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LIVESTOCK WORKING POWER IN EGYPTIAN AGRICULTURE

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Introduction:

Livestock has two roles in the Egyptian economy. First, it produces some major food commodities (animal protein) and industrial commodities (hides) for human consumption. Second, it produces major agricultural inputs. These inputs are animal work and organic fertilizer. The average value of both inputs, together, represents more than one-fourth of livestock output, at constant prices (Table 1). This value is greater than that of any other marketable livestock product except red meat. Animal work and organic fertilizer (manure) value equals the value of milk and milk products. As shown in Table 1, there is a declining trend in animla work output. The average rate of decline is about 1.9 percent annually. Considerable attention has been paid to problems of mechanization and human labor utilization in Egyptian agriculture {References: 1, 2, 3, 4, 5, 6, 7, 8}. To date, however, very little effort has been made to understand and to diagnose the problems and economic issues associated with power derived from livestock {9, 10, 11}.

Indeed, there are some common generalizationa about livestock and associated labor and machinery use in the cited literature. The strategy of agricultural development assumes that spreading mechanization technology all over the Nile Valley in Egypt will liberate livestock from farm work, which in turn will increase milk and meat production and save feed resources for animal protein production. Furthermore, the introduction and use of mechanization is assumed to be associated with positive effects on crop production, rural income and human labor employment.

However, there are some estimates of the requirements for agricultural mechanization. The target of the five year plan is to achieve full mechanization of primary tillage by 1985. This would require a total of 35000 tractors in operation, while until 1977, 27000 tractors (50-65HP) had been either imported or locally assembled. For irrigation pumps, demand is estimated at 3000 diesel sets (6-16HP). The total number required from threshers or machine threshing (tractor power) with full mechanization is about 50000 threshers, while the present population is about 10000 {1 & 4}.

Recent empirical estimations {6, 7} of mechanization benefits (data of 18 villages and the analysis for 8 crops) have failed to prove that there is a significant impact of mechanization on yields. There are general indications to support the claim that the introduction of tractors reduces the period of operations at the village level, even though the cross sectional data provided no evidence {7}. The results of the same reference showed no significant effect on cropping intensity from mechanization. Agricultural mechanization saves labor use by each farm operation for different crops {9}. However, with labor still relatively cheap, most operators have many laborers working with the machine to keep the machine operating at full capacity {7}. For wheat production, the average human hours per machine hours was 3.5

while the ratio of human labor to animal work hours was only 1.8 {12}. This latter study differentiated between human labor accompanying machine work or animal work and pure human labor work. The ratios mentioned were for the human labor acccompanying machinery work and animal work, respectively. The reason for the high labor to machinery hours ratio is due to the fact that most of the family labor available on farm is usually involved in the farm operation done by the machine. However, they actually observe the work of hired labor working with machines. However, if results of the study {8} are accepted, i.e., machinery work saves human labor on farm, the removal of jobs from landless, hired workers, the poorest of the poor, would encourage them to seek work in the cities. The already horrendous difficulties of the cities will be exacerbated {5}. If all agricultural operations are mechanized by 1990, where will the people displaced by such mechanization be employed? Where will the capital come from to create these new jobs? Where will all of these people live? {5}

In light of the above mentioned considerations, it appears that the benefits of mechanization as a substitute for animal work (i.e., the saved livestock output) is the critical feasibility measure for such a policy.

The objectives of this study were: (1) to examine the livestock work pattern and density as farm size changes; (2) to examine the interrelationships between human labor, livestock work and machinery use as family size changes; and (3) to provide empirical estimates for how livestock work affect milk output and for the opportunity cost of milk production.

Animal Work Pattern On Farm:

To present the role of livestock working power in total working power use on Egyptian farms, the different working power sources were transformed into equivalent horsepower (HP) as shown in Table 2. On the average livestock power used per feddan was 429 HP, i.e., 19 percent of total HP per feddan, in 1977, while in the same year machinery HP was 70 percent of the total. Most of machinery power came from machines other than tractors, mainly irrigation pumps.

Calculations of Table 3 reveal that almost all (95 percent) animal power is used on farm rather than being hired out to others. Furthermore, most of the animal work related to crop production is for transportation (carrying crops, crop residues, fertilizers and marure), rather than for such activities as tillage, irrigation, threshing, etc. However, current mechanization programs do not appear to be directed at village level transportation. This is cause to question whether or not mechanization will really replace livestock work very rapidly.

Though donkeys are the dominant work animal on all farm sizes, their proportion within work animals herd structure tend to decrease in favour of work cattle, buffaloes and oxen, as farm size increases. This is a surprising result, because it means that expansion in farm size does not cut the use of cattle and buffaloes for work (Table 3).

The Interrelationships Between Human Labor, Livestock Work, and Machinery Use:

When working power used on farm is calculated on an hours per feddan basis, animal power inputs are found to be substantially higher for small farms (Table 4). However, the findings of Table 5 are some what unexpected. Can we believe that small farms actually use more labor, more animal power and more machinery power per feddan than large farms?

In an attempt to clarify the picture, various power input ratios were calculated and are shown in Table 6. Only the machine to animal use ratio appear to increase gradually as farm size increase, as expected. The results are especially surprising for labor and machine use, since the cost of machine use is expected to rise. Some possible explanation for these phenomena will be presented in the following discussion.

The study of El-Seidy (8) came to a conclusion that there are human labor savings due to mechanization, but examination of the text and tables shows that this conclusion is not quite clear under all conditions, because he compared between several intermediate technological packages of machine, animal and human labor work for several crops. In other words, he did not differentiate between the three types of work reported by Imam and Soliman (12).

It is necessary to distinguish between three phenomena in order to clarify above findings. These are: (1) the factor substitution concept, (2) land use intensification, and (3) differences in technical efficiency. The factor substitution concept would lead us to expect less machinery use, not more, as farm size declines, because machinery costs per unit of area are expected to increase. However, small farms may intensify crop production through both mechanization and animal work inputs.

There is evidence that smaller farms have higher cropping intensity {12, 14}. In addition, the transportation problem within villages and small fragmented farms with dispersed plots force smaller farms to use more work animal power for transportation rather than machinery power, particularly under the multicrop pattern and little marketable output. The hypothesis of technical inefficiency shows that the available machines are poorly suited to small farms, i.e., the small farm uses more machine inputs per unit of land. All these hypothesis are going to be explored in future research work.

Impact of Animal Work on Milk Response:

The above presentation and analysis showed that the economic feasibility of mechanization depends in major part, though not solely, on its substitutability for animal work. Mechanization saves the income foregone in terms of milk due to the use of dairy native cattle and buffaloes for crop production operations.

It is necessary to examine the quantitative impacts of animal work on the milk production of cattle and buffaloes. Two previous studies have estimated the loss in milk production due to animal work on basis of theoretical calculations in terms of the net energy transformation for milk and work or in terms of feed requirements for animal work that would have been saved if animals were liberated from work {1, 2, 3, 4 and 9}. Their estimates ranged from 4.7 piasters to 11.3 piasters for milk yield loss due to one hour of animal work. El-Tambadawy's farm survey showed that there is no loss in milk yield if the animal is worked less than 4 hours per day {10}. However, if the animal is worked more (up to 7 hours per day) the evening milking is less productive and generates a loss of between 1 and 2 kilograms of milk. Hard-work operations (ploughing) decrease daily milk yield between 2-3 kilograms if the animal is used for 7 hours a day. The same hard jobs may lower the milk yield level 1 to 2 kilograms a day if the animal is worked 2 to 4 hours.

Dyer {11} used the data of El-Tambadawy's survey to estimate a milk response function. The estimated functions calculated the marginal value product (imputed cost) of animal work. However, the estimated equations had low coefficients of determination, ranging from 0.09 to 0.36. He used feed equivalents TDN and DP instead of natural feed forms. He used feeds used for the whole season while milk response was average daily milk yield. There must be mullicolinearity between milking days and total feed used per season. He fitted a quadratic form for feed used (TDN and DP). However, because the data were from a cross section survey and not comulative observations, the results were confused. Separation of the milk season into winter and summer, while it is in fact a continuous response surface, caused a lot of problems with the results. As he mentioned, the buffalo summer milk production function estimates were unsatisfactory. His explanation with respect to age effect was not correct because the mean and the modal age was between 7-8 years, which is expected to show the highest average daily milk yield per head. Therefore, the higher the average age beyond 7-8 years, the lower is the average milk yield. EL-Tambadawy {10} showed that the type of animal work operation was the most critical factor affecting milk yield. Dyer {11}, on the other hand, used an aggregate variable to express working hours per season. Finally, all previous research work has not given any attention to milk content (fat percentage) when they calculated the milk loss value due to animal work. Also, all of them compared the values at current domestic prices. To review Dyer's calculations, he cited that the milk loss per hour of work of native cattle reachs 25.5 P.T., which is actually much higher than other previous estimates. This result by itself stresses the need for empirical estimates for this relationship.

In the present study the most critical functional relationship to be captured is the product-product interaction between animal work and milk yield which measures the loss in milk production due to animal work. The specified function included variables other than animal work hours for identification purposes. Animal work was separated into plow work and irrigation work. The dependent variable was farm total milk yield per year (FTMY), in kilograms. The explanatory variables were: the number of female buffaloes greater than 3 years on farm (FBUG3), the number of lactating female cattle greater than 3 years on farm (FCATG3), the percentage of milk produced devoted for calves suckling (SUK), and the percentage of milk produced for sale to merchants (MRC). Feed inputs were included on a per animal unit basis in natural form, as kilograms fed, except for berseem and darawa which were included on a kirat-cut basis. Their symbols are: berseem (BKRCT), darawa (DARKR), hay (HAY), straws (STRAW), feed concentrate mix fed in winter (FCW), feed concentrate mix fed in summer (FCS), and other concentrate feeds fed (OCON). Animal work by type of operation was introduced as working days per head (of either milking cow or buffalo) for plow work (WLPD) and for irrigation (WID).

Other studies showed that some farm structure variables may affect directly or indirectly milk production activity on farm {13, 14}. Therefore, they were included also as explanatory variables. These are: Farm size in feddans (FARSZ), family size (FAMSZ) and family adult females (FADF).

Data used were from 150 farms in 10 villages from upper Egypt, middle Egypt, and the Delta, where the latter was divided into north, east, and mid-Delta. Therefore, 2 villages from each of the five regions were selected randomly. However, only 107 farms were included in the milk response estimation because those farms were with milking animals. In general, the function captured most of the variability in farm milk yield, because the adjusted coefficient of determination was 0.799 (the unadjusted value was 0.829). The correlation matrix of independent variables did not indicate apparent multicollinearity between the concerned variables of the estimated function.

Table 7 shows the estimated regression coefficients of the function in linear form and the corresponding t-statistic values and significance level. As a cross section data set, the regression coefficient of any variable was considered statistically significant if its value was greater than the corresponding standard error at a confidence coefficient 95 percent and above.

To summarize the results, Table 8 shows the classification of the milk response according to the type of effect of each explanatory variable (positive or negative). Dairy herd size and type of animal (buffalo or cattle) are the most important scale variables affecting milk production on farm. All feeds usually used in the summer season have positive impacts on milk production. They are hay, darawa, feed concentrate feed mix used in summer, straws and other concentrate feeds. However, hay is the only variable out of this set which shows highly a significant response. Hay is the only dry forage available in summer which is rich in both energy and protein. Therefore, the increased availability of feeds in summer could significantly raise the annual milk yield per farm.

The effect of animal work on milk production depends upon the type of farm operation served by the animal. Livestock power used for plow work operations is the only type of work that has a significant negative impact on milk yield. Using animal power to operate the sakia for irrigation has a minor but slightly positive impact on milk yield. This result with respect to using buffaloes or cattle for irrigation and the impact on milk yield is supported by field observations cited by El-Tambadawy {10}. Physiologically, sakia operation is a type of moderate animal work that may activate milk production.

Average working days per head per year for plow operations in the sample was 5.5047 days. The standard error of the mean was 0.2745 days. At a confidence level of 95 percent, the maximum and minimum value of this type of animal work per head would be 6.0488 days and 4.9606 days, respectively.

Table 3 shows that the total work done by buffaloes and cattle on farm is 18 percent of total animal work. From the present sample plow work is 21 percent of total cattle and buffalo work on farm. Therefore, plowing by cattle and buffaloes accounts for not more than 4 percent of total animal work on farm. This is the only portion of animal work that results in saving livestock output (milk) when replaced by mechanization.

To evaluate the impact of liberating of one head from plow work, the following equations were used:

(1) FTMY/WLPD = −3.185 kilograms of milk per 1-day of work;

(2) WLPD = 5.505 days per head per year;

(3) 4% fat corrected milk = Yo (.4 + .15d) [Jean's equation]

where Yo is the natural milk yield produced (kgs), and

d is the natural fat percent of milk produced; and

(4) $\frac{FTMY/FRMSZ}{FTMY/WLPD}$ = 10.4 working days per feddan (plow work)

From the sample, one feddan carries 0.23 head of milking buffaloes and 0.24 head of milking cattle, i.e., both types are almost of equal share on farm. The expected saved quantity of milk would replace an equivalent imported quantity. The shadow price of reconstituted imported dry milk (powder, 4 percent fat) was L.E. 150 per ton in 1981 {15}.

From Table 9 it is possible to conclude that on the average a working day per head for plow operations has an imputed cost of P.T. 65.8 in terms of milk foregone (4% fat) at the international price. The saved quantity of milk per feddan due to liberation of cattle and buffaloes from plow work may reach 46 kgs. (4% fat). In aggregate for the Egyptian economy, liberation of milking animals from plow work may save 274,560 tons of milk

(4% fat) per year. In 1979, Egypt imported milk and milk products equivalent to 215,000 tons (4% fat). The saved quantity of milk (4% fat) had a value at international prices of about 41 million Egyptian pounds in 1981. This appears to be the most significant benefit of full farm mechanization in Egyptian agriculture.

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Table 1. The Time Series Trend for Livestock Products Value at Constant Prices in Egypt (1960 - 1978)

Type of Product	Average Annual Value of Animal Product (L.E. Millions)	Percent	Average Annual Change Rate (%)	Adjusted Coefficient of Determination
Red Meat	112	34.8	5.5**	
Milk & Milk Products	82	25.5	5.6**	
White Meat	33	10.2	5.8**	
Eggs	14	4.4	8.6**	
Raw Wool	1	0.3	3.1*	
Honey	1	0.3	104.2**	
Animal Work	40	12.4	-1.86*	
Animal Fertilizer	39	12.1	3.6**	
Total	322	100	4.2	

1. * = significant at P .05, ** = significant at .01
2. The values were deflated using the general wholesale price index (1965/66 = 100)
3. Values of both animal work and manure were calculated using the published costs of production data of both inputs for each crop and weighted by annual cropping pattern and areas.

Source: Calculated from Egypt (AR) - State Ministry for Agriculture and Food Security - Agricultural Research Centre - Research Institute for Agricultural Economics and Statistics: Bulletin of Agricultural Economics and Statistics, Several Issues

Table 2. Role of Animal Work in Total Working Power Use on Egyptian Farm in 1977

Type of Working Power	Weighted Average Per Feddan: Gross Hours per Year	HP per Gross Hour	HP per Year	Proportion of Total HP (%)
Human Labor for:				
Crop	864	1/6	144	6.3
Livestock	690	1/6	115	5.0
Total	1554	1/6	259	11.3
Animal Power for:				
Farm Operation	77	1	77	3.4
Transportation	352	1	352	15.4
Total	429	1	429	18.8
Machinery Power:				
Tractors	8	50	400	17.7
Others	119	10	1190	52.2
Total	127		1590	69.9
Total Working Power	2110		2278	100

Table 3. Livestock Work Pattern on Farm
According to Farm Size Class in Egypt, 1977

	Farm Size (Feddan)					
	0-1	1-3	3-5	5-10	>10	Weighted Average
	Hours/Feddan/Year					
Total Livestock Work	867	473	318	189	78	429
Cattle & Buffalo work 1/	139	76	76	51	18	77
Donkey & Camel work 2/	728	397	242	138	60	352
	Proportion of Total (%)					
On own farm	97	93	96	97	95	95
Cattle & Buffalo work	16	16	24	27	24	18
Donkey & Camel work	84	84	76	73	76	82

1/ for farm operations
2/ for transportation

Table 4. Herd Composition of Work Animals,
According to Farm Size Class in 1977

	Farm Size (Feddan)				
	0-1	1-3	3-5	5-10	>10
	Proportion of Total (%)				
Donkeys	73	72	65	52	55
Camels	24	14	16	13	8
Cattle 1/	3	14	19	35	37

1/ Work animals, only.
Mostly cows, but may include oxen or buffalo.

Source: Calculated from a sample of 10 villages covering Delta and Upper Egypt. It is a subsample, randomly selected from the Farm Management Survey in 1977, conducted by the Ministry of Agriculture (Egypt).

Table 5. Machinery Use Pattern
According to Farm Size Class in Egypt, 1977

	Farm Size (Feddan) 0-1	1-3	3-5	5-10	>10	Weighted Average
	Hours/Feddan/Year					
Total	134	193	101	95	63	127
Tractors	3	13	4	14	10	8
Others	131	180	97	81	63	119

Table 6. Combinations of Working Power Inputs for Crops
According to Farm Size Class in Egypt, 1977

	Farm Size (Feddan) 0-1	1-3	3-5	5-10	>10
Machine hours per hour of human labor for crops	.17	.19	.12	.10	.10
Animal work hours per hour of human labor for crops	1.11	.49	.38	.23	.12
Machine hours per animal work hour for crops	.15	.41	.32	.50	.81

Table 7. Estimated Parameters for Milk Response Model of Cattle and Buffalo per farm under Traditional Mixed Farming System in Egypt, 1981

Explanatory Variable	Estimated Coefficient	T. Statistic	Significance Level
Constant	-343.056	-1.7557	$.05 < P < .1$
FBUG3	+1491.58	+11.6087	$P < .01$
FCATG3	+1099.19	+8.4859	$P < .01$
SUK	-4.6326	-1.4274	$.1 < P < .2$
MRC	-201.162	-1.03122	NSS
BKRCT	-0.5379	-.3852	NSS
DARKR	+15.2231	+.1760	NSS
HAY	+1.01172	+7.8577	$P < .01$
STRAW	+.0046	+0.1226	NSS
OCON	+.0706	+.8125	NSS
FRMSZ	-33.2813	-1.4106	$.1 < P < .2$
FAMSZ	-7.5855	-.3506	NSS
FADF	+19.5212	+.3525	NSS
WLPD	-3.1850	-1.4801	$.1 < P < .2$
WID	+.4939	+.2261	NSS
FCW	-.9845	-2.8689	$.01 < P < .05$
FCS	+.1554	+1.1431	NSS

R^2 = .799

NSS = not statistically significant

P = significance level

N = number of observations = 107 farms

Table 8. Analysis of the effect of various explanatory variables for estimated Milk Response Model

Variable Effect on Milk Production	Significant*	Not Significant
Positive effect	FBUFG3, CATG3, HAY	DARKR, STRAW, OCON FADF, WID, FCS
Negative effect	FCW, WLPD, FRMSZ, SUK	BKRCT, MRC, FAMSZ

*Coefficients of calculated T-statistic which is significant at $P < .2$ is considered statistically significant. This level is reasonably enough for such uncontrolled cross section data, keeping in mind that curvelinearity and interaction effect have not been included in such linear model.

Table 9. Impact of Liberation of Dairy Cows and Buffaloes from Under Plow, on Milk Production in Egypt

		Value
Saved Quantity of Milk (kg) (4% fat):		
per day: Cattle		3.7
Buffalo		5.1
Weighted average		4.4
per feddan (weighted average) per year		45.76
Saved Value of Milk:		
for Egyptian Economy - tons per year		274,560
Saved Value of Milk L.E.:		
per day: Cattle		.555
Buffalo		.765
Weighted average		.658
per feddan ( )		6.841
for Egyptian Economy	L.E.	41,044,596