

Comparative Study of Bullock driven tractors

1. Introduction –

Animals are considered to be the back bone of rural economy in India. Draught animals play a dominant role in our rural economy. Apart from the manual labour, the traditional cultivation in India was based on the use of animal power for 97.6 % of farmers (land owners) accounting for 77.2 percent of land holdings.

India had the largest population of draught animals in the world (Approx. 88Million). This **localized resource** is exhaustible and **available resource** with farmers, yet to be optimized properly.

Animal data (In terms of present Contribution to National Economy):

- Contributes approx 50 % of all the power consumed in farming sector in India so approx annual saving of diesel is 23.75 MT equivalent to INR 21500 crore .
- Gives traction power to 50 million ploughs in villages.
- Gives employment to 20 million people on full time/part time basis in Bullock cart business.
- Transports approx.15% of the total of the load (Tonnes-km) carried by motor transport sector in India.
- In load terms, bullock carts carry more load than the total load transported by railways.
- Provides approx 100 million tons of dry dung per year which is equivalent to INR 5000 crore /year.
- Saves 5 million tons of firewood per year which is equivalent to INR 500 crore per year.
- Provides by products like skin, bone, horn etc. worth INR 100 crore/year.
- Present market value of draught animals @ average 10,000 per pair is INR 30000 crore.
- Gives dung for Bio-gas, cakes & Bio-fertilizers.
- Back bone of Rural economy & an asset in bio-diversity terms.

Animal data in Power Terms:

Type of work- animals (Standard)	Capacity of traction in power terms (HP)	Total power unlocked with 88 Million Draught Animals
Camel	1.50	A. Avg. Power capacity per Animal = 0.5 HP B. Total Power available to be harnessed= 88 Mn.X 0.5 hp = 44 million HP = 30,000 MW
Horse	1.00	
Bullock & Buffalo	0.75	
Mule	0.70	
Donkey	0.40	

*Capacity of Animals vary according to breed & Health Source: Mc Dowell R.E(1975)- Report of

NDRI,UNDP/UNESCO/ICAR Project/CARTMAN.

(http://www.greenenergysolutions.co.in/rural_portable_generator.html)

According to 1991 census there were about 86 million draft animals, which comprise of 76 million bullocks. 8 million buffaloes, 1 million camels and donkeys. The horsepower obtained from 1 bullock is equivalent 0.75 H.P. Mechanization in Agriculture was to the tune of 20% only whereas 80% of the agriculture/farm operations were done by bullock drawn implements.

(<http://www.agriinfo.in/?page=topic&superid=9&topicid=87>)

The draught power of our 83 million draught animals was estimated at equivalent to 30,000 MW in terms of electric power, equivalent to half the present generation capacity of India. In terms of energy, it was equivalent to 50,000 million units worth Rs. 10,000 crores. The draught animals were being used to plough around 100 million hectares of farm land in India, which forms 60 per cent of total cultivable area, (transport 25,000 million ton Km. of freight per year saving 6 million ton of diesel worth Rs. 4,000 crores annually. (www.veternaryworld.org)

In 1961 the contribution of the draught animals to the total energy requirements of the farming system was 71 per cent, by 1991 this was come down to 23.3 per cent almost all operations other than land preparation switched over to electrical and mechanical source of power, even ploughing of land was progressively brought under mechanization. However, ploughing and tilling of land to a very large extent is still draught animal based even where ploughing and tilling operation are carried with tractors, other operations like inter-culture and seed drilling are almost exclusively carried out with bullocks. More than 55 % of the total cultivated area is still being managed by using draught animals. (www.veternaryworld.org)

The population of draught animals had declined to about 77.69 million in 1991-92 from 80.75 million in 1971-72 and was estimated as 77.13 million in 1996-97 contributing 19.12 MkW. This was 14.5% of the total farm power. The average draught animal power availability was estimated at 3.68 ha per pair which was considered far below the normal command area of 1.5-2.5 ha per pair (<http://www.atnesa.org>)

Draught animals are the main source of motive power (tractive and rotary) for the majority of farmers. India possessed the finest breeds of draught animals. Bullocks, buffaloes and camels are the major draught animals for field operations. Horses, mules, donkeys, yak and mithun are the pack animals for transport. These animals are holistic sources of energy and fit well in the rural system.

Among the animals bullocks are used most. The camels (both male and female) are by and large used in transport and as pack animal. Camels are mostly used in desert areas and for operating Persian wheels, Oil Ghans, or Kolhus and also used for tractive power and lifting of water from open wells in few states such as U.P., Haryana, Punjab, Rajasthan, Gujarat and Karnataka. Even, at present, about 60-65 percent of the total cultivated area is being managed by draught animals.

Presently there are about 63 million draught animals in the country (Final Report of Minor Project (RDL750)). Each animal can produce about 0.5 hp of power. (Animal energy-The Potential and Utilisation in India By Dr. R.K.Pillai CARTMAN, Bangalore.) Thus about 31million hp of power can be generated by using draught animals. There is reason to believe that the draught animals have the ability to exert at least for a short period.

The bullock pair may be regarded as the backbone of Indian Agriculture. India possessed the most famous draught breeds in the world. These are Nagori, Khilari, Helikar, Amrit-mahel, Kangayam, Malvi, Haryana, Gir, Angol, Tharparkar and Gaulao. It may be assumed that the bullocks exert roughly 1/12 to 1/5 of their body weight as draught. The horse power of two bullocks engaged in ploughing varies from 0.29 to 1.87. There are cases on record where a good pair of bullocks can do more work than a 4-5 hp small tractor. (http://www.krishiworld.com/html/agri_engg6.html).

The efficiency of using bullocks depends on the feeding, maintenance, manner of yoking and training. It is estimated that about 10% of the animal energy is only utilized at present.

Late Smt. Indira Gandhi ex-Prime Minister of India when she addressed International Conference in Nairobi in 1981 had stated that:

"In this jet age, people refer to Bullock Carts as symbol of the past. However in India animals provide more power than all our power houses, whose installed capacity is 22,000 MW. Replacing them would entail a further investment of 25-40 billion dollars in electricity alone, over and above the loss of farm economy of manure and cheap fuel".

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 scorching sun. As per data available a Ploughman has to walk 65-70 kms. For ploughing a field of 100X100 meters.(Papers presented by Bharatiya Cattle Resource Development Foundation in IIT Delhi) 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. Thus at this speed a pair of bullocks plough 0.8

to 0.12 ha in a day with a desi plough. (http://www.krishiworld.com/html/agri_engg3.html) This operation is quite time consuming and involve lot of drudgery for the ploughman. Besides, the outcome is very low.

The beginning of mechanization of Indian agriculture was made by the use of improved hand tools and improved bullock-drawn implements. Quite a variety of implements are required for carrying various agricultural operations such as ploughing, harrowing, leveling, sowing, inter-culture, application of manures, harvesting, threshing, winnowing etc. A variety of indigenous (desi) implements are in use in the country for the last so many centuries. Some of these implements are crude to look at but are very useful and the consensus of the agricultural engineers of India has been that it would be easier at least as a first step to improve upon the indigenous implements in order to increase their efficiency and thus give to the Indian farmers something which is within their means.

In India, the holdings are generally small, the average farmer is poor, and the draft cattle are also small and ill fed. Taking these into account certain principles have been laid down which are:

1. That the implements and machinery for the Indian farmers should be simple in construction, so that these could be operated by the illiterate farmers, and should either be manufactured or could be repaired by the village artisans or mechanics.
2. The prices of the implements should be within reach of the ordinary farmer.
3. The implements should be light so that these can be easily transported and are suitable for the draft animals.
4. That the implements should be scientifically tested on a fairly uniform basis throughout India.
5. In designing the implements the local available materials are to be used.

The bullock drawn agricultural implements and other devices being used in the country are briefly given below:

1. The traditional Bullock operated country plough is the primary implement used all over India. All indigenous ploughs are of similar design but vary in size and weight to suit the prevailing type of soil, ploughing conditions and the weights and heights of draft animals in the locality. Even having low output (30-40h/ha) and requiring higher number of tillage operations are still being used by farmers on small farms and in regions where economic status of the farmers is not sound.

2. In Andhra Pradesh a simple triangular plate is fixed in front of the body of the plough so that ridges and furrows can be made. This is an indigenous device to convert the country plough into a Ridger. They are also used for making a shallow furrow or sowing seeds and to harvest crops such as potatoes, groundnuts and sweet potatoes.
3. The indigenous harrows and cultivators known as Bakhars or Guntakas are very common implement used in the Deccan for primary tillage, preparing the land and sowing the seed.
4. Mould Board Plough consists of a share and a mould board of steel. It ploughs a square furrow and inverts the soil either completely or partially depending on the curvature given to the mould board.
5. Ridger ploughs have double mould boards. There are in three sizes-the light, medium and heavy.
6. Soil Scoop is used when the soil is to be carried to a fairly long distance.
7. Keni or Levelling Karaha is used in soil conservation for making bunds and leveling the land.
8. The indigenous implement is called Patela or Sohags. It is merely a flat log dragged over the clods by the bullocks. The driver stands on the log to add weight to it.
9. In Uttar Pradesh the Improved Patela is called Singh Patela. It has a series of pointed hooks to crush the clods and collect the weeds.
10. For soil conservation it is necessary to make temporary low level bunds 18 to 22 cm high. For forming such bunds an implement called Bund former was developed at Coimbatore to collect the soil at the wider front and deposit it as a bund behind it.
11. Many seed sowing devices are attached to the desi plough. They are commonly called nari plough, tifan, argada and other multi-type elements that are used in the Deccan. Tubes are fixed to these implements and on the top of these a seedling bowl into which the seed is dropped is fixed. The seedling bowl has a number of holes in it. The construction of the holes is indigenous with the result that the seed falls right into the holes and into the tines.
12. For hoeing line sown crops with bullock power a light desi plough is used in northern India. In the area between the Narmada and the Krishna river, multi-tined bullock operated hoes are used. They are known as Doura, Douri, Dundia and Dulari. When the plants are small multi tined hoes fixed to a single wooden body are also used in Andhra Pradesh and Karnataka. The draft of these hoes is very light and sometimes 4 of them can be pulled by a single bullock. They are commonly known as the Washim-hoe, the Akola hoe, the Baroda hoe and the Triphali.
13. Threshing of crops is done by treading the crops with a team of animals.
14. Green manure trampler, Puddler, Bullock Dozer, Tropicultors, Sugarcane crusher, Chaff cutter/Fodder cutter are also operated using animal/Bullock power.
15. Various indigenous devices have been used for lifting water using animal power these are a Persian wheel/Rahat, a Mhot, a Pikota and Dons.
16. Kanpur Goushala Society has developed a Bullock Driven Generator cum Battery Charger which can completely charge two Battery of 12 Volts in 3 hours. It is an effort for solving the problem of electric power.

17. Kanpur Goushala Society has also developed Multipurpose Bullock Driven Power Device which can run many devices which are normally run by diesel engine/electric power such as Chaff cutter /Fodder cutter, Flour mill(Atta-Chakki), Oil Expeller, lathe machine, Cotton machine, Compressor. This device can also run Centrifugal Pump which can lift water from 30-40 feet depth which is normally lifted by 8 H.P. motor.
18. Bullock Carts have been used especially in rural India as primary means of transporting rural goods, agricultural commodities, manure, farm produce, food grains, fodder etc. since very early ages. Besides, Bullock power was used in local transportation for pulling special carts such as Rath, Bahal, Tonga etc. in social functions which were considered to be a Royal means of transportation. Unfortunately, it could not avail the advantages of technological development as being taken place in other areas of transportation.

Bullock carts account for 56 per cent of transport of goods and personnel in the country. Also, over 80 per cent of farm produce is transported in animal-drawn carts. But considering that India has about 80 million draught animals, which are used for only 100 days a year, the potential for growth is huge. These draught animals can be utilised for another 200 days in carts. Source Down to Earth Dated: 14-12-2004. (<http://www.indiaenvironmentportal.org.in/430>) Bullock Carts remain depending on concept and design of very primitive stage over generations.

Although some modifications in the designs of cart have been done by an NGO – Centre for Action, Research & Technology for Man, Animal & Nature (CARTMAN), Bangalore for smooth functioning of Bullock Carts yet these could not be popularized among the users. With improved carts, it is believed carting incomes can go up in rural and urban areas. "The potential of these modern carts is staggering,' says Prof. N. S. Ramaswamy. Director, CARTMAN "they could be used for carting to factories, seasonal vegetables (in towns and cities), and even given to the landless to earn some money,' says Prof. Ramaswamy.

India has an estimated 14 million bullock carts out of which 13 million are traditional — they have wooden wheels — and one million are improved — they have pneumatic tyres. Traditional carts can carry a load of around one tonne if the animals are stretched to the limit. Of late, carts with pneumatic tyres have become popular especially for towing sugarcane to factories. These can carry a load of 3 tonnes and require one-third the effort on the part of the animals as compared to the traditional cart.

A wooden cart costs approximately Rs 10,000/-. "With tractors still being out of reach for most of the farmers, oil prices shooting up and 80 per cent of farming done on small and marginal holdings — modernizing carts is the answer,' says Prof. Ramaswamy. (<http://www.indiaenvironmentportal.org.in/430>) Bullock carts in its new avatar- Down to Earth-14-12-2004.

The Ministry of Agriculture, Deptt. of Animal Husbandry vide letter number 43/1-2005/Admn III (RTIA) of Feb.14, 2006 had mentioned as under-

“The output of the draught animals in terms of electrical power equivalent was estimated at around 6480 million KWH for farm power and 10800 million KWH for all uses together”.

The draught animal power has come down from 30,000 MWH to 10800 MWH due to no support, no policy, no Ministry/Department to look after.

Planning commission for Xth Plan vide para no. 3.6.12 recorded:

- Need of 80 million bullocks for agriculture and other uses.
- The cost of substitution of Draught Animal Power with petroleum based power also needs to be calculated rationally.

With the introduction of Green Revolution in India, mechanization in agriculture was adopted as one of the major components. The Commercial Banks provided crop loan, medium and long term loan to the farmers for adopting advanced package of practices, using improved agricultural inputs and Tractor and allied agricultural implements for increasing production of food grains. Thus use of Tractors and farm machinery was adopted by a large number of farmers. Later, with the use of Tractors, following disadvantages have been observed:

1. Prices of Tractors and allied implements are rapidly increasing. Operational (Price of petro-products), repair and maintenance costs are drastically increasing. Small farmers cannot afford to purchase and use tractors because of high initial cost, operational cost as well high repair and maintenance cost.
2. Continued application of heavy machinery on agricultural land adds to the compactness of the soil and it also damages physical properties of soil. After many years of practice the soil become so compact that nothing can grow in it because porosity becomes very low and the soil cannot hold enough moisture and air which is vital for plant growth.
3. Damage to soil organisms during tillage.
4. Problem of pollution, developed due to the emission of diesel.
5. Size of land holding with farmers is decreasing. In small holdings (Plots) movement of tractor becomes difficult.
6. Due to not using in agricultural operations, the number of Bullocks which were main source of power in agriculture is decreasing.

With the modernization of agriculture, the use of mechanical power in agriculture has increased but draught animal power continues to be used on Indian farms due to small holdings and hill agriculture. 90 per cent of land holdings are distributed in marginal (below 1 ha) to semi-medium (2 to 4 ha) farm holdings. It covers about 50 percent of total cultivable land.(www.veternaryworld.org)

Small and marginal farmers comprise over 80% of cultivators in India. They cannot afford tractors. Average farm size, too, is becoming smaller due to fragmentation. Also, there exist large tracts of low tractor density. Besides, difficult terrain in several regions (say hilly areas) prevents tractor use. So, exactly how viable is the tractor for such farmers? (<http://www.indiaenvironmentportal.org.in/node/17055>)

Today, the general feeling is that the bullocks are non-economical and are burden on the economy. In fact, they are very good sources of power for agriculture but with the advent of fossil fuels and mechanization in agriculture their use has been dwindling. But now it is becoming increasingly evident that the use of fossil fuels etc. is not sustainable and eco-friendly. It is also leading to high cost of agriculture. Hence the use of Bullocks needs to be promoted.

In Indian economy the animal husbandry always played an important role. The cow and her progeny have been held in an extraordinary religious veneration since times immemorial in Bharat, because of multifarious beneficial uses.

In this regard, Judgement of the Hon'ble Supreme Court in which importance of cow and her progeny has been declared by 7 Judges of Constitution Bench in their Judgement of Oct. 26, 2005 (Civil Appeal No.4937-4940 of 1998) relevant portion noted-

“It is established that the backbone of Indian agriculture is the cow and her progeny and they have on their back the whole structure of the Indian agriculture and its economic system”.

“The value of dung is much more than even the famous “Kohinoor” diamond”.

Cows are reared for milk purpose for human consumption while bullocks serve as an invaluable source of energy. After the productive life; cattle give dung which is very useful input for producing organic manure that enriches soil for restoring the nutrients. Dung is also useful as fuel, in form of dried cakes for cooking and heating. The Panchgavya is used for producing bio-compost, bio-fertilizers, bio-pesticides and treatment of various human ailments. The bullocks serve as a major source of power for traction in agriculture operations, load transportation and other rotary and sundry activities. Bullock carts have been used especially in rural India as primary means of transporting since very early ages. Draught animals powered Indian agriculture to a greater extent in the past but the use of draught animals, with time is dwindling. This leads to their upkeep becoming uneconomical, particularly during off season. It has created great disruption by rendering male animals unusable. Thus male-female (Cows & Bullocks) utilization has caused disparity which is unsustainable.

Recently, new developments have taken place to bring about mechanization of agriculture. Owing to the shortage of diesel oil and its increased price, the use of tractor etc. will have to be restricted to deep ploughing, land leveling, land clearing and other operations which cannot be carried out by bullock power. For short distances bullock carts are more effective than trucks, hence the necessity for improving them. Bullock drawn cultivator and disc harrow has gained popularity due to higher output (2-3 times more area coverage) and better quality of work.

The designs of traditional agricultural implements are based on long experiences and these have served the purpose of farmers. However, there is plenty of scope to improve the design based on animal-machine-environment interaction so as to have more output and increased efficiency without jeopardizing animals and farmers health.

Animal power does not get proper attention and it poses maintenance burden on the animal based farmers. One of the serious problems in Indian agriculture today is the extreme economic conditions which have been forcing farmers to commit suicides in thousands. The unit operational cost of Draught Animal Power could be substantially reduced by their increased use. But the use of animals needs to be made more efficient by the use of advanced technologies. The effort is on to create awareness towards increased utilization of animal energy.

In this context Bullock Driven Tractor assumes an important significance because it reduce the increasing dependence on petroleum products and thermal power by increasing the share of non-commercial primary energy sources in the total energy in the country, in agricultural operations and in rural transportation. This tractor will use the draught power of animals. Using the rotary mode to operate agro-processing machines can increase the present utilization of the animal power. By enhancing their use in the agriculture lot of money can be saved. By the Bullock Drawn Tractor it is implied to have a tilling device which is more efficient than the conventional plough and it also incorporates some of the features of the modern tractor such as providing comfort to the tiller etc. Presently in the country a number of designs of Bullock Driven Tractors are available but there is no systematic evaluation.

A Technology Identification Workshop was organised by Rural Technology Action Group (RuTAG) in May 2009 at IIT Delhi. Bharatiya Cattle Resource Development Foundation, New Delhi had presented details about the Kamdhenu Bullock Driven Tractor (KBDT) and various accessories and tools that could be used with it. The Foundation wanted a survey to be conducted for the KBDTs already disseminated in different parts of the country, feed-back to be collected and further improvements to be made, if require. However, there is need to evaluate the design in a more systematic and efficient manner to increase the ploughing. There is also need to suggest the improvements in existing design and evolving a standardized design. The idea of this project i.e., the Comparative study of Bullock Driven Tractors was conceived in that Workshop.

2. Survey of Alternative Designs of Bullock Driven Tractors-

Bullock driven tractors have been developed in the country by several organizations. These are Central Institute of Agricultural Engineering (CIAE), Bhopal, Bharatiya Cattle Resource Development Foundation (BCRDF), Delhi, Rajasthan Mechanical Works Ltd, Jaipur, and Kanpur Goshala Society, Kanpur. 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 Brahmपुरi 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 is so simple that farmer itself can do it and it takes very less time.

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 Fertilizer Drill, Three Row Seed Drill, Three Row Seed cum Fertilizer 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.

Thus only the Bullock Drawn Tractor model of three companies namely: Kamdhenu bullock driven tractor, Brahmपुरi bullock driven tractor and Shekhar bullock driven tractor were chosen for the study.

3. Details of three different models of Bullock Driven Tractors Studied:-

(1) Kamdhenu Bullock Driven Tractor-

Bharatiya Cattle Resource Development Foundation (BCRDF), Ahimsa Bhawan, F-125, Lado Sarai, New Delhi- 110030, a Registered Trust. Shri Laxmi Narayan Modi is the Managing Trustee of BCRDF, New- Delhi. The Foundation is working for the following objectives:-

1. To project, assist; promote uses of Bharatiya breeds of cattle and bullocks for sustainable agriculture, soil health, renewable energy, eco- friendly agriculture, water conservation and health for all.
2. To promote benefits of cow milk and milk products and lacto vegetarianism.
3. To assist / promote improvement of agricultural hand tools and animals operated implements, animal carts, harnessing systems.
4. To assist /promote Bharatiya (indigenous) breeds of cattle, find solution for feed and health care and phase out cross breeding.
5. To co-ordinate and disseminate, information on optimum utilization of rural resources and improve productivity.

The Foundation has developed a Bullock Driven Tractor named 'Kamdhenu'. A team comprised of Shri Vibhash Trivedi and Shri Sushant Bakal from RuTAG, IIT Delhi visited M/S Santosh Brothers (Agriculture Implements and Foundry Works), M.G. Road, Bhur, Bulandshahar, (U.P.) on 27 August 2010 to collect the related information/data and to discuss about the Kamdhenu Bullock Driven Tractor. The team discussed with the workers of M/S Santosh Brothers (Agriculture Implements and Foundry Works). The Kamdhenu has riding frame, to which various multi-functional implements are fastened with nuts and bolts to do different tillage operations. They told that the frame is the main part of the tractor which has been made with mild steel.

The Kamdhenu Bullock Driven Tractor (KBDT) is mainly used for harrowing with the help of disc harrow. When sugarcane is harvested, the roots of the sugarcane remain in the soil and it is very difficult to remove it. So farmers firstly cut it with the help of disc harrow. So the soil cut and become loose. After harrowing they run cultivator. It is used to remove weed as an inter-cultivation operation without harming the main crop. Normal, mechanical tractors cannot be used for this operation. Small wheels of Kamdhenu Bullock Driven Tractor do not crush the crop

during inter-cultivation operations. It removes high drudgery of the farmers and bullocks and high cost of tractorisation. It greatly improves productivity, reduces drudgery and costs of farming.

Now KBDT has pneumatic tyres model VI with ball bearing and following attachments:

- a) Desi Plough(2 Bottom)
- b) Disc Harrow 6 Discs with one tine cultivator in the centre
- c) Soil turner (Mould Board Ploughs (2 Bottom)
- d) 5 Rows seed sowing
- e) 5 Tynes cultivator
- f) Singh Patela
- g) Ridger
- h) Potato digger
- i) Leveler
- j) Seed Drill

The team was told that approximately 10 units of Kamdhenu tractor are manufactured in the factory each month. The owner of the factory is going to set up a well equipped new factory at Bulandshahar for manufacturing Kamdhenu Bullock Driven Tractor at a large scale. It was told that the Kamdhenu was introduced in the year 2000 and till the visit, BCRDF had distributed nearly 400 units in the country. Instead of such a large supply all over India, not even a single demand had been received from the farmers. All units were distributed with the help of Government. BCRDF had provided special installation training free of cost to the farmers in their villages to purchase the equipment. During the training the trainees appreciated the equipment but after that no response had been received from them.

The pictures and data collected from industry during the visit for Kamdhenu **Bullock Driven Tractor** are as follows:-



PLACE- Bulandshahar

DATE- 27.08.10

NAME OF TRACTOR - Kamdhenu Animal driven tractor

NAME OF MANUFACTURER- Santosh Brothers, Bulandshahar (U.P.)

COST OF TRACTOR- 45,000 Rs

SOIL- It works almost on all types of soil.

WEIGHT- 70 kg

TOTAL LENGTH OF TRACTOR- 2940 mm

TOTAL BREADTH OF TRACTOR- 1590 mm

EQUIPMENTS ATTACHED - M.B. Plough, Desi Plough, Cultivator, Seed Drill Box, Leveller, Digger, Disc Harrow, Ridger.

WORKING- 1 acre in 3 hours.

Website: <http://cowind.org/products.html>

Some of the products of Kamdhenu Bullock Driven Tractor are:-





Distribution of Kamdhenu Bullock Driven Tractor in various states (as on 31st March 2008) reported was:-

S.NO.	STATES	NO. OF KBDT
1.	Uttarakhand	142
2.	Uttar Pradesh	85
3.	Madhya Pradesh	14
4.	Rajasthan	21
5.	Haryana	9
6.	Maharashtra	11
7.	Gujarat	4
8.	Delhi	5
9.	Bihar	3
10.	Jharkhand	5
11.	Karnataka	4
12.	Tamil Nadu	4
13.	Punjab	2
14.	Orissa	1
15.	Kerala	1
16.	Goa	1
17.	Andhra Pradesh	4
18.	Himachal Pradesh	1

A study was conducted at village Kharanja Qutubpur near Laksar, Distt. Haridwar (Uttarakhand) for demonstration of Kamdhenu bullock driven tractor. The model worked satisfactorily and no stress was observed on bullocks during operations.

Benefits of Kamdhenu Bullock Drawn Tractor-

1. Helps in reversal of Rural Deficit Trade Balance
2. Checks degradation of land and harmful effects of agrochemicals
3. Improves health and immunity system
4. Helps in improving humus and micro-nutrients
5. Improves soil productivity including soil structure, biology and chemistry.
6. Checks ground water depletion and pollution.
7. Reduces input costs
8. Checks global warming/climate change
9. Saves about 1500 litres of diesel costing Rs.50,000 per annum.
10. Productivity is better than 3 traditional ploughs and three of them are equivalent to a tractor of 30/35 hp tractor
11. More comfortable than tractor, even elderly persons (either sex) can operate.
12. Avoids barefoot walking behind the plough, in scorching sun, involving 65/70 km for plot of 100x100 meters.
13. With an umbrella, two hooded caps and a can of 3 liters, avoids dehydration, sun stroke.
14. All attachment of farming operations have been made suitable, for bullocks
15. Yoke specially designed and patented which improves bullock power by 12-15% without extra load.

Bonus; extra availability of dung and urine for good manures and bio-pesticides, and generating employment even for elderly persons.

Special Accessories provided by KBDT:-

1. One Umbrella

2. First Aid Box

3. Ceramic water filter candles

5. Can of 3 litres

6. Spade, Sickles

7. Sprouting ute

4. Seeds of Tulsi & Marigold
5. Cane of 3 liters
6. Spade, Sickles & Khurpa
- Sprouting utensils
- 8 Two hooded caps
9. 2 Bells- 2 pieces of clothes, Jota and Nadi
10. Non overflowing funnel (Brass)

Special Package:-

This is designed with a package for prestige and prosperity of farmers:

1. Low cost device for filtering water, (about 75% of water borne diseases can be saved by homemade filters)
2. Specially designed utensil sprouted grains.
3. Concept of health garden of 50-60 sq. meters near their houses along with seeds of Tulsi & Marigold.
4. National Institute of Nutrition have advised that if 6-7 leaves of tulsi taken every day, wards off even Diseases like cancer.
5. Flowers in the house will improve ambience, which is totally lacking.
6. Accounting system: Simplified for use by farmers to enable them to know Profit & Loss of each activity along with position of loans taken or given.
7. There is no other equipment which acts like KBDT.
8. Operation by any gender initiates social change and respect for elderly persons of the family.

Approvals and Supports for KBDT :

- Approved by Ministry of Agriculture, Government of India (No.18-4/2000-MY dated Feb. 6, 2001)
- Tested by Testing Institute, Hisar, (IMP-168/695 July 2001)
- Included in ISOPOM (No.13-5/2004-MY(I&P) dated 14.10.2004)
- Favoring by many banks and NABARD
- Government has sanctioned a subsidy of Rs 5000/- under Macro Management Scheme vide letter F.No.13-5/2004-MY(I&P) 20.8. 2004.
- National Commission on Farmers also recommended KBDT vide Para No. 3.5.4.0 (g) as below :-
 “Several innovations like Kamdhenu bullock driven tractors have been developed, which can perform a variety of operations at a much lower cost. These technologies would also need to be encouraged for adoption on a larger scale”

Commercial test report of Kamdhenu Bullock Drawn Tractor-

(No. IMP-168/695 dated July 2001)

Tested at: Farm Machinery Training & Testing Instt. Ministry of Agriculture (Deptt.of Agri. & Co-operation), Tractor Nagar, Sirsa Road, HISAR- 125 001 (Haryana)

1. DISC HARROW ATTACHMENT-

- 1.1 The operation of disc harrow with the tool bar was found satisfactorily
- 1.2 The depth of operation was varied from 6.4 to 6.8 cm and is considered normal
- 1.3 The width of cut varied from 81 to 83 cm
- 1.4 The average draft requirement was 71.3 to 73.6 kgf and is considered normal for a pair of bullock

2. CULTIVATOR ATTACHMENT-

- 2.1 The operation of cultivator with the tool bar was found satisfactorily
- 2.2 The depth of operation was varied from 6.4 to 6.9 cm and is considered normal
- 2.3 The width of cut varied from 58 to 59 cm
- 2.4 The average draft requirement was 72.4 to 75.9 kgf and is considered normal for a pair of bullock

3. DESI PLOUGH ATTACHMENT-

- 3.1 The operation of two bottom desi plough with the tool bar was found satisfactory except in the paddy harvested and grass infested fields due to accumulation of stubbles in the gap between the plough bottoms
- 3.2 The depth of operation was varied from 7.8 to 9.1cm and is considered normal
- 3.3 The width of cut varied from 30 to 45 cm

4. RIDGER ATTACHMENT-

- 4.1 The operation of ridger with the Tool Bar was found satisfactory

4.2 The depth of ridge formed was measured as 21.8 to 22.8 cm and is considered normal

4.3 The width at the top of the ridge was measured to be 39.8 to 41.0 cm and is considered normal

5. EASE OF OPERATION-

5.1 No difficulty was noticed in the operation of Multi Tool Bar during the course of test at this institute. The mounting and dismounting of the different attachments with the tool bar and their adjustment is easy and can be performed by the operator alone

6. LABOUR REQUIREMENT-

6.1 One semiskilled labour and pair of bullock *is* required for adjustment/ mounting and dismounting of various attachments and operation of the multi tool bar

7. MAINTENANCE / SERVICE PROBLEMS-

7.1 No noticeable maintenance service problem was observed during the course of test at this institute.

(2) Brahmpuri Bullock Driven Tractor:-

The Rajasthan Mechanical Works Ltd. Jaipur developed a tractor named 'Brahmpuri'. The Brahmpuri Bullock Driven Tractor (BBDT) was manufactured at large scale and it was reportedly supplied in various states of India through dealers. Shri Vibhash Trivedi from RuTAG, IIT Delhi visited Shri Gausampada Vikas Avam Sambardhan Kendra, Yashwant Plaza, 79, South Tukoganj, Porwal Chambers, 275, Jawahar Marg, Bombay Bazar Chauraha, Indore (M.P.) on September 2-3, 2010. He met with Mr. Rakesh Porwal who was the dealer of Brahmpuri Bullock Driven Tractor for Madhya Pradesh state. He visited a farm house of the dealer where he was showed the live demonstration of the cultivator by Brahmpuri Bullock Driven Tractor. He discussed with the farmer of the farm house. He was told that there was no difficulty in the operation of the Brahmpuri Bullock Driven Tractor. It is mainly used for sowing with the help of a seed drill and inter-cultivation by attaching dug foot for removing weed from standing crop. The Brahmpuri Tractor does not crush the crop during inter-cultivation operation. Leveler (Dora) is used for small root weeding and covers the seed after sowing. The wheels of Maruti 800 were used in this model.

The picture and data collected from the dealer regarding the Brahmpuri bullock driven tractor are as follows-





PLACE- Indore

DATE- 2.09.10 TO 3.09.10

NAME OF TRACTOR- Brahmpuri

NAME OF MANUFACTURER- Rajasthan Mechanical Works LTD Jaipur

COST OF TRACTOR- Rs. 18000

SOIL- It works on all types of soil

WEIGHT- 65 kg

TOTAL LENGTH OF TRACTOR- 3500 mm

TOTAL BREADTH OF TRACTOR- 1100 mm

EQUIPMENTS ATTACHED- Cultivator, Seed drill box, Dug foot, Twine

WORKING- 1 acre in 3.5 hours.

CONTACT PERSON : Mr. D.K. Gupta

RAJASTHAN MECHANICAL WORKS LTD.

A-188(B) Road No. 6-D V.K.I. Area, Jaipur - 302 013, (Rajasthan,).

PHONE : +(91)-(141)-2331549/2332239/2231654

FAX : +(91)-(141)-2332631

E - MAIL : brahmpuri@hotmail.com, brahmpuri@sancharnet.in

(3) Shekhar Bullock Driven Tractor-

The Kanpur Goshala Society, Kanpur developed a tractor named 'Shekhar'. Shri Vibhash Trivedi from RuTAG, IIT Delhi visited Kanpur Goshala Society, Bhaunti (Pratap-pur), Kanpur (U.P.) on 7th September, 2010. He met Shri. Purushottam Lal Toshniwal, the Key person of the Society. He told that the registered office of Kanpur Gaushala Society is at 55/112(Gaushala Bhawan), Generalganj, Kanpur, (U.P.). The Kanpur Gaushala Society had 635 cows at Bhaunti branch. He mentioned that using Panchgavya, the Society had made various items of daily use, medicines for human and animals use, organic manure and bio-pesticides for Organic agriculture, roofing tiles and various other items to be used for storage of agriculture produced. Shri Toshniwal mentioned that they have developed the model of bullock drawn tractor at the directions of Chandra Shekhar Azad Krishi Avam Prodyogik Vishwavidyalya, Kanpur, and named 'Shekhar'. It has been manufactured in collaboration with Shri Durga Engineering Works Pvt. Ltd., 18-C, Pokharpur, Lal Bungalow, Kanpur. It is run by a pair of bullocks. Bullocks are attached with the help of yoke. In this tractor they used the wheels that have steel frames. This tractor can be used with different attachments/implements i.e. plough, disc harrow, cultivator, soil turner etc. with it. Besides, the Society has also developed a multipurpose bullock driven power device which can run many devices such as flour mill, chaff cutter, cotton machine, water pump etc. Besides, they have developed a bullock driven generator-cum-battery charger which can completely charge 2 nos. Battery of 12 Volts in three hours. Shri Toshniwal arranged a live demonstration of Shekhar in the field of Gaushala. The Shekhar Tractor has two big iron wheels attached with the axle through ball bearing. A chair has been mounted on the axle. A cultivator with 5 tynes was attached with the tractor. A pair of bullocks can plough 2 acres of land in 8 hours. It was told that the petroleum reserves are limited and as the time passes their quantity is decreasing. At the same time their prices are shooting up. Even today the prices of petro-products are so high that the small farmers cannot afford them. So they were thinking about alternative source for agriculture purpose in place of diesel tractor. The problem of pollution, developed due to the emission of diesel, has also become a major concern. Therefore, this bullock driven tractor had been developed by Durga Engineering Works, Kanpur in association with the Kanpur Goushala Society. It is pulled by a pair of bullocks. They need such device for sufficient use of animal power.

The pictures and data collected from the Society during the visit about the Shekhar bullock driven tractor:



PLACE- Kanpur

DATE- 07.09.10

NAME OF TRACTOR- Shekhar

NAME OF MANUFACTURER- Shri Durga Engg. Works Pvt. Ltd. Kanpur

COST OF TRACTOR- Rs. 35,000/-

SOIL- It works mostly on light soil.

WEIGHT- 165 kg

BEAM- 15-25 kg

TOTAL LENGTH OF TRACTOR- 3100 mm

TOTAL BREADTH OF TRACTOR- 1200 mm

EQUIPMENTS ATTACHED- Cultivator, Disc harrow, Plough, Leveller.

WORKING- 1 acre in 4 hours

WIDTH OF TOOL BAR-105 cm

PLOUGHING POWER IN FIELD-25-30 kg

SIZE OF WHEEL-98 cm

CULTIVATOR- (Weight- 30-35 kg, Ploughing power- 75-90 kg, Working capacity-1.75-2.00 acre)

Disc Harrow (Ploughing weight- 80-100 kg, Working capacity- 1 to 1.5 acre)

Plough (Plugging capacity- 90-115 kg, Working capacity- 0.75 acre)

Leveller (For leveling of land, Plugging load- 70-80 kg, Working capacity-based on slope)

Pata (For broken large size mud particles)

Singh Patel (For removing weeds from lands)

Trolley (Light weight trolley can carry 700-800 kg load)

4. Comparison between Mechanical Tractor and Bullock Driven Tractor-

S.No.	PARAMETERS	MECHANICAL TRACTOR	BULLOCK DRIVEN TRACTOR
1.	WEIGHT	The engine and various parts are used in this tractor so it has more weight.	It has less weight because it does not use any type of engine.
2.	COST	It is very costly.	It is cheaper.
3.	OPERATION	The operation is not so easy. It required skilled/trained driver.	The operation is easy. It can be operated by a farmer.
5.	TIME	It saves lot of time.	It takes lot of time.
6.	MAINTENANCE	It requires more maintenance.	It requires less maintenance.
7.	PERFORMANCE	It's performance is more	It's performance is less.
8.	ENERGY	It works on fossils fuel./non-renewable energy	It works on animal power/renewable energy.
9.	POLLUTION	It creates air pollution due to carbon emissions. Hence it is not environment friendly	It does not create any type of pollution. Hence it is environment friendly.

From the above, it has been observed that although the performance of the mechanical tractor is more and thus it saves lot of time but it is expensive and works on fossils fuel, create pollution and thus it is not environment friendly. Besides, it is not within the financial reach of small and marginal farmers. Whereas the bullock driven tractor is cheaper, easy to operate, does not create any pollution viz., environment friendly and use renewable energy and it is within the financial reach of small and marginal farmers. It is suitable and need to be promoted for adoption by the farmers after conducting required R&D.

5. Advantages of Bullock Driven Tractor-

Some of the advantages of bullock driven tractor as compared to the mechanical tractor are as follows –

- (a) Simple design- The design is simple because the main frame and wheels, etc. have been used in the bullock driven tractor.
- (b) Easy to manufacture in mechanical workshop- It can be easily manufactured in workshop because no typical device has been used in bullock driven tractor.
- (c) Low maintenance required- Since no sophisticated device has been used in bullock driven tractor, so it requires low maintenance.
- (d) No vibration and noise problems- The engine is not used in bullock driven tractor, so it has no vibration and noise problem.
- (e) No pollution- Since no fossil fuel has been used in operation of bullock driven tractor so it does not create any type of pollution and vibration.
- (f) Easy to assemble and disassemble. Farmers can do it themselves- The attachments are simple and low weight which can be easily attached by the farmers themselves.
- (g) Easy handling features suited to the major requirements of small farmers.
- (h) The extra equipments like tool box, umbrella, first aid box, etc. may be provided which are helpful for the farmer during operation.
- (i) Helps in reversal of Rural Deficit Trade Balance- By the use of bullock driven tractor, the farmers need not to take the heavy loans from bank, so it will help in reversal of rural deficit trade balance.
- (j) Save foreign exchange- Since no device/part need to be imported so no foreign exchange will involve.
- (k) No adverse effect on health and immunity system- Since the bullock driven tractor do not create any pollution so it has no adverse effect on the health and immunity system of the operator.
- (l) Helps in improving humus, micro-nutrients and soil productivity including
Since bullocks are used in bullock driven tractor, their dung and urine help in improving the physical and chemical properties of the soil, humus, micronutrients and ultimately soil productivity.
- (m) Checks ground water depletion- Using bullock driven tractor in tillage operation will improve the physical properties of the soil due to which percolation of rain water in to the soil will be more and it will recharge the ground water, thus use of bullock driven tractor will check the ground water depletion.
- (n) Low cost- The cost of diesel tractor is very high while the cost of bullock driven tractor is very less, so farmers can afford it.

(o) Save about 1500 liters of diesel costing more than Rs50000 per annum- In operation of bullock driven tractor no fuel is used thus the farmer would be able to save the expense to be incurred on fuel.

(p) All attachment of farming operations have been miniaturized suitable for bullocks- The attachment of the bullock driven tractor can be adjusted for various farm operations as per the need and suitability to the bullocks.

(q) Avoid 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.

(r) Even elderly person of either sex can be operate- Since the operator/ploughman sit on the tractor during operation, even old man/women can operate the tractor.

(s) Checks global warming/climate change- Since physical energy of the bullocks is used and no fossil fuel/thermal power is used, the operation checks global warming/climate change.

6. Methodology for Present Investigation-

As mentioned earlier, the idea was emerged in a RuTAG workshop held at IIT Delhi in which emphasis was laid on systematic evaluation of the bullock driven tractors. The team from IIT Delhi surveyed the available literature, pamphlets, notes provided by the concerned NGOs, manufacturers, studied the various models of bullock driven tractors developed in various parts of the country by their manufacturers/suppliers. The criteria to evaluate various models were decided based on their order of importance. After deciding the criteria for evaluation, the team decided to conduct field visits for on the spot study of the models, discussed with the manufacturers and collect all possible data/information on each model. The performance was evaluated on the basis of data collected from the manufacturers than a performance index was calculated.

The sites visited are Bulandshahar, Kanpur, Indore and Bhopal for investigation to find out the specific details of each model, their performance in the field and to find out as

which model of tractor is best for farmers as per performance criteria laid down. The criteria are weight, size, cost, width and size of wheel, functioning in various types of soil, cultivation capacity, various operations/attachments repairs and maintenance and functionality.

The brief descriptions of the criteria are given below: -

- a) Weight- The weight of attachment is important because its operation makes the soil compact due to which water and nutrients do not easily percolate to the roots of the plants.
- b) Tractor Size- Large size of the tractor create hurdle in turning while small size bullock driven tractor can easily turn in the small plots.
- c) Total Cost-Cost is the important factor for the farmers, cheaper model are given priority in selection.
- d) Width of Wheel- The width of wheel is an important factor during operation. A wide wheel is helpful in easy operation of the tractor.
- e) Functioning in various types of soil- The model which can be operated in all types of soil is preferred.
- f) Cultivation Capacity- The tractor which can cultivate more area in unit time is preferred.
- g) Easiness in Operation- Physical labour/drudgery during the operation is an important factor which is taken care during the selection of the model.
- h) Maintenance- Repair and maintenance is important because farmer would always select the model which requires lesser repair and maintenance.
- i) Functioning- The model in which more attachments can be fixed is always given priority.

7. Comparison of the three different models of Bullock drawn Tractors-

S. No.	Kamdhenu Bullock Driven Tractor	Brahmpuri Bullock Driven Tractor	Shekhar Bullock Driven Tractor
1.	It does not work in black soil.	It works successfully in black soil.	It can be used in all types of soil.
2.	The attachment cannot be maneuvered from operator seat.	Screw drives are provided to maneuver the attachments from operator seat.	
3.	This model is approved by Farm Machinery Training and Testing Institute, Govt. of India, Hissar.	Not approved by any testing institute.	Not approved by any testing institute.
4.	More attachments and accessories are provided by manufacturer as a package along with the tractor.	Only cultivator, seed drill box, dug foot and twine are provided by manufacturer along with the tractor.	Only cultivators, disc harrow, plough, leveler are provided by manufacturer along with the tractor.
5.	Wheels of tractor are made from Mild Steel.	The wheels of Maruti 800 Car have been used in this tractor.	The wheels of tractor are made from Mild Steel.
6.	Beam is made of wood.	Beam is made of Mild Steel.	Beam is made of Mild Steel.
7.	Total cost is about Rs.45,000	Total cost is about Rs.18000	Total cost is about Rs.35,000
8.	Large number of Tractors has been provided with Govt. assistance.	Relatively small number could be sold without any Govt. help.	Small numbers could be sold without any Govt. help.

8. Merits and Demerits of the above three models of bullock driven tractors-

Merits of Kamdhenu Bullock Driven Tractor:

- (a) The length of the model is less as compared to Brahmpuri Bullock Driven Tractor and Shekhar Bullock Driven Tractor.
- (b) More attachments can be used in comparison to Brahmpuri Bullock Driven Tractor and Shekhar Bullock Driven Tractor.
- (c) Cultivation capacity of this model is comparatively more than Brahmpuri Bullock Driven Tractor and Shekhar Bullock Driven Tractor.
- (d) This model can plough 2.66 acres in 8 hours.
- (e) The model is approved by Farm Machinery Training and Testing Institute, Govt. of India, Tractor Nagar, Hissar, Haryana.

Demerits of Kamdhenu Bullock Driven Tractor:

- (a) The cost of this model is more than Brahmpuri Bullock Driven Tractor and Shekhar Bullock Driven Tractor.
- (b) Attachments are lifted manually.
- (c) This model is unfit to work in clay soil.

Merits of Brahmpuri Bullock Driven Tractor:

- (a) Total breadth of the model is comparatively lesser than Kamdhenu Bullock Driven Tractor and Shekhar Bullock Driven Tractor.
- (b) The weight of this model is lesser as compared to Kamdhenu Bullock Driven Tractor and Shekhar Bullock Driven Tractor.
- (c) This model can work in all types of soil.
- (d) It is cheaper than Kamdhenu Bullock Driven Tractor and Shekhar Bullock Driven Tractor.
- (e) The attachments are lifted with the help of revolving screw.

Merits of Shekhar Bullock Driven Tractor:

The attachment is lifted with the help of manually hydraulic system.

Demerits of Shekhar Bullock Driven Tractor:

It can work properly in light soil only.

9. Salient Results of the present study-

Now we come to the results and discussions. In this section firstly we compare important parameters of all three tractors. The parameters like material, length, breadth, weight, size of wheel etc. are used in the comparison table. The comparison table is as follows-

NAME OF INDUSTRY	Santosh Brothers Bulandshahar (U.P.)	Rajasthan Mechanical Works Ltd. Jaipur	Shri Durga Engg. Works Pvt.Ltd. Kanpur (U.P.)
NAME OF TRACTOR (Source of Data)	Kamdhenu (Manufacturer)	Brahmpuri (Dealer)	Shekhar (Manufacturer)
MATERIAL USED (Source of Data)	M.S. (Manufacturer)	M.S. (Dealer)	M.S. (Manufacturer)
TOTAL LENGTH (mm) (Source of Data)	2940 (By measurement)	3500 (By measurement)	3100 (By measurement)
TOTAL BREADTH (mm) (Source of Data)	1590 (By measurement)	1100 (By measurement)	1200 (By measurement)
TOTAL WEIGHT (without attachment) (kg) (Source of Data)	70 (Manufacturer)	65 (Dealer)	85 (Manufacturer)
WHEEL SIZE (Dia.in mms.) (Source of Data)	425 (By measurement)	305 (By measurement)	980 (By measurement)
NO. OF ATTACHEMENTS (Source of Data)	(a) M.B. Plough (b) Desi Plough (c) Cultivator (d) Disc Harrow (e) Seed Drill Box (f) Leveller (g) Ridger (h) Digger (Pamphlet)	(a) Cultivator (b) Seed drill box (c) Dug foot (d) Twine (Pamphlet)	(a) Cultivator (b) Disc harrow (c) Plough (d) Leveller (e) Trolley (Pamphlet)

SOIL TYPE (Source of Data)	All types (except black soil) (Manufacturer)	All types (Dealer)	All types (mostly on light soil) (Manufacturer)
CULTIVATION CAPACITY (Source of Data)	1 acre in 3 hr (Manufacturer)	1 acre in 3.5 hrs (Dealer)	1 acre in 4 hrs (Manufacturer)
WORKING IN 8 HOURS	2.66 acre	2.28 acre	2 acre
TOTAL COST (Rs) (Source of Data)	45000 (including total package) (Dealer)	18000 (including total package) (Dealer)	35000 (including total package) (Manufacturer)

10. Detailed Comparison of Salient Features of Three Different Models of Bullock driven Tractors-

S.NO.	PERFORMANCE CRITERION	C-1
(1)	Weight (Desirable: Without attachment)	x_1
(2)	Tractor size (Desirable: Length x Breadth)	x_2
(3)	Total cost (Desirable: Low cost)	x_3
(4)	Width of Wheel (Desirable: More width)	x_4
(5)	Functioning on various types of soil (Desirable: All types of soil)	x_5
(6)	Cultivation capacity (Desirable: More area cover in minimum time)	x_6
(7)	Easiness of operation (Desirable: Easily operated)	x_7
(8)	Maintenance (Desirable :Less maintenance)	x_8
(9)	Functionality (Desirable: Max. attachment use)	x_9
(10)	Algebraic sum ($X=x_1+x_2+\dots+x_n$)	
(11)	FINAL SCORE= A.S./90x100	

11. Evaluation of different models of Bullock Driven Tractors-

The various designs of the Bullock Driven Tractors are rated based on several performance criteria like weight, size, cost, maintenance, functions of attachments, etc. Each criterion is rated on a scale of 0 (Poor) to 10 (Excellent). In this way we get a single performance index for each BDT which represents a sum of total of all the desirable features which one expects in a BDT. The performance index for BDT is given below:

SCORES: - (a) Excellent-10 (b) Good-6 (c) Average-2 (d) Poor-0

S.NO.	PERFORMANCE CRITERION	Santosh Brothers Bulandshahar (U.P.)	Rajasthan Mechanical Works Ltd. Jaipur	Shri Durga Engg. Works Pvt. Ltd. Kanpur (U.P.)
(1)	Weight	6	10	2
(2)	Tractor Size	2	6	10
(3)	Total Cost	2	10	6
(4)	Wheel Size	6	10	2
(5)	Functioning on various types of soil	10	10	6
(6)	Cultivation capacity	10	6	2
(7)	Easiness of operation	6	2	10
(8)	Maintenance	2	10	6
(9)	Functionality	10	2	6
(10)	Algebraic sum	54	66	50
(11)	Final score	60 %	73.33 %	55.55 %

The three BDT's chosen for the study are assess and compared using the performance index developed in the previous section gives details of the assessments of the three BDT's. The performance indexes of the three BDT's are as follows-

S.NO.	NAME OF BDT	PERFORMANCE INDEX
(1)	Kamdhenu Bullock Driven Tractor	60 %
(2)	Brahmpuri Bullock Driven Tractor	73.3 %
(3)	Shekhar Bullock Driven Tractor	55.5 %

Based on the above assessment the brahmpuri bullock driven tractor seems to have better feature as compared to the other two bullock driven tractors. However it should be noted that the above performance index is just a suggestion index which may be depend on subjective evaluation.

12. Directions for Improvements-

Before improvements in BDT we find out some problems in BDT regarding its functions. The comparison and the performance index of the three bullock driven tractors on the collected data was carried out in the previous section. Based on this comparison and feedback from the farmers the difficulties experienced in the usage of three BDT's are identified. The following table gives details of these difficulties and observations about three BDT's: -

NAME OF MANUFACTURER	Santosh Brothers Bulandshahar (U.P.)	Rajasthan Mechanical Works Ltd. Jaipur	Shri Durga Engg. Works Pvt. Ltd. Kanpur (U.P.)
PROBLEMS /OBSERVATIONS	(a) Attachment is needed to be lifted manually.	(a) The attachment is lifted with the help of revolving screw but the tractor should be stop while lifting attachment.	(a) The attachment is lifted with the help of manually hydraulic system but the tractor should be stop while lifting the attachment.
	(b) The lever is made up of iron.	(b) The lever is may be made up of iron or wood as per farmers availability	(b) The lever is may be made up of iron or wood as per farmers availability.
	(c) Difficulty in the turning due to heavy attachments and large size of lever.	(c) Difficulty in turning because of large size of lever.	(c) Difficulty in turning due to heavy attachment.
	(d) More weight of attachment causes more fatigue and stress on the bullocks.	(d) More weight of attachments causes more stress and fatigue on the bullocks.	(d) More weight of attachments causes more stress and fatigue on the bullocks.
	(e) This tractor has not tested on black soil.	(e) It works with all types of soil.	(e) It works properly with light soil.

	(f) It is approved by Farm Machinery Training and Testing Institute, Govt. of India, Tractor Nagar, Hisar.	(f) It is not approved by any Govt. institute.	(f) It is not approved by any Govt. institute

The difficulties experienced with the three BDT's were identified. The observations give an idea of direction along which improvements need to be made. There are some suggestions for design improvements are proposed so as to make the existing BDT's more efficient. The suggestions are-

- (a) There is problem in lifting the attachment in BDT after the harrowing, cultivating etc. so for lifting the attachments we can use any mechanical system from which the problem of lifting is solved.
- (b) There is a need to redesign the lever to keep it small and make it to stiff so that the problem of turning is solve. We also use hollow lever in tractor because it has less weight.
- (c) The weight of attachments is reducing without change in design. For proper working of attachments with soil we can use the spring loaded system.
- (d) There is a need to use wheels which have less weight for ex- wheels of Maruti 800 is best for BDT.

13. Conclusion-

The bullock driven tractors are studied under the project have the scope of adaptive R & D. Therefore the models need comprehensive technical study in the workshop and evaluation of operation in the field also. None of the models are perfect in their present shape so there is need for further study/evaluation and improvement in the existing designs/models.

14. Source of Information-

- (a) Papers provided by Bharatiya Cattle Resource Development Foundation, New Delhi
- (b) Catalogue of Central Institute of Agriculture Engineering (CIAE), Bhopal,
- (c) Pamphlets and leaflets provided by manufacturers:
 - (i) Santosh Brothers Bulandshahar (U.P.)
 - (ii) Rajasthan Mechanical Works Ltd, Jaipur, and
 - (iii) Kanpur Goshala Society; Kanpur.
- (d) The information/data collected from the different manufacturers during the visit.
- (e) From different newspapers.
- (f) Final Report of Minor Project (RDL750
- (g) Animal energy-The Potential and Utilisation in India By Dr. R.K.Pillai Cartman, Bangalore.)
- (h) The number of pair of bullocks in various states of India was as follows. The data is collected from Deptt. of Animal Husbandry, Dairying & Fisheries (2007) Ministry of Agriculture, GOI
- (i) <http://www.indiaenvironmentportal.org.in/430>
- (j) Ministry of Agriculture, Deptt. of Animal Husbandry vide letter number 43/1-2005/Admn III (RTIA) of Feb.14, 2006
- (k) Information/data collected from different websites-
 - <http://www.organiser.org/dynamic/modules.php?name=Content&pa=showpage&pid=307&page=31>,
 - http://www.sanitation.kerala.gov.in/pdf/workshop/Self_sustainability_and_employment_generation_with_cow_and_Its_Progeny.pdf,
 - <http://www.youtube.com/watch?v=o-1AOb1ocd0>
 - http://www.krishiworld.com/html/agri_engg6.html

 - <http://www.atnesa.org>

 - http://www.krishiworld.com/html/agri_engg3.html

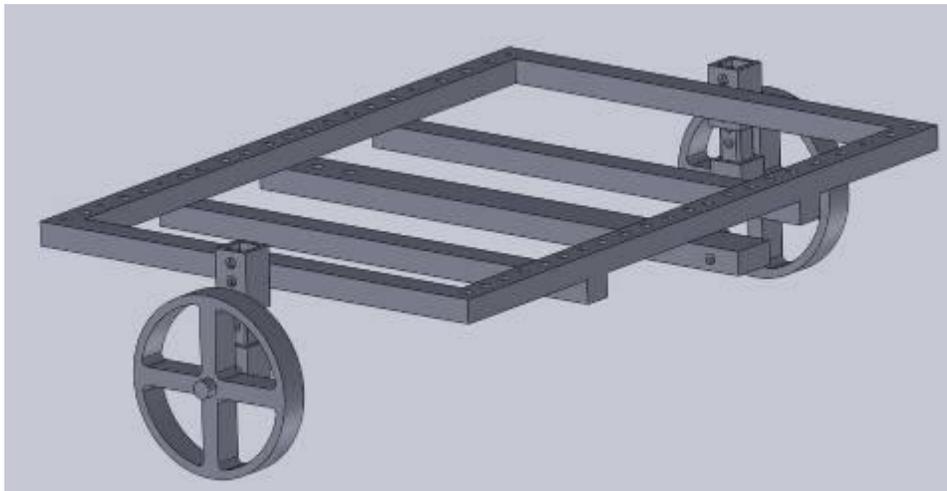
 - <http://www.indiaenvironmentportal.org.in/node/17055>

 - http://www.greenenergysolutions.co.in/rural_portable_generator.html

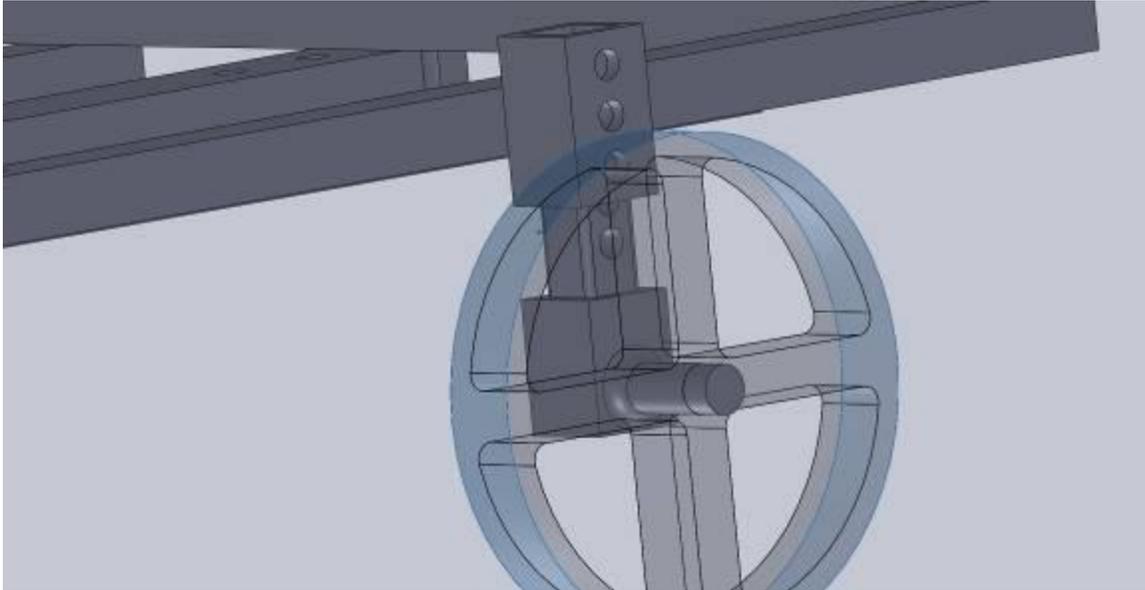
<http://www.agriinfo.in/?page=topic&superid=9&topicid=87>

<http://www.veternaryworld.org>

15. Drawing for future work-



3D model of the Platform

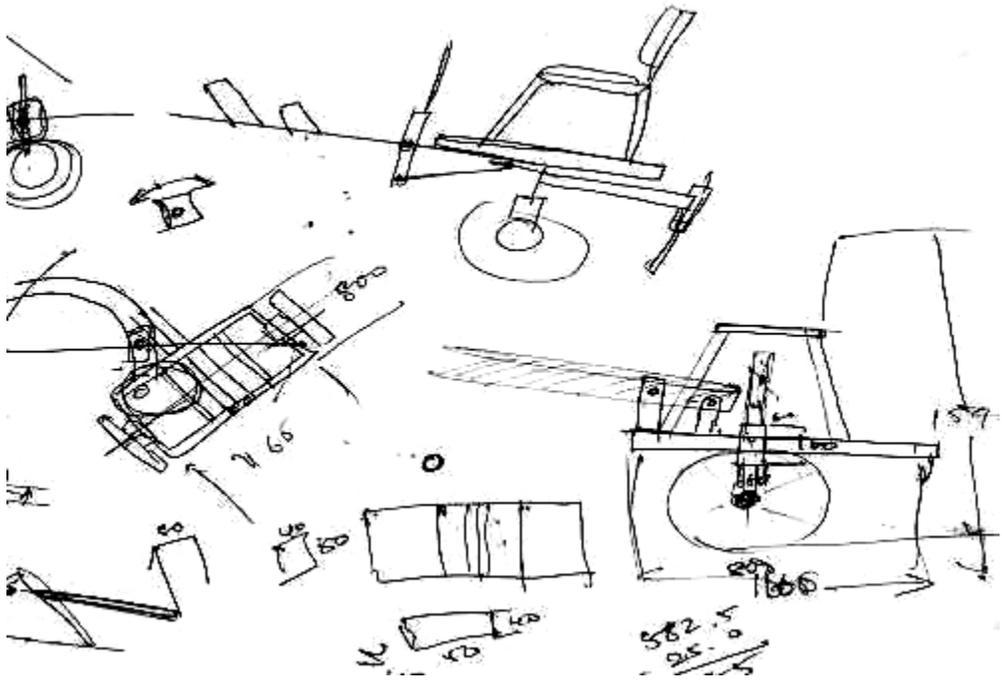
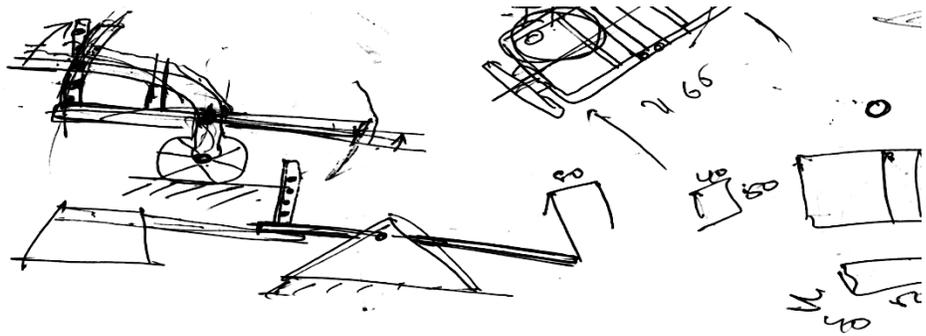


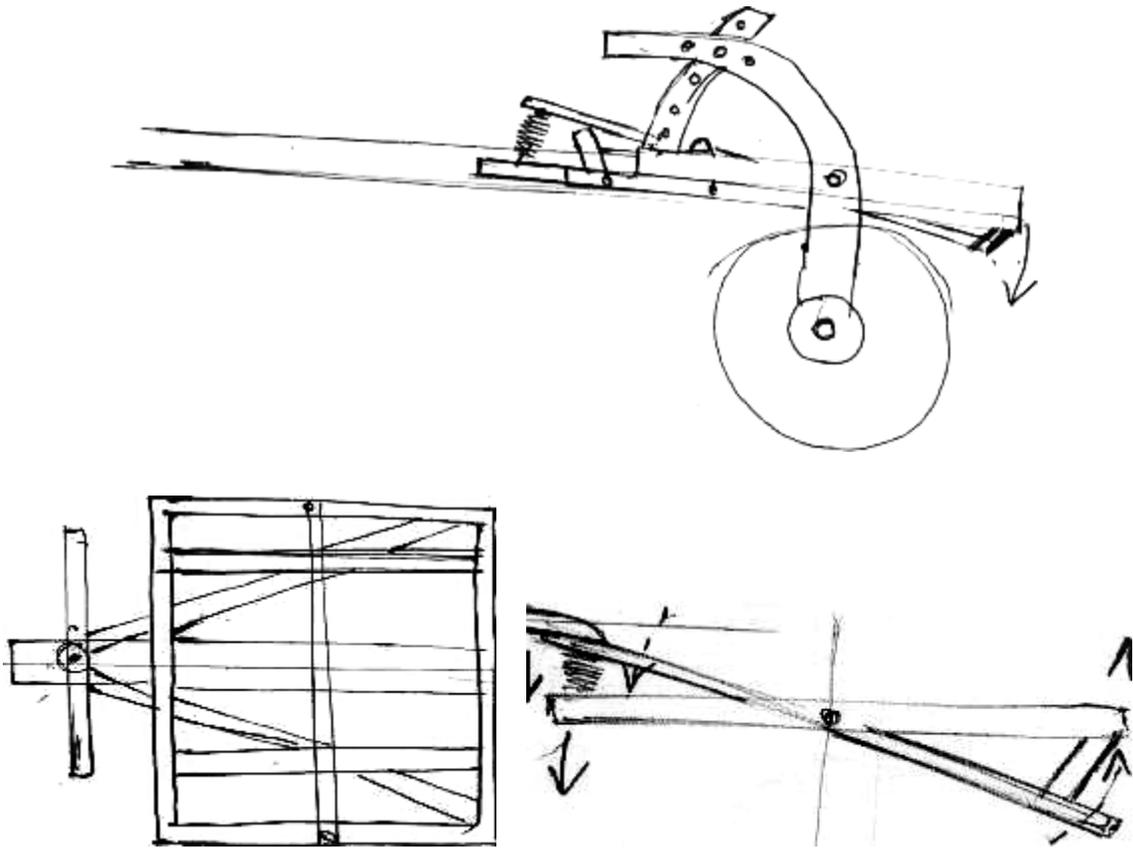
Height Adjustment Mechanism

Looking at the problems we suggested some changes in the design of the above frame, but the difficulties were;

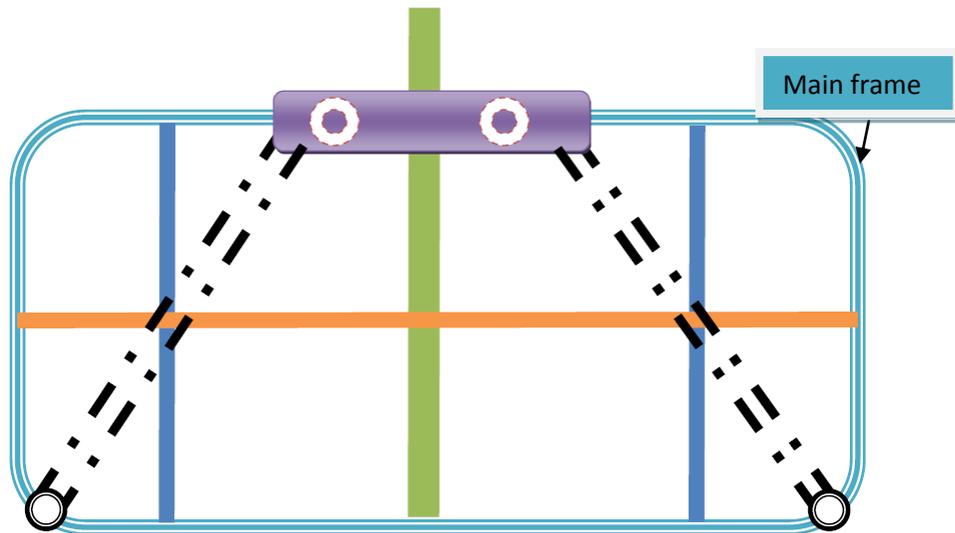
- Cost
- Ease of Manufacturing
- Weight
- Ease of Operation for a single Person
- Ease of Maintenance

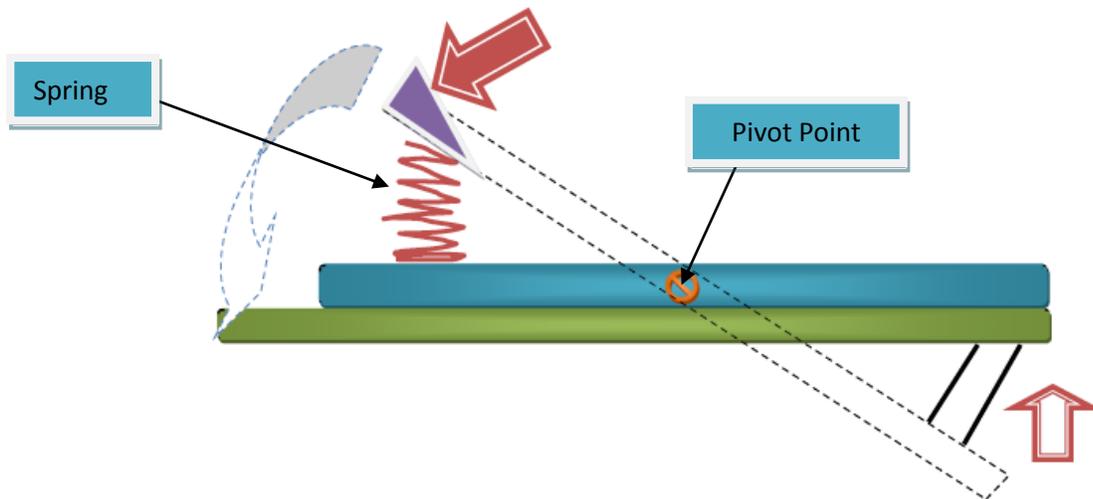
So keeping all the above facts in mind, we did some brainstorming sessions and came out with some solutions and from those we selected one and decided to work on that, here are some of those sketches:



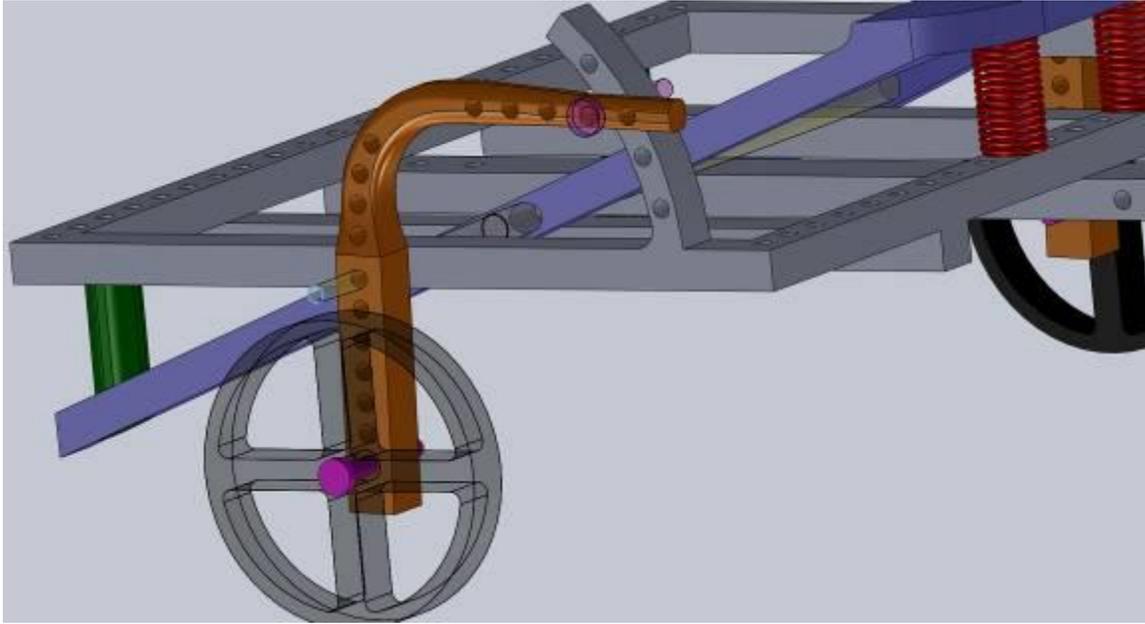


Sketches during Redesign





So keeping this mechanism in mind, we developed the design on the old dimensions of the platform that were provided by the manufacturer. What we did was, we changed the fixed slots for height adjustment to a pivot point, where we can attach one attachment which can be used for both height adjustment and varying the pressure. Also what we did is, we provided a arc on the frame itself on which we can engage or disengage the whole mechanism, so the farmer need not to step down to change the height. And we provided one more attachment that a farmer can push with his legs so that he can easily adjust the pressure on the attachments which are being used for the ploughing. On the above basis we developed a 3-D model.



Schematic Diagram to show the Mechanism

For the solution of maneuvering of the main frame or the platform without getting down from it we provided a new member, which is pivoted on the main frame, and we did some modification in the main frame too by adding an arc where we can slot in the new member as shown in the figure above. Moreover the height of the wheels can also be adjusted as we provided slots for height adjustment.

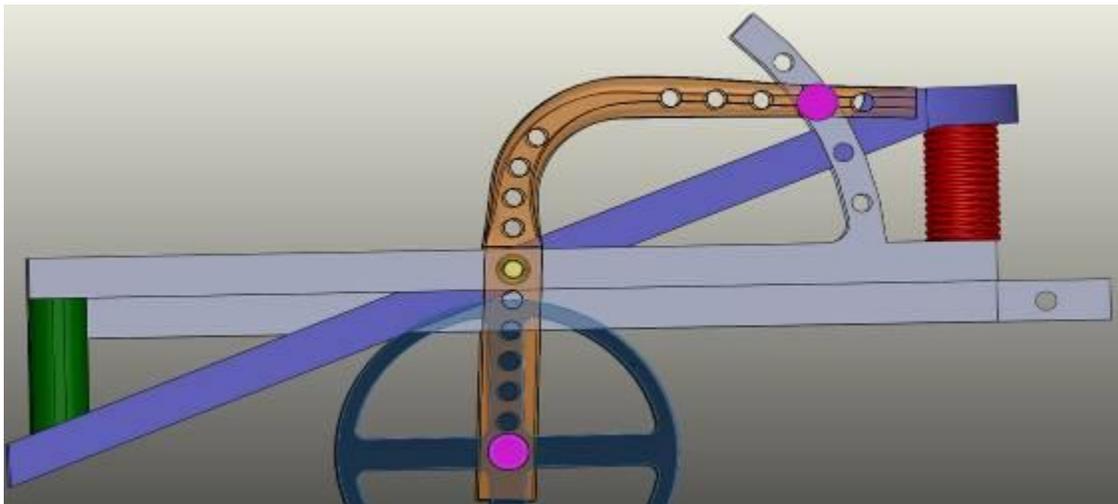


Diagram to show the Mechanism

Another member we added was attached with the main frame and other end is resting on two springs as shown in the figure above, and the end serves as a foot rest too. The farmer just have to push the Foot-rest and that will act as a lever and pulls up the frame from the other end, thus allowing the farmer to move the attachments up and down so that it can be easily pulled by the cattle.

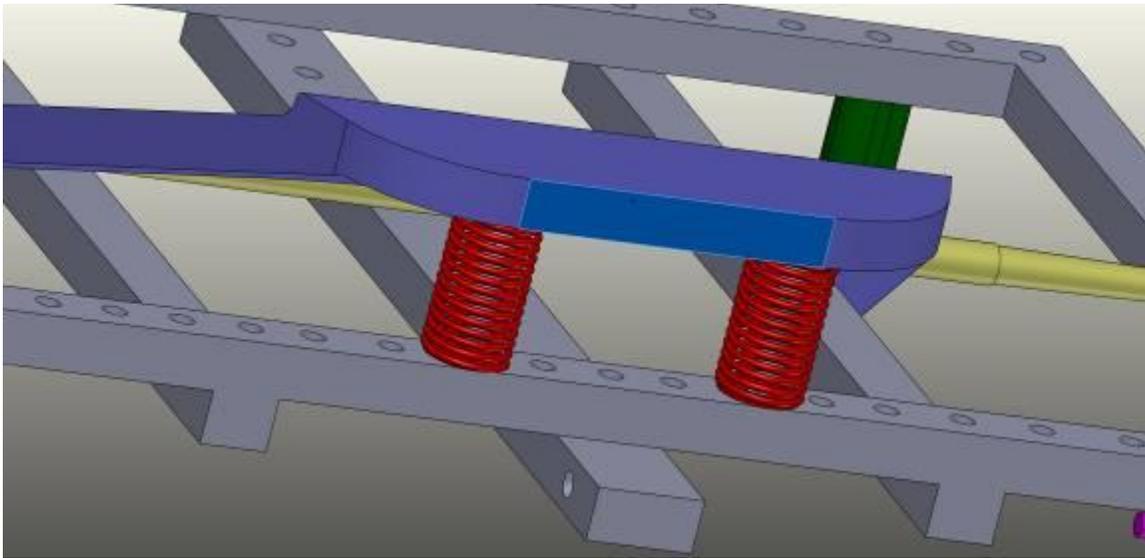
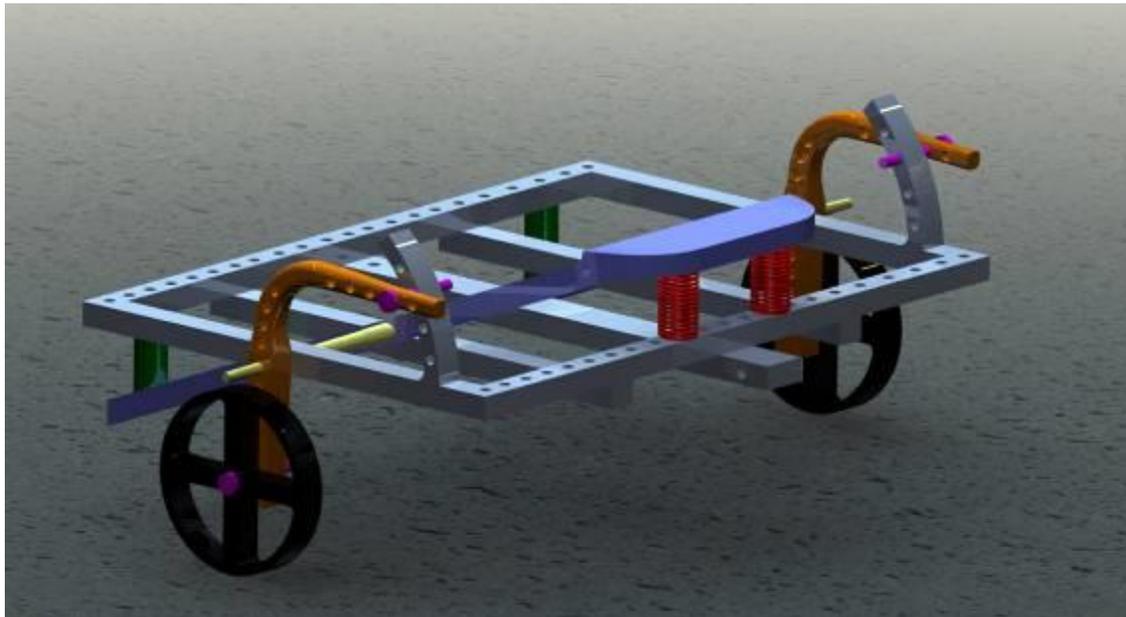


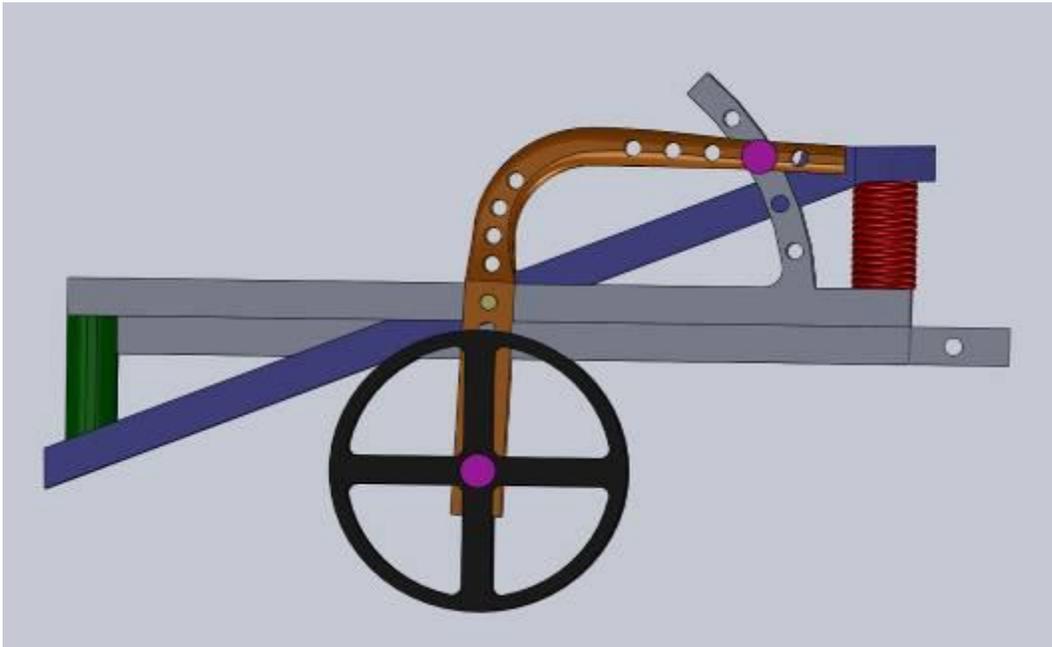
Diagram to show the spring

These springs will be mounted on the main frame, and needs to be pushed when the attachments need to be pulled up.

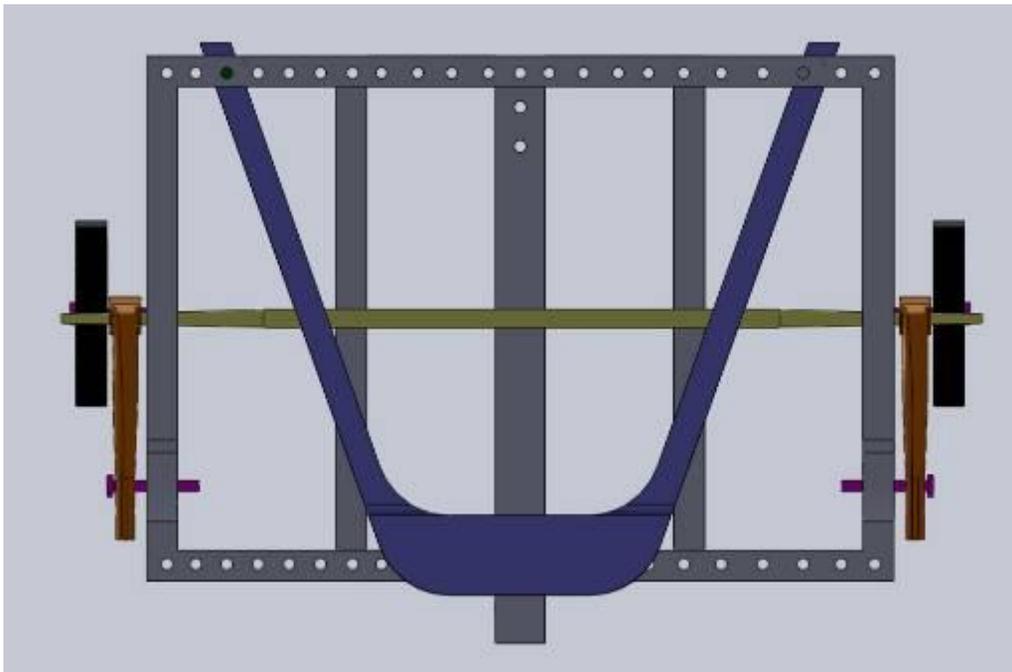
Full Assembly of the Tractor Designed



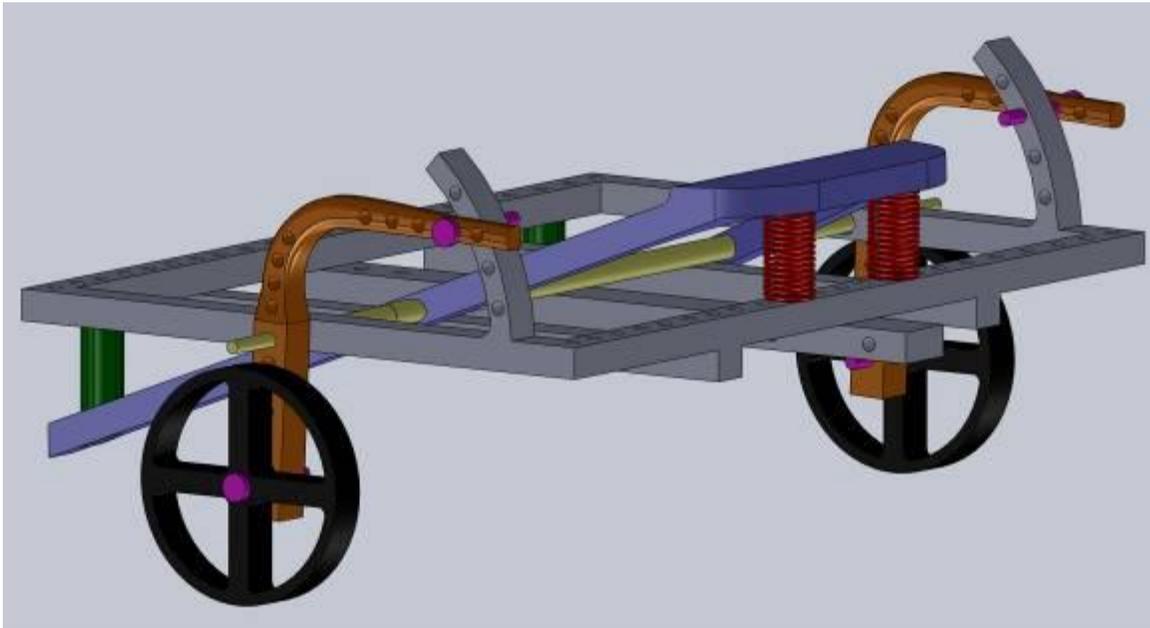
Assembly



Side View

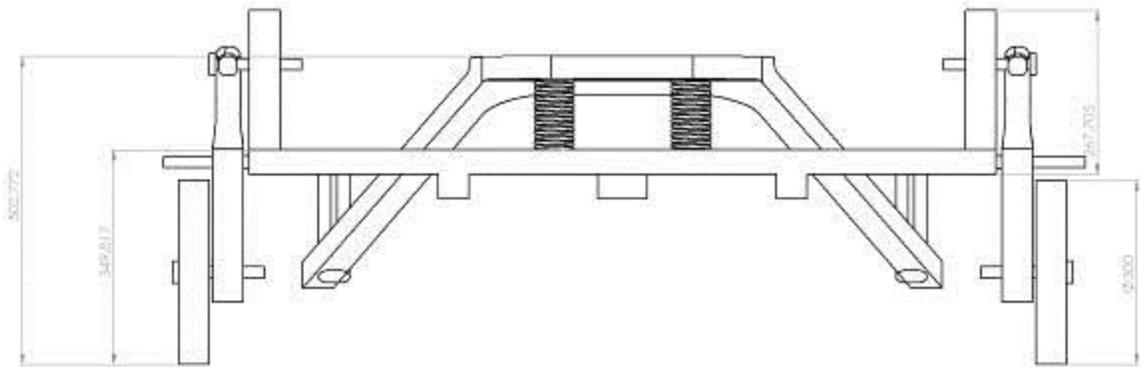


Top View

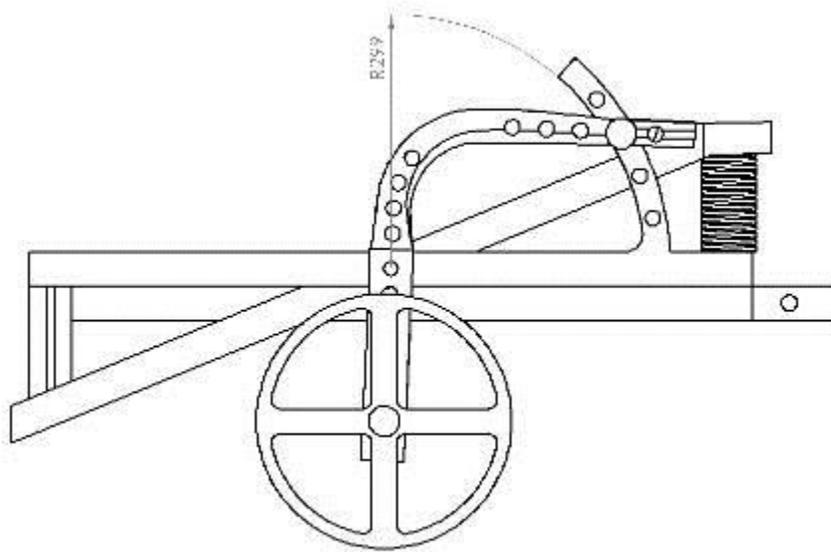


Whole Assembly

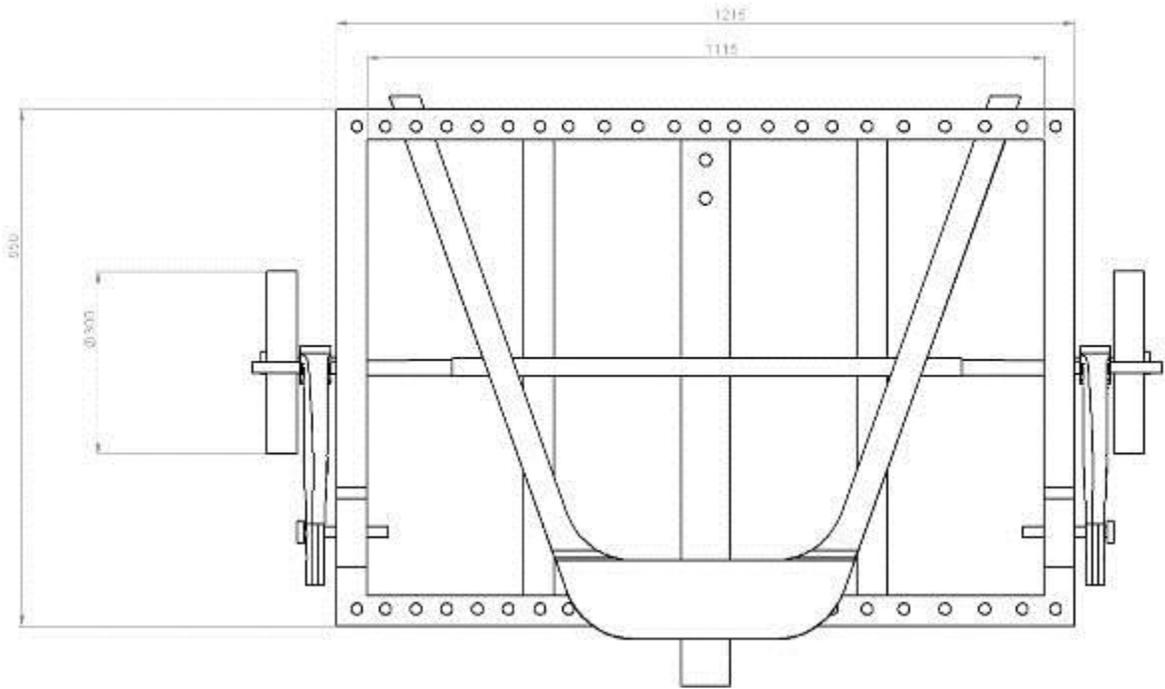
Engineering Drawing:



Front View



Side View



Top View

Further suggestions:

- There are lots of place that can be redesigned to make the tractor more efficient and cheaper, for which there should be a design team that should be formed to get the best output.

- The main areas for redesign should be analyzed technically, that will help more and more farmers to switch to this kind of technology. As there is abundance of cattle in our country, and the tractor itself is much cheaper than a regular tractor.