Comparative Study of Bullock Driven Tractors

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.
- Back bone of Rural economy & an asset in bio-diversity terms.

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.veterinaryworld.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.veterinaryworld.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 Ghani, 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 31 million 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.krishiworl.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. 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.
3. 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.
4. 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.
5. Keni or Levelling Karaha is used in soil conservation for making bunds and leveling the land.
6. Soil Scoop is used when the soil is to be carried to a fairly long distance.

7. Ridger ploughs have double mould boards. There are in three sizes—the light, medium and heavy.

8. 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.

9. 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.

10. 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.

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. 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??

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.
Fig. 1 Visit for Kamdhenu Bullock Driven Tractor