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APPROPRIATE TECHNOLOGY  
FOR  
RURAL ENERGY

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PLANNING AND DEVELOPMENT OF ANIMAL ENERGY RESOURCES IN INDIA  
Background Paper

PLANNING AND DEVELOPMENT  
OF  
ANIMAL ENERGY RESOURCES IN INDIA

by

N. S. Ranaswamy

## Introduction

1. Progress of civilization is closely linked with the services of work-animals to mankind for millenium. Work animals not only provide motive power to millions of ploughs, carts and agricultural implements but also leave behind to man food and leather at the end of their working life. In our country the contribution of work animals to the economy is of paramount importance. Yet, by and large, we have neglected their development, utilization and welfare. We extract excess power from them beyond their normal capacity by resorting to cruel methods. Development of animal energy resources and their proper utilization, and a bit more of timely care and compassion to the work animals will be definitely going to benefit our country. Our poor people, farmers and carters, the environment, the economy, and the society at large have a stake in them, and therefore, owe a responsibility to pay attention to this vital resource.

## Animal Energy Neglected

2. All over the world, scientists are searching for new forms of energy. A great deal of Research and Development effort is going on everywhere, including in India, to tap energy from sun, wind, tides, dung, etc. Hugh investments and millions of man hours of scientific and engineering talents are being mobilized and applied to hundreds of other areas, yet, here is an excellent example of a readily available source of energy - most appropriate and within the economic and technological capability of millions of farmers - totally neglected. Whatever efforts are now going on regarding work animals are only a fraction of a fraction of what is needed, considering the investment and the vast potential of economic benefits to the country and reduction in suffering to the animals.

## Magnitude of Animal Power

3. We have roughly 80 million work animals - 70 million bullocks, 8 million buffaloes, 1 million horses and 1 million camels. In addition, there are donkeys and elephants which are

also used as work animals. Though no reliable scientific data are available, for purposes of general calculation, we may take that each animal is capable of generating, on an average, half a horse power (for details see Note 1). This means that our work animals can generate 40 million H.P., i.e., equal to approximately 30,000 M.W. of electrical power. Incidentally, installed capacity of electrical energy today is only 26,000 M.W. Not many are aware of the magnitude of power made available to us by these worthy animals. To produce and make available 30,000 M.W. of energy at the millions of points of application, would need an investment of 300,000 millions of rupees. A work animal may cost anything between Rs. 500 to Rs. 2000. Investment today on work animals and the adjunct infrastructure may be of the order of Rs. 100,000 million.

#### Neglected System

4. In spite of such a colossal magnitude, the system is neglected. Part of this neglect is apparently due to an impression amongst scientists and policy makers that animal energy is a passing phase in development, and that modernization of agriculture, and even our society, would necessitate elimination of work animals. Well meaning professionals and scientists have warned that this work on animal energy may well be a retrograde step, and that we should allow this system to die a natural death. I agree that work animals are to be eliminated as an energy source. But that day is far off. Are we to keep quiet till then? Perhaps not. Economic analysis would reveal that this is just not feasible, and may not be even desirable, for years to come. Animal energy will remain as the appropriate energy resource for this country's peculiar situation.

#### Animal and Farm Output

5. Methods ranging from the primitive to the modern mechanized ones are being used in Indian agriculture. It has been estimated that two-thirds of the energy input into our farms comes from animals, and out of the rest, 20% comes from

man's muscle and only 10% from other forms of energy like fossil fuels, hydro-electric and thermal resources. Scientists estimate that only if the present energy input level to our farms is doubled, optimum output could be obtained. This means that there is a real shortage of energy in the agriculture sector. Such a large quantity of energy may somehow come by over a period of time, though not easily, from hydro-electricity, thermo-electricity or fossil fuels. But capital investment of great magnitude is required to tap these resources. A massive investment is being contemplated during the Sixth Plan period to substantially augment electrical energy. Planners wish to allocate a good part of it to rural areas.

6. But the process will necessarily take time, meanwhile, there is a demand for electrical energy from other equally vital sectors. We are importing crude oil to the extent of 20 million tons. In view of the international crisis in crude oil, free use of diesel for farm needs is not feasible in the future, unless indigenous availability goes up substantially. All these factors point towards the need for exploring possibilities of augmenting animal energy - the one already in position.

#### Trend away from Animal Energy

7. A certain amount of mechanization is, and would be, taking place in specific regions and in individual farms scattered all over the country, where conditions are conducive to such a switch over. This need not be discouraged. On the contrary, this process can even be encouraged so that over the next few decades work animals can be replaced. However, those conditions for large scale application of diesel or electrical energy do not now exist over parts of the country. In the meantime, animal energy is appropriate in most situations and is available in abundance. Efforts should be made to apply animal energy intensely, productively and efficiently. Simultaneously, efforts to tap energy from sun, wind and tide and extension of conventional energy can continue. It is not as if we have to live with animal energy for ever, far from it. It is complementary to other resources today.

### Animal Energy - Why

8. Improvement would call for, first of all, a great deal of technological, economic and social surveys as well as studies of all aspects of work animals, their utilization methods, economic and social efficiency, etc. Massive effort should be immediately made by way of R & D, Organization & Systems in order to put Animal Energy Resource Management on a scientific and humanistic plane. The following points may be pertinent here:

- a) There is shortage of energy in the farms
- b) Animal energy is already available and is appropriate to our needs
- c) Animal energy can be augmented
- d) Crude oil has to be imported, and there is alternate demand for electrical energy from coal and hydel
- e) Energy from sun, wind and tides will take decades before they are available for mass level application at reasonable rates.
- f) Animal energy is under-utilized, and there is tremendous wastage at all levels

### Animals - part of Rural Scene

9. The above factors are strong enough to show that animal energy resources are appropriate and cannot be neglected in India and several developing countries. Situations where animal energy is appropriate are simple and easy to comprehend. Over 60% of our farm holdings are small - less than one acre or less. This size of farm cannot justify the use of tractors. For holdings of less than 10 acres or so, tractors may not be economical. Hence, most of our farmers cannot afford to have a tractor. Even where they can afford, the maintenance, infrastructure and technical manpower are not easily available. Though Government agencies have taken a number of measures to improve farm efficiency, the use of tractors and the replacement of animal energy by diesel have not gone a long way.

10. Energy is readily available with the farmer in the form of animals. The farmers use the animals for a good variety of purposes. Over and above agricultural uses, the farmer uses the animal energy for drawing his carts, if he has one, for lifting water for irrigation for oil extractions, for threshings etc. When a male calf is borne - it is either kept by the farmer or sold off to be used as work cattles. No initial investment is made in many cases. The process goes on as an integral part of village custom and routine. The feed for animals come mainly from pasture land and fodder from the farmers' own crops. The animal dung is useful in agriculture as manure and in domestic life as fuel. After the working life is over, animals are usually sold for the production of meat and leather. Thus the animals fit into the real scene in a fundamental manner. Bio-gas plants are coming up using dung more efficiently. Again, a case in favour of animals.

11. Though there is no reliable estimates regarding the allocation of animal energy as per the various types of applications, a qualitative analysis shows that they are used for:

- a) Exclusively for ploughing
- b) Ploughing, water lifting and other farm operations
- c) Ploughing and carting
- d) Exclusively for carting as in cities and semi-urban areas
- e) Carrying load as in the case of mules, donkeys, etc.

#### Carts for Rural Transportation

12. There are some estimates to show that 2/3rds of rural transportation of goods is in animal drawn carts, 50% of our villages do not have road surfaces fit and safe enough for trucks and tractors. Only animal drawn carts can ply on these roads - tracling all kinds of terrains, ravines, streams, paddy fields and so on. In fact cart is considered as a versatile vehicle evolved over centuries. Loads to be carried at a time, during most parts of the year, are far too small for tractors and trucks. Also, distances moved are short, say 10 to 20 kilometers,



and so is the journey time. Under these conditions trucks cannot be kept busy enough at levels necessary for profitable operations. Moreover, trucks and tractors are beyond the financial means of our typical farmers. All these factors make carts the only appropriate means of transportation in most parts of our rural areas. Carts are used for passenger transport as well. Tractors and trucks will, and shall come in, when favourable factors emerge. However, conditions for the emergence of these factors will take time. Meanwhile, efforts should be made to modernize the animal energy system in the rural areas to keep up the pace of augmenting production, and economic progress.

#### Animals and Mechanization

13. Most of the marginal farmers may not even be able to own animals. They hire them now. Often they do a bad job of preparing the ground as they cannot afford animals - owned or hired - in adequate measure. When he goes up to the next higher economic level, he buys animals, carts, etc. This also leads to the use of fallow land. Such gradual raising of economic competence is being brought about by the impact of a variety of factors such as: better seeds and irrigation facilities, double cropping, land reforms, extended and easy credit, better price for agricultural produce etc. - all improving his economic viability.

14. When the landless labourers, peasants, share croppers, marginal farmers, small farmers, etc., get elevated to the next higher economic group, the process of acquiring animals and carts takes place. That is why, perhaps, we find that population of work cattle and carts is increasing as a whole, and in every state, except in Kerela, Punjab and Haryana, where mechanization is replacing the use of animal energy. The process of increased use of animal energy on one side and mechanization at the other, thus reducing the use of animal energy, will be going on simultaneously. But the predominance of animal energy may continue for quite some time to come.

16. According to some pilot studies, animal drawn carts in urban areas and in cases, where animals are used for exclusively carting in villages, are able to get freight for 200 to 300 days a year. Except in metropolitan cities, where they are being discouraged, cart population is increasing in most towns. Of course, proportion of goods carried by carts, compared to motor trucks in cities, will be small. This is unlike in the rural areas where carts carry a much higher proportion. Cart operations are monetized in cities. Carts with increased carrying capacity using pneumatic tyred wheels give a decent living to the carters in cities as well as in sugar cane growing areas.

17. Carts will be economical and will compete with trucks in cities when:

- a) Distance moved is short
- b) Loads are below the capacity of trucks
- c) Loading and unloading time is high, compared to journey time.
- d) Narrow roads and lanes are involved.

While animals will continue to be replaced by small vans and trucks in certain cities, additional carts will come into operation when villages become larger and reach the population size of towns, which in turn become bigger towns, and so on. This process of mechanization on the one hand and increased use of animals is visualized for the next four decades even in towns. The same conditions exist in the case of transport of sugar and other cash crops where loads is assured for long periods in a year.

18. The foregoing analysis of carting shows that, for the next few decades, mechanization process on the one hand (when villages become cities), and increased use of animal energy on the other, (along with the gradual process of upgrading of marginal farmer to rich peasants and small villages to big towns), will be taking place side by side.

Freight moved by Carts

19. The livestock and bullock-cart census shows that number of carts may be about 15 millions, and that the number is increasing. We have no data to assess type of cart, number of days of use, ownership pattern, cost, animal type, life etc. For that matter, we do not know the sectorwise application of animal energy, to farming and carting. Recently, the Ministry of Shipping and Transport has sponsored a socio-economic survey of bullock-cart transportation, to be conducted by NCAER (National Council of Applied Economic Research) in the North India and the Indian Institute of Management, Bangalore, in the South. Results will be available by the end of 1979. A similar proposal to conduct a comprehensive socio-economic survey of animal energy is being submitted to the Department of Science and Technology. Meanwhile during the last two years, pilot studies were made in some areas with the support of Department of Science and Technology

20. Though not useful for accurate projections, observations during pilot studies and perceptions have given a feel of the situation. Based on these, in an ad hoc way, an attempt has been made below to assess the freight carries by carts. Though the figures are projections on assumed data, the analysis will not be seriously vitiated as the objective is only to assess the order of magnitude of freight carried by carts in rural and urban areas.

Particulars	On predominantly		
	Rural areas	Urban areas	
1. Carts - Millions	12	3	
2. Average freight-tons	$\frac{1}{2}$	$\frac{3}{4}$	) Figures based on pilot studies
3. Average distance moved with freight - kms/day	10	20	
4. Average number of days of use per year	52	260	
	(One day per week)	(5 days per week)	

This is based on the index of organization of India. This is a critical figure, yet to be assessed.

21. From the above, freight carried is calculated as under:

	Million ton kms
1. Freight carried by carts, 12 x $\frac{1}{2}$ x 10 x 52 plying predominantly in rural areas	- 3120
2. Freight carried by carts, 3 x $\frac{3}{4}$ x 20 x 260 plying predominantly in urban areas	- 11700
	<hr/> 14820
3. Approx. Total in million ton kilometers	15000

The figures regarding load levels, number of days of operation and distance moved are typical averages based on observation made during pilot studies in five districts. Even if the data are not accurate, the conclusion that animal drawn carts form an important system cannot be denied.

22. Compared to carts, trucks and railways carry 100,000 and 200,000 million ton kms respectively. Investment in the bullock cart system, including cost of animals, may be Rs. 30,000 million. Investment in railways is a round Rs. 45,000 million.

#### Animal Energy Appropriate

23. These factors indicate the appropriateness of animal energy resources in our country. They have developed through centuries of use and perfection. Rural development today is dependent on animals though more of mechanization will continue to take place. It has also been observed that the animal energy resources of our country are not put to efficient use. In view of this, it is necessary to look into the possibilities of exploiting all potentialities of animal energy resources in the country.

Potentiality of Animal Resources

24. The magnitude of animal energy now available in India and its potentiality for development have not received recognition in India by the policy makers, planners and professionals. Though not reliable scientifically, a few have attempted to assess the energy output of work cattle, such as bullocks and buffaloes. The energy output is dependent on the breed of the cattle, its size and weight, nutrition levels, etc. It is said that draught power is somewhat related to the weight of the animal itself. There is wide variation in size and weight of the cattle in different parts of the country. The giant size bullocks of the Haryana - Punjab region are perhaps double the size of the puny breeds of some parts of South India. The he-buffaloes in the Moradabad Division of U.P. are also, perhaps, double the size of their counterparts in the South. In the South, there are certain breeds such as the Kangayam, which can be compared with the better breeds in the North.

25. It is fortunate that highly scientific work is going on in our country for evolving better breeds of milch cattle, and we have been quite successful in developing high grade milch cattle. Though work cattle are equally important to our economy, the same amount of attention has not been given to them in respect of R & D for developing better breeds. Even the distribution of the better breeds, now in use, to different parts of the country has not been done. It is time that such a conscious developmental effort is made. A massive investment of funds in facilities and personnel is to be made in our R & D centres to raise better breeds of work cattle. The benefits will surely be spectacular. The he-buffaloes are excellent draught animals for certain regions in the country. We have not made attempts to increase the he-buffalo population in the country. Instead, it is reported that, in some places, male calves are killed immediately after birth. The potential of buffaloes and methods of raising them are by themselves projects to be studied and implemented.

26. Two bullocks together are able to give about 80 to 120 lbs. of power, and they are able to walk at the rate of two to three miles per hour. Estimates made by scientists of the draught

power of bullocks are between 0.4 h.p. to 0.6 h.p. It may perhaps be more for certain categories of bullocks and he-buffaloes. As we are concerned here with assessing the order of magnitude of animal energy available, we can take the average figure, that is 0.5 h.p. per animal. For 80 million animals, this will work out to 40 million h.p. which is roughly equal to 30,000 megawatts. Incidentally, this is more than the amount of energy now being produced by electrical installations in the country.

27. It is not suggested that animal energy can be, or should be, replaced by electrical energy. However, the comparison has been made to highlight the order of magnitude of investment required for an alternate source of energy. To generate, distribute and to make available 1 kilowatt of electrical energy at the point of application, investment called for may be about Rs. 10,000. We can produce 1 h.p. with an investment of Rs. 1,000 in animals. To replace animal energy by electrical energy therefore would need an investment of Rs. 300,000 millions. This is not ofcourse strictly true as there are other factors which will reduce the investment required. For instance, electrical motors can work for much longer hours than the animals. Electrical motor may accomplish more work with 1 h.p. than the animals. But we are not able to take advantage of this, since most farms are small and the increased capability cannot be spread over a large number of units due to organizational problems.

28. Studies should be made to compare the maintenance cost of two animals and the corresponding device using electrical or diesel energy. During 8 hours of use, the cost of energy may be (at the subsidized rate) roughly Rs. 1.5. Surely, two animals would cost more for maintenance, if fed with commercial feed. But rural economy is not a system where such input output calculations can be made. Most of the time, the feed is from local resources available at the very nominal cost. Studies on mechanizations with tractors have come out with figures of break even point, cost benefit analysis, investment efficiency capital-labour trade off, etc. But all these are based on the present level of efficiency of animal-implement system, which is not correct.

## Animal Vs Other Energy Sources

29. We are also assuming that the speed and rate of operation are not critical in farm operation and for transporting the kinds of materials now carried by bullock cart. Animal maintenance has to continue even when they are not needed, while electrical motors, tractors and trucks can be shut off. Therefore, comparison between animals on the one hand and other forms of energy on the other, cannot be carried too far. Each is appropriate for a set of conditions, and is complementary.

30. Even for small holdings, tractors can be utilized efficiently and economically wherever tractor service centres giving tractors on hire can be introduced. Tractor co-operatives can also do a similar job, but we have not been successful in introducing tractor cooperatives in a large way. In Kerala, with organized tractor services and infrastructural availability, they have been able to introduce tractors in small farms efficiently. Also in Kerala, labour cost is high and man is competing with animal for land. So the animal is giving way to mechanization. Such things are happening in Haryana and many other pockets in India as well. This process of upgrading to mechanization will continue.

31. Studies should identify factors which impede and foster efficiency - whether by animals or tractors or trucks. Investment, maintenance, infrastructure, organizations, credit, subsidies taxes, laws, land reforms, irrigation rates etc. are some of the innumerable factors that influence efficiency of operations. When these change, economics of animal versus other energy sources would also throw up a different picture. The situation today is that animal energy and their implements have not improved over centuries, and we compare the most modern with these.

32. For instance, for ploughing and carting together, use per year may be only a maximum of 150 days. For the rest of the days, other applications have to be identified. The optimum use of animal energy will depend on the extension and expansion of its uses wherever it is advantageous, and for this the appropriate technological base of animal energy utilization in the diversified form, like

milling, threshing, oil extraction, grinding, blowing etc. has to be established. Similarly, when there is improved economic activity and levels in the countryside, transportation by carts will also get a fillup. When the carts improve their pay load, as described later, they will compete with trucks for short distance traffic, and thus increase their utilization in rural and urban areas.

33. Animal energy should also take over some of the tasks now being performed with manual energy, wherever it is desirable. In the urban areas, carts are already being utilized for a good part of the year fairly intensely. Further, there is good scope for designing numerous varieties of carts for specific purposes, where carts are more appropriate. Water, milk, kersoene, vegetables, beverages, cereals, edible oils, crockery and cutlery for parties, furniture, paper, construction materials and such innumerable other items are to be delivered to distribution or vending points, such as, households, shops, hotels, offices, construction sites, educational institutions, cinema houses etc. Another classical case is garbage collection and disposal. Here numerous collection points are involved, where carts are ideal. In fact, the bins can be so designed as to be loaded as still are and containers, and empties kept in position by another set of carts. A greater deal of the unpleasant and dirty handling now involved can be eliminated. Collection and placement of empties should be done at night - a good solution from the public hygiene and traffic point of view.

34. The characteristics of this kind of transport, which make carts suitable are:

- a) short distances
- b) frequent stops for loading and unloading taking time
- c) speed is not important
- d) loads below truck capacity
- e) numerous supply and distribution points to be reached at the same time
- f) narrow roads and lanes.

But as carts impede smooth and fast flow of traffic, such transport should be during off peak hours and at night.



## Improved Utilization

35. In spite of the lack of sufficient data, it is certain that optimum utilization of the animal energy resource in the country is not now being made. Improvement in the utilization of the existing capacity will lead to increased productivity, which may be obtained in the following ways:

- a) Increased number of days of use per year and number of hours per day to levels, which should not impose any undesirable burden on the animal.
- b) Improved transmission efficiency.
- c) Improved designs of carts, implements, ploughs, etc. yoked to the animal, for increased application efficiency.
- d) Increased draught power itself by better breeds of cattle, giving adequate food of right quality and keeping them healthy.
- e) Increased working life of animals.

36. Studies show that productivity is low on all these counts, and there is enormous scope for improvement. Pilot studies and developments and improvements already effected have shown the potential for improvements.

37. Out of 80 million work animals, distribution between rural and urban areas is assumed as follows:

Animals	In millions		
	Total	Rural	Urban
1. Bullocks	70	65	5
2. Buffaloes	8	8	Small No.
3. Horses	1	Small No.	1
4. Camels	1	1	Small No.
	80	74	6

These figures are by no means accurate. Better figures can be got only when we know the proportion of carts in urban areas.

38. Most of the work animals are in the rural areas (65 million bullocks and 8 million buffaloes). Among these, say, 70 million are used for farming operations, ploughing being the predominant form of use. Ploughing and other farming operations may take upto 100 days a year, and carting about 50 days a year. This means that the animals are put to use only for half a year. (Those engaged exclusively incarting could be using the animals for more number of days.) It is as if 35 million h.p. of animal resource, is lying idle. This is a colossal figure in monetary terms, or from any other point of view. This is at a time, when farms are short of energy by 50%.

39. The following may improve utilization:

- a) increased use of animals for ploughing in multiple cropping when other conditions become favourable
- b) Reclamations of fallow land
- c) Other uses for animal energy
- d) Animal hire services, cooperation etc.

In turn, this would need:

- a) R & D for implements design
- b) manufacture and supply
- c) credit and cooperation
- d) organization and systems
- e) training and extension, etc.

For implementing these projects, extension studies of the hardware and software systems now in use as well as the improved versions are to be conducted.

#### R & D Leads

40. To achieve the objective of improved utilization of animal energy, R & D efforts have to be channelized in several directions. The R & D leads could be identified in each area of activity starting from the generation of bio-energy in the animal to its utilization for purposes like ploughing, carting, water lifting etc. The various types of R & D leads can be classified as:

- a) Harnessing
- b) Improved animal drawn implements

- c) Improved animal drawn carts
- d) Veterinary services
- e) Animal Care
- f) Breed Development

#### Harnessing Devices

41. Today, in India, ploughing is done by two animals, bullocks or buffaloes. The yoke is connected through a pull-beam to the plough. The yoke, the present harnessing device, rests on the neck against the hump of the animal. The whole system entails a certain amount of transmission efficiency loss. Whether the transmission efficiency can be increased by a better harnessing device is yet to be investigated. This is equally true of water lifting, where animals walk down a ramp lifting a large bucket of water, which is discharged when the animals reach the end of the ramp. While discharging, part of the water spills back to the tank or well. After the discharge of water, the animals walk backwards taking the bucket down to the water surface of the well. It can be seen that half the animal's effort is wasted in walking and that too walking backwards. In the Percian wheel, this is avoided since the animal's effort is continuous and water is raised all the time, unlike in the existing case where work is done only in half the cycle. Similarly, threshing, grinding and other operations, now being carried out by old mechanisms, designed in the villages, can be probably improved. Here is a major area for enquiry for R & D methods improvement, etc. in respect of designing better harnessing devices to be yoked to the animal as well as the implements themselves. Better designs will increase efficiency of transmission as well as application.

#### Improved Animal Drawn Implements

42. Work animals are mainly used for ploughing. Traditionally, India has used wooden ploughs, though iron ploughs as well as iron shoed ploughs are in use in some parts of the country. The ICRISAT, an U.N. organization in Hyderabad, is experimenting with improved designs of ploughs, and it is reported that it may be possible to get double the amount of work without extra burden on the animal. But ICRISAT's work is essentially for dry farming. How far this would be applicable for ploughing wet fields is not known. Ofcourse, various

Agricultural Universities and agro-machinery corporations have attempted to produce improved ploughs and implements and they have achieved, in many cases, some success. Private companies and agro-machinery corporations of state governments are working on improved designs and manufacture. But the quality of design effort has to be improved. Far more intensive studies on R & D are required in order to bring about some improvement in the transmission and work efficiency of ploughs.

43. In some of the Indian ocean countries as well as in China, the harnessing devices as well as attachments are different to some extent. This may also have to be studied. In one such design, it was seen that the plough was far away from the animals (which incidentally gives the animal relief from being beaten as often as is happening in the existing design structure in India.) To what extent these are beneficial to the animal and would improve efficiency is not known. The yoke itself is rough which hurts the animal's neck. A lot of work has been done by the FAO on Water Buffaloes in China. It is reported that they are getting more from water buffaloes, than what we have been able to do. FAO has produced an excellent manual and two books on water buffaloes. Similar studies should be done on the Indian work cattle including bullocks and buffaloes. As regards other agricultural operations, animals have been used to varying extents on many odd jobs. In certain parts of India water lifting is largely done by animal power. Experiments have been tried to use animal power for drilling, producing electricity etc. There is good scope for exploring new applications and in improving designs, thereby increasing the work efficiency and working life of animals. Also, new applications will help the farmer to make use of his animal resource to a larger extent, rendering his economy more viable.

#### Improved Animal Drawn Carts

44. About 80% of the carts could be in rural areas where only 50% have road. It would not be possible to introduce rubber tyred carts in most such areas. In towns, rubber tyred carts can be easily introduced. Already, two-wheel carts, with hard or

pneumatic tyred wheels, some with smooth bearings, some with worn-out truck axles, etc. while others with A.D.V. (Animal Drawn Vehicles) axles are plying. Their pay load is more than that of the traditional cart, which is about one ton or less. Iron rims are damaging the roads, loss may be in millions of rupees. Essential features of the traditional cart i.e. large diametered two wooden wheels, iron rims etc. may have to be retained. But improvements can be made by way of smooth bearings, lighter platform and better harnessing device. A brake - a simple one - such as a wooden pole hung in the rear which, when rubbed against the wheel, acts as a brake, or a sophisticated brake shoe activated by a bar and level could be considered. Today the animals are using their necks to slow or to stop the carts.

45. An important point to be borne in mind here is that the present stock of traditional carts cannot be thrown away. Ways have to be found whereby the existing carts are themselves upgraded for better performance. This can, perhaps, be done by introducing smooth bearings, brake and smoother yoke. The new ones to be made can be manufactured with standard designs. This would mean a great deal of R & D training on redesign, manufacture, supply of right kind of materials, credit etc. and finally massive extension and propaganda to take modernization to the masses.

46. In the city areas, numerous combinations and types are being visualized - single and double bullock, three and four wheeler, hard and pneumatic rubber tyred wheels, different types of platforms to suit various kinds of materials, different load carrying capacities, etc.

47. Improved versions for both rural and urban use will definitely increase pay load and reduce burden on the animal. Increased pay load means larger earning capacity, increased transport capability, less exertion for the animal etc. The carts will be able to compete with three wheelers and trucks. This may even give rise to increased employment and development. Higher earnings may perhaps lead to better food to the animal, which are today not adequately fed. Since the cart - man ekes a

marginal existence with the traditional cart, he often starves the animal and works sick animals as well, for one day loss in carting would mean starvation for him as well. With higher earning levels, the animals are likely to get some rest and better food. It would also lead to better draught capability.

48. The last point regarding carts is the yoking device. The third point of load is the animal's neck. Though the carter tries to balance, sample observations showed that a pressure of 100 kgms was on the necks. This affects draught capability, as energy is wasted in carrying load instead of pulling. Life is also reduced. Extra food has to be consumed for restoring energy wasted. Further, the rough yoke, moving all the time, is injuring the animal's neck due to constant rubbing and friction. Most of the animals develop neck sore and often neck gall and cancer. Random studies have shown that the working life of the animal is reduced and they are being sent to the slaughter houses ahead of their useful life, as the neck already injured is unfit for use. Even an one year working life may cost the owner 100 rupees. On 80 million animals, if we were to lose one year of working life, the loss in the working life of the animals, say 10 years, may amount to Rs. 8000 million i.e. Rs. 800 million per year.

49. The design of the yoke in the traditional cart is the most pernicious part of the design. Something has to be done to save the animal of the acute agony it is suffering all through its working life. Experiments are being done in IIMB with a double piece yoke, which is already in use in China for single buffalo carts. In this design concept, one yoke sits on a saddle mounted on the animal's back, which takes the vertical load, thrust and shock load in all directions. The second yoke, a small piece, sits loosely on the hump of the animal like the present yoke. The latter gets engaged immediately when the animal moves forward. All vibrations are taken by the first yoke. Also impacts and stresses which arise when braking, turning, tilting, etc. and shocks transmitted from the wheel through the platform are taken care of by the first yoke sitting on the saddle. The

animal's skin on the back and neck is unaffected by them. If we can achieve a good design for both single and double bullocks, this will be a break-through in design. Animal's life can be increased and it can be given a great deal of comfort. Design and trials are being carried out.

50. Thus, it can be seen that a great deal of improvement can be brought about in the cart designs of various types, which would improve the efficiency of the system and earnings to the carter on the one side, as well as reduced effort and increased comfort and longer life at the other for the animals.

#### Veterinary Services

51. In terms of science and technology of veterinary services, India does not lack technical manpower by Western standards. However, the present organization and infrastructure of the veterinary health care delivery system has to be studied to assess its appropriateness for the country. The system may be efficient in its own way, but it has not been made available to the large masses of cattle, to protect and to take care to their needs. The study should evolve a more effective structure of veterinary services that would have mass level efficiency. There is a feeling that the present veterinary services, like the medical system, reaches only a fraction of the population. Perhaps, a larger network, like the Primary Health Care Centres, may have to be thought of.

#### Animal Care

52. In spite of the religious acceptance of the NANDI as part of the devine system, work animals in India are under fed and their health is poor. In fact, neglect of animal energy is a good example of the vagaries of the non-organized sector. The first three years in the life of a cattle is significant in terms of development of energy and capability to work hard. An extensive study has to be made all over the country regarding rearing of cattle so that an institutional infrastructure can take over the male calves for developing them into healthy

work animals. Care of an animal during its working life is as important as its care in the period of growth. The example of the Chinese practice of protecting the feet of water buffaloes with nylon net shoe may be mentioned here. This method of buffaloes may reduce the incidence of foot diseases. In India, where bullocks and buffaloes are used for ploughing and carting, care should be taken to develop proper shoes for them.

53. The primitive method of branding with hot iron and castrating animals by crushing testes often lead to economic loss besides the druelty aspect. Hence measures should be taken to introduce scientific methods of castrating animals in order to reduce pain. Branding should be abolished. Animal feed is another area for study. Development and manufacture of proper feed on commercial basis has to be taken up. Water troughs should be installed all along roads where there is intense animal traffic. All these, and many other measures, will improve health and working life of work animals.

#### Breed Development

54. It is necessary to study and classify the various factors like working life, power generating capacity, tenacity, resistance to deseases etc. and its relationship to various breeds. Breed development in India is mainly devoted to milch animals and not much has been done on work animals. Experiments should be started on the development of strong and stable work animals which have resistance to common diseases, and which can work in the environment and live on locally available food. Thus it may be possible to qualitatively improve the present cattle population and at the same time introducing new breeds. Doubling the energy by better breeds is within reach, as there are such breeds already today.

#### Current Research on Animal Energy

55. Funded by the Department of Science and Technology, some design improvements have been evolved. The IIM-B has approached this Department as well as the Ministry of Shipping and Transport for additional funds to carry on design work in a more intensive



way. There is countrywide interest in the project, SAIL (Steel Authority of India), Syndicate Bank, UP Government and other agencies are now awarding prizes for improved designs. The Dunlop Company had brought out their version of improved cart in the forties. The essential features were pneumatic tyres, strong platform and roller bearings, which together has increased the cart capacity 2 - 3 times. Firestone Company is now experimenting with solid rubber tyres which could be fitted to large diameter steel wheels, which can ply on unpaved village roads. Large diameter wheels are a must to negotiate pot holes, slushy terrain etc.

56. Engineering institutions and private companies are now working on new designs. The Dept. of Science and Technology is considering proposals to document carts and animals. ESCAP is interested in a study of the cart system in the region. An exhibition in Delhi on carts evoked countrywide interest.\* All these developments of the last two years are a welcome sign.

#### Conclusions

57. It can be seen from the above analysis that there is, firstly, under-utilization of animal energy resources. Secondly, transmission efficiency is low. Thirdly, the mechanical efficiency of applications is low. Due to all these, there is a tremendous wastage of animal energy. This is taking place at a time when the farms are desperately in need of additional energy, which cannot easily come by fossil or hydraulic energy. This paper is not an argument for retaining animal energy power for ever. Animal energy will continue to be replaced by other forms of energy when certain economic and organizational conditions emerge. This process should be encouraged.

58. The simultaneous process of increased utilization of animal energy will take place at one end, while at the other end animal energy will continue to be replaced by other forms of energy. This dualistic process is governed by various factors. In the villages, with the increase in size of farms, increase in productivity and output, increase in market prices, etc. we

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\*) SAIL is carrying out value Engineering studies to improve carts.

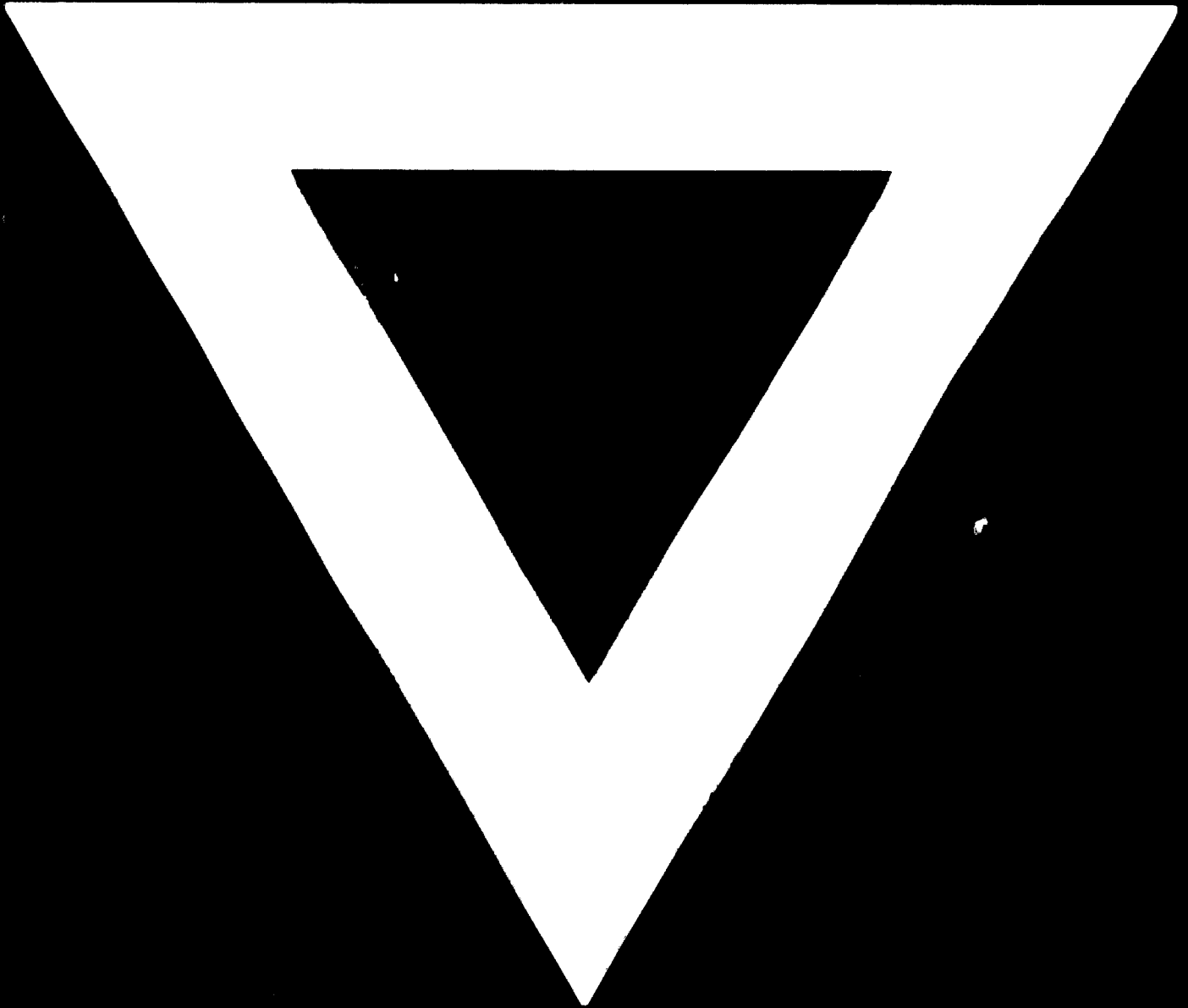
will progressively witness the increased use of animal power. Similarly, increased urbanization and development of new towns and cities will lead to increased use of automobiles and less use of animal power. Thus acquisition of animals on the one side and replacing them on the other by mechanization will also continue.

59. What this note wishes to highlight is that all this has to be studied from techno-socio-economic angles, and that R & D, commercial manufacturing operations and distribution, credit etc. will have to be organized urgently.

60. This note has also attempted to assess the magnitude of animal energy and its distribution amongst sectors of application. There is a need for policy-makers and planners to take the necessary steps for creating organizations and institutions as well as for providing them with necessary funds and support to put animal energy to a place of importance in research. Already, there is tremendous enthusiasm in India for energy from wind, solar, tides etc. We have done this, since we have the leadership given by Western countries. They have passed the stage of animal energy and, therefore, we have nothing to imitate from them. A time has come when we have to give the leadership. A number of countries in the Indian ocean region are also using work animals. All of them will benefit from our experience.

61. Arithmetic exercises can be carried out to work out the economic relations between man and animals as well as animals and other forms of energy. We can work out elegant equations showing the cost benefit analysis, the break even point where animal energy will be replaced by other forms of energy, the number of tractors and trucks which are required to replace animal energy in the farms and roads etc. But at this stage, all these exercises are not easily feasible in the absence of reliable data. But clearly animal energy is appropriate to India, due to numerous reasons. It is neglected due to lack of understanding, and also because it belongs to the non-organized sector, which is neglected by all. The non-organized sector has no access to the development process. Let us correct this.

**1-82**



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