MECHANIZATION ALTERNATIVES FOR THE MOST COMMON SIZES OF FARMS IN GUATEMALA

by

VICTOR HUGO MENDEZ Estrada

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Approved by:

G. H. Larson
Major Professor

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INTRODUCTION

Guatemala is the northern most country of Central America. It is located between 14^{o} and 18^{c} north latitude and 89^{o} to 92^{o} east longitude. The Guatemala economy is based upon the export of agricultural products. The principal exports are coffee, cotton, sugar cane, beef and bananas.

Guatemala has undergone a rapid process of industrialization since 1960 when the Central American common market was founded. Despite that, agriculture still remains the largest employer of labor and is the first branching sector of the economy.

Guatemala has about seven million inhabitants. Of these, about sixty-five percent live in rural areas (Censo General 1979). Its total area is 108,889 square kilometers (45,452 square miles).

The physical features of the country are quite variable and are characterized by a south coastal plain where the best soils of volcanic origin in the country are located. They are very deep and fertile. The northern plains are characterized by very shallow sedimentary soils which do not adapt well to intensive agriculture. Between the plains there is an east-west mountain range which crosses the country from Mexico to the west and Honduras to the east. The soils are of volcanic origin, but difficult to farm because of the steep slope of the land. Part of this land is planted with permanent crops, such as coffee and rubber. Another part consists of natural forest. The rest is planted with annual crops such as maize and black beans which causes a very serious erosion problem.

The country is divided into three slopes: the Pacific slope, the Atlantic slope, and the Gulf of Mexico slope. The largest rivers flow northward to the Atlantic and to the Gulf of Mexico. Some of them are navigable by small boats. The rivers that flow to the Pacific are smaller and none of them are navigable.

The wind blows steadily from the north and insures a mild climate throughout the year, mainly in the mountain region. The daily and seasonal temperature variations are minimal, from about 10^{o} to 25^{o}C. Precipitation is about 1000 millimeters per year. On the southern coast and in the northern region, temperatures can be as high as 35^{o}C with precipitation of about 3000 millimeters per year. There are two clearly defined seasons in the country. The rainy season occurs during the months of May through October and the dry season occurs from November through April.

Irrigation is practiced on part of the southern coast near Mexico and in the eastern part of the country, which is very dry. About 28.9 percent of the land is suitable for farming and is used for cultivation. Most of the remainder has slopes from sixteen to forty-five percent (Censos Agricolas 1964). Conservation measures must be used with permanent crops and it is almost impossible to produce clean, cultivated crops.

Guatemala has an unusual variety of soils. Most are of volcanic origin and these are the most productive. These soils are located on the southern coastal plains where sugar cane, cotton, bananas and grasses are grown. Guatemala's total land area if 108,889 square kilometers. About sixty percent of this area is hilly and mountainous.

The total exploited area amounts to 3,448,776.2 hectares. Of these, 995,253 hectares are crop land that covers 28.9 percent of the total, 1,051,946 hectares are grasses that cover 30.5 percent of the total and 810,648.7 hectares are forest that covers 23.5 percent of the total. The remaining 17.2 percent is land with no crops and land where the crops are lost (Censos Agricola 1964) (Tables 1 and 2).

This variety of climatic and topographical conditions leads to the production of a large number of different crops as shown in Table 3 (Censor Agricola 1964). About 525,964 hectares covering fifty-two percent of the crop land are used to cultivate maize, the principal cereal used for food in Guatemala. Following maize, the second largest cultivated crop is coffee which covers 231,646 hectares or twenty-three percent of the total crop land. Following that are cotton and sugar cane plantations.

As indicated, more than half of the crop land is used for the production of maize, a food crop. Because of the indigenous agricultural practices of the farmers, yields per hectare are very low and almost every year, corn and other food crops must be imported. Most of the food crops are grown on small farms without the use of new techniques. Therefore, modernization of the agricultural methods is needed to increase yield per hectare.

One important part of modernization in agriculture is mechanization. Farm mechanization in Guatemala has increased rapidly during the last few years. Evidence of this is that the number of tractors used in the last fifteen years has increased about eighty percent, from 3160 in 1964 to 14,093 in 1979 (Censor Agricolas 1964-1979). However, about

eighty percent of the tractors are used on big farms which are involved in the production of export crops. On the small farms, where most of the food crops are grown, mechanization has increased very slowly. Alternatives need to be found in order to improve food production, mainly on the small and medium size farms. This could result in the improvement of the standard of living and reduce the poverty of the rural people in Guatemala.

Table 1. Estimation of the General Land Distribution in Guatemala

Land Use	Square Kilometers	Percentage
Total Area	108,889	100.0
1. Area used for cities, lakes, roads, other land and non-exploited land	74,465	68.4
2. Exploited land area	34,424	31.6
a. Land used in agriculture	14,473	13.3
b. Land used in grass production	10,500	9.6
c. Forest and other land	9,451	8.7

(Censos Agricolas 1964)

Table 2. Use of the Exploited Area for Permanent and Annual Crops

Land Use	Hectares	Percentage
Total exploited land	3,448,736.2	100.0
1. Grasses	1,051,946.0	30.5
a. Permanent cultivated grasses	544,422.9	15.8
b. Natural grasses	471,412.9	13.7
c. Semi-permanent grasses	36,110.2	1.0
2. Crops	995,253.0	28.9
a. Annual crops	675,833.2	19.6
b. Permanent and semi-permanent crops	319,419.8	9.3
3. Forest	810,684.7	23.5
4. Land with no crops	414,763.3	12.0
5. Land where the crops are lost	35,817.6	1.0
6. Other land	140,271.6	4.1

(Censos Agricolas 1964)

Table 3. Area Used for Each Crop

Crop	Hectares	Percentage
Total Area	995,253.0	100.0
Maize	525,964.0	52.85
Coffee	231,646.1	23.27
Cotton	85,428.7	8.58
Sugar cane	41,653.5	4.18
Wheat	22,901.9	2.30
Beans	19,490.1	1.96
Bananas	9,945.6	1.00
Rice	8,663.9	0.87
Lemon tea	8,347.5	0.84
Rubber	7,140.7	0.72
Plantain	6,103.3	0.61
Citronella	3,592.4	0.36
Potatoes	3,077.2	0.31
Pineapple	2,488.5	0.25
Sorghum	2,482.9	0.25
Tomatoes	2,473.8	0.25
Cacao	2,364.6	0.24
Oranges	2,298.1	0.23
Tobacco	1,610.0	0.16
Peanuts	500.5	0.05
Sesame	457.1	0.04
Broad beans	359.8	0.04
Kenaf	342.3	0.03
Henequen	336.0	0.03
Apples	251.3	0.02
Pears	213.5	0.02
Plums	175.0	0.01
Other crops	3,837.4	0.04

(Censos Agricolas 1964)

OBJECTIVES

The primary objectives of this report are:

1. To study and explain the current status of mechanization in Guatemala and give some alternatives for improving the standard of living and reducing the poverty of the rural people there.

2. To give some alternatives for mechanization of the small sized farms in Guatemala (less than seven hectares), where most food crops are produced by people with very low income.

3. To give some alternatives for mechanization of medium sized farms in Guatemala which include farms from seven to twenty-two and one-half hectares.

About ninety percent of the farms in Guatemala used only human labor and animal power in 1979 (Censos Agricolas 1979) while seventy-eight percent of the area cultivated in the developing countries in 1975 (FAO 1975) was farmed with hand tools and draft animal technology. Therefore, it appears that Guatemala is above the average in the use of hand labor.

Humans are not an efficient source of power, mainly because of the tropical climatic conditions of Guatemala (Gifford, R. C., 1981). Initially, efforts must be made to improve hand tools in order to make human power more efficient. Then, draft animal technology needs to be introduced and applied. In some situations, the introduction and application of mechanical power may be required. Increasing power alone will not solve the problems on the small farms; however, it must be done in conjunction with a general modernization of the farm. This would

include the introduction of other technology, knowledge, and motivation, as well as the provision of institutional and infrastructural arrangements which would insure a receptive environment for technological changes.

DIFFERENT SIZES OF FARMS IN GUATEMALA

There is a wide range in the sizes of farms in Guatemala. Some are less than one hectare. These constitute about 60.5 percent of the total while covering only 4.14 percent of the total cultivated area. There are a few farms that are greater than nine thousand hectares.

Farm size in Guatemala has been decreasing year by year because of the custom of the division of farms by parents among their sons. This has resulted in the formation of very many micro-farms. About 89.7 percent of the farms consist of less than seven hectares and account for 16.05 percent of the total crop land. About 96.3 percent of the total number of farms are less than 22.5 hectares and cover about 27.7 percent of the total crop land. For the purposes of this report, farms with less than seven hectares are designated as small farms and those between seven and twenty-two hectares are designated as medium sized farms. The remainder of the farms which cover about seventy-two percent of the cultivated land are divided in different sizes as shown in Table 4 (Censos Agricolas 1979). These account for about four percent of the total number of farms.

In this report, greater emphasis will be given to the study of the small farms (subsistence farms), with some emphasis given to the study of medium size farms.

The subsistence farmers have been virtually forgotten by the government and by some international institutions. They cannot get credit because they do not have enough land to secure the loans. They cannot use new technology such as improved varieties, fertilizers, or new and improved tools because they do not have the money to buy them. In some cases they do not know they exist because the government extension programs do not provide them with the information. Since they do not produce export crops, they do not have the advantage of special infrastructures, such as roads. In some cases, they produce only subsistence crops for the immediate family. Many subsistence farmers and their families work only in the rainy season because in most cases, they do not have irrigation. They then must migrate to the coffee and cotton plantations to work for about four months in the harvesting of these products. An analysis of data from the FAO 1970 World Census of Agriculture, carried out by FAO and the World Bank, confirms the heavy preponderance of small farms in most developing countries. These data also indicate that the number of landless agricultural laborers is probably greater than hitherto realized.

The census states, "It appears that farm size in the developing countries is becoming smaller due to population pressures and/or official action." It adds, "For the near future it must be accepted that the small farm enterprise in developing countries is essentially a permanent institution. The long term solution to the problem of food, development and poverty must, therefore, be sought in improving the productive capacity of small farms and landless laborers and providing additional off farm employment for much of the rural labor force."

Table 4. Number of Farms and Distribution of Land According to Size of Farm in Guatemala

Size of Farm	Number of Farms	Percentage of Number of Farms	Area in Hectares	Percentage of Total Area
Less than 1.4 hectares	369,291.0	60.5	174,404.24	4.14
1.4 to 3.5 hectares	127,049.0	20.8	265,738.66	6.31
*3.5 to 7.0 hectares	51,234.0	8.4	238,165.07	5.60
**7.0 to 22.5 hectares	40,084.0	6.6	494,179.56	11.74
22.5 to 45.0 hectares	9,089.0	1.5	281,903.06	6.70
45.0 to 450 hectares	12,298.0	2.0	1,273,847.30	30.27
450 to 900 hectares	860.0	0.14	522,336.90	12.41
900 to 2250 hectares	383.0	0.06	494,884.61	11.76
2250 to 4500 hectares	73.0	0.01	220,626.72	5.43
4500 to 9000 hectares	15.0	-	85,444.79	2.03
Greater than 9000 hectares	6.0	-	156,333.10	3.71
Total	610,346.0	100.00	4,207,864.00	100.00

(Censos Agricolas 1979)

*About 89.7 percent of the farms are less than 7.0 hectares. These cover about 16.05 percent of the total area.

**About 96.3 percent of the farms are less than 22.5 hectares. These cover 27.79 percent of the total area.

PRESENT STATUS OF FARM MECHANIZATION IN GUATEMALA

In general, the farm mechanization in Guatemala improved between 1964 and 1979, which is the latest data available.

Table 5 (Censos Agricolas 1979) shows the extent to which the various forms of power are used in Guatemala.

Table 5. Types of Farm Power Used in Guatemala in 1979

Total Number of Farms	Tractors or Mechanical Power	Animal Power	Animal and Mechanical Power	Human Labor
528,792	27,142	25,929	16,236	459,485
	Percentages of Use of Various Types of Power			
100	5.13	4.90	3.07	86.89

According to FAO source estimates, seventy-eight percent of the area cultivated in the developing countries (excluding China) in 1975 was farmed with hand tools and draft animal technology. In contrast, mechanical power technology was used on eighty-two percent of the area cultivated in the developed nations (FAO, 1970).

Table 6. Area Cultivated with Three Power Sources in 1975 (Area in Millions of Hectares)

Categories of Countries	Area Covered	Total	Power Source: Hand Labor	Draft Animals	Tractors
Developing Countries	Area	479	125	250	104
	% of Share	100	26	52	22
Developed Countries	Area	644	44	63	532
	% of Share	100	7	11	82
World Total (Excluding China)	Area	1,123	169	313	611
	% of Share	100	15	28	52

From Table 5 it can be seen that about eighty-seven percent of the power in Guatemala is human power and only 4.9 percent is animal power. Most developing countries are ahead of Guatemala in their use of animal and mechanical power, according to Table 6.

Another important factor is the ownership of machinery. According to Table 7, more than half of the machinery used on farms is rented by companies and the hire and custom tractor system is used. However, the companies have machinery that is appropriate only for big farms and

the cost of rental is very high. The machinery is used for land drainage and other extensive practices. This hire and custom tractor system is not used for small and medium sized farms.

Table 7. Machinery Ownership in Guatemala

Total Number of Farms Using Machinery	Own Machinery	Rent Machinery	Own and Rent Machinery
57,310	27,233	28,871	1216
100.0%	47.52%	50.37%	2.12%

(Censos Agricolas 1979)

As was mentioned before, industrialization has improved in Guatemala in the last fifteen years. There has been an increase in numbers of all types of machines with the exception of electric generators. These decreased in number because more farmers are now under the national electrification plan.

From Tables 8 and 9 (Censos Agricolas 1964-1979), we can see increases as high as three hundred percent or more in tractors and combines, about two hundred percent in planters, pickups and jeeps, and more than one hundred percent in other machines or equipment, such as iron plows, theshing machines, mechanical harvesters, cultivators, and trucks. We can also see an increase of only thirteen percent in draft animal wood plows. This implies that draft animal technology has been more or less static.

To study this phenomenon of mechanization increase, we will divide the country into different geographical zones, as shown in the map (Fig. 1), in order to see what sizes of farms are getting the mechanization benefits. The division will be: central region, southern region, western region, northern region, and eastern region. Most of the big, export crop farms are located in the southern and part of the western regions. In 1964, these regions combined had about 81.5 percent of the total number of tractors, about 49.1 percent of the total number of iron plows, and about 82.6 percent of the total number of planters. They had only 1.9 percent of the draft animal wood plows (Censos Agricolas 1964).

On the other hand, the central, eastern, and part of the western zones had only 15.1 percent of the total number of tractors, about 13.3 percent of the total number of planters, but had about sixty-four percent of the total draft animal wood plows. Most of the small and medium sized farms are located in these three regions. Data are unavailable for 1979, but it can be assumed that the introduction and increase of mechanization have taken place in the big and medium irrigated farms and not in the smaller ones.

Attempts to clear the forest land and make it suitable for farming have been made since 1970, but these attempts have been mostly unsuccessful, due to lack of proper planning.

In summary, we can conclude that most of the high income, export crops produced on large farms have been cultivated using modern technology with improved and imported mechanization equipment. Problems remain in the mechanization of certain specialized operations such as the harvesting of coffee, cotton, and tobacco.

On the other hand, small farmers continue to use the centuries old indigenous methods, producing low yields and suffering excessive soil losses due to erosion of the steep slopes they cultivate. Most of them continue to use human power and inefficient hand tools.

Table 8. Equipment and Vehicles, April 1964.

	Number
Gasoline, diesel and L.P. gas engines	3,714
Electric motors	1,300
Electric generators	1,490
Wood plows	38,092
Iron plows	5,675
Tractors	3,160
Threshing machines	428
Planters	782
Mechanical harvesters	265
Cultivators	1,648
Combines	99
Machinery for humid coffee processing	3,188
Machinery for dry coffee processing	1,677
Machinery for sugar cane processing	6,249
Trucks used on farms	1,355
Jeeps and pickups used on farms	2,080
Oxcarts and wagons	5,460

(Censos Agricolas 1964)

Table 9. Equipment, Machinery and Vehicles, 1979.

	Number	Increase in % 1964-1979
Gasoline, diesel and l.p. gas engines	6,126	165
Electric motors	3,489	168
Electric generators	1,133	-23
Wood plows (draft animal plows)	43,235	13
Iron plows (tractor drawn plows)	11,677	105
Tractors	14,093	345
Threshing machines	1,215	184
Planters	2,481	217
Mechanical harvesters	761	187
Cultivators	3,725	126
Combines	477	381
Machinery for humid coffee processing		
Machinery for dry coffee processing		
Machinery for sugar cane processing		
Trucks	3,471	156
Jeeps and pickups	6,712	223
Oxcarts and wagons	15,243	179
Harrows	8,480	
Hand threshers for corn	3,239	
Fumigation pumps	41,117	
Irrigation pumps	4,016	

(Censos Agricolas 1979)

Comparing the data from 1964 and 1979, we can see the increase in the use of equipment, vehicles and machinery. In most cases, it is more than one hundred percent, but in some cases involving the use of tractors, planters, and combines, the increase was more than two hundred percent or even three hundred percent.

1) Central region
2) South region
3) West region
4) North region
5) East region

Guatemala Map Divided By Regions

Figure 1

GENERAL MODERNIZATION OF THE FARM

An increase in yield per area is not dependent solely on mechanization. Mechanization is one of many factors that small and medium farmers need to use in order to increase production.

Infrastructure is one of the most important parts of the system. Most of the small farms are in the central and western regions. If a subsistence farm is to be changed to a commercial farm, better roads and transportation are needed to take products to the market. The government needs to provide better road systems in these areas.

Irrigation is another important factor in the developing of the small and medium farm. In some cases, it is possible to construct government irrigation projects, but in others, the farmers have to buy their own mechanical pump sets. Irrigation allows intensification and diversification of the cropping system. Then farmers are not dependent on rainfall as the only source of water and they are able to get two or three crops per year from the same land.

Development and introduction of new varieties of crops are two important aspects needed in order to increase yield. The new varieties have to be resistant to diseases and insects, mature early, and give a high yield per unit area. The Science and Technology Agriculture Institute (ICTA, 1978-1979) has developed new varieties of maize, black beans, rice, wheat, etc., which are adapted to these conditions. The principal problem is with their introduction. Most of the farmers do not experiment with the new varieties because they are unfamiliar with them or do not want to take the risk. The problem here is a lack of

extension agents. There are too few people working in this field. Many demonstrations need to be performed in each region; if not, no one will plant the new varieties even though they are available.

Fertilizer is another means of increasing yield. Most of the small and medium farmers use a very small amount per unit area or do not use it at all because the chemical fertilizer is too expensive. In addition, sometimes the fertilizers have been used indiscriminately without soil analysis, causing problems and losses to the farmers.

Farmers need to learn how to conserve their natural resources, such as soil and water. A very serious problem in steep slope farms is erosion. It causes the loss of many tons of soil each year. Farmers with farms of this type need to take advantage of soil conservation practices. The use of a crop that covers the land after the main crop is harvested is important. Cowpeas or other plants that adapt well to the region can be used. Contour farming methods also need to be taught.

Many times, the farmers get a good yield per hectare, but it is lost after harvesting due to inadequate drying and storage facilities for the products.

In addition to the different inputs, appropriate mechanization technology that is suited to the conditions of the farms is needed in order to increase production.

MECHANIZATION ALTERNATIVES FOR SMALL FARMS (LESS THAN SEVEN HECTARES)

The alternatives for small farms must be studied according to the actual status of these farms.

Introduction of Small Hand Machines or Tools

As mentioned before, the most commonly used farm power source in Guatemala is human power; therefore, special emphasis must be given to this type of power, even though it is inefficient. R. C. Gifford states, "Farming on the basis of hand tool technology seldom exceeds a subsistence level. The area that can be cultivated by a single family is limited; typically not more than two hectares." In another paragraph he states, "Humans are not an efficient source of power under the conditions which are typical of the developing countries. Then it is clear that power is the major constraint on increasing agriculture output of farming when using only hand tool technology. However, we have to give some alternatives for this source of power to increase its efficiency and to reduce drudgery." (Gifford, R. C., 1981).

Development or introduction of hand equipment and tools could be the way of attaining the above objectives. Tools devised in other developing countries could be tested and adapted for the conditions in Guatemala.

One of the new machines or tools utilized could be the new soy bean planted developed in Thailand (Khamsaeng, M., Vuthijumnonk, K., 1981). The planter was developed by the department of farm machinery. This is one way of applying appropriate technology in agriculture.

The planter started from a very simple type, consisting of only a small steel tube with handle in a plastic cone. It was improved by

adding modern and appropriate mechanisms. Finally, the last version called Mae-Jo5 (Figure 2) was completed.

The advantages of the Mae-Jos planter are: 1) The seeds are uniformly released (about two to four seeds per hole), and 2) The farmer can work faster, it is more convenient, and more seeds are saved. He can plant 2000-2500 holes per hour.

Some precautions to be taken when using this planter are: 1) The planter should be used in conjunction with a digging machine, and 2) The seeds should be graded to more or less uniform size.

This machine could be used to plant maize in Guatemala after testing, adjustment and necessary modification. The maize is planted in rows and the distance between rows is about seventy-five centimeters and the distance between the holes within rows is about eighty centimeters, using two to four seeds per hole. We can conclude that the planter pattern is almost the same as that of the Mae-Jo5 planter. (Khamsaeng, M., Vuthijumnonk, K., 1981).

In the case of weeding, tillage, and cultivation, the most commonly used tool is the hoe. Modern materials need to be introduced to improve durability and cutting edges. Tool design must be modified to be more suitable for new crops, different types of soils, different types of tasks, and/or to reduce drudgery.

In the article written by Amir Ukham, there is an example of how a small rotary power weeder (Figure 3) has been used for weeding rice in some Asian countries. This weeder is pushed by hand, but uses a one horsepower engine as a power source. Rotary power weeder description: a one horsepower engine powers the weeding rotors through a gear reduction box. Light sheet metal shields protect the rice plant. The