

## REVISED ENERGY MODEL FOR AN AGRICULTURAL UNIT

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**Key words :** Energy modelling, Farming system

### ABSTRACT

By means of setting up appropriate energy models, the input-output relationship in economic terms can be obtained which is one of the most effective ways of evaluating and improving farm activities in rural areas in any region. In this paper, an energy model for agricultural units for Bangladesh, proposed earlier by some research workers in this area, is scrutinized and some modifications are suggested. To calculate the farm surplus income which ultimately contributes to "quality of life" of the farmers, the units of the revised energy model which lead to the farm income and farm expenditure are clearly pointed out.

### INTRODUCTION

The standard of living or in general the quality of life of a community or group of people is measured by the quantity of total energy used per capita in that community (Dalal, 1973). For countries where networks for the distribution of energy is limited to only selected urban and suburban areas and where vast rural areas depend for energy on human and animal muscle power and farm and animal waste, it is not yet possible to derive reliable figures for energy per capita. It is not only the quantity of electrical energy consumed per person in the fortunate electrified areas, but the total energy produced and obtained from all possible sources existing in the particular region or country that can be a valid index in this connection.

Identification and categorization of the energy produced and utilized in various forms in rural areas, can lead to developing a quantitative

dynamic model for the flow of energy to facilitate study of farm activities.

In this paper, a revised energy model for an agricultural unit is proposed after scrutinizing and modifying the model developed earlier by Huq (1975).

#### Energy Resources in Agricultural Farm

All the various activities in the farm (including the domestic life of the agricultural family depending for its livelihood and other necessities) can be broken up into two categories:

1. Energy that is applied for obtaining the finished products of the farm viz. food crops and cash crops, and
2. Energy that is consumed for making life more comfortable in the farm unit.

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### Animal Energy

In typical non-mechanized farms of Bangladesh, the primary and major source of energy is that provided by animals e.g. bullocks and water-buffaloes.

It is found that out of 8760 hours in a year, a bullock cannot be effectively used for more than 1500 to 1600 hours. For the purpose of giving a numerical perspective, it may be stated that various estimates place the bullock power as between  $\frac{1}{4}$  horse power to  $\frac{1}{2}$  horse power, continuous.

In order to evaluate the effectiveness of animals as a source of power to a farm as a closed (quasi-closed) system of production, a realistic unit of animal energy would be bullock-hour per unit of land per year. For evaluating farm activities, the unit may be further modified by "bullock-hour/acre/capita/year".

Animal energy is applied to the agricultural unit for (i) ploughing, (ii) irrigation to some extent, (iii) traction and (iv) threshing, etc.

### Animal Waste

A cow produces about 14 kg/day (ESB, 1976), in average, of animal waste. It may be assumed that the amount usable is half i.e. 7.0 kg/cow/day. Animal waste is used in the farm for the purposes of cooking and manuring. It may also be assumed that  $\frac{2}{3}$  of the total usable amount is used for cooking and the rest 1.3 (2.3 kg per cow per day) is used for manuring.

### Energy Feed Back

It is observed for the purpose of setting up of an energy model, that, in order to obtain mechanical energy output from farm animals, energy must also be supplied to them (input energy) in the form of feed. This feed is obtained from the outputs of the farm itself and some supplementary animal food is purchased by the cash income from the farm.

Existence of several feed back loops (including animal waste production and utilization) in the overall energy model must thus be recognized.

### Human Energy

Although it is possible to estimate, for the setting up of energy models in a farm, the efficiency of human being as energy conversion units, the attempt may not be worth while. The reason is the animals are introduced for replacing human muscle power. However, considerable amount of human power is used in the farm, if not for traction, then for irrigation, sowing, planting, weeding, harvesting, threshing, winnowing, etc.

The application of human labour in the farm is so varied in type that it is difficult to quantify it; but, as raw power, it supplements, animal energy in the farm to a great extent. The assumption of  $\frac{1}{4}$  horse power output of a man is (for normal working hours) is a reasonable quantitative estimate, so far as irrigation energy is concerned (Hafizuddin, 1978).

Family members provide a part of human energy needed for the farm and the cost of food for them is provided from the farm income. The rest of human energy is applied through external labours. It may be assumed that internal manpower available is 1 man (for family size varying from 4 to 6).

### Other Forms of Energy in the Farm

For setting up of an over-all energy model for agricultural units, a few other types of energy directly or indirectly active for crop growing must also be taken into account. These are solar energy (providing heat and chemical energy); chemical energy provided by animal wastes which in turn is a partial output from food provided to farm animals; chemical energy provided by chemical fertilizers which are energy-intensive products of industry; rain water with stored potential energy derived ultimately from solar energy; irrigation water

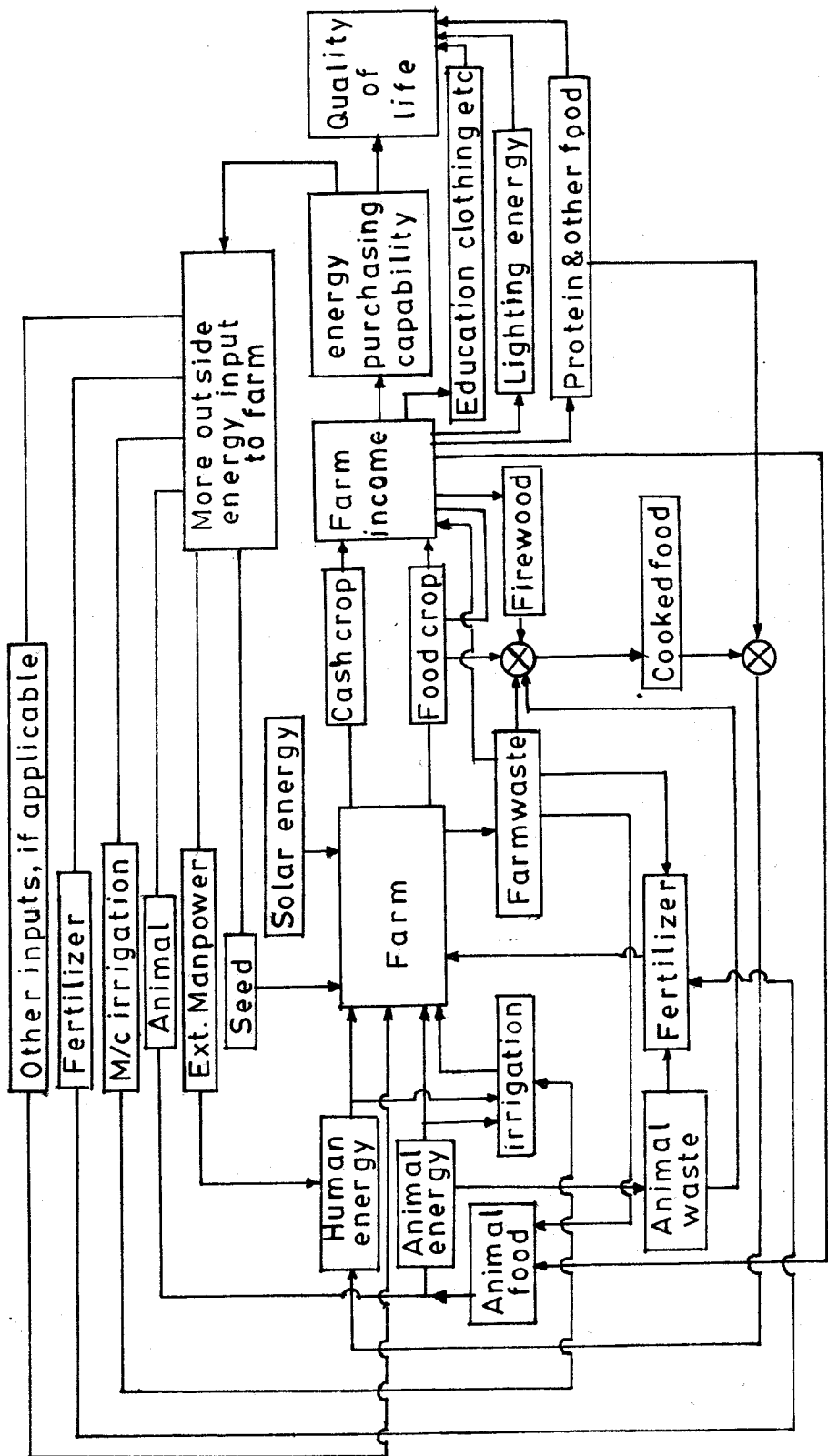


Fig.1 Revised energy model for an agricultural unit.

provided by either muscle power or by machine power (from fossil fuel or electricity) or a combination of these, heat energy (for cooking) provided by farm waste and animal waste produced from the farm itself and a portion is provided by firewood purchased from the cash income of the farm. The existence of energy feedback loops at various stages can also be identified.

### Revised Energy Model, With Some Feedback Loops

With the above comments, a more complete and realistic qualitative model is suggested with the forward and backward flow of energy, as shown in Fig. 1. It may be stated that the aim of agricultural units is to produce food crops i.e. edible outputs, so as to secure a basic and minimum standard of living. This standard of living is commonly measured in terms of income per capita of the human beings subsisting on a particular unit. Another way of looking at the output of the unit is to determine "how much energy could have been bought (from sources outside the unit) from the net income of the farm, in addition to all the energies available in various forms inside the farm". Some of the energy purchasing capability of an agricultural unit, can be reinvested in the farm for the purposes of artificial irrigation by power pumps, chemical fertilizer, improved seed, external labour, purchasing more animals or even better food for the family members and animals, etc. In an ideal situation, the farm income per capita (or energy purchasing capabilities) should increase in a faster rate than the rate of reinvestment.

### Energy Model and Farm Surplus Income

The energy model can be made precise and useful with appropriate quantitative data inserted at the various stages to evaluate farm activities.

By identifying all the items which lead to farm income and farm expenditure, farm surplus income per capita or energy purchasing capability/capita may be evaluated. From the model, it is clear that the items leading to farm income includes crop production, crop and animal wastes. The items leading to farm expenditure are fertilizer, irrigation, animal financing, external manpower, seed food for family, animal food, lighting and cooking, etc. With relevant data used for all these items, actual farm surplus income/capita or energy purchasing capabilities/capita may be calculated.

### CONCLUSION

For evaluating and improving the economic activities of the farm, numerical data for all the stages of the energy model is to be derived. Collection of all necessary data needs extended survey and research. With numerical data available, it will be possible to observe the effects of various parameters e.g. (i) farm size, (ii) family size, (iii) fertilizer cost (iv) irrigation energy (human, diesel, electric) etc. on the surplus income.

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## ON FARM EVALUATION OF IRRI MULTI-CROP UPLAND SEEDER

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**Key words :** Seeder, Performance, Field capacity and efficiency, Maize, Sunflower

### ABSTRACT

Field performance of IRRI multi-crop upland seeder was done at Regional Agricultural Research Station (RARS), BARI, Ishurdi with maize and sunflower seeds. The field performance of the planter was highly encouraging. The field capacity of the seeder were 0.144 ha/hr and 0.162 ha/hr for sunflower and maize respectively. The field efficiency for sunflower and maize were 63.43% and 61.30% respectively at 3.2 km/hr forward speed. Seeding by this machine was about 3 times cheaper than hand seeding. At the present wage level of Tk. 60 per day the seeder has a break even area of 3 hectare per year.

### INTRODUCTION

Broadcasting seeds over the loose soil and subsequent thinning of plants are the common practices in Bangladesh. Grain drill tends to give higher yield than broadcast seeder because of greater uniformity of seed distribution and uniform seeding depth (Barger *et al.*, (1972). Brammer (1977) showed similar results from his study in Bangladesh. Kemp (1966) developed a 9-row combined seed and fertilizer drill capable of sowing 493 kg/ha wheat and 137 kg/ha to 818 kg/ha fertilizer. Ali (1977) developed a multi-row seed drill for rice and wheat which gave a poor performance associated with crushing of seeds and non-uniform seed delivery. Saif and Alam (1983) developed a multi-row seed drill suitable for rice and wheat; but various modifications are needed in metering cell shape, power transmission, seed rate selector, and pull beam mechanisms. Kumar *et al.* (1986) developed a 5-row seeding attachment for wheat and barley. The overall performance of the machine was satisfactory. The maximum seed breakage obtained was 2.7% and field capacity was 0.228 ha/hr. Bangladesh Rice Research Institute (BARI)

has developed similar animal drawn seed drill for rice. The seeding rate of BARI upland seeder was 30-37 kg/ha, the field capacity was 0.08 ha/hr and the draft of the machine was 50-55 kg. The damage caused by the metering system was found 1-3% which is negligible (BARI, 1986). Awadhal (1987) reported testing of a 4-row planter; its field capacity was 0.25 ha/hr.

Like all other farm machines, seeders should also be technically and economically suited to local needs and contribute to increased food production through increased yield. Experiences in some countries of the region have proved that proper sowing can only be carried out by seeding equipment of sound performance.

This study was aimed at testing and evaluation of a seeder for a number of crops and soil conditions. It was a collaborative work of BARI-IRRI farming system programme with the following objectives :

1. To test the performance of the IRRI designed multi-crop upland seeder in farmers' field condition,
2. To modify the machine as needed.

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## MATERIALS AND METHODS

A five row multi-crop upland seeder (Fig. 1) obtained from IRRI through the IRRI-BARI Farming System programme, was tested in both laboratory and field condition with maize and sunflower. The planter has the flowing specifications (Table 1).

In the laboratory test, the equipment was calibrated for the test crop for standardization of metering mechanism, i.e. seed delivery rate, seed distribution pattern, and seed breakage. In the field, experiments were conducted at RARS, BARI, Ishurdi during the winter season of 1992-93. Two tests T<sub>1</sub> (seeding by machine) and T<sub>2</sub> (hand line sowing) were replicated thrice. The crop was fertilized with N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O as per requirement of respective crops.

Table 1 Specifications of IRRI upland seeder

No. of Rows (maximum)	5 at 20 cm spacing
Row spacing	20 - 90 cm
Spacing within row	20, 25 and 50 cm
Length	158 cm
Width	108 cm
Height	73 cm
Weight (hopper empty)	105 kg
Hopper capacity (per row):	
seed section	2.5 kg rice seed
fertilizer section	3.3 kg fertilizer
Crops	Rice, sorghum, corn, mung bean
Power	2 men alternating

Data on missing hills, seed dropped per hill, hill and row spacing, depth of seeding, power requirement at working speed of the planter, field capacity, and field efficiency were recorded for each crop at the time of seeding. The field capacity and field efficiency of the machine were measured by time taken to plant a given area of land. Time required to plant 30 m × 20 m plot was noted and total loss or idle time in seed filling, turning, head land planting, and adjustment

were also noted separately. Comparative statement of cost in machine and hand sowing were made by measuring the working accuracy and labor requirements as per RNAM Test Code. For cost analysis following assumptions are made (Table 2).

Table 2 Assumptions for cost analysis

Machine cost	\$ 295 (Tk. 11,800)
Machine life <sup>2</sup>	8 years
Salvage value <sup>2</sup>	10% of purchase price
Annual interest <sup>3</sup>	8%
Taxes, Insurance & Shelter <sup>3</sup>	3 % of purchase price
Repair maintenance <sup>3</sup>	8% of purchase price per 100 hrs
Labour wage	\$ 1.50 (TK. 60) per 8 hrs

<sup>1</sup> Bockhop (1988), <sup>2</sup> RNAM (1983), <sup>3</sup> Hunt (1977)

## RESULTS AND DISCUSSION

Data pertaining to the machine performance in the laboratory test with respect to different parameters are presented in Table 3. The metering mechanism was found suitable in the laboratory test at 3 km/hr. The seed breakage was about 3.5% for maize and 2.80 % for sunflower which is acceptable (Kumar et al, 1986).

The field test data of different parameters in machine and hand planting are presented in Table 4. The machine was pulled by a power tiller though it was designed for a single animal. The draft requirement ranged from 65 - 80 kg which was beyond the capacity of an average pair of bullocks of Bangladesh.

Furrow opener and closer functioned well as land preparation was good. The machine slip was 9.1% during the field test. The average calculated field capacity and field efficiency were 0.162 (ha/hr) and 63.43 % for maize and 0.144 ha/hr and 61.32% for

sunflower respectively. The field capacity was low due to unskilled operators.

Table 3 Laboratory test data on metering device for maize (Barnali) and sunflower (DS-1)

Parameters	Maize	Sunflower
Machine speed, km/hr	3	3
Theoretical seed rate, kg/ha	9.98 <sup>a</sup>	7.8 <sup>c</sup>
Actual seed rate, kg/ha	11.04 ( $\pm$ 0.378) <sup>b</sup>	7.98 ( $\pm$ 0.31) <sup>b</sup>
Crushed seed rate, kg/ha	0.398 ( $\pm$ 0.12) <sup>b</sup>	0.22 ( $\pm$ 0.13) <sup>b</sup>

<sup>a</sup> considering 2 seeds per hill; <sup>b</sup> means of 5 passes;

<sup>c</sup> considering 3 seeds per hill

For sunflower, machine planting produced 4.2% missing hills. Missing hills were observed in machine planting due to mechanical handling of seed (seed breakage or inadequate cell fill) which is acceptable. Seed per hill was also significantly different in each method. The machine produced an average of 4 seed per hill compared to 5.3 for hand planting with sunflower. For maize, machine produced an average of 2.4 seed per hill compared to 4.2 for hand planting. Perhaps this was due to lack of skill of the laborers.

Hill spacing was slightly higher (33 cm) in case of machine planting. This might be due to the skidding of the ground wheel of the planter. Established hill percentage after 15 days of planting were also significantly different in each method. Machine planting gave an average of 95.8% established hills in comparison to 99.3% in hand planting of sunflower. For maize, machine planting produced lower row spacing. This was perhaps due to the

limitation of the metering mechanism of the seeder as mentioned in specification (Table 1). The yield in hand and machine were different. Though the difference in yield in magnitude seems to be small but they were statistically different. This was perhaps due to the differences of hills established in the beginning.

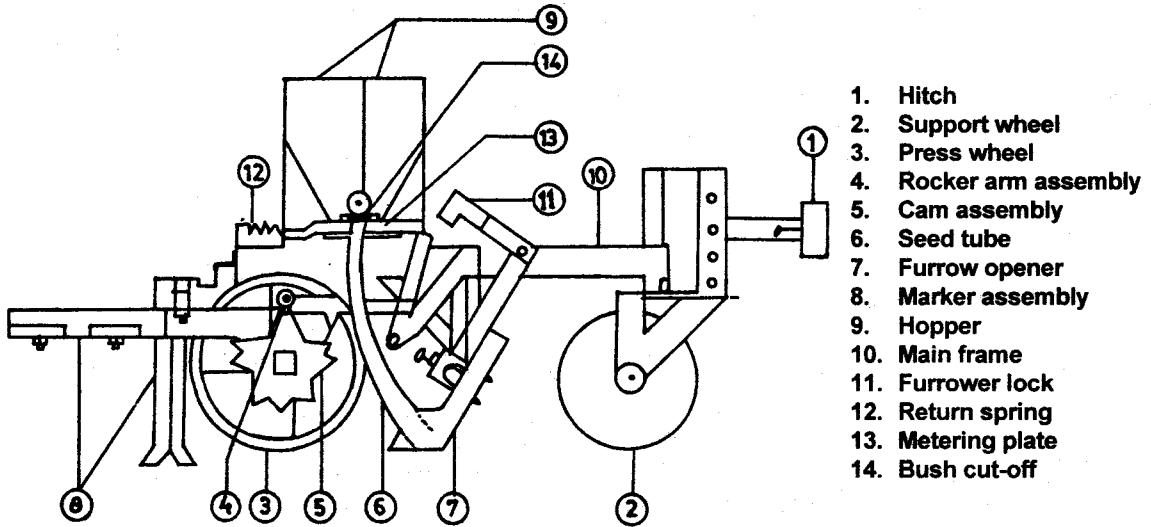
Considering the fixed and variable cost for machine operation, machine planting was found about 3 times cheaper than that of hand planting. Machine planting incurred a planting cost of Tk. 497 for sunflower and Tk. 444 for maize. Hand seeding cost was Tk. 1480 for sunflower and Tk. 1416 for maize. The relationship between the total cost/ha and the annual area to be cultivated is shown in the Fig. 2 for sunflower. At the present wage level of Tk. 60 per day, the machine has a break even level at 3 ha per year. The calculated cost effective area was 3.15 ha/yr which showed a good agreement with graphical value.

## CONCLUSION

The overall performance of the machine was satisfactory. The average working capacity of the machine was 0.144 ha/hr for sunflower and 0.162 ha/hr for maize and required 16 man-hr/ha. The machine is quite heavy as it weighs 105 kg. It needs a power tiller for pulling. The cost of seeding seems to be high; this may due to high initial price of the machine.

## RECOMMENDATION

1. The machine should be tested with other seeds like soybean, mung bean, rice, wheat, etc.
2. The machine could be made with light materials for weight reduction and for easy pulling by draft animals.



1. Hitch
2. Support wheel
3. Press wheel
4. Rocker arm assembly
5. Cam assembly
6. Seed tube
7. Furrow opener
8. Marker assembly
9. Hopper
10. Main frame
11. Furrow lock
12. Return spring
13. Metering plate
14. Bush cut-off

Fig. 1 Schematic diagram of IRRI upland seeder

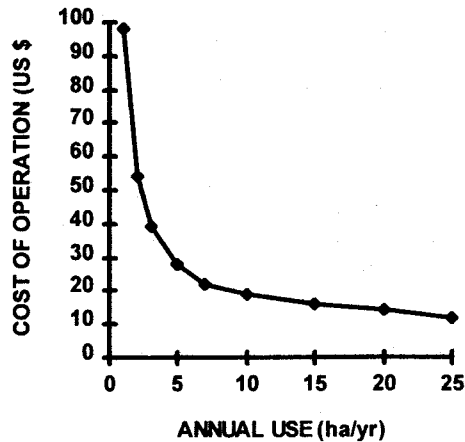


Fig. 2 Curve showing cost of operation as affected by the annual use of the seeder

Table 4 Comparison of some important parameters for machine and hand seeding  
 [ Average performance : Sunflower 0.144 ha/hr; Maize 0.162 ha/hr ]

Parameters	Planting Technique			
	Sunflower		Maize	
	Machine	Hand	Machine	Hand
Missing hill, % **	4.20	0.00	4.80	0.00
Seed per hill, no.	4.00	5.30	2.40	4.20
Hill spacing, cm **	33.00	30.00	22.50	25.00
Row spacing, cm	45.00	50.00	76.00	75.00
Established hill, % *	95.80	99.30	96.20	99.50
Seeding rate, kg/ha	7.98	11.60	10.10	16.04
Depth of planting, cm *	2.90	3.40	3.20	3.60
Wheel slip %	9.10	----	9.10	----
Yield, t/ha	1.30	1.21	3.61	3.72
Seeding cost (Tk./ha) **	443.60	1408.00	496.80	1416.00

\* significant at 5 % level \*\* significant at 1% level

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