HUMAN AND ANIMAL POWERED MACHINERY

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Summary

The limited agricultural production in developing countries where farm size, terrain or economics hinder tractor-powered mechanization demands more efficient use of human power and animal traction with suitable equipment for varying operations.

The use of human powered equipment is the basic level of mechanization, and improved equipment designs are intended to enhance productivity in respect to energy efficiency and ergonomics.

Animal traction refers to the harnessing of power and resilience of suitable species and breeds of small and large animals to carry or draw loads. High utilization of draft animals and their auxiliary equipment is a precondition for its profitable adoption.

A demand-driven development and innovation system is necessary for the adoption of

improved human and animal powered equipment.

Their optimal utilization therefore requires their development for unique types and levels of production, with flexible technical capacities to manage changing levels or diversities of production.

Sound technical development, controls in technology transfer and appropriate decision support techniques should therefore assist farmers in developing countries to shift from level of subsistence production.

However, it is recognized that the current growth of human population especially in these countries exceeds the sustainable yield of life support systems which is indicated by the declining forest reserves, human encroachment into fragile lands leading to high rates of soils erosion and desertification, and the lowering water tables.

Timely awareness of the pertinent negative environmental impacts and effective means of attenuating them, are necessary for sustainable production.

1. Introduction

Mechanization may be described as the application of engineering technology to enhance production in agriculture, forestry and related natural resource industries.

In industrialized countries, advances in the development of agricultural and forestry machines, has guaranteed the technical feasibility of the methods for increasing labor productivity. Engine powered machines suited to different tasks are available in the markets, while human powered equipment is designed and improved to meet pertinent ergonomic considerations. These have reduced the drudgery associated with the related tasks. Excessive physical exertion in power-intensive operations such as transport, milling and grinding, pumping and threshing have generally been attenuated in modern agriculture practiced in these countries. This may be viewed in respect to the growth of agricultural tractors and harvester-thresher stocks (Table 1) against the more-or-less constant land areas under arable and permanent crops, and the declining pastureland (Table 2). With the advent of precision agriculture and the development of sensors and computer operated systems, the level of mechanization of control-intensive operations including seeding, weeding, pest control, winnowing and harvesting, and sorting of fragile crops such as fruits have also improved. However, there are significant amounts of activities in agriculture and forestry production, which still require the use of human powered equipment. The situation in most developing countries is the converse. There are increasing areas of land under arable and permanent crops (Table 2). The active population in agriculture is also increasing (Table 3) with a high proportion involved in subsistence production in small and medium sized lands, and the trend is expected to continue in the short to medium term (Figure 1). Agricultural wages are relatively low. Hence, a significant increase in the application of mechanical powered systems is not sustainable, economically. It is therefore rational to maintain manual labor and draft animal power (DAP) systems alongside engine powered mechanization aids.

Region		Tractors					Harvester-threshers			
		1979-81	1988	1989	1990		1979-81	1988	1989	1990
Developed countries		18453232	21185216	21288448	21304416		3289515	3726985	3689240	3671899
N. America		5425035	5505300	5519400	5529000		834470	823200	822100	821000
Europe		8441626	10293285	10410033	10427321		816120	831905	826450	821929
Oceania		423783	410400	409000	408000		61998	60000	59850	59700
Former USSR		2629333	2780000	2689000	2609000		701333	735000	689000	655000
Other		1533466	2196234	2261020	2331100		875593	1276880	1291840	1314270
Developing countries		3455688	4879127	5116842	5240055		214225	277112	289766	307204
Africa		203734	270713	276654	284791		12617	19029	19435	19920
Latin America		1117980	1382770	1399778	1413144		125600	145070	147386	149555
Near East		658234	988733	1012014	1044060		28425	27787	27986	29241
Far East		1468493	2229313	2420769	2490414		47202	84748	94478	108005
Other		7247	7598	7627	7646		381	478	481	483

Adapted from FAO (1991)

Table 1: Number of agricultural tractors and harvester-threshers in use

Its primary objectives are to improve the productivity of land and labor and to raise net incomes. In the process, there is increased use of human and animal powered tools and implements, and mechanical sources of power for operations such as land clearing, tillage and cultivation, water control, material handling, processing and storage. Environmentally sensitive methods are preferred in sustainable production systems.

Land use	Area, million ha			
	1975	1980	1985	1990
Developed Countries				
Total area	5623	5623	5623	5623
Land area	5489	5492	5492	5492
Arable and permanent crops	668	673	675	672
Arable land	645	650	652	650
Permanent crops	23	23	23	22
Permanent pasture	1265	1260	1250	1235
Forest and woodlands	1881	1868	1885	1900
Other lands	1674	1690	1681	1685
Developing countries				
Total area	7768	7768	7768	7768
Land area	7587	7587	7587	7587
Arable and permanent crops	726	744	756	772
Arable land	662	676	687	700
Permanent crops	64	68	69	72
Permanent pasture	2045	2073	2116	2167
Forest and woodlands	2287	2232	2175	2128
Other lands	2530	2538	2540	2520

Adapted from FAO (1991)

Table 2: Land use by level of economy

Region and classification	Population in millions			
	1975	1980	1985	1990
Developed countries				
Total	1124	1168	1209	1251
Agricultural	167	144	122	102
Economically active:				
Total	519	552	579	601
Agricultural	80	70	60	50
Percentage in agriculture	15.5	12.7	10.3	8.3
Developing countries				
Total	2955	3280	3641	4046
Agricultural	1932	2052	2167	2287
Economically active:				

Total	1244	1404	1584	1765
Agricultural	851	923	993	1051
Percentage in agriculture	68.4	65.7	62.7	59.6

Adapted from FAO (1991)

Table 3: Total population, agricultural population and economically active population

Currently, 52 percent of the cropped area in developing countries is cultivated using DAP. Human labor and tractor mechanization cover the remaining 26 and 22 percent, respectively. However, patterns of utilization of the three sources of power vary significantly by region as exemplified in Table 4. Agricultural production and labor productivity have remained inadequate in most of these countries, due to conflicting mechanization policies and development objectives. For example, various donor-funded projects in these countries have developed improved ploughs; tool carriers; equipment powered by human energy, steam, biogas, wind, solar energy and animals; dryers; shellers, threshers and hydraulic pumps, but with low rates of adoption. Hand tractors, conventional tractors and their scaled models, have also been used with modest levels of adoption. Consequently, it has been acknowledged that appropriate mechanization strategies may be used to alleviate the low productivity of land and labor in these regions. Appropriate mechanization is the application of human, animal and mechanical equipment in agriculture and forestry with due regard to inherent technical, socio-economic and cultural constraints.

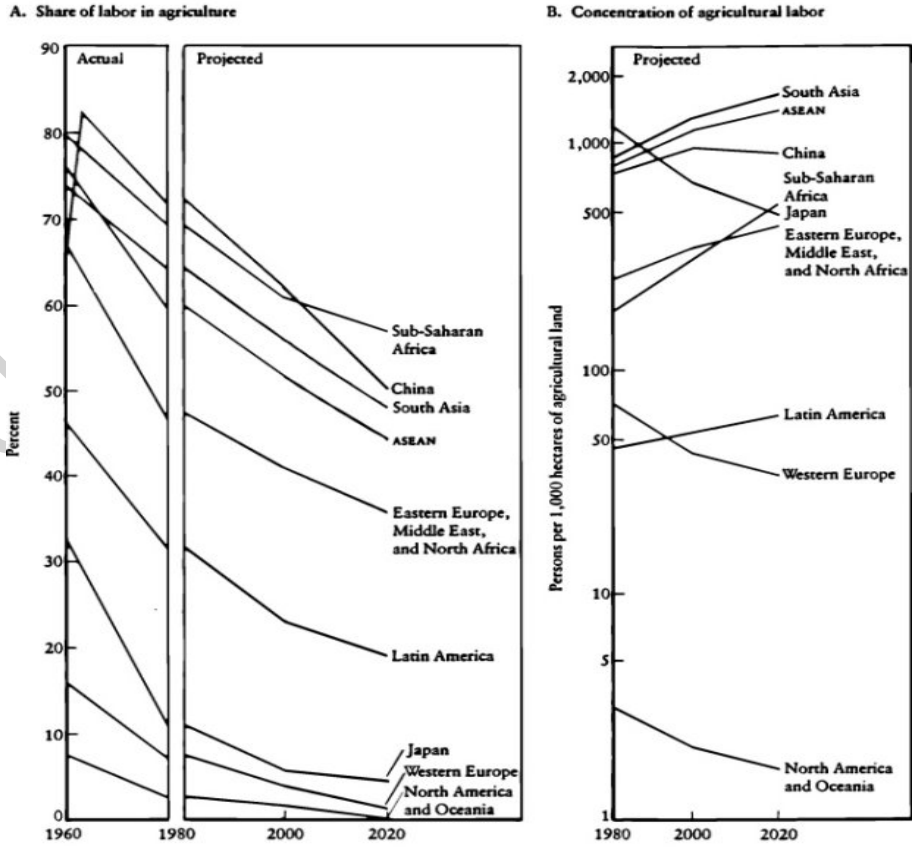

Figure 1: Actual and projected trends for agricultural labor force, 1920-2020

Source: World Bank (1987). Agricultural Mechanization: Issues and Options. The World Bank, 85 pp. Washington D. C.

It is recognized that the current increase in human population especially in the developing countries exceeds the sustainable yield of life support systems. The reducing forest reserves, eroding soils, high rates of desertification and declining water tables show that the pressure on cropland, forests, grassland and water resources is excessive. Efficient and envirogentle utilization of human and draught animal powered machinery will therefore remain vital factors to the advancement of humankind.

Region	Source of power for cultivation		
	Tractor	Animal	Human
Northern Africa	5	81	14
Ethiopia	2	85	13
Southern Africa	3	15	82
Kenya	5	15	80
Latin America	28	16	56

Source: Gebresenbet, G and P. G. Kaumbutho (1997). Comparative analysis of the field performance of a reversible animal-drawn prototype and conventional mouldboard ploughs pulled by a single donkey. *Soil and Tillage Research* **40**:169-183.

Table 4: Patterns of utilization of tractor, animal and human power for cultivation in selected regions of developing countries

2. Human Powered Operations and Equipment

Human power is the elementary level of mechanizing agricultural and forestry operations. It constitutes the use of tools, implements, machines and vehicles powered by human energy. The use of hand tools and equipment typically has a low investment. Ownership and operating costs are also low, the necessary technical input for operation is basic, but different levels of skill and experience may be required to handle each tool. Inherent drudgery and limited capacities are major disadvantages for operations where timeliness is paramount. There is also a disadvantage where high precision and repeatability are desired.

Figures 2 through 5 illustrate some common human powered equipment in agriculture and forestry. Pertinent operations include:

- clearing of vegetation/stubble including cutting trees (machetes, axes, hand and chain saws);
- land preparation and soil manipulation (blade and tined hoes and pickaxes);
- seeding or planting (broadcasting by hand or seed fiddle, dibbling, jab planting and use of single or multi-row seeders);
- weeding (weeding hoes and cultivator weeders);
- fertilizer and manure application;

- crop protection (manual or power knapsack sprayers and dusters);
- harvesting (scythes, sickles, knives, drags, forks and rakes);
- processing and preservation of food and feed (baling, mechanical threshing, manual and mechanical shelling and grinding);
- transportation (head or shoulder load, backpack, handcarts and bicycles), and;
- other secondary tasks such as operation of hand and treadle pumps to lift water.

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Biographical Sketch

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