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Rapporteur's Report on Economics of Energy Use in Agriculture

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I

INTRODUCTION

Energy has assumed unrelenting importance as an indispensable input for economic development. Agricultural experts and economists all over the world have marshalled ample evidence to support that energy use per hectare has direct bearing on the crop yields. Indian agriculture has witnessed a tremendous transformation since Independence particularly due to the green revolution of the sixties and the white revolution of seventies. As a sequel, the food production and milk production have increased about four-fold, leading the country towards near self-reliance and food security. Energy has played a key role in this transformation process. Notwithstanding the achievements in the agricultural sector, the fact is that much remains to be achieved in the face of mounting demand for agricultural commodities with the increasing population, rising per capita income and growing awareness about health and nutrition. In a land scarce agrarian economy like ours, a large volume of additional production has to be achieved by energy intensification and judicious management of energy systems. The energy intensification-led growth strategy for augmenting agricultural production could be viewed as a 'double-edged weapon' which cuts the bottlenecks for higher production in the short run on one count, while it prunes the stock of natural and non-renewable resources in the long run, on the other. This 'double-edged' nature of energy intensification has given rise to umpteen apprehensions about imminent energy crisis and environmental hazards, raising concerns about sustainability of agricultural production systems. The issues of energy requirement and management had drawn the attention of the Indian Society of Agricultural Economics as early as 1976. The apprehensions about energy economics and sustainablility have further aggravated during the past couple of decades.

This indeed calls for a sharper and deeper understanding of energy demand and supply for agriculture; comparative economics of different energy sources; exploitation of non-conventional energy sources; management and conservation of energy inputs, sustainable energy use pattern and the like. The issues on energy economics have received appropriate cognisance by the Indian Society of Agricultural Economics once again, culminating into the present conference session theme on this vital subject. The theme has attracted the attention of a large number of agricultural economists and researchers from different parts of the country, though a large majority of the papers pertained to the states of Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Tamil Nadu and Himachal Pradesh. Interestingly enough, these states happen to consume relatively more energy in agriculture due to the wider spread of green revolution and farm mechanisation.

As many as 44 four papers devoted to different issues of energy use in agriculture, are accepted for discussion in the Conference. Majority of the accepted papers concentrated

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on the issues of energy use pattern, energy requirement, comparative economics of mechanical versus animal energy, determinants of energy use and employment effects of energy use in agriculture.

II

ENERGY USE PATTERN, ENERGY REQUIREMENT AND ENERGY USE EFFICIENCY IN AGRICULTURE

India, being a large country, presents wide variations in energy use pattern, energy requirement and its use efficiency. Studies on these aspects of energy in agriculture hence become central to the understanding and planning of energy use. As many as 19 papers concentrated on this issue.

Higher energy use in paddy and cotton (20 GJ/ha) and least energy use in pulses and millets (5 GJ/ha) was observed by Subrahmanyam *et al.* for Andhra Pradesh. R.N. Yadav *et al.* estimated total energy requirement of potato in Bihar at 6,571 m.cal./ha. For Haryana, Himmat Singh *et al.* and B.S. Tomer and Kiran Kapoor concluded that energy use was maximum in irrigated agriculture as compared to dryland agriculture. They further observed higher energy consumption in wheat cultivation and least energy use in the cultivation of 'guar' and 'jowar'. A.S. Saini *et al* found that in Himachal Pradesh, maize-potato-wheat rotation drew higher level of energy (38 GJ/ha) among the crop enterprises and amongst the milch bovines, crossbred cow consumed maximum energy of 33 GJ/head. S.P. Saraswat and P.S. Dahiya reported that in Himachal Pradesh commercial crops utilised more labour and capital as compared to the cereal crops, while for the same state, D.V. Singh worked out that the total energy requirement of apple was 1.46 lakh MJ/ha and energy input required per quintal of apple was found to be 659 MJ. P.S. Birthal *et al.*, investigating in Madhya Pradesh agriculture, found that wheat was energy intensive crop (5,592 MJ/acre). A.M. Jaulkar and V.N. Singh reported that in Madhya Pradesh, bullock power was hardly used for 50 per cent of the break-even level (2,190 hours/year), while tractors were used almost to their break-even levels. Amarjit Singh and A.J. Singh also observed that in Punjab, wheat and paddy were the most energy intensive crops, which consumed more than 75 per cent of the total energy use in agriculture. In Uttar Pradesh, J.S. Amarnath reported that the sugarcane required maximum energy/ha, followed by paddy.

With regard to the relative importance of inputs in the total energy use, R.N. Yadav *et al.* observed that manure and fertiliser together constituted about 62 per cent of the total energy use, while the share of seed alone was nearly 30 per cent in potato cultivation. Saini *et al.* found that fertiliser, farmyard manure and labour were the most prominent sources of energy supply in Himachal Pradesh, while D.V. Singh reported that in apple cultivation, common property resources provided the major portion of the energy input.

Nilabja Ghosh, highlighting the electricity use in Indian agriculture, stated that the percentage share of electricity consumption in agriculture has increased by nearly five-fold to 22 per cent in 1992-93 as compared to 1960-61.

Birthal *et al.* in their study in Madhya Pradesh also established that fertiliser and electricity accounted for a share of 34 per cent and 23 per cent of the total energy input respectively. A.M. Rajput *et al.*, working on the energy use in groundnut production in Madhya Pradesh, found that seed and human labour were the important inputs with a share of 22 per cent and 18 per cent of the total energy respectively. In yet another study on soybean based farming in Madhya Pradesh, H.O. Sharma and S. Nahatkar observed that seed and fertiliser were the major sources of energy. For the same state, C.L. Thakur found that in wheat cultivation, 80 per cent of the total energy was derived from the commercial sources. P.P. Pawar *et al.* studied the energy use pattern in Maharashtra and reported that firewood, human labour and animal power provided 32 per cent, 20 per cent and 25 per cent of the total energy use respectively. In the case of Orissa, P. Samal reported that animal and human labour, and seed and fertiliser emerged as most important sources of inputs. He further observed 8.5 per cent growth in fertiliser use and 1.92 per cent growth in total energy use in Orissa.

For Bihar, R.N. Yadav *et al.* demonstrated that output-input energy ratio in potato production was 2.56, with least variation across the size categories. In a more detailed study, Saini *et al.* observed that in Himachal Pradesh, sorghum-berseem crop combinations yielded maximum energy efficiency (5.86). They observed that, by and large, energy efficiency in irrigated farming was higher than rainfed/dry farming conditions. Among the milch animals, crossbred cows showed higher energy efficiency ratio. Birthal *et al.* in their comprehensive study of the energy use efficiency for Madhya Pradesh estimated that for every 100 MJ of edible energy, wheat crop utilised 33 MJ of input, while maize consumed only 8 MJ. But, the farmers cultivated more of soybean and wheat despite their low technical efficiency, being moved by higher profits and considerations of subsistence. In another study, Sharma and Nahatkar found that in soybean based farming, energy efficiency ratio was nearly 7.57.

Reporting on the temporal changes in energy use efficiency in Punjab, Amarjit Singh and A.J. Singh found that the gross value of energy output/1000 MJ of input energy fell to 92 (1994-95) from 202 (1970-71). But, Bant Singh *et al.*, examining the energy use efficiency in the same state, claimed that energy efficiency marginally increased over the years (from 1.26 in 1972 to 1.32 in 1993). They maintained that the increased yield is largely responsible for this marginal improvement. For Uttar Pradesh, it was found that paddy had the highest energy use efficiency of 12.25 (Amarnath), while R.S. Tripathi reported that wheat-soybean and barnyard millet-wheat-barley farming systems had higher energy use efficiency ratio. He further observed that pulses and potato sown in October turned out to be energy inefficient crop enterprises.

III

COMPARATIVE ECONOMICS OF ANIMAL ENERGY AND MECHANICAL ENERGY USE IN AGRICULTURE

The farming conditions and economics influence the choice of mechanical and bullock power in agriculture. Understanding the comparative economics of these sources of farm power is essential for energy use. However, only eight papers were devoted to this issue.

In Haryana, the growing tendency to replace bullock power by machine power was observed despite the former being economical (U.K. Pandey *et al.*) The number of tractors in Haryana was as low as 4,803 during the late sixties, which rose to 1.85 lakhs during the late nineties. Further, it is found that for farms less than 10 ha, bullocks are more economical sources of energy, while for farms of more than 10 ha, tractors are more economical. Jaulkar and Singh reported that in the case of Madhya Pradesh irrespective of the size of farms and kind of operations, bullock power costed 30-50 per cent more than tractor energy and the returns on tractor operated farms were higher by 58 per cent compared to the bullock operated farms. The benefit-cost ratio (BCR) for tractor farms was 4.0, while it was just 1.44 for bullock operated farms. Surendra Singh *et al.* found that the energy cost/ha of paddy and wheat cultivation was relatively lower on bullock operated farms than on tractor operated farms in Punjab. Despite the higher energy cost per ha, they highlighted the advantages of tractor as a source of farm power, since tractors saved about 70 per cent of time in farm operations and their maintenance was relatively easier.

T. Alagumani reported that human and bullock energy was utilised to the maximum on non-mechanised farms, while mechanical energy use was maximum on mechanised farms of Tamil Nadu. R. Rajesh and S. Kombairaju, analysing the impact of tractor drawn implements in Tamil Nadu, felt that tractor drawn implements not only facilitated fast completion of timely farm operations but increased notably the net returns/ha as compared to non-mechanised farms.

Evaluating the impact of tractor use in Uttar Pradesh, Balishter and K.M. Mithlesh concluded that tractorisation favoured intensive farming and farm output rose by more than 45 per cent compared to bullock operated farms. Another study in Uttar Pradesh endorsed that tractor operated farms yielded higher returns and earned extra returns by rented services. The study also highlighted the speedy completion of operations on tractor farms (V. Prasad *et al.*). In yet another study, it was interesting to observe that in Uttar Pradesh, farms with partial mechanisation (mechanical + bullock power) proved to be superior in terms of energy efficiency and net returns in potato cultivation as compared to non-mechanised and fully mechanised farms (C. Sen *et al.*). S.R. Yadav *et al.*, comparing the tractor and bullock operated farms in Uttar Pradesh, inferred that tractor farms demonstrated higher cropping intensity and irrigation. The energy efficiency was found to be 1.67 and 1.37 on tractor and bullock operated farms respectively.

IV

DETERMINANTS OF ENERGY USE IN AGRICULTURE

Energy use in agriculture is governed by a host of factors like agro-climatic conditions, nature of farming, governmental supports in terms of subsidies, credit availability and the like. An in-depth analysis in terms of the factors influencing it would not only be crucial for energy use planning but also for the public policy as well. Nine papers covered some aspects of this issue.

It was interesting to know that in Andhra Pradesh, area expansion and coverage of HYVs were important determinants of energy use but when they reached a plateau, the extent of fertiliser use, irrigation and cropping intensity displayed their crucial role in determining the energy use (Subrahmanyam *et al.*). R.N. Yadav *et al.* through Cobb-Douglas production function established that irrigation and seed have considerable influence on energy use in Bihar agriculture. Studying the determinants of energy use, A.C. Gangwar *et al.* felt that the average yield of crops, area under HYVs and agricultural investments had profound influence on the extent of energy use in Haryana. In another study, B.S. Panghal and T.S. Chahal stated that energy use was dictated by farm size and they further observed that it increased with increase in farm size. V.K. Singh *et al.* observed inverse relation between farm size and conventional energy use, and non-conventional energy use exhibited its direct relation with farm size. They noted that social costs of energy also influenced the extent of energy use. Saini *et al.* established that energy use in Himchal Pradesh was governed by enterprise mixes and energy optimising plans (energy or return optimisation). On the other hand, the extent of precipitation and levels of irrigation were considered to be important determinants of energy use by M.R. Chandrakar and A.K. Koshta in Madhya Pradesh.

S.N. Tilekar *et al.*, while studying the determinants of use of machinery in Maharashtra, found that value and size of farm land, level of irrigation and cultivation of commercial crops had positive relation with the energy use. Through an elaborate study, Amarjit Singh and A.J. Singh in Punjab inferred that net sown area and expenditure on fertiliser determined significantly the level of energy use on the farm. They also felt that variation in energy demand due to changes in agro-climatic conditions, cropping pattern and government policies on subsidies and price supports, would also influence the extent of energy use in Punjab. Tripathi reported that in Uttar Pradesh, fertiliser and manure were the important determinants of energy use in most of the farming situations.

V

EMPLOYMENT EFFECTS OF SOURCES OF ENERGY USE IN AGRICULTURE

There is no conclusive evidence on the nature and extent of employment effect of sources of energy use in agriculture. For a broader policy frame and technology adoption, knowledge of employment effects of sources of energy use becomes a necessity. This issue has attracted the attention of writers of seven papers.

P.M. Sharma *et al.* attempted to study the impact of farm mechanisation on employment in Rajasthan. The results indicated that farm mechanisation reduced considerably the labour employment in all the regions studied. As a result, nearly 70 per cent of the bullock power and 40 per cent of human labour turned out to be surplus. K.R. Jahanmohan and K.R. Sundaravadarajan observed that in Tamil Nadu farm mechanisation resulted in displacement of 0.82 bullocks/ha (about 90 per cent of the total bullock requirement before mechanisation). Interestingly enough, mechanisation has absorbed about 10 per cent more labour per hectare as compared to before mechanisation.

Balishter and Mithlesh, probing into the employment effect of tractor use in Uttar Pradesh, arrived at the conclusion that mechanisation favoured labour absorption owing to enhanced cropping intensity, while D.K. Singh indicated that in Uttar Pradesh, tractorisation displaced about 10 per cent of the total farm labour on an average, but displacement was significantly higher in the case of paddy cultivation. Again operationwise, it was threshing, ploughing and sowing which accounted for maximum displacement, resulting in large labour surplus in the region. S.R. Yadav *et al.* highlighted that mechanisation marginally reduced labour absorption in Uttar Pradesh.

B.R. Garg and K.K. Jain, while studying the electricity subsidy in Punjab, observed that mechanisation of operations of agricultural crops led to nearly 23 per cent decline in labour use/ha. B.S. Dhillon and M.S. Toor studied indirect employment due to farm machinery in off-farm jobs in Punjab. They included a variety of backward and forward linkages with the farm machinery, from manufacture of machinery till post-harvesting process of farm products which generated indirect employment. They estimated that in Punjab, the farm machinery generated an indirect employment of about 15.20 crore man-days/year.

VI

EXPLOITATION AND ECONOMICS OF NON-CONVENTIONAL ENERGY SOURCES

Rising shortage and increasing cost of conventional energy sources and environmental consequences of their intensive use in agriculture have necessitated the search for alternative sources of energy, particularly of non-conventional sources and their economics. Only five papers dealt with this issue to some extent.

M. Lakshmi Narasaiah, expressing concern over the steeply rising fossil energy use in Indian agriculture and at the global level, observed that energy contribution from biomass is hardly 7.5 per cent of the total energy input and advocated the need for exploiting non-conventional energy sources for a sustainable energy system. S. Lakshmi, realising the growing energy shortages, highlighted that in Tamil Nadu, tapping of biogas and solar energy sources could mitigate the energy gaps particularly for domestic purposes.

N. Manimekalai and A.M. Abdullah made a good attempt to study the potential of wind energy in Tamil Nadu. They felt that wind energy could be a good source of non-conventional energy particularly for windy locations in the coastal territories of southern Tamil Nadu, Kerala, Gujarat, Maharashtra and Lakshadweep. They highlighted the progress achieved by Tamil Nadu in the exploitation of wind energy. The viability of wind mills in terms of net present value (NPV) has been found quite favourable. They pleaded for government incentives to popularise wind energy.

Brahm Prakash *et al.*, discussing the problems and prospects of non-conventional energy in Uttar Pradesh, stated that biomass fuels (crop residues, other agro-industrial wastes); animal waste (dung, biogas); municipal wastes, solar radiation and wind power are potential non-conventional energy sources which must be exploited to the maximum. They felt that with enormous crop residues, agro-industrial wastes, about 500 million tonnes of dung; 5.8 kWh/day sunshine for about 300 days, potential wind energy being 597 x 10^9 MJ and animal energy generated being 40,000 H.P., energy gaps can be bridged to a greater extent by properly exploiting these non-conventional sources, which could be produced at economical costs.

C. Sekar and Saraswathi Eswaran worked out the economic viability of biogas plants in Tamil Nadu and found that the pay back period was 4 years, BCR was 2.72 and IRR was 50.43 and all these attributes endorsed the economic viability of biogas plants.

VII

COSTING OF ENERGY

Costing is central to the pricing of any commodity and sustainable use of it. Computation of private cost and social cost (the real cost) hence assumes importance. Four papers covered some aspects of costing of energy in their analyses.

Sekar and Eswaran compared the energy cost of solar water heater and fire wood for heating 100 litres of water in Tamil Nadu. They found that the cost of heating by solar heater was Rs. 15.50, while it was Rs. 17 by firewood. They also estimated that the cost of cooking meals for a family of 5 by solar cooker was 60 per cent cheaper than by fire-wood/kerosene. In another study for Tamil Nadu, S Iyyampillai and Abdallah Eltoum A.M. found that due to subsidised electricity charges, electricity is being injudiciously used by the farmers. In terms of real costing, they felt that the cost of electricity per acre would be not less than Rs. 20,000/ha/year to the farmers. C. Ramasamy and C. Sekhar worked on production and marketing of charcoal in Tamil Nadu. They found that the quantity of charcoal produced though depends on tree quality, extent of maturity and moisture, yielded 30 per cent charcoal. The cost of one tonne of charcoal was estimated at Rs. 1,620, of which 62 per cent being wood cost and 37 per cent being the labour charge. Charcoal producers' share in the consumer rupee was found to be 48 per cent.

Birthal *et al.* found that in Madhya Pradesh, non-renewable energy sources were cheaper than renewable energy sources viewed in terms of market prices. The cost per MJ of mechanical energy was estimated at Re. 0.44 (while it was Rs. 2.44 for human labour and Rs. 1.23 for bullock labour); per MJ of fertiliser at Re. 0.35 (Re. 0.52 for manure), while at Re. 0.05 per MJ of electricity. The lowest cost per MJ of electricity was largely attributed to subsidised electricity charges to agriculture.

VIII

SOME CRITICAL OBSERVATIONS

It is observed that comprehensive studies pertaining to energy conservation; environmental consequences of energy intensive agriculture; economics of non-conventional energy sources; impact of subsidies and trade liberalisation on energy use; and sustainable energy use pattern were either too few or attempted in limited analytical frames. In-depth research attempts on the aforesaid issues would have added to the discussion of the session theme on 'Economics of Energy Use in Agriculture'.

While studying energy use pattern and energy use efficiency, the contributors of papers appear to have paid least attention regarding plantation crops and livestock enterprises. By and large, issues concerning energy conservation also did not receive due research attention. Implications of comparative economics and employment effects of mechanical versus animal energy use would have been more meaningful had researchers taken adequate cognisance of saving aspect of non-renewable energy sources and utilisation of renewable energy sources. The analyses of energy use in agriculture could have revealed more concrete guidelines and implications for sustainable energy use in agriculture had the paper writers included social benefit-cost analysis in the broader methodological frame.

IX

ISSUES FOR DISCUSSION

1. How does energy use pattern in agriculture present spatio-temporal variations? What are the estimates of energy demand and supply of different farming systems?
2. What are the farmers' considerations in opting for either mechanical or animal energy for farm operations? Which source is economical under what farming conditions? Should the economics (costs and benefits) be the sole criterion in opting for the energy source or should the saving aspect of non-renewable energy be the over-riding criterion?
3. What are the determinants of energy use in agriculture, particularly taking into consideration the agro-climatic conditions and level of agricultural commercialisation under different farming systems?
4. How do the sources of energy use in agriculture affect the employment, primarily labour absorption or displacement effects of farm mechanisation?

5. Whether it is technically possible and more importantly, economically viable for tapping non-conventional energy sources, mainly, solar, wind, biogas, tidal, etc., as sustainable energy source for agriculture?
6. What are the environmental consequences of the extent and sources of energy use in different farming systems? Do eco-friendly technologies have some role to play in mitigating the problems?
7. How do subsidies and trade liberalisations operate to influence energy use and their efficiency in agriculture?
8. What are the methodological issues in social benefit-cost analyses and how best these can be utilised as a practical guide in energy use planning in agriculture?
9. What should be the strategic options for improving the energy conservation and energy use efficiency in agriculture?