ECONOMICAL COMPARATIVE STUDY BETWEEN TRACTOR, DIESEL, ELECTRIC MOTOR AND ANIMAL AS A PRIME MOVER FOR NILE IRRIGATION.

Prof.Dr. A.A. Nasser(1) Prof.Dr.S.M.Wehabaa(2)
Prof.Dr. Es. A.Salem(3)& Eng. A.M. Easa(4)

INTRODUCTION

The economical studies of irrigation methods must be considered for researchers in the field of agriculture development. Numerical study have been taken for conventional irrigation methods, such as, water wheel (animal or electric motor as a prime mover), different types of irrigation pumps with many sources of power.

In general, cost is usually classified into two categories viz, fixed and variable costs each of which includes some items according to circumstances. However, the fixed cost may be considered as including the annual charge (depreciation), insurance, taxes, housing and labour costs. The variable cost includes, repair and maintenance, fuel and oil costs.

For comparison the total cost per feddan for each irrigation method has been worked out in this work as indicated below.

1 - Electrically Driven Pump:

Assuming a pump with discharge at 300 m^3/hr. (8"/8") as an average size.

Average annual water requirement/fed. = 6800 m^3

Max. water requirement/day/fed. = 76 m^3

Assuming 16 working hours/day,

The pump will be sufficient to irrigate $\frac{300 \times 16}{76}$ = 63 fed.

1) Abdel Hady Abdel Bary Nasser, B.Sc. Ph.D. Professor, Head of Production Engineering & Machine Design Dept., Faculty of Engineering & Technology, Menoufia University.
2) Saad Mohamed Wenabaa, B.Sc.,Ph.D., Professor, Chairman of Mechanical Power Eng. Department & Dean of the Faculty of Engineering & Technology, Menoufia University.
3) Esam Ahmed Salem, B.Sc., M.Sc., Ph.D, Professor Faculty of Engineering, Alexandria University.
4) Ahmed Mahmoud Easa, B.Sc., M.Sc., Lecturer, Faculty of Engineering & Technology, Menoufia University.

If we take a factor of safety to cover stoppages and failure of electric current 1*, we can assume this pump will be sufficient to irrigate 50 fed.

Price of this pumping unit including pump, motor, C/B, cables, and suction and delivery pipes = 1100 L.E.

Cost of pump/fed. = 22 L.E.

1.1- Calculation of Annual Cost of Irrigation/fed.:

1.1.1- Electric Energy:

Average annual water requirement/fed. = 6800 m^3

Average manometric lift = 3.5 m.

Manometric efficiency of pump = 70 %

Motor efficiency = 85 %

One K.W.H. $= \frac{3600 \times 102}{1000}$ = 367.2 t.m.

The total energy requirement/fed./year

$$= \frac{6800 \times 3.5}{367.2 \times 0.7 \times 0.85} = 109 \text{ K.W.H.}$$

adding 10% for lighting and other accessories:

the total annual energy requirement/fed.= 120 K.W.H.

Tariff of one K.W.H. for small power consumers= 15 mill.

The total annual cost of electric energy/fed.=120x0.015

= 1.8 L.E.

1.1.2- Operation and Maintenance:

Operation and maintenance of electric network is included in the price of K.W.H.

Operation and maintenance electric pump/year= 8% of its price.

= 0.08 x 22=1.76 L.E.

Total annual cost of operation and maintenance/fed.

= 1.76 L.E.

1.1.3- Labour Cost:

One attendant/unit at a yearly salory of 480 L.E.

Annual cost of labour/fed. $= \frac{480}{50}$ = 9.60 L.E.

1.1.4- Interest and Depreciation:

Assuming sinking fund depreciation 2* by 25 years at 12% interest rate, the annual cost of interest and depreciation/fed. = 22 x 0.127 = 2.8 L.E.

1.1.5- Total annual cost of irrigation/fed.

= 1.8 + 1.6 + 9.60 + 2.8 = 15.8 L.E.

2 - Diesel Driven Pump:

Assuming the same average size of pump (300 m^3/hr.8"/8")

Assuming 12 working hours/day, the pump will be sufficient to irrigate $\frac{300 \times 12}{76}$ = 47 fed.

If we take a factor of safty to cover stoppages, we can assume that this unit is sufficient to irrigate 30 fed.

Price of this unit including diesel engine, pump, suction and delivery pipes = 2400 L.E.

(1800 L.E. for diesel engine and 600 L.E. for the pump and accesories).

Cost of diesel engine/fed. = $\frac{1800}{30}$ = 60 L.E.

Cost of pump/fed. = $\frac{600}{30}$ = 20 L.E.

2.1- Calculation of annual cost of irrigation/fed.:

2.1.1- Fuel:

Average manometric lift	= 3.5	m.
Manometric efficiency of pump	= 70%	
Diesel engine efficiency	= 85%	
One H.P.Hr. = $\frac{75 \times 3600}{1000}$	= 720	t.m.
Total energy required/fed/year	= 126	H.P.Hr.
Internation price of diesel price	= 120	L.E.
Specific fuel consumption/H.P.Hr.	= 250	grms.
Total annual cost of fuel/fed. = $\frac{120 \times 250}{10^6} \times 120$	= 3.78	L.E.

2.1.2- Lubricating Oil:

Specific lubricating oil consumption/H.P.Hr. = 5 grms.

and to be doubled to cover oil changing.

Price/Kg. of lubricating oil	= 1.0	L.E.
Annual cost of lubricating oil/fed. = $\frac{126 \times 10}{1000} \times 1.0$	= 1.26	L.E.

2.1.3- Operation and Maintenance:

Annual cost of operation and maintenance of diesel engine = 10% of its price

Annual cost of operation and maintenance of pump = 5% of its price

Total annual cost of operation & maintenance/fed.

= (0.10 x 60 + 0.05 x 20) = 7.0 L.E.

2.1.4- Labour:

One attendant for operation and minor maintenance at yearly 700 L.E./unit.

Annual cost of labour/fed. = $\frac{700}{30}$ = 23.33 L.E.

2.1.5- Interest and depreciation:

Assuming sinking fund depreciation 2* by 25 year for pump and 12 years for diesel engine at 12% interest rate, the annual cost of interest and depreciation/fed.

= 60 x 0.127 + 20 x 0.161 = 10.85 L.E.

2.1.6- Total annual cost of irrigation/fed.

= 3.78 + 1.26 + 7.0 + 23.33 + 10.85 = 46.22 L.E.

3 - Pump Driven with Tractor:

The following information can be considered in the analysis of the tractor costs:

The initial price	= 8000	L.E.
The expected life	= 15	years.
Salvage price	= 800	L.E.
Tractor horsepower	= 65	H.P.
Average annual water required per fed.	= 6800	m^3
Max. required water per day per fed.	= 76	m^3

The tractor operates 2400 per year in the normal conditions as 8 hours per day for 300 days.

3.1- Tractor fixed costs:

3.1.1- The annual charge and depreciation:

The sinking-fund method or the annuity method 2* can be used for calculating the annual charge and depreciation, The annuity method is more accurate, Therefore it will be used.

Then;

The annual charge = (I - S) R + Si

Where:

R - the annuity factor = $A/\frac{1 - (1 + i)^{-n}}{i}$

$= A/\frac{1 - (1 + 0.12)^{-15}}{0.12}$

A - the amount to be recovered = unity

i - the interest rate = 12%

Then,

The annual charge = (8000 - 800) x 0.161+ 800x0.12
= 1258.34 L.E.

3.1.2- Insurance and Housing:

For tractors, insurance and housing can be neglected because it is not universal practice to insure farm machinary.

3.1.3- Labour cost:

The average annual labour cost about 750 L.E.

Annual cost of labour/fed. $= \frac{750}{25} =$ 30 L.E.

3.1.4- Taxes:

Taxes can be taken as 12 percent annually from the capital cost, i.e.

Taxes $= \frac{(8000 - 800)}{2} \times 0.12 =$ 432 L.E.

Annual cost of taxes $= \frac{432}{25} =$ 17.28 L.E.

3.2- Tractor Variable Cost:

3.2.1- Operation and maintenance

Operation and maintenance can be taken 15% of the tractor price.

Annual cost of operation and maintenance
= 0.15 x 1258.34 = 188.75 L.E.

Annual cost of operation and maintenance/fed/year
$= \frac{188.75}{25} =$ 7.55 L.E.

3.2.2- Fuel consumption cost

By assuming that the tractor works at one half load driving the pump, the tractor will be considered as working at power of about 30 brake horsepower to drive the pump and make up for the power losses. Fuel consumption (f.c.) equals the brake horsepower (B.HP) multiplied by the brake specific fuel consumption (b.s.f.c.). 2*.

Then,

f.c. = b.HP. x b.s.f.c.
= 30 x 0.234 = 7 lit/hr.

Where,

The specific fuel consumption at 30 HP and 2000 R.P.M. equals to 0.234 lit/B.H.P.hr. 2*.

Then,

The fuel consumption cost equals the rate of fuel consumption lit/hr. multiplied by the cost per lit. (0.025 L.E.) thus,

The fuel consumption cost (f.c.c.) will be:

f.c.c. = 7 x 0.035 = 0.245 L.E.

f.c.c./fed/year

$$= \frac{0.245 \times 8}{25} \times 20 = 1.568 \quad \text{L.E.}$$

3.2.3- Oil Cost:

Can be estimated as 20-25 percent of fuel cost 2*.

Then,

The oil cost/fed/year = 0.063 L.E.

Total cost of irrigation/fed/year from the tractor only

= 30 + 17.28 + 7.55 + 1.568 + 0.063 = 56.46 L.E.

3.3- Annual Irrigation Cost per Feddan from the Pump:

- Assuming a pump with discharge of 300 m^3/hr.
- Suction and delivery pipe diameters 8/8"
- Average annual required water/fed. = 6800 m^3
- Max. required water/day/feddan = 76 m^3
- The tractor works 8 hours per day, at which the pump will be sufficient to irrigate about $\frac{8xx\ 300}{76}$ = 31.5 Fed.

If we considered a factor of safty to cover stappages of the pump or tractor, we can assume that, this pump will be sufficient to irrigate about 25 feddan per day.

- Price of this pumping unit including suction and delivery pipes about 500 L.E.
- The expected life for the pump = 15 years.

3.3.1- The pump fixes costs:

- The annual charge and depreciation

$$R = A/\frac{1 - (1 + i)^{-n}}{i} = 0.161$$

The annual charge = (I-S) R + Si

= (500-0) 0.161 + 0 = 80.5 L.E.

3.3.2- Interest and Depreciation:

- The annual cost of Interest and depreciation/fed. per year = 80.5 x 0.161 = 12.96 L.E.
- Insurance, Taxes, Housing, Labour costs: These items can be neglected.
- The fixed cost of the pump = $\frac{80.5}{25}$ = 3.22 L.E.

3.4- Pump Variable Cost:

3.4.1- Repair and maintenance:

Can be taken 5% from intional price.

Repair and maintenance costs = 0.05 x 80.5= 4.03 L.E.

annual cost of irrigation of repair and maintenance/fed/ year = $\frac{4.03}{25}$ = 0.161 L.E.

3.4.2- Fuel and Oil

This items can be neglected

3.4.3- Then, the total cost of irrigation/fed/year from the pump = 12.96 + 3.22 + 0.161 = 16.34 L.E.

3.4.4- Total cost of irrigation/fed/year for the tractor driven pump = 56.46 + 16.34 = 72.8 L.E.

4 - Animal Driven Water Wheel:

A water wheel is sufficient to irrigate on average area of 15 fed. in seven days by using three cows, i.e., one water wheel/15 fed. and one cow/5 fed. 1*.

4.1- Calculation of annual cost of irrigation/fed.:

4.1.1- Food:

Average extra daily food/head. = 1.0 L.E.

Annual cost of extra food/fed. = $\frac{100 \times 1}{5}$ = 20 L.E.

4.1.2- Losses Milk Production:

Loss of milk/working hour amounts to one Kg.

Loss of milk/day (6 hours) = 6 Kg.

Loss of milk/year (100 days) = 600 Kgs.

Price of one Kg. of milk at farm gate = 0.25 L.E.

Total annual cost due to losses in milk production/fed. = $\frac{0.25 \times 600}{5}$ = 30 L.E.

4.1.3- Labour:

One attendant/water wheel during 100 days = 200 L.E.

Annual cost of labour/fed. = $\frac{200}{15}$ = 13.33 L.E.

4.1.4- Operation and Maintenance of water wheel:

Price of water wheel = 700 L.E.

Annual cost of operation and maintenance of water wheel = 12% of its price.

Annual cost of operation and maintenance/fed.

$= \frac{700 \times 0.12}{15}$ = 5.60 L.E.

4.1.5- Interest and Depreciation:

A - Animal:

Price of one cow = 500 L.E. to be sold after 5 working years at 300 L.E. due to change in quantity of meat and milk.

Interest/fed. during 100 days $= \frac{200 \times 0.1774}{5} \times \frac{100}{360} = 1.97$ L.E.

Annual cost of interest and depreciation/fed.

= 1.67 + 1.97 = 3.64 L.E.

B - The water wheel:

Sinking fund depreciation by 15 years at 12% interest rate.

Annual cost of interest and depreciation/fed.

$= \frac{700}{15} \times 0.161$ = 7.51 L.E.

4.1.6- Total annual cost of irrigation/fed. by using Animal driven water wheel:

20 + 30 + 13.33 + 5.6 + 3.64 + 7.51 = 80.08 L.E.

Then, the following table represents the total cost of irrigation one feddan by using different types of prime-movers per year, if the means of irrigation owned or hired and the comparison between the various types shown in Fig. (1).

Type of Prime-movers		Irrigated area/ year(feddans)	working time/ day (Hours)	Total cost fed/year L.E.
Tractor	owned	25	8	72.80
	hired	25	8	78.25
Diesel	owned	30	12	46.22
	hired	30	12	55.22
Electric	owned	50	16	15.8
	hired	—	—	—
A.W.W.		2.14	6	80.08

6 - Recommendation:

It is arecommended to use both diesel (Portable or fixed) or electric pump for Nile irrigation, because of the inviromental and economical situation in Egypt. By the use of diesel pump will save 32% of costs due to animal water wheel and 29% of costs due to the use of tractor.

By the electrification of Nile irrigation of 0.5 million feddans will yield the following benifts;

1 - Decreasing the cost of irrigation 25 million L.E./year.
2 - Increase of agricultural intensitiveness due to irrigation facilities.
3 - Obtaining the optimum use of rural electrification project by using electricity during day time in productive projects in agriculture and in irrigation.
4 - Creation of new mechanical and electrical industrial required for electric pumps (motors, pumps, pipes... etc.) as well as agriculture and animal industried for food.
5 - A new manner of sinking must be pushed to the field use. Concerning with the unit operation for small farmers mechanical-optimally using the Power Unit (Diesel engine) owned or hired. Electrification of Nile irrigation with a new net work will give us chance for electrifing the threashing, winnowing corn milling and other active on the field of industriliszation.

6 - Controlling irrigation water to prevent seapage and evaporation caused by slow irrigation by water wheels. New lands can be reclaimed and irrigated by spared water.

7 - Getting rid of one of the main causes for escaping boys from compulsory Education which increase illiterateness that hinders National Production.

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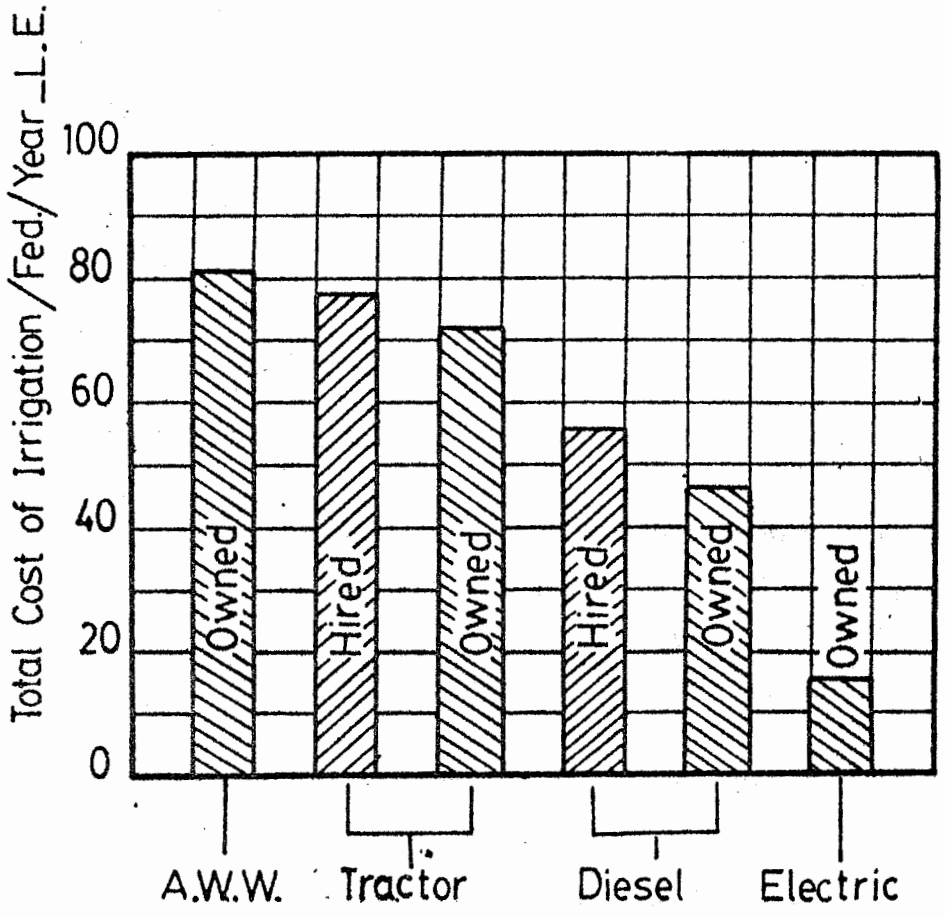

Fig.(1) Total Cost For Different Types of Prime_Movers.

" دراسة اقتصادية مقارنة بين مصادر الطاقة المختلفة لوسائل الرى النيلى "

أ.د. عبدالهادى ناصر ، أ.د. سعد محمد وهيبه ، أ.د. عصام أحمد سالم
م. أحمد محمود عيسى

فى هذه المقالة أجرينا دراسة اقتصادية بين (موتور كهربى ـ محرك ديزل ـ جرار ـ حيوان) ـ ومن تحليل نتائج هذه الدراسة الاقتصادية وجد مايلى :

ـ تكاليف رى الفدان سنويا بواسطة الساقية التى تدار بالحيوان اعلى مايمكن اذا قورنت بوسائل الادارة الأخرى فهى على التوالى (٨٨ر٨٠ ، ٨ر٧٢ ، ٢٢ر٤٦ ، ٨ر١٥) جنيه مصرى للحيوان ـ المضخة تدار بالجرار ـ المضخة تدار بالديزل ـ المضخة تدار بموتور كهربى على التوالى .

وفى هذه المقالة أيضا تمت دراسة اقتصادية لكهربة وسائل رى $\frac{1}{3}$ مليون فدان فوجد أنه يتم توفير ٢١ مليون جنيه سنويا . علاوة على الآثار الجانبية للمشروع مثل انشاء صناعات جديدة (مضخات ـ موتورات ـ مواسير) ـ تطبيق المشروع فى كهربة وسائل اخرى (آلات حصاد ـ ماكينات طحن الحبوب ....) ـ علاوة على ترشيد استخدام المياه .