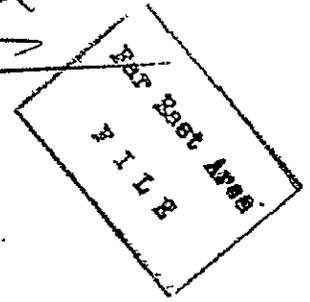


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INCREASING THE WORK EFFICIENCY OF THE WATER BUFFALO  
IN DRAWING THE PLOW AND OTHER DRAWN IMPLEMENTS THROUGH THE  
USE OF IMPROVED HARNESS

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Acknowledgements.

Introduction.

Outline of Report:

1. The importance of the water buffalo in the Near East, Middle East, Far East and other countries.
2. Uses as a draft animal.
3. Inefficiency of harness now in use.
4. Improving the harness.
5. Improved harness can be made locally by the farmer or shoe maker and blacksmith.
6. Value of increased efficiency.
7. Explanation of tests and demonstrations employing the improved harness.
8. Illustrations of harness.
9. Explanation trials are incomplete, need more work.

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INTRODUCTION:

Little or no improvement has been made in the harness attaching the water buffalo to the wooden plow in the past 1500 years. Over the past five years the author has observed the water buffalo and the oxen at work in the fields in Mexico, India, Pakistan, Syria, Egypt, Thailand, Laos and Vietnam. Having grown up with the horse-and-mule agricultural economy, he felt that something could and should be done to improve the efficiency of these animals, particularly that of the water buffalo, by providing better harness. The so-called horse collar has been successfully used on horses and mules for many decades.

This work is in its infancy and will continue until improvements are made or the buffalo is no longer used - a very remote possibility in these areas of the world. Many types of harness could have been made and experimented with, but the collar, hames, breast strap, back band and trace chains were chosen for the initial experiments because they had proved to be successful in the past. The large area of draft contact of the collar and breast strap make it most desirable, as that is the No. 1 problem involved. These or other improvements in harness must be such that the farmer can build them out of indigenous materials, as his cash for such purchases is limited.

Other types of hitches and harness should be tried, such as the double ox-bow. Time and circumstances did not permit us to try other types of harness.

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1) THE IMPORTANCE OF THE WATER BUFFALO.

For hundreds of years the water buffalo has played a major role in the lives of millions of people in Africa, Asia, and other areas of the world. It is estimated that 80,000,000 buffaloes are located in these areas. Time has not provided another animal to take the place of the buffalo, since the days of the first domestication of the original species. Temperament and resistance to hot weather, diseases, insects and parasites, plus the ability of the animal's digestive system to convert dry grass, weeds, rice straw and other poor foods into sufficient nourishment to maintain itself, make the buffalo most suitable to these areas. However, the versatility of the buffalo completes the requirements of an animal of such major importance. He is basic to the economy in many areas.

The following list is impressive, in that one animal can serve so many purposes, with so little consideration being paid to raising food for his keep:

I. Beast of burden -

- a) Power for plowing, leveling, planting, cultivating.
- b) Power for Persian-type water wheels, pumping water for human consumption and for irrigation.
- c) For transporting packloads and people on his back.
- d) To draw carts, sleds etc. to haul logs, lumber, farm products to market, and for transport of people.

II. Source of food -

- a) Milk.
- b) Butter.
- c) Ghee (cooking oil)
- d) Meat.

III. Source of materials -

- a) Manure for fuel.
- b) Manure for fertilizer.
- c) Urine for fertilizer.
- d) Urine for curing certain skins.
- e) Hides for shoes, clothing and other commercial products.
- f) Horn for cutlery handles and ornaments.
- g) Bone for meal for feed and fertilizer.

\* Knap's buffalo report.

2) USE AS A DRAFT ANIMAL.

While the buffalo is not the most efficient source of animal power in the world, he is the most versatile and adaptable for this purpose in the areas where he is predominant.

The large cloven hoof of the buffalo provides flotation to walk in soft muddy fields and allows the hoof to be withdrawn easier. Work in the rice fields is performed under muddy conditions, with plowing and puddling to prepare the land for transplanting rice. The soil is so hard in the dry season that it is impossible to plow it with the wooden plow and animals, and plowing is done after the rains have softened the ground.

The physical structure of the buffalo and the distribution of his body weight over the feet and legs are important factors in making him a good draft animal.

Continued work in muddy fields does not have the bad effect on the hooves and legs of the buffalo that it does on mules or even oxen.

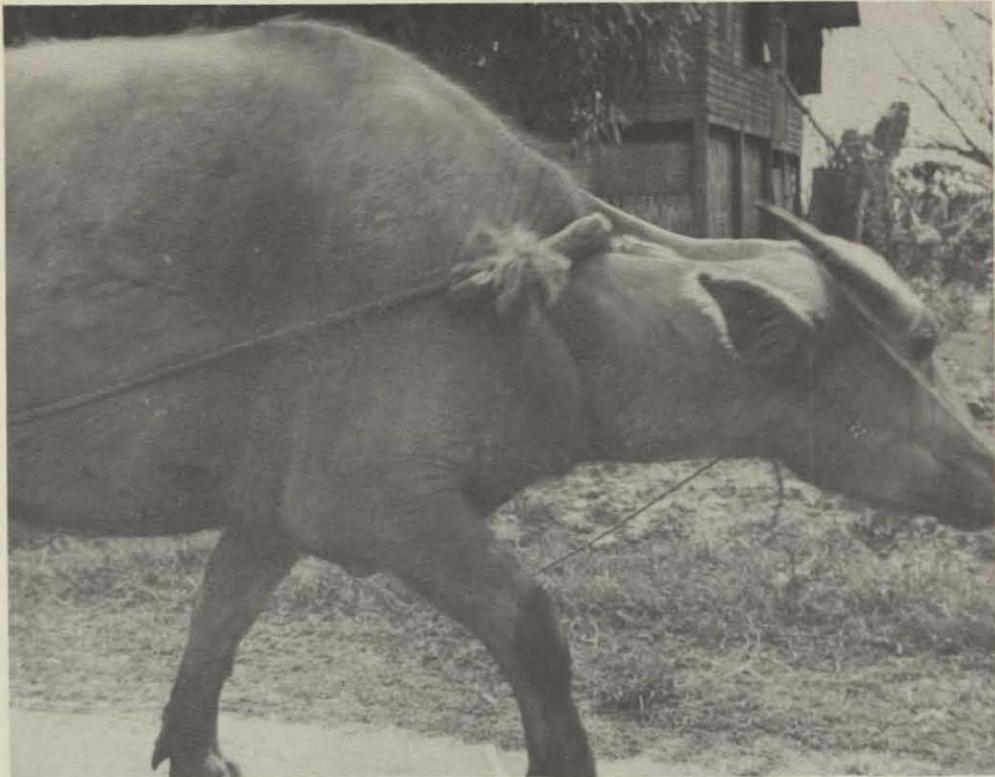
The buffalo is now used for power to plow, level, and puddle rice land, in plowing, seed-bed preparation, and cultivation of upland crops, and to draw carts and sleds hauling things on the farm and to market.

In some countries the buffalo is used to pump water with the Persian water wheel by means of a sweep.

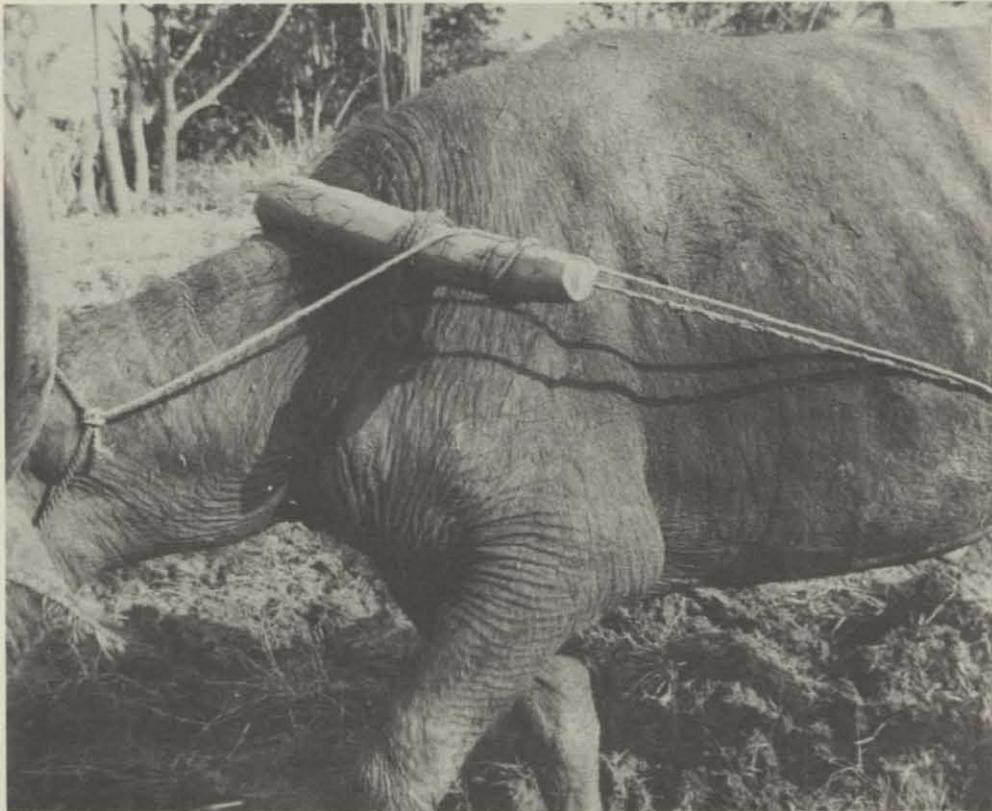
In many areas the buffalo is the sole source of power for draft purposes, therefore the means of producing food crops.

3) INEFFICIENCY OF HARNESS NOW IN USE.

The inefficiency of the buffalo as a draft animal at present is due largely to the type of harness used to attach him to the draft load. The yoke is made of wood or bamboo, in many shapes and sizes, and its position is on top of the animal's neck at the withers. A rope or strap is tied to one side of the yoke, passed under the animal's neck and back to the other side of the yoke where it is tied; this holds the yoke in position when under a load. When the yoke is pulled back by the load, the rope under the throat pulls tight against the animal's windpipe, restricting normal breathing. Thus, the air intake is reduced and fatigue sets in very shortly after the animal begins pulling the load. (See pictures 57-3113 - 57-3303)



No. 57-3303



No. 57-3118

Another disadvantage of the yoke is the small area of contact on the animal's neck or withers. Thus, the load is concentrated and high pressure is built up as the yoke digs into the animal's flesh, causing discomfort or pain. This, coupled with the restricted breathing, greatly reduces the animal's draft efficiency. (See pictures 57-3302-04)



No. 57-3302



No. 57-3304

No back band is on the harness as used now. The back band has a great stabilizing influence on the plow and is also a means for controlling vertical depth adjustment of the plow. Plow depth is now controlled by the length of the traces. Traces are of buffalo hide or inferior rope. (See pictures 57-3308 - 57-3309)

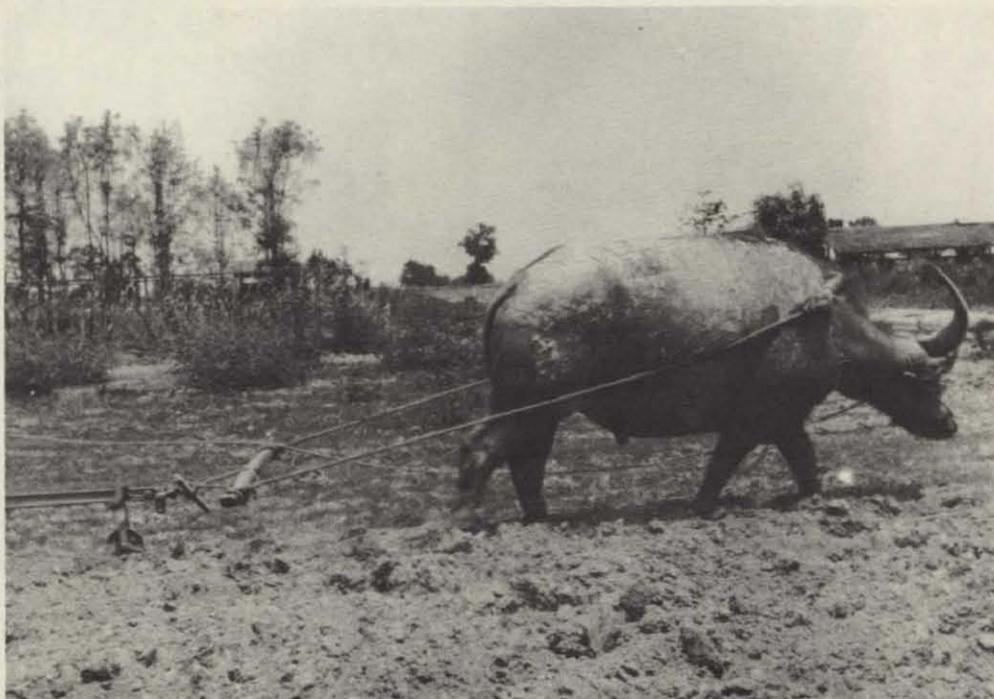


No. 57-3308



No. 57-3309

With the present yoke arrangement the buffalo is unable to utilize its full weight in pulling a load because the hitch is too high in relation to his center of gravity. (See picture 57-3307)



No. 57-3307

As a result of all these things the buffalo can work only a few hours each day and plow  $\frac{1}{2}$  rai of land.<sup>A</sup>

The contact or draft area of the yoke is approximately 25 square inches.

#### 4) IMPROVING THE HARNESS.

In attempting to improve the harness, thought was given to what we wished to accomplish and the problems that exist --

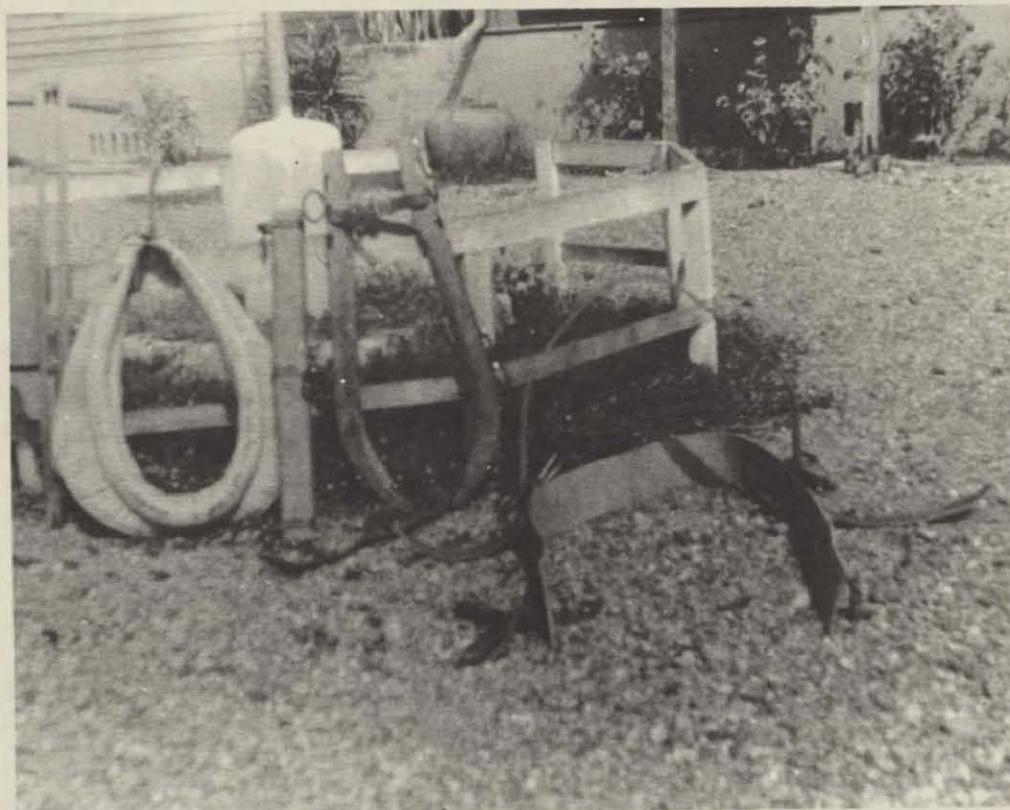
- a) Provide a draft medium with more contact or draft area.
- b) Eliminate choking or interference with the animal's normal breathing.
- c) Adjustments in harness to control plow depth and stability.
- d) Cost.
  1. Materials to be purchased.
  2. Availability of indigenous material.
  3. Labor.
  4. Not too complicated to make and operate.
  5. Adaptability to the buffalo.
  6. Acceptability by the farmer.

<sup>A</sup> Elliott and Garner Report - The Buffalo as a Work Animal.

In reviewing the problems involved after many observations and discussions with Department of Agriculture officers and farmers it was decided to run the first experiments with the horse collar-hames-backband-steel-trace-chain combination and the breaststrap-backband-rope combination, as this type of harness had proved successful and incorporated the things we required.

Consequently a canvas collar, a leather breast strap and backband were made in a local saddle and shoe shop. Hames were cut from local wood. A local blacksmith made the hooks, rings etc. and installed these plus the steel strap on the outside edge of the hames for added strength. A pair of chains bought in the market made into traces. A single tree was fashioned from local wood. The hooks, cuffs and rings were made by a local blacksmith.

Our first trials were very encouraging and indicated that we were on the right track and that tests should continue, although at a later time some other innovation in the type of harness might come into the picture as the result of our experiments or at the suggestion of farmers. (See picture No. 57-2759 Collar, hames, breast strap, single tree.)



5) HARNESS CAN BE MADE LOCALLY.

We have borne in mind continually the importance of the cost factor in procurement or in making the harness at home.

a) Collar can be made with covering of --

1. Leather.
2. Cotton canvas.
3. Heavy rice bag burlap.
4. Pliable bamboo or grass matting.

The stuffing material can be kapok and rice straw.

The lasting quality of these materials is in the order they are listed, but care and the amount of work done with the equipment will also determine how long they will last.

b) Breast strap can be made of --

1. Leather.
2. Cotton canvas, 6 ply sewn together.
3. Heavy rice bag burlap - 4 ply sewn together.
4. Pliable bamboo or grass matting, as many ply as necessary sewn together.

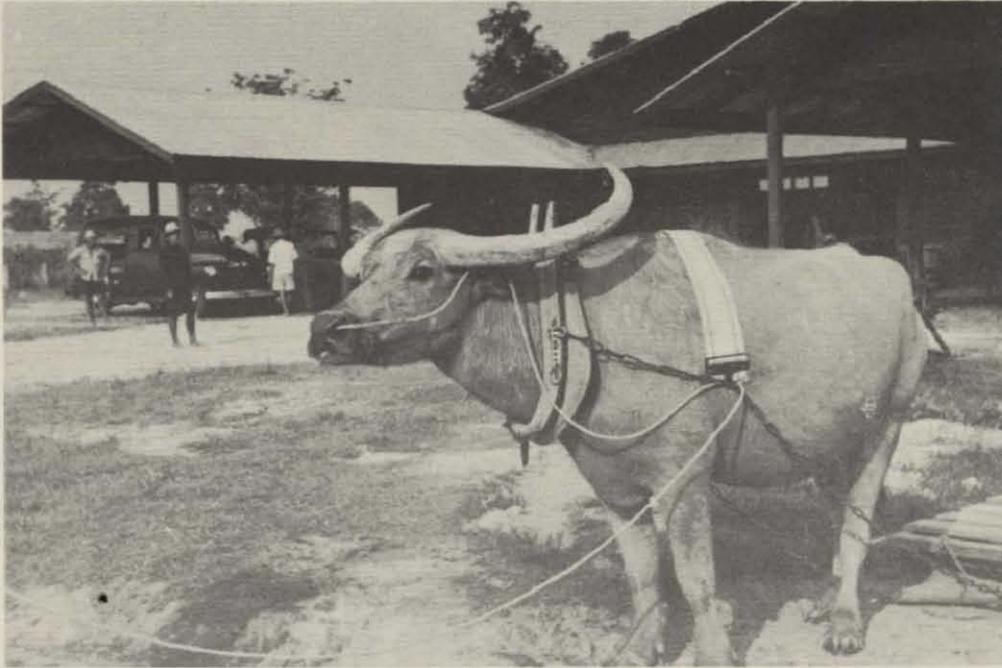
Breaststrap rings for fastening traces can be made by the local blacksmith.

(See picture No. 57-3321)



c) Hames can be made of local hard wood. wood that does not split easily is best when the curved part of the hame is cut out with a saw. Heating and bending is best. The iron required can be bought locally. A local blacksmith and carpenter can make the hames. If and when the wood members of the hames are broken or beyond service, the irons can be removed and installed on new wood. The irons should last for an indefinite period of time.

d) Chain for traces can be made or locally purchased. These chains should last for an indefinite period, and replacement from wear will be negligible. (See pictures Nos. 57-3310-16)



No. 57-3310



No. 57-3316

The collar should fit the animal well to prevent shoulder galling. A collar fits properly when there is room for a man's hand, flat, between the animal's skin and at the lower inside of the collar. (See picture No. 57-3313)



Buffalo are of various sizes and will require collars from size 18 to 24 inches.

It is important that the roll that holds the hames in place be built very rigid, and that upper face of the collar be wide enough for good draft area and to hold the hames in place under load.

- e) The backband can be made of --
1. Leather.
  2. Canvas.
  3. Heavy rice bag burlap.
  4. Pliable bamboo or grass matting.

Backband dimensions are 5 inches wide, 44 inches to 50 inches in length.  
(See picture No. 57-3315)

When 2, 3, or 4 are used for material, 2- or 3-ply should be sewn together for strength.

f) The backband buckle can be made of sheet iron by a local blacksmith.  
Sample buckles are in the USOM Agricultural Division.



No. 57-3315

6) VALUE OF INCREASED EFFICIENCY.

The ability to serve man as a draft animal as a source of power is only one of the many virtues of the water buffalo. However, it is one of the most important ones. Millions of people over the Near East, Middle East, Far East, Africa and other countries depend on the water buffalo to plow their rice fields, pump water for growing the rice, haul the cut rice to the threshing floor and there thresh it by walking or treading the grains of rice out of the heads.

As crop diversification becomes more prevalent in these countries the buffalo will be called on to do more work in the field than he has in the past. More work days will be required for plowing and cultivating to produce such crops as corn, sugar cane, peanuts, kenaf, and soybeans, which require several cultivations per crop season for best production.

Pulling planters for these crops is an important job for the buffalo. Seed planted with an animal-drawn mechanical planter are deposited at a uniform controlled depth and properly covered. This results in a greater percentage of germination of seed, emergence and survival of the seedling, and uniform growth of the plant and ripening of the fruit.

One authority states there are 80,000,000 head of buffalo in the Near East, Middle East, Far East and other areas. The tests and trials that have been conducted indicate that the efficiency of the buffalo is increased 25 percent or more on draft loads when using the collar and hame harness. Very favorable results were gotten when using the breast strap, also.

If only one half of the 80,000,000 buffalo are draft animals and the efficiency were to be increased 25 percent, that would be equivalent to adding 10,000,000 additional animals to the existing population. At a cost of \$60 per head, this is equivalent to a value of \$600,000,000.

The economic value of the buffalo can be increased as his production capacity is increased.

7) EXPLANATION OF TESTS AND DEMONSTRATIONS WITH THE IMPROVED HARNESS.

Trials and tests were run on --

- a. Plowing.
- b. Harrowing.
- c. Maximum load tests, employing a loaded stone boat.
- d. Endurance tests, employing a loaded stone boat.

(a) Although the land generally was too hard to plow during the dry season when our tests were run, we did find a few areas where we could plow the land while it was dry. Several other areas were irrigated, so as to soften land for plowing.

Generally, the results were very satisfactory. The animals could plow for longer periods of time without rest, respiration was less violent, and their general condition appeared to be better when using the improved harness.

(b) Results when pulling the peg-tooth harrows were about the same as in plowing. In both tests a. and b. the ability of the buffalo to work longer hours continuously, plus the better draft advantage, probably account for the percentage increase in work.

Table I. Approximate Draft Area.

Yoke	30 sq. inches	Depending on type
Collar	100 sq. inches	Depending on size
Breast Strap	96 sq. inches	Depending on width

Table II. Plowing and Harrowing.

Yoke	100%	Base
Collar	125%	25% increase in work
Breast Strap	125%	25% increase in work

(c) Maximum load tests were made employing a loaded stone boat or sled constructed of wood -- 2" x 6" runners covered with plank. Several tests were made. Earth was used for weight. The stone boat was loaded until the buffalo could not move it. Recordings were made of the actual weight of maximum loads moved. A hydraulic dynamometer was used to determine force and friction co-efficient. The indigenous yoke harness and the improved harness were used in all trials.

Table III. Maximum Load Tests

Type of Harness	Maximum Load moved	Draw Bar Pounds Pull	Base	Net % increase
Yoke	1250 Pounds	542	100%	0
Collar	1550 Pounds	672	124%	24%
Breast Strap	1405 Pounds	609	112 $\frac{1}{3}$ %	12 $\frac{1}{3}$ %

(d) Endurance tests were run on several occasions, employing a stone boat loaded with earth. Total weight of the stone boat, plus load was 750 pounds. A course of 550 yards length was used. Our observations were that the buffalo was much less fatigued when the improved harness was used. It was necessary for the animal to stop for short periods to catch his breath and rest when the yoke harness was used. The animals held a more uniform pace when using the improved harness.

Table IV. Endurance Tests.

Type of Harness used	Distance	Time Required	Draw Bar Pounds Pull	Time required in %
Yoke	550 Yards	31 $\frac{1}{2}$ minutes	325.5	Base
Collar	550 Yards	21 minutes	325.5	33 $\frac{1}{3}$ % less
Breast Strap	550 Yards	18 $\frac{1}{2}$ minutes	325.5	41.27% less

Table V. Horse Power Test.

Type of harness used	H.P. developed	% of increase
Yoke	0.522	Base
Collar	0.773	48%
Breast Strap	0.885	69.5%

These findings are not assumed to be conclusive, due to the limited trials, but the information gained is encouraging and indicates the project has merit. More work should be done under actual field conditions during the crop season when it is possible to do extensive plowing.

Farmers who saw the demonstrations were definitely interested, as they realized that improvements in the harness are needed.

Officers in the various departments of the Ministry of Agriculture are interested in this work and wish to continue it. The Rice Department wants several sets of harness for each of its experiment stations to loan to farmers. The farmers can use it in their own fields and some will make harness of their own.

The Research and Extension Divisions of the Department of Agriculture are very interested and wish to continue the demonstrations.

Both the Rice and Agriculture Departments have been most cooperative.



No. 57-3320  
One of the trial runs



No. 57-3095  
Endurance test - pulling loaded slide



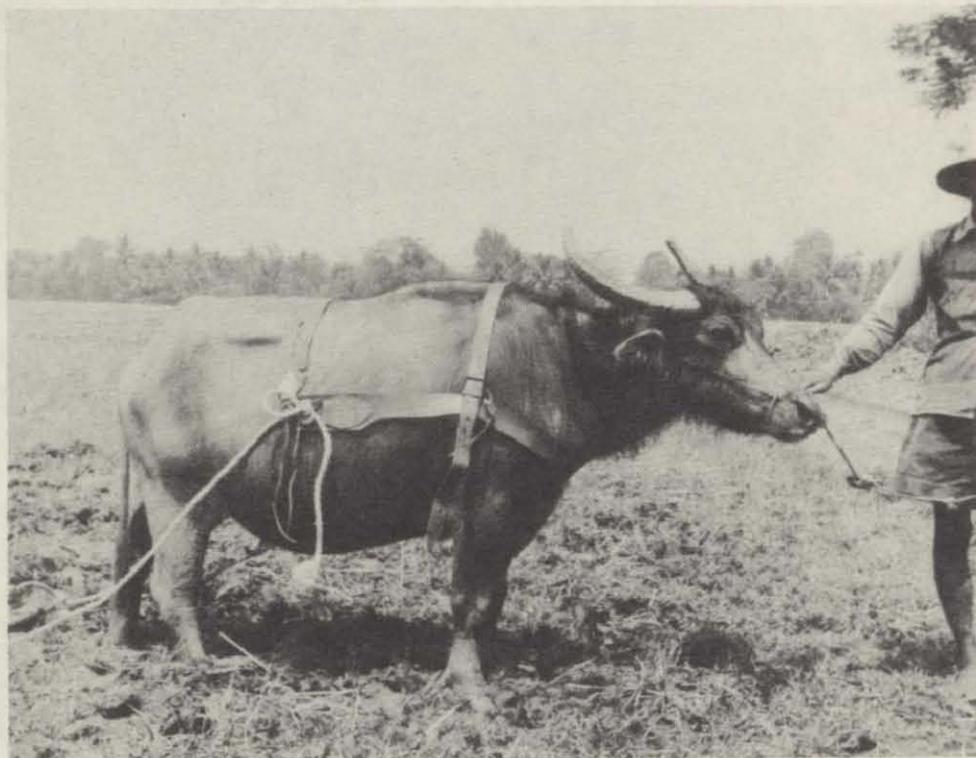
No. 57-3121  
The Thai wooden plow does a good job.



No. 56-2483  
A frame type rigid harrow.



No. 57-2477  
Flexible harrow made of bamboo.



NO.57-3164  
Grass rope were used as traces as an expediant and were very satisfactory.