Chapter 13
Improving the Design of Bullock Driven Tractor (BDT) to Make It User-Friendly

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1 Introduction

Bullocks and other male animals have been well-proven traditional sources of DAP and are extensively used by the majority of farmers in rural India. Thus, they are considered to be the backbone of the rural economy in India. The total number of Cattle in the country as per the 2012 Census is 190.90 million numbers [1].

Mechanisation in agriculture has majorly contributed to the success of the green revolution in India. Nevertheless, tractors and advanced allied agricultural implements which are used for enhancing the productivity is adopted majorly by the wealthy farmers. However, poor and marginal farmers with smaller land holdings remained dependent upon DAP due to poverty.

Presently, with the ever-increasing cost of agriculture and exhausting natural resources, farming is considered to unsustainable and loss-making business. Therefore, to cultivate sustainable and eco-friendly agricultural practices for farmers with smaller land holdings in the country, the use of Bullocks needs to be promoted. With this state of affairs, BDT could reduce dependence on fossils fuels and supports a holistic approach towards sustainable farming.

The efficiency of Draught animal power can be improved by increasing its usage. Also with the introduction of efficient design which could increase productivity without harming animal and farmer health will boost efficiency. However, the link between the implement-manufacturer, researcher and the farmer is fragile in India

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[2]. Thus, there is a need to strengthen the said link by identifying the need at the grassroots and problems associated with adopting technologies.

Thus, this paper presents one such initiative for improving the design of Bullock driven tractor to make it user-friendly.

2 Need for the Intervention in Improving Existing BDT

Bharatiya Cattle Resource Development Foundation, New Delhi expressed the need for technical intervention for KBDT during RuTAG regional workshop. The Foundation suggested a survey for the disseminated KBDT in different parts of the country. Inputs from the feedback will help in improving the problems incurred in KBDT. However, it was suggested to re-evaluate the design more systematically and efficiently to increase the plough and comfort to the farmer and the animal [3].

3 Survey of Various Designs of Bullock Driven Tractors

Bullock driven tractors have been developed in the country by several organisations. Central Institute of Agricultural Engineering (CIAE), Bhopal, Bharatiya Cattle Resource Development Foundation (BCRDF), Delhi, Rajasthan Mechanical Works Ltd, Jaipur, and Kanpur Goshala Society, Kanpur [3].

Central Institute of Agricultural Engineering, Bhopal have developed Bullock driven agricultural implements named as Multi-carrying Tool, Bharatiya Cattle Resource Development Foundation, Delhi developed Kamdhenu Bullock Driven Tractor, Rajasthan Mechanical Works Ltd. Jaipur developed Brahmpuri Bullock Driven Tractor and Kanpur Goshala Society, Kanpur developed Shekhar Bullock Driven Tractor. These Bullock driven tractors and their attachments are portable, i.e. they can be attached and detached according to the type of application. The attachment and detachment are so simple that farmer itself can do it and it takes very less time [3].

The CIAE, Bhopal had developed Bullock driven agricultural implements such as Improved Bakhar, Patela Harrow, Lugged Wheel Puddler, Patela Puddler, Mustard/Small Seed Sowing Drill, Two Row Seed Drill, Two Row Seed cum Fertiliser Drill, Three Row Seed Drill, Three Row Seed cum Fertiliser Drill and Animal Drawn Planter which are independently complete implements operated by the Bullocks and these are not the attachments to the Bullock drawn Tractor, therefore, these have not been included in the study [2].

Thus, only the three models of Bullock Drawn Tractor, namely, Shekhar Bullock driven tractor (Fig. 1), Brahmpuri Bullock driven tractor (Fig. 2) and Kamdhenu Bullock driven tractor (Fig. 3) were chosen for the study.

Fig. 1 Shekhar BDT. *Source* [3]

Fig. 2 Bhrampuri BDT. *Source* [3]

4 Objective and Results of the Comparative Study

A Comparative Study of Bullock Driven Tractors was conducted under RuTAG-IIT Delhi with the goals to accurately assess the technology and comparison of performance as well as the costs variations for different designs and to suggest improvements where necessary and cross flow of information among different designs/manufacturers to learn from each other. The study revealed that none of the models was acceptable in their present shape and there was a need for further intensive study/technical evaluation and improvement in the current designs/models. All the models had large scope for further adaptive enhancements to make them user-friendly and efficient.

Fig. 3 Kamdhenu BDT. *Source* [3]

While conducting a comparative study of the three different models of the Bullock Driven Tractors the following problems were observed:

- There was a problem in lifting the attachments such as harrow, cultivator, seed drill, etc.
- There was difficulty in the turning of BDT due to heavy attachment and large size of the lever.
- More weight of the tractor, as well as attachments, caused more fatigue and stress on the Bullocks.
- The Bullock Driven Tractors did not correctly work in clay soil.
- The price of the BDT needs to be made more affordable for the farmers of small holdings.

5 Methodology in Developing Lifting Mechanism in Kamdhenu BDT by RuTAG IIT Delhi

After a detailed study, following improvements in the existing designs/models are envisioned to be carried out

1. A mechanical system such as revolving screw or hydraulic type system was studied for lifting the attachments.
2. The lever was redesigned to keep it small and stiff enough to solve the problem in the turning of the BDT due to heavy attachment. The mechanical advantage of the lever was held high enough to handle 50–100 kg weight easily by hand.

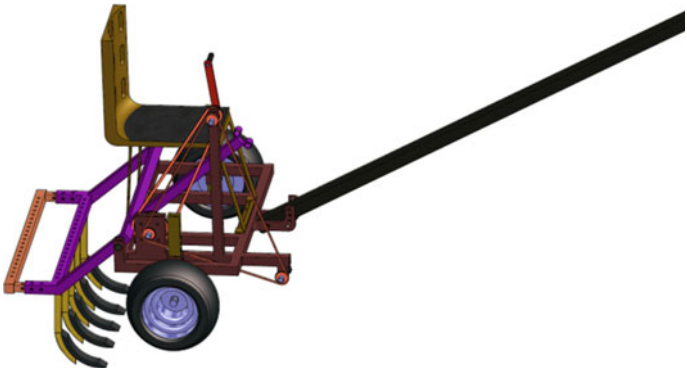

Fig. 4 CAD model of BDT

3. The weight of the tractor and the attachments was reduced without change in design to reduce the fatigue and stress on the Bullocks. The improved BDT was designed such that maximum accessories including inter-culture operations could be operated.
4. Easier manufacturing operations of the BDT and its attachments. The operation of the BDT and the attachments is easy, and the price is affordable for the farmers of small holdings.
5. Ergonomically easier in operations.

6 Development and Testing of Mechanisms for Lifting Attachments

The study revealed the requirement for interventions to deal with the problems associated with the existing BDT's developed by various organisations. It was found during the survey that the attachments are fixed to the BDT chassis and cannot be lifted when desired. Therefore, various mechanisms for lifting were studied, and requirement and methodology for incorporating a mechanism for lifting attachments in Kamdhenu BDT were analysed, and changes were included. Out of various designs, two mechanisms (chain-sprocket and winch-wire rope) were modelled using CAD (Fig. 4), and prototypes were fabricated, and field tested (Fig. 5).

6.1 Chain-Sprocket Mechanism

The chain-sprocket mechanism (Fig. 6) Incorporated the rolling chains and variously sized sprockets. An arrangement was designed which while holding the attachments such as a plough, cultivator, etc., can be moved in either upwards or downwards positions as seen in tractors.

Fig. 5 Chain and sprocket mechanism

Fig. 6 Chain-sprocket mechanism

Fig. 7 Movable frame

The movable arrangement is a rectangular frame of span equal to the span of BDT chassis and is hinged at both the ends to the chassis (Fig. 7). The movable frame has an extended arm which is attached to a rolling chain which passes through three idler sprockets placed in the same plane and is driven by a rolling chain and sprockets in parallel plain incorporating a crank which can be rotated in both the directions (Fig. 6). When the crank is rotated the rolling chain attached to the extended arm of the frame in the parallel plane also rotates and hence the frame is lifted or lowered eventually. During testing, it was observed that there was a need to incorporate a locking device which can stop or lock the movable frame at the desired position. Therefore, a ratchet and pawl locking device were developed and attached to one of the hinges (Fig. 8). This locking device incorporated two ratchets, and two pawls fixed on a shaft connected to the frame. The locking device locks the frame in either upwards or downwards directions (Fig. 8). Both the pawls were released using a foot operated lever (Fig. 9). Somehow, the locking device did not work to the level of satisfaction during testing. Therefore, it was abandoned. Therefore, team decided to develop a much simpler solution for lifting or lowering frame using winch and wire rope. It can self-lock and can be easily procured from the market.

Fig. 8 Ratchet and pawl locking device

Fig. 9 Foot operated pawl release pedal

6.2 Winch and Wire Rope Mechanism

Winch and wire rope mechanism incorporates a wire rope and a self-locking winch (Fig. 10). The extended arm of the movable frame is attached to the wire rope which passes through two pulleys and winch in the same plane (Fig. 11). When the level of the winch is rotated, the frame is lifted and locked simultaneously at a desired position within the range of maximum harrow displacement. The mechanism seemed reliable during testing, and it is easily available in the market. Also, it is economical compared to a chain and sprocket mechanism.

The iron chair has been replaced with the used-car seat to increase the comfort of the farmer. Also, the lever length has been optimised and is fabricated using mild steel. BDT with winch and rope mechanism was successfully field tested with tractor (Fig. 11) in the micro model facility at IIT Delhi and Dahina Village during July 2016 (Fig. 12).

Fig. 10 Winch-wire rope device

Fig. 11 Wire rope and self-locking winch

7 Final Field Testing Data of BDT

Performance of modified Bullock Driven Tractor got improved compared traditional plough. Traditionally, farmers used to plough their fields with country plough using Bullocks as a source of physical energy. In this operation, ploughman has to walk behind the Bullocks in the scorching sun. As per data available, a ploughman has to walk 65–70 km. For ploughing a field of 100 × 100 m [3]. Bullocks engaged in ploughing walk at a speed of about 1.7 miles per hour and slow down to 1.2 miles per hour at the end of a day's work. This operation is quite time-consuming and involves

Fig. 12 Testing at Dahina village

a lot of drudgery for the ploughman. Besides, the outcome is very low, whereas the advantage of using BDT is that it eliminates barefoot walking of ploughman behind the plough in scorching sun and rain. Since a seat has been fitted on the device, ploughman can sit on it during the operation. Even older adult of either sex can operate the tractor. A farmer can attach multiple ploughs in comparison to the single plough which enhances productivity. The field testing depth of plough and time of working of Bullocks has been recorded during few hours of testing at Dahina village in Haryana (Table 1). From table, it can be calculated that the average speed of ploughing using BDT is around 3 miles per hour, which is considerably higher than a conventional plough. Full-day (8 h) testing of BDT will be conducted soon.

The design has provided comfort to farmer and animal. Field testing was successful and, overwhelming comments were received from the farmers. Two sets of BDT has been distributed, and field tested to Madhya Pradesh Vigyan Sabha Bhopal and Wainganga Samudayak Vikas Kendra, Balaghat MP.

8 Conclusion

It was identified that the farmers are not using the BDT because of the very basic requirement of comfort for which it was designed. The farmers were finding it difficult for the Bullocks to turn at the end of the field while farrows were inside the soil. Sometimes, they had to climb down from the BDT and help the Bullocks for turning. Another critical problem was its cost. In this backdrop, the smooth and cost-effective lifting mechanism was designed appropriately with rope and winch incorporated in the BDT. The prototype was fabricated and tested. Lightweight pneumatic wheels

Table 1 Testing results at Dahina village

Sl. no.	Plot size in feet	No. of Bullocks/sets	Starting time	End time	Total duration in Min.	No. of furrow	Depth of furrows in Inches	No. of round (1 round = 100 m)	Remark
1.	(110 × 100) ft	02	11:00	11:02	02	04	4″–5″	02	
2.			11:05	11:09	04	04	4″–5″	03	
3.			11:10	11:11	01	04	4″–5″	01	
4.			11:15	11:18	03	04	4″–5″	02	
5.			11:19	11:22	03	04	5″–6”	03	
6.			11:23	11:26	03	04	4″–5″	03	
7.			11:27	11:28	01	04	5″–6″	01	
8.			11:58	12:02	04	04	4″–5″	03	
9.			12:03	12:07	04	04	6″	03	
10.			12:08	12:10	02	04	5″–6″	02	

of the car are used for easy movement in the field. It has been tested in Dahina village, Rewari, Haryana. After testing, the problems of the requirement of the locking device and some minor problems of fixture were identified and had been modified in the prototype. The new model of BDT is lightweight, and significant issue of lifting the plough has been improved. Also to improve ergonomics, the seat of an old car has been used in place of a steel chair to provide comfort to the farmer and make it more user-friendly. The problems faced by the farmers have been addressed and solutions are proposed. A modified BDT has been developed, tested in the villages in Haryana and Madhya Pradesh. A manufacturer (M/S Santosh Brothers) has been trained for mass production. Thus, the modifications in BDT has resulted in substantial improvement in the operation and has increased the comfort for the farmer and animal. Further effort is required for promoting BDT use in the village.

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