which soil is moved. Depending on the soil type and the volume of soil moved, it may be necessary to add an extra 25 to 50kg/ha of DAP at a cost of between \$ 6 and \$ 13 per hectare.

Once a field has been leveled, plowing techniques must be changed to keep it level. Farmers are encouraged to plow from the center of the field out rather than continuing to use the traditional technique of plowing from the outside of the field in to the center. If appropriate plowing techniques are used, re-leveling the whole field should not be necessary for at least eight to ten years. Measurements taken in fields in the second and third year after leveling have shown very little variation in surface topography. The levelness of the field has been maintained after two crops.

Financial Benefits of Land Leveling

Although the initial cost of land leveling is an extra expense, a cash flow over a period of years shows that financial benefits do result from land leveling. The table below is a cash flow that outlines the additional cost and benefits over an eight-year period. The costs allow for

Table 3. The additional cost and financial benefit from land leveling

Year	1	2	3	4	5	6	7	8
Additional cost (\$/ha)								
Leveling	50	10	0	0	0	0	0	0
Plowing	15	0	0	0	0	0	0	0
Fertilizer	13	6	0	0	0	0	0	0
Financial benefit (\$/ha)								
Grain yield	53	53	53	53	53	53	53	53
Reduction in weeding	8	8	8	8	8	8	8	8
Cumulative cash flow	-17	38	99	160	221	282	343	404

an extra plowing and extra fertilizer in the first and second years. The benefits include reduced weeding costs of 40%.

This table shows that there are major financial benefits to be gained through land leveling. What the table does not include are the other benefits and opportunities of being able to direct seed, plow the field on time, harvest evenly ripened crop and shed floodwaters more rapidly.

While poor farmers may have problems financing a contractor to level land, it is quite possible for all farmers to level part of their land each year using animals and harrows during the normal plowing cycle.

Options for Land Leveling

Draft animals, such as buffaloes and oxen, 2-wheel tractors or 4-wheel tractors can all be used as power sources to level a field. Different systems require different field conditions and operating time to complete the task.



Fig. 5. Leveling field with the help of leveling board pulled by draft animals.

- Draft animals and 2-wheel tractors using harrows and leveling boards. These leveling techniques require total water coverage of the field and require 7 to 8 days for a 2-wheeled tractor and 12 days per hectare of land using draft animals.

- 4-wheel tractor using rear mounted tractor blades or drag buckets. 4-wheel tractors are very effective for leveling both wet and dry fields. Wet fields are best leveled with a rear-mounted tractor blade. Dry fields are best leveled using hydraulically operated drag buckets. Tractor work rates are dependent on the tractor's capacity and the amount of soil to be moved. It takes approximately 8 hours to level 1 hectare with a rear mounted tractor blade. This reduces to about 4 hours when using a drag bucket.
- More level and smooth soil surface
- Reduction in time and water required to irrigate the field
- More uniform distribution of water in the field
- More uniform moisture environment for crops
- More uniform germination and growth of crops
- Reduction in seeds, fertilizer, chemicals and fuel used in cultural operations
- Improved field trafficability (for subsequent operations)



Fig.6. Laser leveler attached to a 4-wheel tractor.

- 4-wheel tractor with a laser-controlled bucket. The use of laser-controlled equipment results in a much more level field – up to 50% better than leveling using other techniques.

Benefits of Laser Leveling

Laser leveling systems are commonly used in agricultural applications in Australia, Japan and the United States. Increasingly, laser-guided systems are being used in lesser developed country contexts as well. Laser leveling results in a much more level field. Accuracy can be improved by as much as 50%.

The **benefits** over other land leveling methods include the following:

- More level and smooth soil surface
- Reduction in time and water required to irrigate the field
- More uniform distribution of water in the field
- More uniform moisture environment for crops
- More uniform germination and growth of crops
- Reduction in seeds, fertilizer, chemicals and fuel used in cultural operations
- Improved field trafficability (for subsequent operations)

The **limitations** include the following:

- High cost of the equipment/laser instrument
- Need for skilled operator to set/adjust laser settings and operate the tractor
- More efficient for regularly sized and shaped field

III. Laser-controlled Land Leveling Systems

How Laser Leveling Works

The laser-controlled system requires a laser transmitter, a laser receiver, an electrical control panel and a twin solenoid hydraulic control valve.

The laser transmitter transmits a laser beam, which 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 or closes

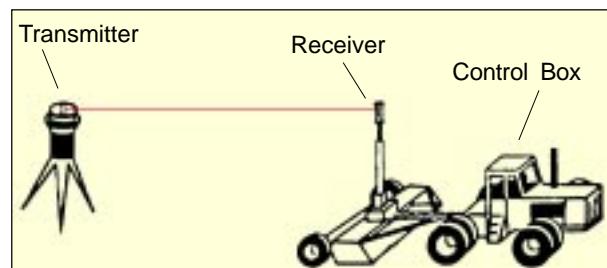


Fig.7. Diagram showing major components of a laser leveling system.

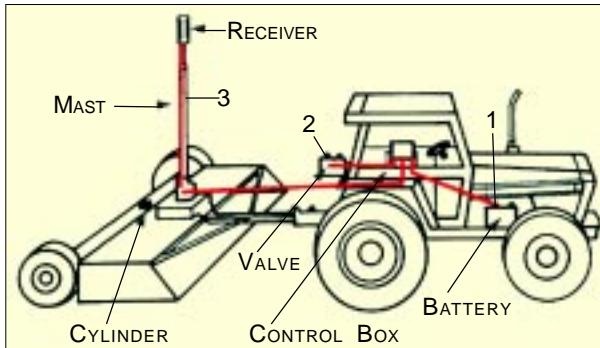


Fig.8. Diagram showing connectivity of a laser-controlled leveling system with the control box fitted in a tractor.

the hydraulic control valve, which will raise or lower the bucket.

Some laser transmitters have the ability to operate over graded slopes ranging from 0.01% to 15% and apply dual controlled slope in the field.

4-wheel Tractor: A 4-wheel tractor is required to drag the leveling bucket. The size of the tractor can vary from 30-500 hp depending on the time restraints and field sizes. In Asia tractors ranging in size from 30-100 hp have been successfully used with laser-controlled systems. It is preferable to have a 4-wheel drive tractor than 2-wheel drive and the higher the horsepower the faster will be the operation. Power shift transmissions in the tractor are preferred to manual shift transmissions.

Plow: The fields will require plowing before and after land leveling. Depending on the



Fig. 9. Disc harrows being used to loosen hard layers exposed due to shifting of soil.

amount of soil that must be cut it may also be necessary to plow during the leveling operation. Disc, moldboard or tine plows can be used.

Drag Bucket: The leveling bucket can be either 3-point linkage mounted or pulled by the tractor's drawbar. Pull type systems are preferred as it is easier to connect the tractor's hydraulic system to an external hydraulic ram than connect to the internal control system used by the 3-point-linkage system. Bucket dimensions and capacity will vary according to the available power source and field conditions. A 60 hp tractor will pull a 2 m wide x 1 m deep bucket in most soil types. The design specifications for the bucket should match the available power from the tractor. Typical specifications for a 50 HP tractor are given in Annexure I as an example.

Laser Transmitter

The laser transmitter mounts on a tripod which allows the laser beam to sweep above the tractor unobstructed. With the plane of light above the field, several tractors can work from one transmitter.



Fig.10. Laser transmitter

Laser Receiver

The laser receiver is an omni-directional receiver that detects the position of the laser reference



Fig. 11. Laser receiver being adjusted on the mast. Inset picture shows a close-up of a laser receiver.

plane and transmits these signals to the control box. The receiver mounts on a manual or electric mast attached to the drag bucket.

Control Panel

The control box accepts and processes signals from the machine mounted receiver. It displays these signals to indicate the drag bucket's position relative to the finished grade. When the control box is set to automatic, it provides electrical output for driving the hydraulic valve. The control box mounts on the tractor within easy reach of the operator. The three control box switches are On/Off, Auto/Manual, and Manual Raise/Lower (which allows the operator to manually raise or lower the drag bucket).



Fig.12. A view of the control panel.

Hydraulic Control System

The hydraulic system of the tractor is used to supply oil to raise and lower the leveling bucket. The oil supplied by the tractor's hydraulic pump is normally delivered at 2000-3000psi pressure. As the hydraulic pump is a positive displacement pump and always pumping more oil than required, a pressure relief valve is needed in the system to return the excess oil to the tractor reservoir. If this relief valve is not large enough or malfunctions damage can be caused to the tractors hydraulic pump.

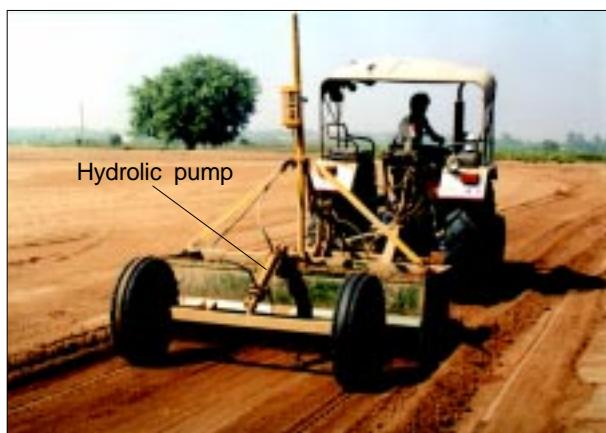


Fig. 13. Hydraulic pump used to supply oil to raise or lower the leveling bucket.

Wherever possible it is advisable to use the external remote hydraulic system of the tractor as this system has a built-in relief valve. Where the oil is delivered directly from the pump to the solenoid control valve, an in line relief valve must be fitted before the control valve. The solenoid control valve, when supplied by the laser manufacturers has a built-in relief valve.

The solenoid control valve controls the flow of oil to the hydraulic ram which raises and lowers the bucket. The hydraulic ram can be connected as a single or double acting ram. When connected as a single acting ram only one oil line is connected to the ram. An air breather is placed in the other connection of the ram to avoid dust contamination on the



Fig.14. Hydraulic control system.

non-working side of the ram. In this configuration the weight of the bucket is used for lowering.

The desired rate at which the bucket raises and lowers will depend on the operating speed. The faster the ground speed the faster the bucket will need to adjust. The rate at which the bucket will raise and lower is dependent on the amount of oil supplied to the delivery line. Where a remote relief valve is used before the control valve, the pressure setting on this valve will change the raise/ lower speed. Laser manufacturer supplied control valves have pressure control adjustments on both the bypass relief valve and the raise and lower valves.

When using a hydraulic ram, the ram should be positioned so that the ram body is connected in such a way as to push from the bucket frame rather than the depth control wheels.

IV. How to Laser-level Land

Overview

Laser leveling requires soil to be shifted from the high points of the field to the low points in the most cost-effective way. In most situations fields will need to be plowed and a topographic survey undertaken before leveling commences.

Step 1. Plowing the Field

Plow the field preferably from the center of the field outwards. It is preferable to plow the field when the soil is moist because if the soil is plowed dry a significant increase in tractor power is required and large clod sizes may result. If the soil is very dry a one-way disc or moldboard may be required. Disc harrows or tine implements are ideal for second workings. All surface residues need to be cut up or removed to aid soil flow from the bucket.



Fig.15. A rotovator is being used to cut up the surface residues.

Step 2: Conducting a Topographic Survey

Once the field is plowed, you should conduct a topographic survey to record the high and low spots in the field. From the surveyed readings you can then establish the mean height of the field by taking the sum of all the readings and dividing by the number of readings taken. Then, using a field diagram and the mean height of the field you can determine a strategy to effectively move soil from the high to low areas.

Lasers are now widely used to accomplish a topographic survey. They are very accurate, simple to use and readily available in most countries. Recordings can be taken up to a

radius of 300 meters from the transmitter. One person can operate a laser level.

A zero-slope laser level will cost approximately US \$ 1,000 and is a very effective and accurate means of surveying. The more complicated machine control systems can cost up to US \$ 10,000.

The laser surveying system is made up of a laser transmitter, a tripod, a measuring rod and a small laser receiver. A major advantages of laser surveying is the accuracy, simplicity of use and only one person is needed.



Fig.16. Checking the laser transmitter and receiver communication for actual field survey.



Fig. 17. Taking survey readings in the field with reference to a fixed datum.

Other Equipment

Other equipment may be needed when using a laser system for topographic surveying. This includes:

- **Tape:** One 100-meter tape. White metal tapes are more accurate, fiberglass tapes are generally more robust
- **Staff:** if a measuring rod is not available. The staff is preferred as metric, upright with an E-type, pattern. Check the accuracy of the scale on the staff using a steel tape because some staff faces may be out by one or more centimeters
- **Compass:** If direction and bearings are to be recorded a compass will be required. The compass can be used to set magnetic north on the level and allow recordings to be taken from it
- **Pegs/Hammer:** Pegs, preferably painted white, are required especially for marking out a grid survey or temporary marks
- **Book:** A notebook is required to record all measurements and other information required to make sense of the survey work completed in the field. Enough detail should be recorded so that the levels could be rechecked if necessary. The notebook should be small enough to fit comfortably into a shirt or trouser pocket
- **Pencil/Eraser:** A pencil and eraser are preferable to an ink or biro type pen in the field. Mistakes can be easily remedied, pencils will not run out as an ink pen will and a pencil will still function even if the paper becomes a little wet through perspiration.

Using a Laser Level

1. Open the tripod legs and adjust the individual positioning of the legs until the

- base plate is relatively level. Use the horizon as a visual guide to get the base plate level.
2. Attach the laser transmitter to the base plate.
 3. If the laser is not self-leveling, adjust the individual screws on the base of the transmitter to get the bubble into the center of both circles. Most lasers will not rotate unless the transmitter is level.
 4. Once the transmitter is level attach the receiver to the staff and activate the sound monitor.
 5. The laser is now ready to commence recording heights.

Step 2.1: Recording Survey Measurements

All measurements should be recorded in a field book that can be easily carried in a shirt or trouser pocket. There are a number of ways to record data in a field book but the open field plan system is the easiest when surveying for leveling purposes.

Field Plan Format

When leveling a field or placing contour banks in a field it is often easier and less confusing to record the data on a scaled or grid map that visually represents the field.

Field Plan

A benchmark is used so that any point in the field can be checked back against a reference if the need arises and to check the accuracy of the survey. The levels are recorded on a grid map. Change in elevation or comparing individual readings or subtracting each reading from the mean height of the field can determine slope.

In the case of a land leveling exercise, where a cut/fill map is required, it is best to use the mean height of the field as a reference

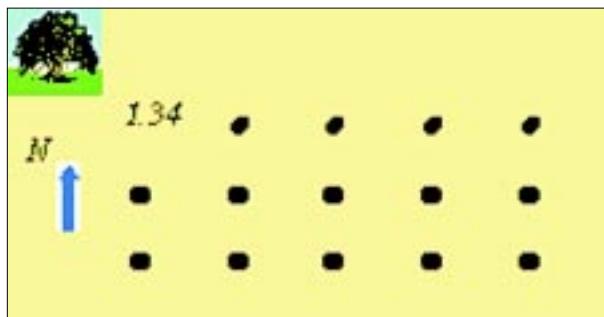


Fig.18. Bench marks for checking the accuracy of the survey.

point. To determine the mean height of the field add together all of the measured points and divide by the number of measurements.

A new map is then drawn which shows the difference between the mean height of the field and the recorded height. *For example*, if the mean height is 1.00 m and the actual height is 1.50 m then there is a low point of 0.5 m. This is recorded as a positive figure and when leveling land this area must be filled.

By doing this for the complete field a cut/fill map is drawn and an estimate of the volume of soil that needs to be shifted can be calculated.

Error due to Earth's Curvature

The laser transmitters are designed for use at distances up 300 meters. Beyond this distance, the curvature of the earth becomes a consideration. The error from the earth's curvature affects a laser transmitter the way it does a surveying instrument. Elevation readings at long distances will appear lower than they actually are. The following table shows the amount of error for a straight line of sight due to the curvature of the earth.

Distance	Amount of error
150 m	1.5 mm
300 m	6 mm
450 m	15 mm
600 m	24 mm

Step 3: Leveling the Field

Leveling a field involves the following steps:

1. The laser-controlled bucket should be positioned at a point that represents the mean height of the field.
2. The cutting blade should be set slightly above ground level (1-2 cm).
3. The tractor should then be driven in a circular direction from the high areas to the lower areas in the field.



Fig.19. Tractor should be driven in circular direction in the field from high to lower areas.

4. To maximize working efficiency, as soon as the bucket is near filled with soil the operator should turn and drive towards the lower area. Similarly as soon as the bucket is near empty the tractor should be turned and driven back to the higher areas.
5. When the whole field has been covered in this circular manner, the tractor and bucket should then do a final leveling pass in long runs from the high end of the field to the lower end.
6. The field should then be re-surveyed to make sure that the desired level of precision has been attained.
7. In wet areas where there is poor traction or a chance of bogging the tractor, care needs to be taken to fill the wet areas from the effected edge in a circular motion.

8. If the fields are plowed in lands and leveling undertaken in the areas of soil settlement in the second year, the fields should not require further major leveling works for at least 8 years.
9. Maintain or repair levees.



Fig. 20. Repairing levees

Estimating Time Requirements

The length of time taken to level the field can be calculated by knowing the average depth of cut from the cut/fill map, the dimensions of the field, the volume of soil that can be moved by the bucket and the tractor operating speed. (See the example for estimating time length on the next page).

Measuring Distance

It is important to be able to measure distance as many of the critical decisions that are made on a farm are based on being able to measure distance with some degree of accuracy. Calibration of equipment, determination of application rates, measurement of yield/unit area and speed of operation are a few variables that depend on distance measurement as input.

There are many ways to measure distance. The most common methods are using a tape measure or a calibrated step.

Example for estimating time length:

Variable	Calculation	Example
Field dimensions (meters)	none	100 m x 50 m
Average depth soil to be cut (cm)	none	25 cm
Leveling bucket dimensions	none	2 m x 1 m x 1 m
Bucket fill	none	50%
Tractor speed (average of when the bucket is full and empty in km/hr)	calculated average	8 km/hr or 8000 m/hr
Volume of soil to be moved	Field area/2 x average depth cut in meters (m)	$100 \times 50/2 \times 0.25 = 625 \text{ m}^3$
Volume soil in bucket (m^3)	bucket dimensions x bucket fill	$2 \times 1 \times 1 \times 0.5 = 1 \text{ m}^3$
Number of trips required	volume of soil to be moved x no. of trips	$625/1 \times 2 \text{ (full and empty)}$ $= 1250 \text{ trips}$
Average trip length	50% of field	$100/2 \text{ m} = 50 \text{ m}$
Total distance traveled (m)	no. of trips x average trip length	$1250 \times 50 \text{ m} = 62500 \text{ m}$
Time required (hours)	distance (m)/speed (m/hr)	$62500/8000 = 7.77 \text{ hours}$

In the example above, approximately 8 hours are required to level this field. This is an estimate which will vary according to the skill of the operator, the soil type and operating conditions.

Tape Measure

The tape measure is the most common instrument for measuring distance. Tapes can be made of steel, fiberglass or plastic and vary from 1 to 200 meters in length. As most discrepancies occur at change stations, the longer the tape measure used, the more accurate will be the distance measured.

Care must be taken to use the starting point of the tape. On some tapes this will be a metal ring or tag and on others it will be where these are joined to the tape proper.

Steel tapes will be more accurate than other materials but can be less flexible and more prone to damage when being used.

Using a Tape Measure

1. Check that the tape measure is complete. Tapes are often broken and repaired which usually means shortening the tape
2. Hold the start of the tape at the first point and applying a reasonable load to the tape, read off the second mark.

3. In windy conditions a third person may be necessary between the two measured points to help align the tape.

The Calibrated Step

In a number of instances it is not necessary to know the exact distance. Where errors of less than 5% are acceptable distances could be measured by a calibrated step. Each individual will have different sized steps for different environmental conditions.

To calibrate a step, each individual must count the number of steps taken to walk a known distance in each environmental condition. This will vary according to the walking surface, the presence or otherwise of obstacles and the slope.

How to calibrate your step:

1. Mark out a distance of 100 meters
2. Walk at normal walking speed and stride length over the measured 100-meter course and count the number of steps

3. Repeat this at least twice and preferably 4 times
4. Add up the total number of steps and divide by the total distance walked
5. The outcome will be your step factor
6. It is then possible to calculate the distance between two objects by walking at normal speed counting the number of steps and dividing this by your step factor.

Example

1. I walked 100 m and I took 107 steps. I walked back over the 100 m course and this time I took 113 steps
2. My total number of steps for the course up and back was 220 (107+113) and I walked 200 m
3. By dividing the 220 steps by 200, my step factor will be 1.1
4. Therefore, if the distance between two objects was 40 of my regular steps, the actual distance is $40/1.1$, which equals 36.6 m approximately.

Checking/Calibration of a Laser Transmitter

The laser transmitter should be periodically checked for accuracy.

Most laser transmitters have two horizontal level adjustment screws that allow minor adjustments to be made along the two axes of the horizontal plane. The axes are usually labeled "X" and "Y". All checking and calibration procedures are done at the zero slope reading.

Items Required to Check the Accuracy of the Transmitter

1. A suitable tripod that allows you to rotate the transmitter in 90 degree increments.
2. A minimum 65-meter range that is unobstructed and as close to flat as possible.

Checking/calibrating Procedure

1. Mount the unit on a tripod at one end of the 60 m range and level it. Set 'X' and 'Y' axes grade counters at zero. With auto leveling transmitters, turn the transmitter control switch to the AUTO position and wait for the Auto Mode Indicator Lamp to stop flashing.
2. Station a rodman with a receiver at the other end of the range 60 m away.
3. Align the laser, using the sighting scope or groove, such that the 'X' is pointed directly at the rodman. Make sure the pentamirror is rotating and the Auto Mode Indicator Lamp has stopped flashing (if appropriate).
4. Have the rodman take a precise reading to within 2 mm and mark the reading as X1.
5. Rotate the transmitter 180 degrees and wait at least 2 minutes for it to re-level. In non-auto leveling transmitters, manually re-level the transmitter. Have the rodman take another accurate reading and mark it down as X2.

Outcomes

- If the difference between X1 and X2 is less than 6 mm, no adjustment is necessary and the laser can be assumed to give the correct reading.
- If the difference is between 6 mm and 38 mm the transmitter then needs to be calibrated and this can be done locally in the field. See calibration of the transmitter.
- If the difference is 38 mm or greater the unit must be re-calibrated at an authorized service center. You cannot recalibrate it in the field without damage to the unit

Note: If the difference is 38 mm or greater the unit must be re-calibrated at an authorized service center. You cannot recalibrate it in the field without damage to the unit.

Calibrating the Transmitter Locally

If the difference in transmitter readings is between 6 mm and 38 mm then the transmitter can be calibrated locally.

Procedure

1. From the two previous readings calculate the "X" average = $(X_1 + X_2)/2$ and have the rodman adjust the detector on the rod to the "X" average. (Center the detector between the two readings).
2. Locate the "X" calibration screw and adjust it to align the beam to the "X" average at the detector. If gentle turning of the calibration screw cannot align the beam, return the unit to an authorized service center for calibration.
3. After adjusting the beam, allow for the unit to stabilize before taking the next reading,

then repeat the entire above procedure to check your work and do a fine readjust if necessary to get it just right.

4. After adjusting the "X" axis rotate the transmitter 90 degrees to the "Y" axis. Point the "Y" axis directly at the rodman, using the sighting scope or groove and repeat the above steps. Call the readings Y1 and Y2 and calculate the "Y" axis average as you did in step 1.

The same procedure may be employed by directing the beam onto a wall 60m away. Instead of having the rodman recording on the staff, make a mark on the wall at X1 and X2 and then draw a line in the center. The beam is then adjusted until it is recorded at the centerline. This system is useful if there is no rodman available or a measuring staff is not available.

V. Troubleshooting

Problem	Cause/Solution
Bucket will not raise or lower	<ul style="list-style-type: none">• Check the transmitter is working• Check hydraulic connections• Check electric connections on solenoid• Check pressure relief valve setting on control valve• Check for contamination in oil lines
Bucket doesn't respond in certain parts of field	<ul style="list-style-type: none">• Line of vision between transmitter and receiver blocked• Receiver the same height as tractor cabin• Laser beam above or below the receiver height
Bucket will only move in one direction	<ul style="list-style-type: none">• Check hydraulic connections• Check electric connections on solenoid• Check pressure relief valve setting on control valve• Check for contamination in oil lines
Bucket shudders when first started	<ul style="list-style-type: none">• Oil cold or no load in bucket• Check pressure relief valve setting

(Continued on next page)

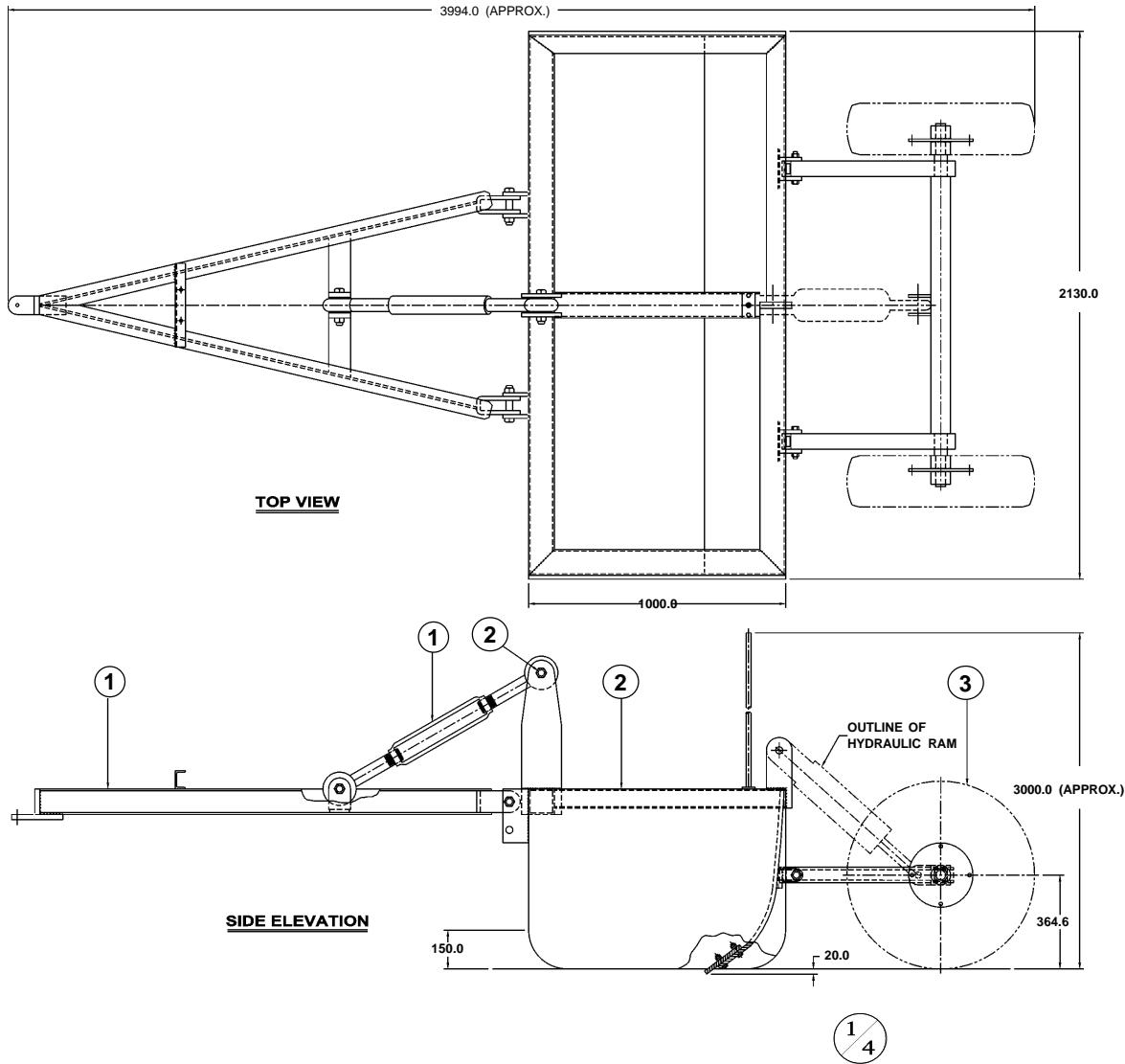
Troubleshooting (*Concluded*)

Problem	Cause/Solution
Bucket raises and falls automatically	<ul style="list-style-type: none"> ● Check line of vision ● Check electronic connections on solenoid ● Check oil level in tractor hydraulic system
Field uneven	<ul style="list-style-type: none"> ● Traveling too quickly ● Raise and fall speed too slow
Field not level or slopes the wrong way	<ul style="list-style-type: none"> ● Check the levelness/calibration of the transmitter ● Soil too compacted for bucket to cut
Soil not flowing out of the bucket	<ul style="list-style-type: none"> ● Soil too wet ● Too much foreign matter in soil
Soil not flowing into the bucket	<ul style="list-style-type: none"> ● Too much crop/weed residue on surface ● Soil too compacted

Annexure I

Design Specifications of a Typical Drag Bucket

STANDARD PARTS			
REF.	PART NO.	DESCRIPTION	QTY.
1	CPTI-STD-002	TURNBUCKLE, M50 Ø	1
2	CPTI-STD-003	HEX. HEAD BOLT WITH NUT, M24 Ø x 110 LONG	8

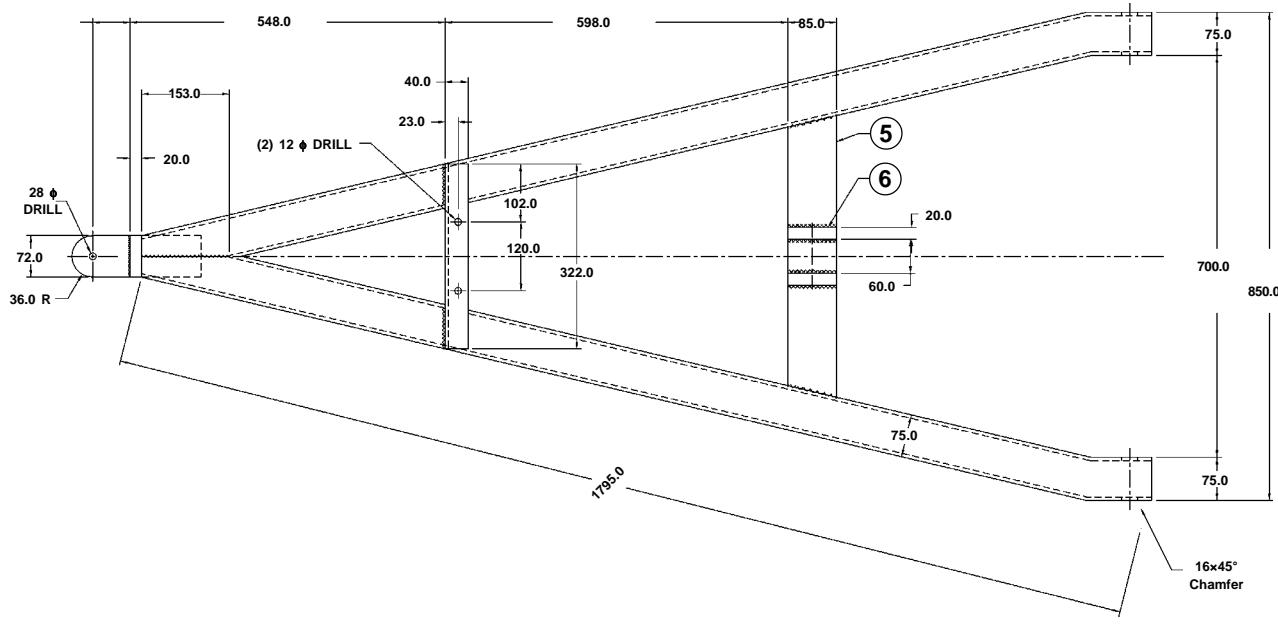


REF.	PART NO.	DESCRIPTION	REQ'D	DRAWING NO.
3	CPTI-SA-003	PNEUMATIC TIRE ASSEMBLY	1	CPTI-SA-003
2	CPTI-SA-002	BUCKET TYPE LEVELER ASSEMBLY	1	CPTI-SA-002
1	CPTI-SA-001	HITCH FRAME ASSEMBLY	1	CPTI-SA-001

FABRICATED PARTS

INTERNATIONAL RICE RESEARCH INSTITUTE
AGRICULTURAL ENGINEERING DIVISION * LOS BAÑOS, LAGUNA * PHILIPPINES

STD. TOLERANCE IF NOT SPECIFIED MILLIMETER $\pm 1.0^*$ ANGULAR ± 1 DEG.	TITLE: CPTI - CAMBODIA PROJECT TRACTOR IMPLEMENT MAIN ASSEMBLY		
	DWN BY: R. Angco	DATE: 05-05-99	SCALE: 1 : 16
THIRD ANGLE PROJECTION	CHKD BY: JR		USED IN:
	CONCEPT: JR		
ALL DIMENSIONS ARE IN MILLIMETER	DESIGN: JR		DRAWING NO.: CPTI-MA-001
	APPD: JR		



HITCH FRAME ASSEMBLY

CPTI-SA-001
 (USED IN CPTI-MA-001)
 REQD:
 1 ASSEMBLY
 SCALE:
 1 : 8

(2/4)

REF	PART NO.	NAME	REQ'D	MATERIAL
6	CPTI-PT-006	FRONT TURNBUCKLE HOLDER	2	20 THK. x 85 M.S. FLAT BAR
5	CPTI-PT-005	CHASSIS CROSSMEMBER	1	20 THK. x 85 M.S. FLAT BAR
4	CPTI-PT-004	CHASSIS	2	75 x 75 SQUARE BAR
3	CPTI-PT-003	BRACKET	1	40 x 70 C-CHANNEL
2	CPTI-PT-002	END PLATE	1	20 THK. x 72 M.S. PLATE
1	CPTI-PT-001	HITCH MOUNTING BRACKET	1	20 THK. x 72 M.S. FLAT BAR

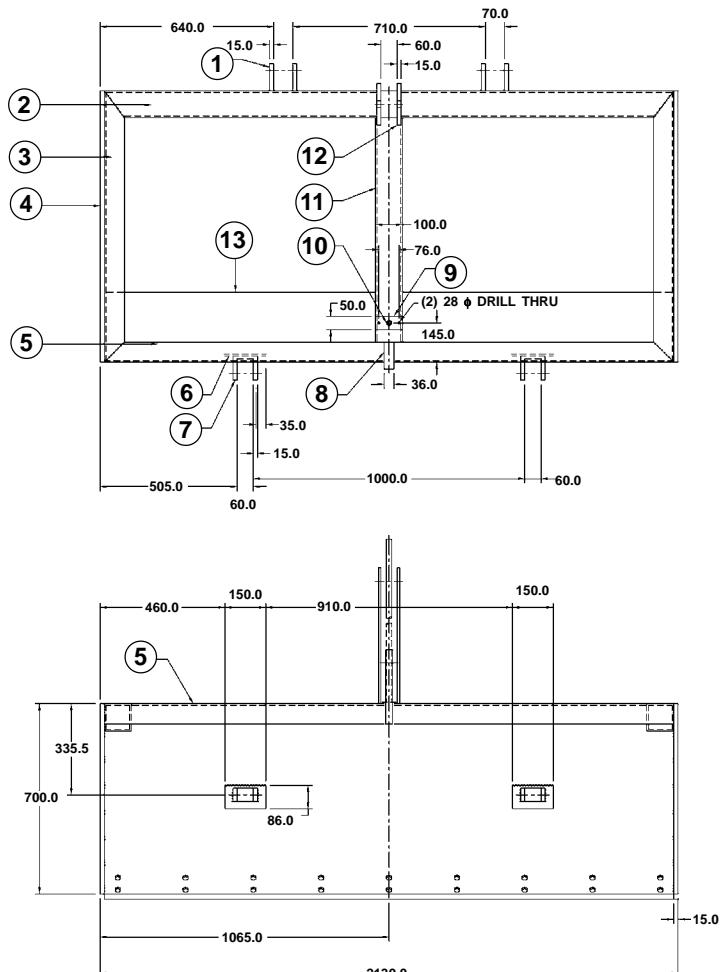
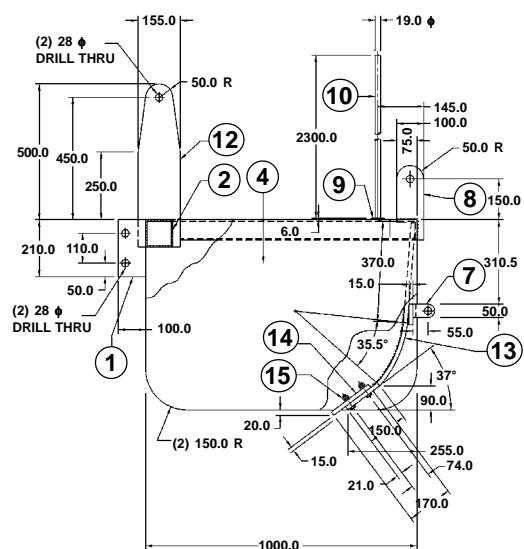
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STD. TOLERANCE IF NOT SPECIFIED MILLIMETER $\pm 1.0^{\circ}$ ANGULAR ± 1 DEG.	TITLE: CPTI - CAMBODIA PROJECT TRACTOR IMPLEMENT HITCH FRAME ASSEMBLY		
* DOES NOT APPLY TO HOLE SIZE	DWN BY: R. Angco	DATE: 05-05-99	SCALE: 1:8
THIRD ANGLE PROJECTION	CHKD BY: JR		USED IN:
ALL DIMENSIONS ARE IN MILLIMETER	CONCEPT: JR		
	DESIGN: JR		DRAWING NO.: CPTI-SA-001
	APPD: JR		

BUCKET TYPE LEVELER ASSY

CPTI-SA-002
REQD:
SCALE:

(USED IN CPTI-MA-001)
1 ASSEMBLY
1 : 16

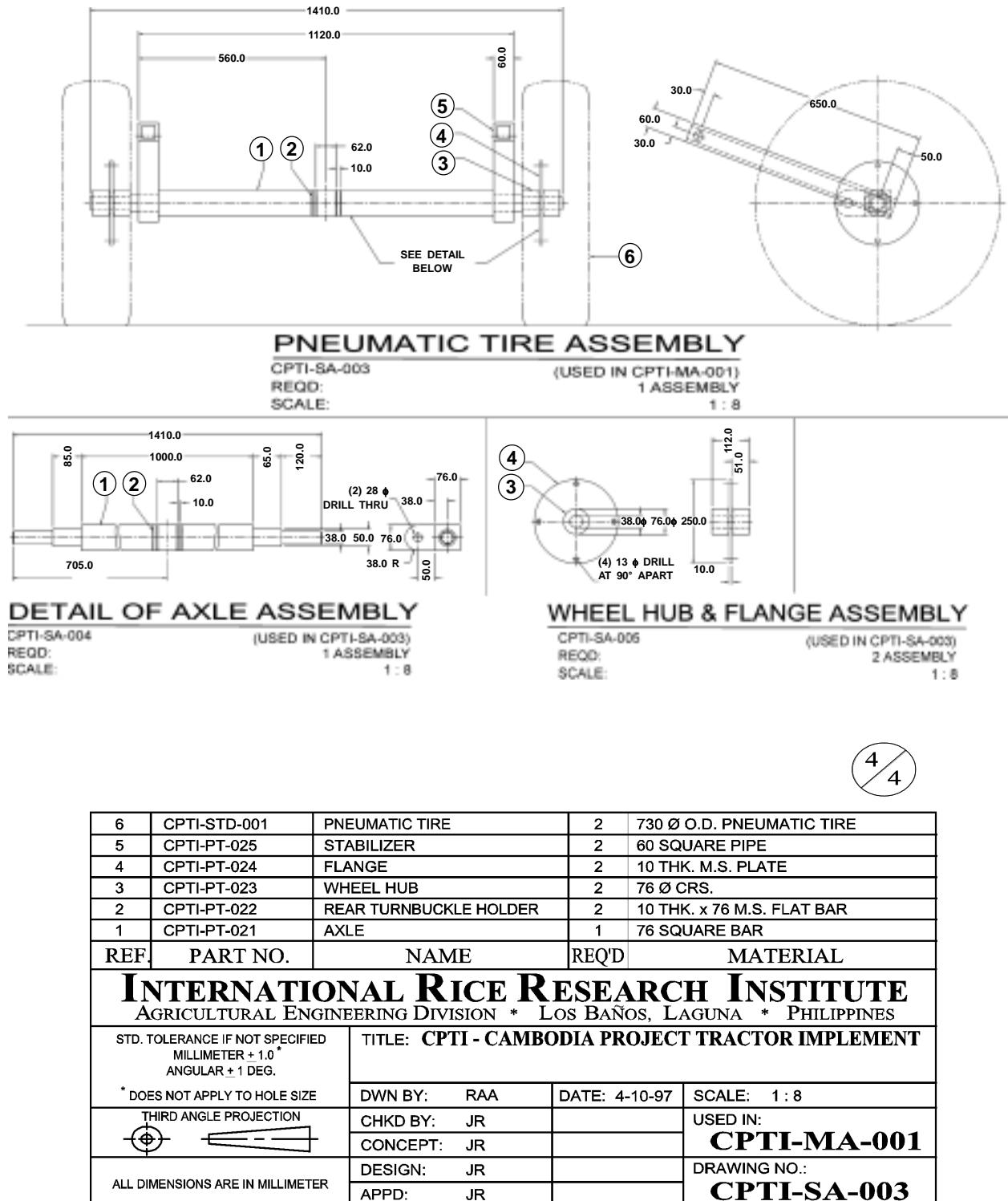


REVISED: APRIL 24, 2002

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REF	PART NO.	NAME	REQ'D	MATERIAL
15	CPTI-STD-004	HEX. HEAD BOLT W/ NUT & F.W.	18	M12 Ø x 1.75 x 50 LONG
14	CPTI-PT-007	BLADE EXTENSION	1	15 THK. M.S. PLATE
13	CPTI-PT-020	SKID	1	15 THK. M.S. PLATE
12	CPTI-PT-019	REAR TURNBUCKLE HOLDER	2	15 THK. x 155 M.S. FLAT BAR
11	CPTI-PT-018	MIDDLE FRAME	1	100 x 100 SQUARE TUBE
10	CPTI-PT-017	VERTICAL BAR	1	19 Ø ROUND BAR
9	CPTI-PT-016	BASE PLATE	1	6 THK. x 50 M.S. FLAT BAR
8	CPTI-PT-015	HYDRAULIC RAM MOUNT	1	25 THK. x 100 M.S. FLAT BAR
7	CPTI-PT-014	REAR BRACKET HITCH	2	15 THK. x 50 M.S. FLAT BAR
6	CPTI-PT-013	BRACKET PLATE	2	12 THK. x 86 M.S. FLAT BAR
5	CPTI-PT-012	REAR HORIZONTAL FRAME	1	75 x 75 ANGLE BAR
4	CPTI-PT-011	SIDE HOUSING	2	15 THK. M.S. FLAT BAR
3	CPTI-PT-010	SIDE FRAME	2	75 x 75 ANGLE BAR
2	CPTI-PT-009	FRONT HORIZONTAL FRAME	1	100 x 100 SQUARE TUBE
1	CPTI-PT-008	FRONT BRACKET HITCH	4	15 THK. x 100 M.S. FLAT BAR

STD. TOLERANCE IF NOT SPECIFIED MILLIMETER ±1.0° ANGULAR ±1 DEG. * DOES NOT APPLY TO HOLE SIZE		TITLE: CPTI - CAMBODIA PROJECT TRACTOR IMPLEMENT		
THIRD ANGLE PROJECTION		DWN BY: R. Angco	DATE: 4-8-97	SCALE: 1 : 16
		CHKD BY: JR		USED IN: CPTI-MA-001
		CONCEPT: JR		DRAWING NO.: CPTI-SA-002
ALL DIMENSIONS ARE IN MILLIMETER		DESIGN: JR	APPD: JR	



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Rice-Wheat Consortium for the Indo-Gangetic Plains

The Consortium is an Ecoregional Program of the Consultative Group on International Agricultural Research (CGIAR), managed by CIMMYT, involving the National Agricultural Research Systems, the International Agricultural Research Centers, and the Advanced Research Institutions. Its main objective is to promote research on issues that are fundamental to enhance the productivity and sustainability of rice-wheat cropping systems in South Asia.

These objectives are achieved through:

- Setting priorities for focused research on problems affecting many farmers.
- Promoting linkages among rice-wheat research specialists and other branches of research and extension.
- Encouraging interdisciplinary team approach to understand field problems and to find solutions.
- Fostering quality work and excellence among scientists.
- Enhancing the transfer of improved technologies to farmers through established institutional linkages.

Financial support for the Consortium's research agenda currently comes from many sources, including the Governments of Australia, Netherlands, Sweden, Switzerland, and the Department for International Development (DFID), the International Fund for Agricultural Development (IFAD), the United States Agency for International Development (USAID), and the World Bank.



Facilitation Unit
Rice-Wheat Consortium for the Indo-Gangetic Plains
CG Block, National Agriculture Science Centre (NASC) Complex,
DPS Marg, Pusa Campus, New Delhi 110 012, India
Telephone + 91 (11) 5822940, 5827432 Fax + 91 (11) 5822938
E-mail: rwc@cgiar.org
Visit our World Wide Web site at <http://www.rwc.cgiar.org>

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