SESSION 3

Contractors in Agriculture: Consequences and Developments on Agricultural Machinery. A Preliminary Analysis

Aad JONGEBREUR - Session Chairman

Welcome to this Session: "Contractors in Agriculture: consequences and developments on agricultural machinery".

Coming to this subject of the afternoon session of this meeting of the Club of Bologna, I think that we can also refer to the opening of this morning, when the Chairman mentioned in his remarks that machines, power or mechanisation are often key factors in agricultural production systems. I think that contractors in agriculture in several countries are well known. In some regions we are aware of the phenomenon of what we call "over-mechanisation" in the private fauns. I think in the afternoon discussions this point will also arise, and also the point of view of optimizing the economic results of farms is playing an important role in making use of contractors. Other points will be discussed in the afternoon session and I will give the floor to present the first paper, which is written by Prof. Castelli, from the Institute of Agricultural Engineering, University of Milan, and Prof. Piccarolo from the Institute of Agricultural Engineering of the University of Turin. Prof. Castelli, please take the floor.

Prof. Giorgio CASTELLI
Prof. Pietro PICCAROLO
Institute of Agricultural Engineering of Milan
Institute of Agricultural Machinery of Turin
Italy

CONTRACTORS FOR INDUSTRIALIZED AGRICULTURE: CONSEQUENCES ON AND DEVELOPMENT OF MECHANISATION SYSTEMS. A PRELIMINARY ANALYSIS IN INDUSTRIALIZED COUNTRIES

1. Agricultural development and mechanization

1.1 A new agricultural model

Farm mechanisation is a driving factor in agricultural development and has increasingly contributed to the achievement of agricultural objectives over the years **(Figure 1).**

In the industrialized countries, especially in Europe and Japan, the period following World War II was characterized by growing mechanisation and major technological break-throughs. This was a response to the two-fold need to cope with the exodus of manpower and to reduce production costs by increasing labor productivity.

During this period, which extended to the late '70s, the growth of mechanisation, the introduction of new cultivars and the increasing use of fertilizers and pesticides boosted the farming system to high yields and the gradual production of food surpluses.

Starting in the '80s, a series of socio-environmental and economic indicators denounced the inadequacies of this agricultural model. On the one hand, they pointed up the environmental damage caused by the loss of soil fertility, by erosion, by the percolation of chemicals into water tables and by the pollution of air and water. On the other, the financial waste caused by the storage of surpluses (the EC, for ex-ample, spent 9 billion US$ in 1991 to this end).

Hence the need to create a new agricultural system, that can be indicated by the term "sustainable agriculture". Although the meaning of the term has not yet been fully defined, the objective of this new system is to create - at least for the main crops - a development "compatible" with environmental protection and the internationalization of agricultural policies.

The practical consequence almost for EC countries **(Figure 2)** will be to reduce:

— the agricultural used area;
— the consumption of fertilizers and pesticides;
— the agricultural workers:
— the prices of many farm products.

These interventions obviously will have both direct and indirect consequences on contracting.

1.2 Effects on mechanisation

In the industrialized countries, the process of mechanisation, with growth rates rising annually, began after World War II and continued basically until the early '80s.

During the years following the second oil crisis, investments in machinery began to decline (**Table 1**).

Nonetheless, the power of tractors and the working capacity of new machinery continued to increase. At the same time, the active population in agriculture declined, in parallel with an increase in the average age of farmers.

In the EC countries, for example, investments have declined by 30% in the past ten years, at constant currency, with peaks of 58% for Italy and 51% for Spain. Only France has shown a different trend with an increase of almost 5%.

Table 1 indicates that investments per unit of AUA also decreased during the same period, through to a slightly lesser degree, due to a parallel decline in the total cultivated area.

The difficult economic situation in the early '90s has further aggravated this crisis. 1991 was a black year for farm machinery. In France, for example, total income was among the lowest in the past ten years, while the number of machines sold declined from the previous year in almost every sector. Tractor sales decreased by 20%, combines by 23% and soil preparation machinery by 17%. Essentially the same figures were registered in Italy.

This decline in new machinery sales was the result of numerous factors. The high annual growth rates in the '70s (greater than 10%) often led to situations of over-mechanisation. Furthermore, the growing power of tractors, the increased working capacity of implements and the reduction of soil preparation operations caused a gradual reduction of machinery working hours per hectare and per year, with an useful life higher than the technical obsolescence.

In Italy, for example, average annual utilization is currently estimated at 250-300 hours per tractor.

These elements have obviously had a strong_ impact on the incidence of mechanisation cost, for farming and animal breeding raising. This incidence, according to the countries and the structural conditions of agriculture in each of them, may vary from 20 to 50% of the production costs for the main crops. Hence the need first to reduce costs to make farm, competitive and then to rationalize the use of the machinery.

1.3 Multi-farm utilization of machinery

The problem of mechanisation is therefore linked to the problem of better utilization of machinery and manpower, which cannot always be achieved at the individual farm level This has spawned the intra-farm or collective use of this machinery, which may take various forms.

Interchange. Machinery and services are interchanged among the farmers. This traditional formula permits farmers operating on large farms to pass the benefit of their machinery on to small farmers. Moreover, it permits small farmers to have machinery and equipment. This solution, once heavily practiced in some countries, is now in sharp decline.

Co-ownership. The machinery is purchased by two or more farmers, who become co-owners and use them collectively. This solution, still used in some countries, is losing importance.

Cooperation. The cooperative use of farm machinery may take various forms:

— full range of machines suitable for satisfying any requirements of the participants and with wide operating radius;
— specialization in the use of a single machine;
— machines that enable a restricted group of farmers living in the same area to cope with peaks in work load.

This form has been widely used in countries like France and Germany (former Federal Republic).

Rental and leasing. Under rental, the machine is given to the farmer, without an operator, to perform a certain work, against payment of a rental charge. Leasing is a form of rental, widely used in other sectors, that has spread to some extent in farming. These forms are generally quite costly but can be stimulated by special fiscal or credit facilities.

Contracting. This service is provided by specialized firms that perform work with their own machinery on behalf of farmers. Contractors generally have good technical expertise and are equipped with efficient, modern machinery. Intra-farm use, in fact, permits good hourly utilization of the machines, which are replaced as needed. This form of activity originated at different times in the various countries, but in any case not recently. It has been gaining importance and now seems a technical and economical valid tool to solve the growing need for innovation in agriculture.

In general terms, the development and type of common utilization of the machines is associated with the structural, social and farming conditions in the various countries (**Table 2**).

The average size of farms within the EC countries, for example, varies widely, from 7.7 ha in Italy to 30.7 ha in France. The opposite pattern is found for the ratio of farmers to the total population, which ranges from 15% in Spain to 4.7% in the Netherlands.

The age of farmers also reveals significant differences. In Italy 28% of them are over 65. This percentage drops to 13% in the Nether-lands and to a more 6% in Germany (former Federal Republic). On the other hand, farmers below 45 years of age account for over 30% in Germany and the Netherlands against less than 18% in Italy and Spain.

Finally, while only 12% of farmers in Italy declare themselves to be full-time, this figure rises to 75% in the Netherlands. France and Germany report 57% and 43%, respectively.

This variable pattern of farm situation in the various EC countries becomes even more variable if we extend the analysis to all the industrialized countries.

The consequence is a different attitude toward the inter-farm use of machinery.

This difference is manifested both in the extent of the phenomenon as such and in the choice of the forms of machinery use (inter-change, cooperation, contracting, etc.). Thus, for example, while contracting is the form most widespread in Italy, other countries like France and Germany seem to favor the cooperative use of machinery.

2. Relationships between contracting and structures

2.1 Services performed by contractors

In almost all the industrialized countries, contracting initially involved wheat threshing and plowing. Over the years. however, the crops and range of processes and services offered have increased significantly.

The general economic crisis, the constraints of EC farm policy and international trade agreements, along with changing markets, the pre-cariousness of cropping alternatives and the reduction and growing cost of manpower have gradually discouraged farmers from investing large financial resources in machinery.

This has favored the expansion of contracting. In fact, at present, contractors work on a vast range of crops, from wheat to corn, from sunflowers to soybean, from sugar-beets to various types of industrial crops, including the harvesting of fodder, the vintage and the harvesting of different tree crops.

Regarding the type of operations, the range of practices performed by contractors has grown considerably, though harvesting and tillage still lead the rankings. Contractors increasingly perform planting. weeding and fertilizing operations, to the point of providing total management of entire crops and farms.

To cite an example, in Italy, and more precisely in the Po River Valley, a sample area of 200,000 ha managed by contractors yielded the following breakdown of operations performed:

- harvesting-threshing 50.8%;
- crop processing 12.4%;
- tillage 8.9%;
- other operations 19.6%;
- total management 8.3%.

The farms prevalently served were found to have less than 20 ha (80% of the total), with mixed cropping pattern. In terms of cultivated area, however, there was a strong predominance of large farms (70% of the total), confirming the fact that the use of contracting is advantageous even for them.

"Total farm management" is the most complete service provided by contractors. In this case, in fact, the owner depends on the contracting firm for all his farm mechanisation requirements, limiting his participation to select the cropping pattern. The result is an expansion of area managed by the same machine independently from the land ownership. It may involve several hundred hectares, with the creation of large production units assigned to the professional expertise and operating capacity of the contractor.

In relatively recent times, contracting firms have begun offering their services in non-farm sectors, such as the maintenance of public and private green areas. This extension permits the firms to:

- reduce periods of underemployment;
- make better use of available manpower;
- increase the working hours of their equipment while reducing the incidence of fixed costs on the unitary costs.

In Italy the contractors category covers up to 50% of the farm-machinery work requirement, and everything seems to indicate this incidence will grow.

In all the advanced countries, in fact, the demand for contracted services is growing in every production sector, farming included, to obtain qualified specialized services that cannot be economically performed within the sector itself.

We have unfortunately been unable to obtain similar data for other countries.

2.2 Types of contracting firms

With reference then, once again, to the situation in Italy, there was an 8- 10% reduction in the number of firms in 1991. This means that the market is rejecting the weaker operations. At the same time, there is a general growth trend in both machinery assets and turnover.

In fact, the contracting business, with its 850 million US$ invested in new machinery in 1991, is the only positive market segment.

The total sales of contracting firms (1.7 billion US$ in 1990) represents around 3% of gross saleable product and 10% of the intermediate products consumed by Italian agriculture.

In a recent survey on contracting, which involved more than 400 firms, it was found that:

- the average age of the firms is over 20 years;
- over 80% work only in the agricultural field;
- the small firms (with less than 500 kW of installed power) prevail in numerical terms;
- three-fourths of the land area worked is covered by large firms;
- the manpower employed averages three persons per firm;
- the power installed in each firm was between 250 and 1,000 kW (the big firms accounted for 70% of total power);
- the average annual utilization of tractors was around 500 hours;
- the power available per hectare worked was 2-3 time lower than that of the larger farms;
- their operating radius is rather limited: from less than 5 km for contractors who also manage a their own farm, to 10 km for the specialized firms.

In Spain, a similar survey carried out revealed the predominance of proprietorships. In particular:

- — in earth movement, the average is represented by proprietorships with 2-3 machines and investments of 95,000-280,000 US$. Medium-size firms with 6-7 machines reach investments of almost 1 million US$;
- — soil and crop preparation operations are a virtual monopoly of small firms with investments on the order of 90,000-95,000 US$;
- — wheat harvesting is dominated by proprietorships with 1-2 machines with investments of 100,000-300,000 US$;
- — the proprietorships also prevail in sugar-beet and cotton cultivation;
- — some large associations for processing and marketing the products have a machinery pool worth over 2,000,000 US$ each, utilized only by the associated farmers.

3. Possibilities and limitations on the use of contracting

3.1 Operations costs

In the industrialized countries, as mentioned earlier, the cost of mechanisation represents from 20 to 50% of the total cultivation cost. But if we consider tariff applied by contractors in absolute terms, the differences between the various countries are significant.

In Italy, for example, the contracting prices are often double those found in the USA. Even if we take into account the different structures and crop intensities, which reduce the comparison to a first approximation, it could be interesting to examine the rates applied in the two countries.

As shown in **Table 3,** the costs of services rendered by Italian contractors in the northern regions are on average 85% higher than costs in New York State. In some cases, the cost is more than twice as high (tillage: 100 US$/ha versus 40 USS/ha; harvesting of silage corn: 196 US$/ha versus 92 US$/ha, 1989 data).

The reasons for this difference lie not only in the differences between the two agricultural systems but also in the inadequacy of farm structures and, most probably, in the higher costs of machinery and fuel in the Italian market.

Furthermore, the size of farms in Italy is generally small and the ownership fragmented. This reduces the working efficiency of the machinery and tends to exclude the use of high-capacity equipment, as they are more heavily penalized by inadequate production structures.

US contracting firms are able to realize greater economies of scale because of the large areas served. The operating radius in Italy. as said. is 5-10 km and rarely exceeds 20 km. In the USA, firms even move from state to state, spanning as much as hundreds of km.

To provide some more detailed indications for a comparison between performing work internally and assigning a portion or all of the cropping operations to a contractor, we made a detailed analysis of the items that go to make up the cost of these operations.

Without going into the algorithm used, we would emphasize that the optimal size of equipment pools has become an increasingly critical factor, given the oft-mentioned gap between production costs and gross saleable output.

As is widely recognized, the problem can only be completely and effectively resolved by considering the farm as a system and determining the size of the farm machinery chain as a whole. This taking into account the various operations to be performed on the all existing cropping pattern.

Nevertheless, a global approach presents numerous difficulties. In fact, the early experiments conducted on models designed for this purpose have shown that their application to actual farming situations presents several problems.

For this reason, in determining the optimal size of an equipment pool, we utilized a simplified model. The results, though valid in first approximation, may form the basis for a productive, in-depth discussion on the technical and economic functions of contractors.

3.2 Technical and economic dimensioning of mechanisation chains

The optimal size of a mechanisation chain may be defined from an economic and/or technical standpoint.

The classic procedure for technical dimensioning of a mechanisation chain pool has long been known. It refers essentially to two limiting factors: the time available for executing the operation and the surface area to be worked. The known ratio between the two quantities allows to define the work capacity of the chain and thus the size of the machine.

The approach for economic dimensioning is slightly different. In fact, it considers not only the aforesaid technical-operational parameters but also the following:

— the fixed annual costs of the machine and manpower and, particularly, their incidence on the operation in question;
— the percentage weight (linked to the years of machine utilization) of fixed annual costs, calculated from the price of the machine (procedure valid only in first approximation but commonly used);
— the price of the tractor and implement.

Considering these additional parameters and the assumption that the price of the machines is directly proportional to their size, it is possible to define the optimal size of the chain from an economic standpoint. In other words, this determines the size that, with the assumptions made, will ensure the minimum cost per unit of worked area.

In conclusion: technical dimensioning gives the size of the equipment necessary to work a certain area within the useful time available; economic dimensioning determines the size offering the minimum operating cost.

3.3 Considerations on the two dimensioning criteria

The two criteria were applied to an example from which we shall attempt to draw some considerations of a general nature connected with the contracting problem.

The chain considered was composed of a tractor and an implement. In the hypothesis shown in **Table 4**, the results obtained from the model (**Tables 5** and **6)** indicate that for a given area of 25 ha, for example, technical dimensioning gives an implement of 1.39 m width and a tractor of 28 kW in round figures. while economic dimensioning gives an implement of 1.72 m and a 35 kW-tractor.

This means that against the technical solution. a wider mechanisation level (increasing the size of the equipment by 23.7%) would be better from the economic standpoint. In this case, the work could be completed in 97 hours rather than 120, with a lower cost per unit of worked area, though not much lower (167 US$/ha versus 171).

The results are summarized in **Figure 3**, which shows two curves (unit operation cost and implement size) obtained on the basis of economic and technical dimensioning.

Point A on the cost curve indicates the area size at which it is necessary to shift from economic to technical dimensioning to respect the useful time period, under those conditions.

Thus for a generic surface area two different situations can be founded:

— the technical dimension is smaller than the economic: this means that the user may select an equipment size greater than necessary to operate within the useful time period reaching an economic advantage; in a few words, he works and spends less;
— the technical dimension is larger than the economic one: this means that, while observing the limits due to the useful time period, the user is forced to select a size greater than what would ensure him an economic minimum.

The curve of unit costs as a function of surface area (look back to **Figure 3),** however, confirms that the lower unit costs can only be achieved by operating on large areas. However we must not forget that farm size is often an exogenous variable to the problem and, as such, cannot be modified when employing the farm machinery.

3.4 Farming or contracting operations?

From the above, the decision between operating internally or assigning tasks to a contractor is linked to two considerations: the first of a strictly technical-economic nature and the second of a more general nature.

The general aspects, already partly discussed, refer primarily to the current period rather unfavorable to agriculture in many industrialized countries, which discourages heavy farm-level investments.

Secondly, there is the problem of rising manpower costs and the social problems often associated with it: the farmer-entrepreneur may prefer, often for reasons beyond mere economics, to utilize a contractor if that enables him to reduce the fixed manpower level of the farm.

Another point relates to the need for flexibility in farm production. Long amortization periods limit this possibility, so the farmer prefers to utilize a contractor and be free to choose the crops or livestock he prefers.

These considerations often do not reflect rigorous logic and are difficult to quantify.

A more rigorous examination of the situation is possible, however, if we pose the problem (use farm equipment or a contractor) in terms of technical-economic analysis. Although the indications that may emerge must be evaluated in light of the general characteristics mentioned above, the aforesaid model may make a useful contribution.

The technical-economic analysis must indicate the unit costs of each operation, utilizing the farm machinery, so that they can be compared with the rates charged by the contractors.

In this connection, we must bear in mind that the fundamental (but not only) difference between a farm and a contracting firm is that the constraint on the former is the number of machine working hours, which are in turn conditioned by useful time available. This time is usually longer for the contractor, either because he can move on big areas and he is not generally tied to specific agricultural requirements as is the farmer.

To analyze this aspect with a concrete example, we considered the tillage operation, one of those frequently performed by contractors.

With the data shown in **Table 7**, we computed the minimum farm cost per hectare, i.e. the minimum possible cost to the farmer utilizing his own farm machinery. In this case, the hours of tractor use are obviously conditioned by the area to be tilled. For the operation in question, we assumed that it requires 30% of the total utilization time of the tractor.

The resulting range is thus from 278 total tractor working hours/year for an area of 10 ha (with 83 hours of use for tillage) to 463 total hours/year for an area of 40 ha (120 hours for tillage). The corresponding unit costs range from 271 US$/ha (209 US$/ha without considering manpower) to 192 US$/ha (172 US$/ ha without manpower).

Note that the foregoing values, the initial assumptions (machinery prices, rates of utilization, unit working capacity) remaining equal, are the minimum achievable under any conditions. Any other "tractor+plow" combination would raise costs. In other words, for each area considered, these are the threshold values for farm mechanisation. If the work of the con-tractor costs less than that value, it is surely advantageous from an economic standpoint.

The model takes into consideration the different situation in the case of the contractor, who is limited only by the useful time and not by the area to be plowed. More specifically, whatever the area to be plowed, the annual utilization of the tractor was assumed to be 1000 hours in a first simulation and 500 hours in a second.

Briefly stated, the results (**Figure 4**) show that costs of the contractor are always lower than those of the farm.

Given current rates, which in Italy stand around 170 US$/ha for the operation in question, this cost is reached by the contractor with as little as 20-25 ha, working with an equipment pool composed of a 90-kW tractor and three- furrow plow.

This means that a contractor operating on larger areas (as in almost all cases) makes a profit on his work (N.B.: the cost of manpower has already been considered). For example: working on 100 ha, the unit cost becomes 130 US$/ha, with a net profit of US$ 4,000.

The results are different assuming the use of the 500 hour/year tractor. As shown in **Figure 5,** in this case the two curves (internal vs. contractor) intersect, indicating a ceiling area of around 30 ha, beyond which the use of the farm's own equipment is more economical, for the operation in question.

As a conclusion, the use of the contracting is largely economically justified and meets the evolution of the agricultural systems. Consequently it deserves to be supported both by manufacturers and policy makers.

4. Conclusions

The benefit/cost analysis favors the utilization of contractors, at least for farms with areas below a ceiling value, assessable on a case by-case basis with suitable models (the one pro-posed or others similar to it).

The contractor who utilizes tractors 800-1000 hours/year makes a good profit. If the tractors are utilized 500 hours/year it is worthwhile only for small or midsize farms.

The limits connected with the International Agricultural Policies and the costs associated with the use of permanent farm labour favour the use of contractors.

In many cases, the current development of machinery, intended as types and sizes, has been achieved with a "farm-level" approach. overlooking the specific needs of a user class (the contractors) that can operate without the limitations typical of a farm.

This paper does not presume to deal with the topic exhaustively, especially from the international standpoint. But the considerations it makes seem to have demonstrated the importance and immediacy of the problem. We therefore propose that the members of the Club be asked, in a future meeting, to report on the experiences in their own countries.

References

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Figure 1 - Evolution of development goals in farm mechanisation systems

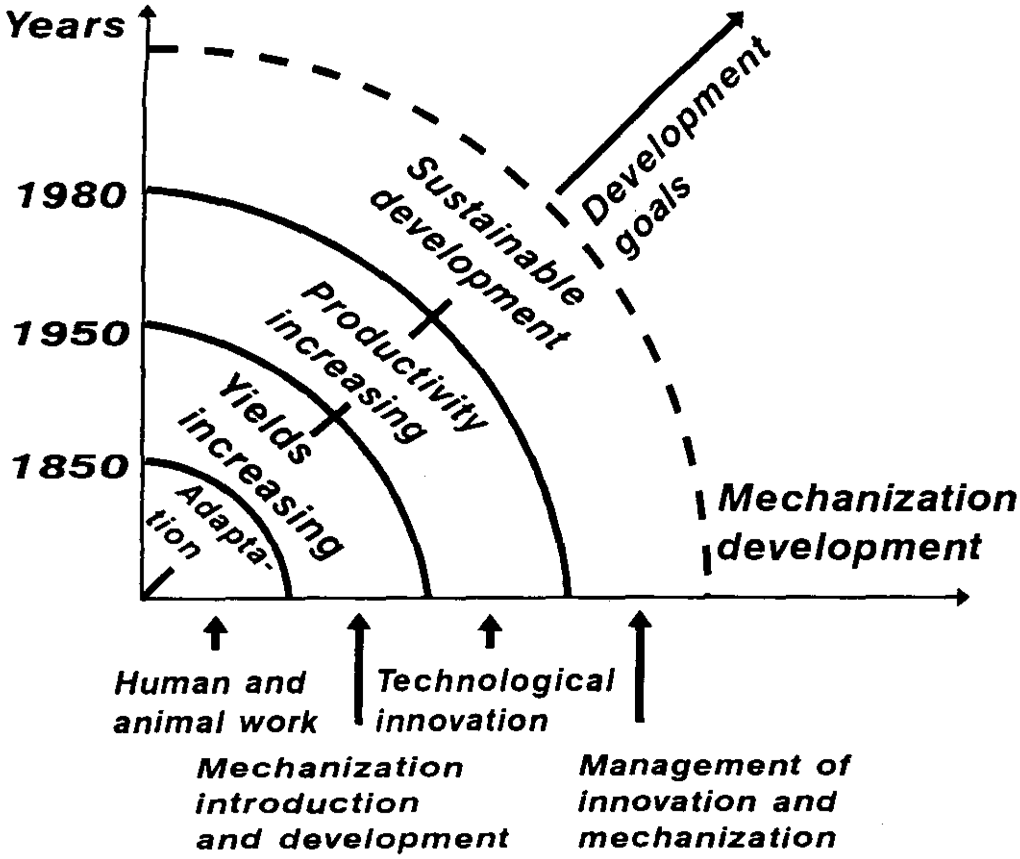

Figure 2 - Future possible actions deriving from low input sustainable agriculture. They regard the following: (A) cultivated area; (B) pesticide consumption; (C) agricultural workers; (D) price of cereals

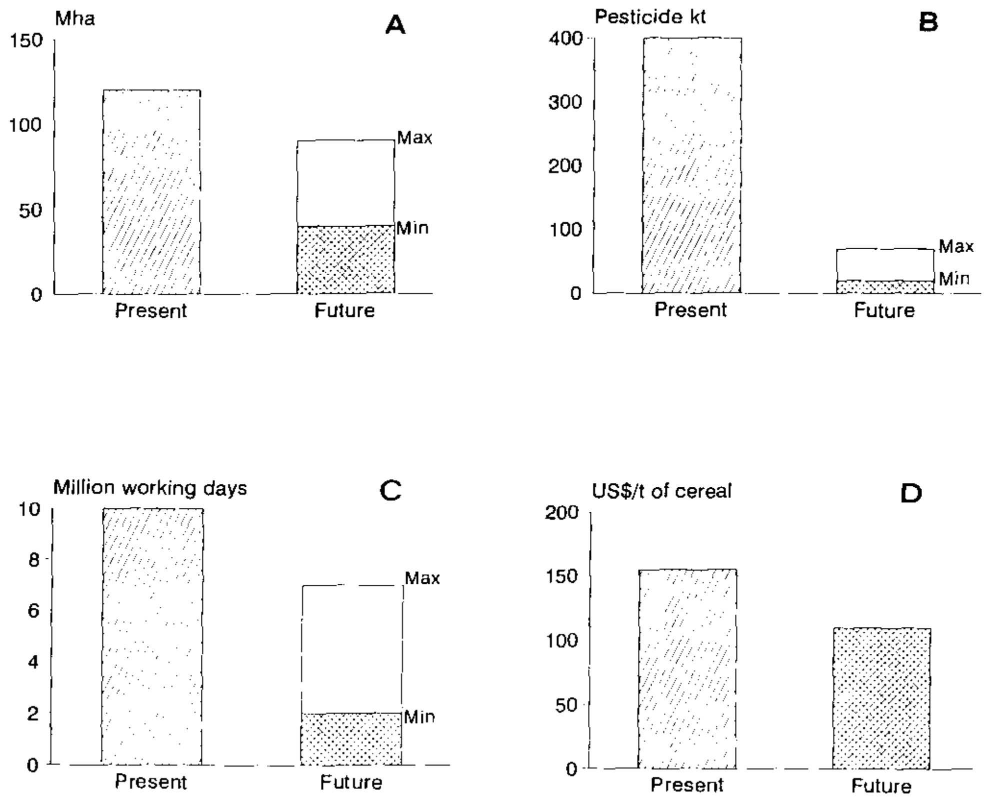

Figure 3 - Unitary cost and optimum sizing of a mechanisation system vs. worked area.

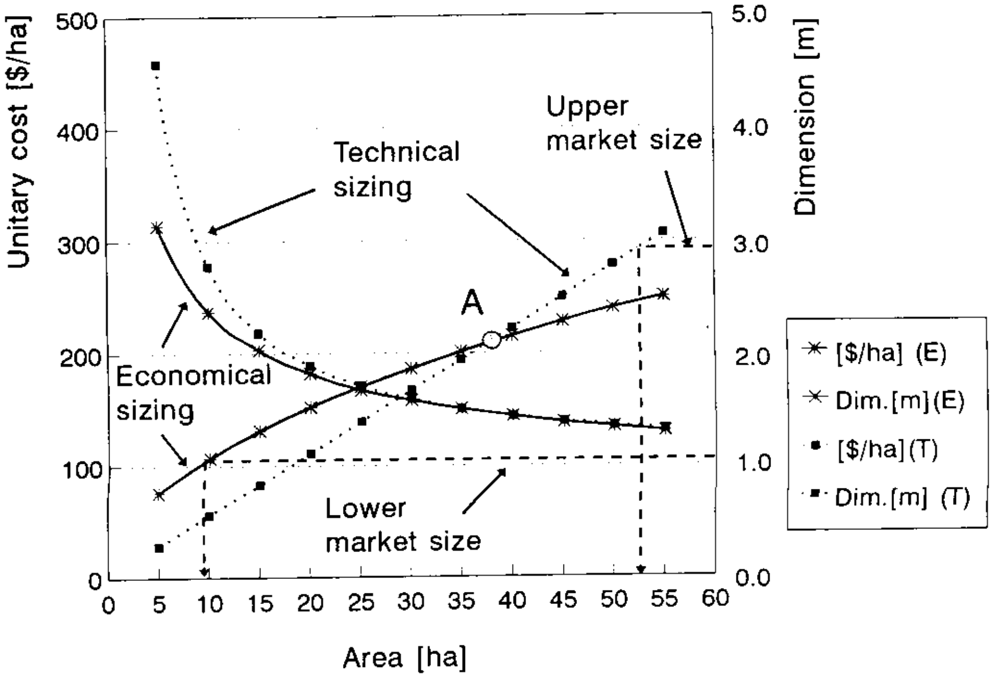

Figure 4- Unitary cost of a mechanisation system (tractor+ plow) vs. worked area (Yearly working time of tractor: farmer = depending on area; contractor = 1,000 hours).

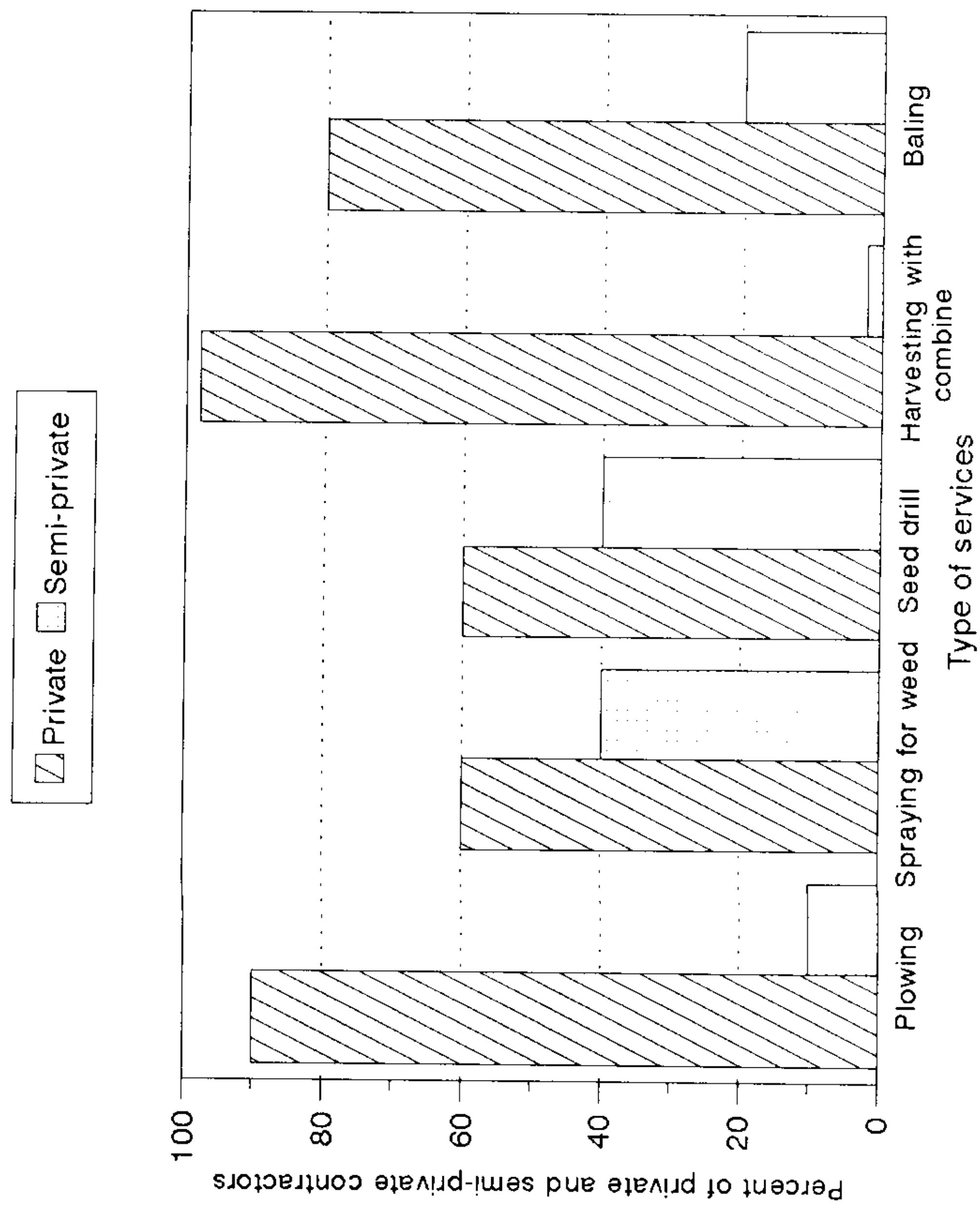

Figure 5 - Unitary cost of a mechanisation system (tractor + plow) vs. worked area (Yearly working time of tractor: farmer = depending on area; contractor = 500 hours).

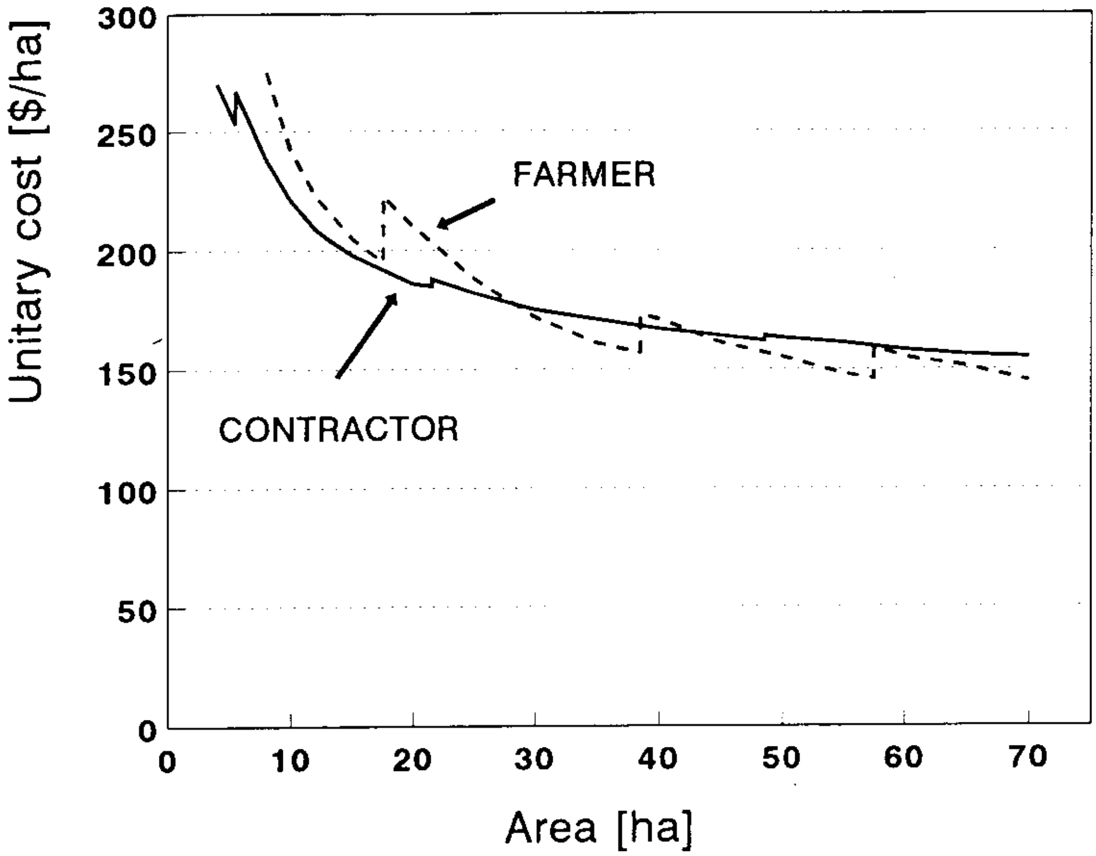

Table 1 - Investments for farm equipments in some EC countries

COUNTRY	TOTAL INVESTMENT (10^3 US$)			UNITARY INVESTMENT (US$/ha)		
	1980	1987	δ(%)	1980	1987	δ(%)
			COURRENT MONEY			
Italy	2.269.446	1.956.039	-13.4	127	113	-11.3
France	1.503.454	2.526.668	68.1	47	80	69.9
Germany	2.017.791	2.074.443	2.8	165	173	4.9
Great Britain	986.505	988.154	0.2	52	53	1.8
Spain	667.214	693.202	3.9	24	25	4.2
			CONSTANT MONEY (1980)			
Italy	2.269.446	950.906	-58.1	127	55	-56.6
France	1.503.454	1.572.247	4.6	47	50	6.4
Germany	2.017.791	1.675.293	-17.0	165	140	-15.1
Great Britain	986.505	697.599	-29.9	52	37	-28.8
Spain	667.214	326.076	-51.1	24	12	-50.0

Table 2 - Agricultural economical and structural parameters in some countries (1988)

	EC	ITALY	FRANCE	GERMANY	HOLLAND	SPAIN
Average Farm area (ha)						
A.U.A. (1)	16.5	7.7	30.7	17.6	15.3	16.0
Agricultural workers						
(% of total)	8.0	10.5	7.1	5.2	4.7	15.1
Farmers vs. age						
- < 45	21.0	17.0	27.2	33.5	31.4	17.5
- > 65	23.7	28.0	15.1	6.1	13.1	25.9
Farmers' work inside the farm (% of total work time)						
- < 50%	56.7	69.5	28.1	48.0	11.9	64.6
- 50-99%	16.2	17.8	14.3	8.5	13.8	12.0
- 100%	27.1	12.7	57.6	43.5	74.2	23.7

(1) farms with A.U.A. < 1 ha are not included

Table 3 - Prices of some contractors' services in: (A) Northern Italy; (B) New York State

OPERATION	(A) (US$/ha)	(B) (US$/ha)	δ (%)
Plowing	102	40	155
Harrowing	52	30	73
Fertilizers' spreading	21	12	75
Wheat and barley seeding	34	22	55
Mais seeding	36	27	33
Pesticide spreading	23	15	53
Mais combine harvesting	112	65	72
Wheat and barley combine harvesting	102	52	96
Soybean combine harvesting	125	65	92
Mais silage harvesting	196	92	113

Table 4 - Main figures used in the example discussed in the report

Tractor fixed costs incidence on the considered operation	20%
Implement fixed costs incidence on the considered operation	100%
Coefficient for determining yearly tractor fixed costs	17%
Coefficient for determining yearly implement fixed costs	15%
Tractor hourly cost per m of implement width	0.15 US$/h·m
Implement hourly cost per m width	4.6 US$/h·m
Tractor unitary price	770 US$/kW
Implement unitary price	2300 US$/m
Hourly manpower cost	15 US$/h
Rated power required per m of implement width	20 kW/m
Work rate per m of implement width	0.15 ha/h·m
Workability period	15 days
Daily working hours	8 hours

Table 5 - Output from simulation (technical sizing)

AREA (ha)	IMPLEMENT SIZE (m)	TRACTOR RATED POWER (kW)	WORK HOURS (h)	UNITARY COST (US$/ha)
5	0.28 (1)	5.6	120	458
10	0.56 (1)	11.1	120	278
15	0.83 (1)	16.7	120	218
20	1.11	22.2	120	189
25	1.39	27.8	120	171
30	1.67	33.3	120	159
35	1.94	38.9	120	150
40	2.22	44.4	120	144
45	2.50	50.0	120	139
50	2.78	55.6	120	135
55	3.06 (2)	61.1	120	132
60	3.33 (2)	66.7	120	129

(1) Value lower then minimum market size

(2) Value greater then maximum market size

Table 6 - Output from simulation (economical sizing)

AREA (ha)	IMPLEMENT SIZE (m)	TRACTOR RATED POWER (kW)	WORK HOURS (h)	UNITARY COST (US$/ha)
5	0.76 (1)	15.2	44	314
10	1.07	21.5	62	237
15	1.31	26.3	76	203
20	1.52	30.3	88	182
25	1.70	33.9	98	167
30	1.86	37.2	108	158
35	2.01	40.1	116	150
40	2.15	42.9	124 (2)	144
45	2.28	45.5	132 (2)	138
50	2.40	48.0	139 (2)	134
55	2.50	50.0	146 (2)	130
60	2.63	52.6	152 (2)	127

(1) Value lower then minimum market size

(2) Value greater then maximum market size

Table 7 - Main figures used in the evaluation of plowing costs

Tractor fixed costs incidence on the considered operation	20%
Implement fixed costs incidence on the considered operation	100%
Coefficient for determining yearly tractor fixed costs	17%
Coefficient for determining yearly implement fixed costs	15%
Tractor hourly cost per m of implement width	0.15 US$/h·m
Implement hourly cost per m width	5.2 US$/h·m
Tractor unitary price	770 US$/kW
Implement unitary price	3850 US$/m
Hourly manpower cost	7.5 US$/h
Rated power required per m of implement width	50 kW/m
Work rate per m of implement width	0.20 ha/h·m
Workability period	20 days
Daily working hours	8 hours

A. JONGEBREUR

Thank you, Prof. Castelli, for your nice presentation and paper, which is directed to the case of the industrialized countries. The floor is open for discussion.

Y. SARIG

I have a question-comment. Although I fully agree with Prof. Castelli's findings, there is one problem that sometimes hinders the better use of contractors. If you are talking about a seasonal-type operation (your examples focused on plowing and on tractors) we know that contracting work is expanding across-the-board, including harvesting, and when you are talking about harvesting everybody wants the machine in his own plot at exactly the same five days because he needs to pick it at the optimum maturity. If the contractor would buy a machine for each one of them, it is almost like for the grower to own the machine him-self. How do you reconcile this problem?

G. CASTELLI

It is not easy, but this problem is more important for a cooperative or common use of machines. Contractors can utilize their machines over a longer period.

In the case of the common use of machines between different farmers, each farmer wants to utilize the machine at the same time. The contractor is a firm that makes a contract with each farmer: from this point of view a contractor is better than common use of machines. This is the experience in Italy, because in the Italian situation a common use of machines is not frequent, while contracting is a very important tool for the mechanization of different operations in the farm.

G. PELLIZZI

I wish to report an experience I had. A few years ago a big farmer (600 hectares on rice cultivation, near Bologna) told me that he has not a single combine harvester because he should need to have almost five combine harvesters to harvest all the 600 hectares in time but if he wants to have these five combine harvesters he should need to pay five people the whole year round, and this is more expensive than using contractors. So I think that also for the timeliness requirement, the use of contractors, if a contractor firm is well organized, could really give satisfaction to both farmer and contractor.

K.TH. RENIUS

An answer to Dr. Sarig: I think that if you will set up a good economic balance you have to introduce time costs, ie. the costs of harvesting too early or too late (sugarbeet, for in-stance, is a typical case). You have to introduce that in your balance, otherwise man) calculations will not be good enough.

A second comment: you also have to introduce, for some cases, the question of whether the farmer has time or not. If the time is available by himself, he can introduce a cost for that available time which is very low: otherwise he has nothing to do so it is ridiculous to employ a contractor. These two principles must be incorporated in many cases. to get a complete balance.

A. JONGEBREUR

May I ask Dr. Sarig if this is satisfactory? Maybe he has some concrete examples in mind?

Y. SARIG

I think that the two points made by Prof. Renius are definitely completing the picture. They are very well taken. I agree with him totally.

D.H. SUTTON

Just two points. One is that the conflict of timing, i.e. when everyone wants to have the cereal crop harvested at the same time, is clearly more acute in those countries where there is no variation in harvesting time, but I'll just quote two examples, one in the United States and, to a lesser extent, in Mexico, countries which span a number of latitudes, where the harvesting period is over a much longer period, then contracting can be a very profitable exercise because you mount your team in a caravan and they move from North to South and South to North.

Secondly, I suppose as agricultural machinery gets more and more complicated, and therefore more and more expensive, then really contracting becomes more and more the way to do it. I presume you would agree with this.

I wanted to ask whether you have done any calculations on other equipment than tractors and plowing and combines? Have you done any costs of other more specialized equipments?

G. CASTELLI

No. We had just time to give an example of calculation, but we don't have a detailed calculation for all the operation, but I think it is possible to do it - there is no problem because the model is complete.

L. LEHOCZKY

I would like to ask my Italian Colleagues how they feel about the effectiveness of the work, because some years ago I had the opportunity to see contractors work in Holland, where they used to harvest sugar-beet, on a radius of about 15 km, and the problem was where should the men start and which farmer will be the next one because of the sugar content. So I was told that the contract of the contractors also includes a kind of bonus for the quality of the harvested product.

The second thing I would like to ask you is - if you know something about it - if there is a kind of relation between the capacity of the machine and the *area* of the farms served. I think that if it is a large machine, on small plots the effectiveness, financially, would be another one. It was mentioned just some minutes ago that in the United States they send this kind of caravans at harvesting time up to Canada and they make very good money there because the period of using the combine harvester was extended to about three months, which is something else - in Italy I think it is only some weeks. This must be calculated also. I don't know if you know something about this.

Have you had some experiences?

G. CASTELLI

We have some comparative data between Italy and United States. We find a very high difference between the contractor price in Italy and in the USA. In Italy it is in some cases twice as much as in the United States. This means that the structural problems of the farms - little farms, little plots - have a big incidence on the cost of operation, so we found that there is this big difference in contracting costs in Italy. We think that we need some policy that can help farmers to adapt their farm to these new big machines. Only thus we can utilize completely the performance offered by the new machines with very high capacity of work.

A. JONGEBREUR

But did you see in your results any correlation between the type of crops and the work radius of the different machinery?

G. CASTELLI

We haven't found this correlation.

Y. **KISHIDA**

I would like to explain the situation in Japan. In Japan the Government has been trying ways to reduce the production cost in the price of rice and they promoted an effective use of machinery. One of the things they wanted to promote was a co-use of the machinery. like the contracting. But one thing is very different from other countries: the value of time is very different from one country to another. That means that by introducing mechanization the farmer can get spare time and this spare time can create more value. In the case of Japan the average investment for farm machinery now is only about 2.5% of the total farmer's income, because 80% of income comes from off-farm income. In many cases at present the problem is that if some farmer wants to ask for another person to get the contracting but sometimes he can't find an operator because the operator says "If you pay more we can do it but if you cannot pay we don't do it", because they can find another and better chance to get income in another industry. The same thing I found in China, when I visited the Shanghai area. The farmer was running a 1.5 hectare farm, but everybody - the husband had a job in a factory, the wife was a factory worker and also the daughter had an-other job; but he is still operating a 1.5 hectare farm with two crops (rice and wheat). I wondered how they can manage and he said: "I can get contracting service from the service company: plowing, soil cultivation, planting, crop protection and harvesting". That means that there the farmer does nothing. Then he said: "Farming is very profitable and I will expand the size next year, from 1.5 to 3 hectares".

I think that the criteria for contracting the use of machinery is highly related to some social conditions and how time can create the added value. In the case of Japan every farmer can access very easily any kind of factory or another job and they will never waste the time. But in some other countries like Canada still in the 1,000 hectare farm the busy season lasts only two months and the other ten months maybe there is no work. But in the case of Japan, even the small farmers, in the idle time of the farming season they can get a lot of income from another sector. When we evaluate the value of contracted time we have to think about this opportunity, ie. how a farmer can get an income from another sector.

A. JONGEBREUR

I think that is more or less a comment on the different situations we meet in different countries all over the world. In the most extreme case you mentioned, in China, the contractor is a farmer and the farmer has nothin[g] to do with the farm, I think.

A. LARA

If we look at the problem from the point e: view of the contractor we could think that the contractor is always trying to make the biggest income possible. It may be very interesting to know if this situation was considered in the research by Prof. Castelli. I think that this problem is a problem of demand and supply. The competition between contractors is going to play a very important role on the price of the service. I don't know if you could give us some words on that or whether you think that some research is needed for identifying that situation.

G. CASTELLI

It is a very interesting question. We have in Italy - I refer to the Italian situation, of course - a lot of small contracting firms, with a limited radius of working area. In these cases there is no competition or very little competition because there is only one contractor for this small area. If the area becomes bigger. maybe this problem of demand and supply will become important.

B.D. WITNEY

Could I raise some issues in relation to **Figures 4** and **5** presented in the paper of Prof. Castelli? We have already discussed the question of the importance of timeliness. If you introduce timeliness to those diagrams, then instead of getting the "sore tooth" unitary cost of the different sizes of machines, you would land up with a smoother curve than is shown here.

But, that aside, can I then refer to the contractor cost, because if you identify a contractor as working 500 hours, he selects his size of tractor and his size of plow to match that tractor and then the unitary cost of the contractor is fixed and it is a horizontal line in this diagram, rather than a declining cost, as shown.

G. CASTELLI

The lines I show are the costs for the contractor, not the price of the service offered by the contractor to the farm (obviously, the price is a horizontal line because of the fact it is one figure). In this case we demonstrate that if the tractors utilized by the contractors work 1,000 hours - and this is a very frequent situation, because tractors utilized by contractors work this amount of hours per year - the contractor has a profit in comparison with the farm. So in this case the farmer has a convenience to utilize the contractor service and the contractor has an economic benefit in his work. Both are happy.

B.D. WITNEY

May I come back on that point, please? Within your calculations you have assumed that the contractor is going to achieve a certain amount of work, and that influences the shape of the curve. I understand what you are doing but I think you are taking the answer almost in advance. A contractor will decide in advance how much land he is likely to be able to plow and buy his equipment and provide a service at a fixed price and he hopes that enough customers will come along to accept that service.

Prof. Franco SANGIORGI
Italy

I would say that the problem of contractors is more a problem of regional planning. Regional planning means regional planning of the whole agricultural activity. The second problem is that together with the contractors' problems we must study the social problems, let's say the problems connected with the choices of the farmers - how they behave in relation to contracting or common use of machinery and so on. These problems cannot be disjoined but must be considered together. A third thing: if we consider a small radius of influence, it means that the contractors must work on a wider range of crops and on more operations, while a bigger radius means that the contractors can be very specialized, i.e. only harvesting or only plowing and so on. In my opinion - it is a proposal, of course - for the next Meeting it would be interesting to form three working groups.

A. JONGEBREUR

Maybe we can discuss this during the Recommendations.

BA. SNOBAR

I would like to cite some examples of how contracting was a must in developed countries such as the United States. One example is on grape harvesting. This could not be done without the use of contracting services. The wineries bought the machines and went and harvested the crop in about ten days, and the cost of harvesting was reduced (this was in 1970-71) from 55 US$ per ton to 19 US$ per ton. The wineries usually contract farmers, and they went to the farmers and said "I'll harvest. Give me the crop on the vine and I'll harvest it for you; and I will detract from the price 19 US$, not 55". The quality of the grapes of course was excellent.

Another example is tomatoes for processing, almonds, pistachios - everything. Those big machines that cannot be owned by a farmer, no matter how big these are, have to be contracted. And solve a lot of problems, really.

J. ORTIZ-CAÑAVATE

Coming back to the question of Dr. Witney. I think in the **Figures 4 and 5**, maybe the reason that this is not by contractor and horizontal line it is because here it considers also the cost of transport. Maybe you have here like 5 km or a specific distance and this is the reason why it is not a horizontal line.

G. CASTELLI

No, the reason is not that. The reason is that we apply the same algorithm for the farmer and for the contractor and we found that for the contractor if the tractors of the contractor work 1,000 hours/year it is possible to have a lower cost than for the farmer. The different slope of the curve is correlated just on this subject and in the different area worked. But our model is not so sophisticated as to take into account the distance between the different farms. However this is a good suggestion for improving the model.

A. RIJK

I have a totally different question, actually. Contracting of course is very important in industrialized as well as developing countries. It is an important sector also for the mechanization system, for industry and so on. I think, Dr. Jongebreur, you are aware that in the Netherlands studies have been done on how profitable it was for the contractors and I think at any time one-third of the contractors is about to go bankrupt. Have you done any studies on this in Italy, I mean how really these people financially make ends meet and what sorts of difficulties there are? I think this situation in the Netherlands has not improved much. A study was done a couple of years ago but I think the latest information is still like that.

G. CASTELLI

In Italy the situation is a little bit different; the average costs for a farmer are higher due to the different structural conditions of agriculture (small farms, small plots, etc.). In this case, the gap between the costs for a farmer and for a contractor is wider. In other words, there is margin for the contractor's profit.

A. RIJK

You mean on financial profitability? In the Netherlands there is, they have done substantial research studies saying that the contracting business in agriculture is a very risky business and you don't get rich: you are happy has if you don't go bankrupt. As I mentioned, that study indicated that one-third of contractors was always on the brink of bankruptcy.

A. JONGEBREUR

To add some more information on that point I remember that we had about 1,700 firms for contracting in agriculture and there is an estimation that before the year 2000 there will remain only 700 firms for contracting, which means that more than half of them will disappear.

O. MARCHENKO

It seems to me it would be interesting for you to know about our experience. We have _ structure like contractors, for collective and state farms. They have good educated mechanics and they are allowed to do man} works for state and collective farms. They use equipment to a very high degree; they have good facilities for repairing this equipment. At the same time collective farms and state farms have no expensive equipment. Just now, when we go to reform our agriculture and develop new forms of farming, we have looked back and right now we are on the way to recreating such a form of services. For example just now more than 700 grain harvesting groups are working in our agriculture, to help collective and state farms, and some lease-farming groups, to harvest grain, to harvest forage and to fulfill other jobs. We consider that it is a very promising way, i.e. creating contractors, and for our country it has been decided that we will develop these contractor forms.

A. JONGEBREUR

Thank you for these comments. I propose, Ladies and Gentlemen, that we go over to the presentation of the paper with regard to the developing countries. May I introduce Dr. Snobar, who will present the paper on Contractors and Agriculture, with reference to the situation in Jordan.

Prof. B.A. SNOBAR
Agricultural Mechanisation Dept
Univ. of Jordan

CONTRACTORS IN AGRICULTURE: CONSEQUENCES AND DEVELOPMENT ON AGRICULTURAL MACHINERY. A PRELIMINARY ANALYSIS IN THE DEVELOPING COUNTRIES

1.Introduction

Farming in the developing countries has been characterized by the existence of small enterprises. Today, however, whether his farm is small or large, a farmer can no longer rely on the labor of family members, because they could get better wages working somewhere else. Yet, small farmers are obliged to enlarge their farming area in order to meet the increasing demand for agricultural products and to increase their income in order to sustain their standard of living. The fact that fewer and fewer family members are providing the necessary labor force needed on the family farm and the urgent need to enlarge farm size have made it necessary to rely on farm machinery to perform the agriculture operations. However, the prohibitive capital investment needed makes owning such machinery impossible.

Therefore, in most developing countries, farm machinery contractors play a vital role in the introduction, use and development of farm machinery.

In this paper an attempt will be made to show the role and importance of agricultural machinery contractors in the developing countries through preliminary analysis in Jordan as a case study.

1. Contractor services

As early as 1936, farm machinery contractors in Jordan started to provide custom services to the farmers in different districts. Plowing and cereal harvesting were among the first contractor services provided. Without such services the agricultural sector would have suffered. The labor movement away from the agricultural sector, which paid and still pays less wages than other sectors, continued from the beginning of the creation of other sectors in Jordan and peaked in the mid 70's and 80's. Since the mid 70's the labor force in the agricultural sector in Jordan has continued to de-cline (25% in 1970 to 6% in 1990). This decline has been offset by non Jordanian labourers On 1990 the total labor force in the agricultural sector was 90,000, of which 60% were non-Jordanians). The reliability on permanent and seasonal non-Jordanian manpower in the agricultural sector is not wise, especially in a job market where the other highly paid sectors attract such laborers and the non-Jordanian laborers are becoming scarce and expensive.

The only way to perform the hard farm operations with reasonable cost and timeliness is to resort to the use of agricultural machinery. Owning the needed machinery is impossible for the individual farmers, since the capital investments are beyond their financial capabilities. In addition, the farm are too small to justify such ownership and would result in an unrealistically high cost of farm operations. Therefore, the alternative to owning farm machinery was getting the services through contractors at a feasible cost. **Table 1** and **Figure 1** show comparisons between the cost of agricultural operations performed through private ownership and contractors. **Table 2** shows the percentage of services provided by contractors and by the private ownership. It is clear from this table that the farmers' reliance on contractors is high in Jordan. In addition to the economical advantage, contracted services offer numerous other advantages over the private ownership, including the following:

- enable the small farmers to mechanize farm operations;
- optimize the use of the machinery, thus reducing the number of machinery units used by the agricultural sector in a particular country.

Table 3 shows a comparison between number of selected farm machines needed in the case of contractors versus those needed in the case of individual machinery ownership:

- — perform the operations properly through proper machinery management and skilled operators;
- — make the services needed readily available, thus improving the timeliness of the operations;
- — enable part-time farmers and absentee landlords to cultivate their lands. It is estimated that about 50% of the farmers in Jordan are part-time farmers:
- — offer wider range and type of machinery and implements to choose from;
- — do not require capital investment on the part of the user (the farmer);
- — reduce pre-mature failure of machinery and implements through proper and sufficient stocks of spare parts, thus increasing the life span of the machinery;
- — are a means for introducing and transferring innovative ideas, new machinery and technology;
- — use appropriate machinery and implements particularly those needed for sustainable development.

2.1 Private contractors

The private sector, and the public sector in some cases, has pioneered in providing farm machinery contractual services.

The private sector started with farmers owning tractors and plows providing services to other neighboring farmers. In some cases, such as combine harvesters, the services were provided through non-farmer contractors (business oriented type). **Figure 2** shows the type and percentage of services provided by the private contractors. This figure shows the important role private contractors play in providing a considerable percentage of agricultural machinery contracting services.

2.2 Public contractors

Public farm machinery services are mainly provided by the Ministry of Agriculture (MoA) for particular operations such as orchard spraying.

The public sector usually provides contracting services when the private sector hesitates to become involved, because the services requested are too costly, too risky or require technology unavailable to this sector. In this case the public sector was obliged to perform such operations at subsidized prices, helped by transferred technology.

Such constraints are not appealing nor could they be afforded by the private sector. As soon as the farmers are convinced, the technology become available and a profit can be made, the private sector will be actively engaged in providing such services. At this time public contractors are not in operation.

2.3 Semi-private contractors

The semi-private contractors such as the Farmers Union Association in the Jordan Valley and the Jordan Cooperation Organization (JCO) provide integrated contracting services which no other contractors provide.

In this paper, the contracting services provided by the JCO's farm machinery hiring stations in three main rainfed areas of Jordan will be given as an example.

In these areas, the main strategic crops such as wheat, barley and forages are produced. Because of the importance and high potential of the rainfed area, and due to the unusually low yields obtained from it, two research projects were conducted to improve the yields of strategic crops. One lasted seven years in the 1960's and the other lasted five years in the 1970's. The results showed that with proper land preparation, seeding and weed control techniques (new technology package), which rely mainly on the use of non traditional farm machinery, the yields could be doubled or tripled. However, the recommended new technology package for agricultural production in the rainfed area was not accessible to farmers because of the unavailability of the farm machinery needed for its execution, a responsibility no one would assume. There-fore, in order to make use of the results obtained from such valuable research, JCO in 1981 decided to take the responsibility of making the recommended farm machinery input available through the hiring stations it intended to establish in several locations of Jordan.

After 10 years of providing farm machinery contracting services to large areas at reasonable charges (**Table 4**), during which time it demonstrated to farmers the important contri-bution these services could make to increasing yield and net income, private contractors were encouraged and actually started providing similar services at competitive charges. Such services did not only increase yields and net income, but also helped the part-time farmers and absentee landlords to farm their lands without having to be present and with-out having to hire expensive manpower.

3. Conclusions

It can be concluded that contracted farm machinery services offer numerous advantages over private ownership, particularly in the developing countries. In most cases, if such vital services are not provided, agricultural production may cease to exist. The high capital investment needed, the limited experience in managing, operating and maintaining farm machinery and the limited awareness and knowledge of available technology and development in the agricultural machinery field, the small holdings, the high cost of operation, the low net income generated by traditional agriculture and the diversified operations and type of machinery needed within the same farm, make ownership of farm machinery by individual farmers impossible and unfeasible. However, if a viable agricultural sector is to survive in the developing countries, and because the use of agricultural machinery is one of the most important components of agricultural development, a way should be found to make machinery services available by different means of contracting.

Until now, the services provided by different contractors proved to be practical, readily available and low in cost. Services provided by the public, private and semi-private organizations and agencies were found to be most successful in Jordan and in several other developing countries as well.

Contractors could he specialized in the mechanisation field, so they are able to dem-onstrate the use of new agricultural machinery, contribute to the development of the machinery and optimize its use.

The success of contractors in providing agricultural machinery services in the developing countries has undoubtedly contributed to the advancement and sustenance of agricultural production in these countries; otherwise, without the contractors, agricultural development would have been slowed down or come to a halt. At this stage the speaker would recommend that when a request for international funds or financial aid is put forward by a developing country, the development of agricultural machinery in these countries, the contractual type, particularly by the private or semi-private sectors, should be encouraged and may be placed as a prior condition, for some countries where this is applicable, for approval of funds.

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Figure 1- Comparison between cost of operation performed by private ownership of some selected farm and charges by contractors, as of 1992 prices

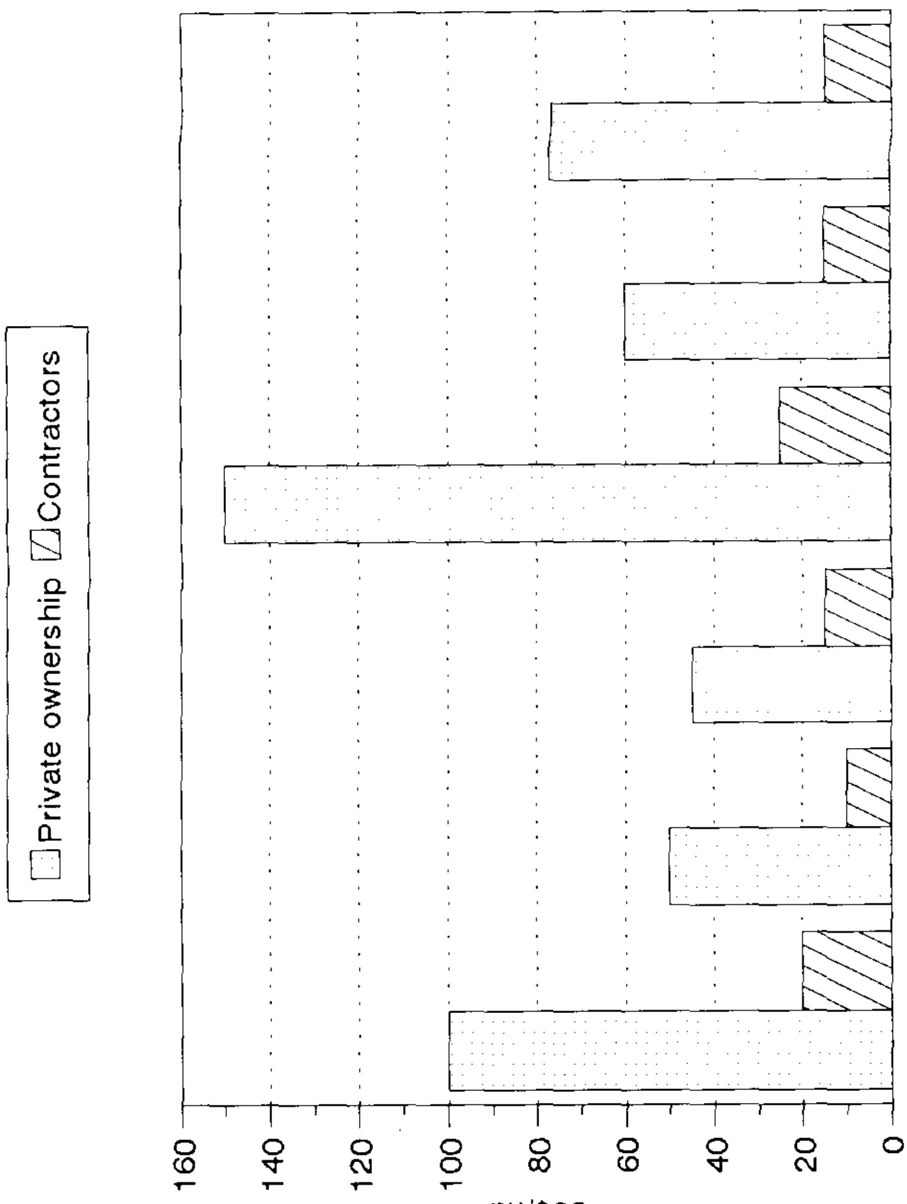

Figure 2 - Estimated private and semi-private contractors as percent of the total contractors

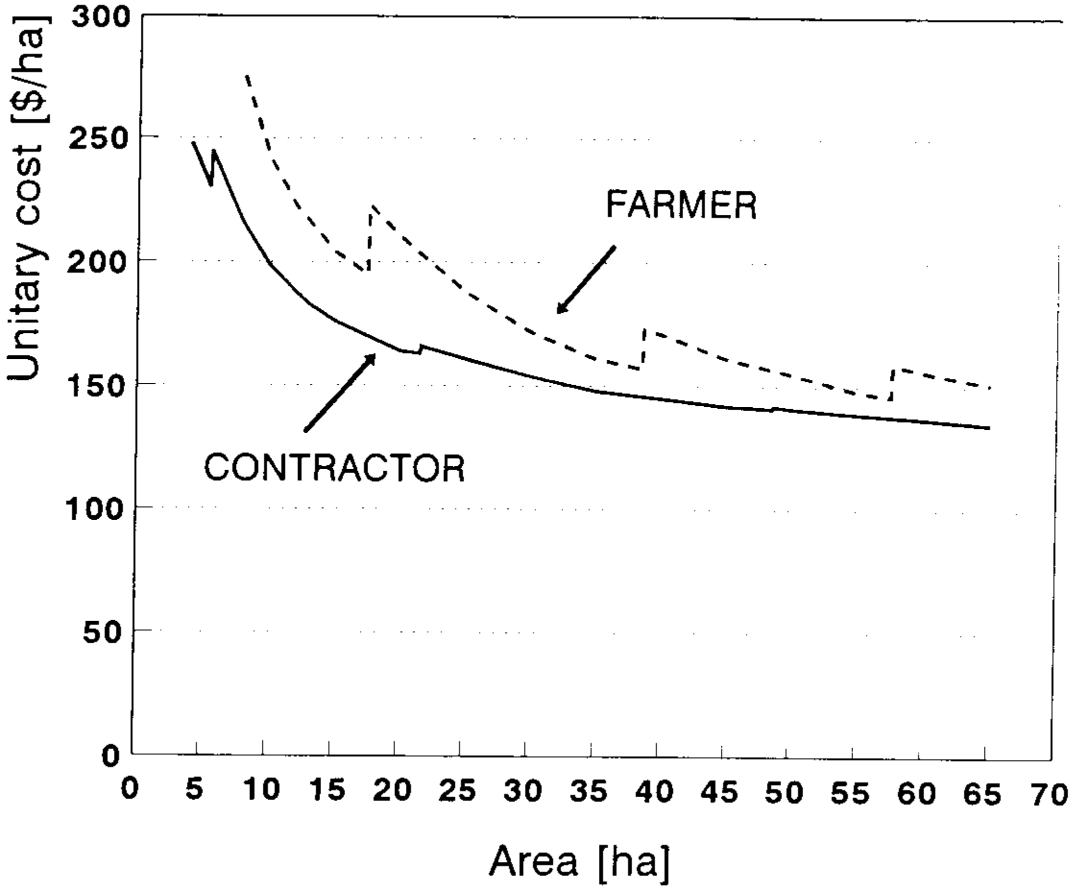

Table 1 - Comparisons between cost of operations performed by private ownership of some selected farm machinery and charges by contractors as of 1992 prices

TYPE OF IMPLEMENT	COST OF PRIVATELY OWNED MACHINERY (US$/ha)	CHARGES BY CONTRACTORS (US$/ha)
Disk plow	100	20
Moldboard plow	100	20
Chisel plow	50	10
Sprayer	45	15
Combine harvester	150	25
Mower	60	15
Baler (50 bales/ha)	75	15

The cost for privately-owned machinery was calculated based on an average farm size of 20 ha, which is considered above average in the rainfed area. It is assumed that the owner does not use his machinery outside his farm

Table 2 - Percentage of services provided by the contractors and privately owned machinery

TYPE OF SERVICES	CONTRACTORS (%)	PRIVATE OWNERSHIP (%)
Plowing	60-70	30-40
Spraying for weed control	95-98	2-5
Spraying for plant protection by back mounted sprayer	5-10	90-95
Spraying for plant protection by stationery hose sprayer	40-50	50-60
Planting with seed drill	90-95	5-10
Cereal harvesting with combine	95-98	2-5
Cereal threshing with tractor operated thresher	90-95	5-10
Mowing with rotary mower	90-95	5-10
Baling	95-98	2-5
Transporting with trailer	70-80	20-30

This table was constructed based on estimates made through personal observation, own experience and some studies made for particular areas in Jordan. It is not based on collected data or available documented information

Table 3 - Comparisons between number of farm machinery needed for Jordan in case of services provided by - contractors and services provided by private ownership

TYPE OF MACHINERY	NUMBER NEEDED	
	CONTRACTORS	PRIVATE OWNERSHIP
Tractors	4000-5000	20000-30000
Plows	5000-6000	40000-45000
Trailers	1500-1800	6000-7000
Boom sprayers	100-120	4000-4800
Mowers	100-150	500-750
Balers	150-200	500-800
Seed drills	350-500	3500-5000
Threshers	500-600	5000-6000
Combines	150-200	1200-1600

This table was based on actual statistical data and calculations made as per the recommended number of working ho... per season for the implements and per year for the tractors in case of contractors. In the case of private ownership ... calculation were based on serving a private farm of 20 ha.

Table 4 - Type of services, charges, areas served by JCO's farm machinery hiring stations in Jordan over a 5-year period. Sources: Annual reports and records of the JCO.

TYPE OF SERVICES	1992 CHARGES (US$/ha)	AREA SERVED (*) (ha/year)
Chisel plowing	10	1100
Sweep plowing	10	1700
Seed drilling	12	3900
Spraying	14	3000
Fertilizer spreading	4	300
Forage mowing	23	150
Baling	20	1000
Cereal harvesting	23	1300

(*) Mean of 1984-1988 seasons

A. JONGEBREUR

Thank you Dr. Snobar for your very interesting paper. We learned about a lot of figures and also that the difference between the cost for the contractors and for the private farms is quite considerable. Another interesting point is also the difference between the private con-tractors and the semi-private contractors.

Ladies and Gentlemen, the floor is open for discussion on the paper. Who takes the floor for the first question?

D.H. SUTTON

Can I start by making three points? One, I would like to emphasize the last point that Dr. Snobar made, about the danger of Government's departments (Ministries particularly) operating hire services. We carried out a study for the World Bank some years ago on government-operated tractor hire services and we investigated some 15 or 20 government services throughout the world. Without exception these were found to be uneconomic, inefficient, a drain on resources, and negative contributors to agricultural development and mechanization in particular. I think it is a salutary lesson of course that the problem had been centering around the motivation, the management of the operation and I fear that still in some cases the management of operations nowadays in those services still exists - centers around the government way of doing things, so the incentive is not to produce efficiency but just to carry out the work. We should constantly urge the governments to avoid falling into that trap again, they should not invest in government-operated services. The contracting services we have been talking about and hearing about have been generally those in the private sector, and I think that should be encouraged.

Could I also refer to **Table 3** of Dr. Snobar's paper? There are some very interesting figures quoted there, which in one sense of course are not good news for small farm machinery manufacturers. If the trend is likely to be to greater use of contractors, then the volume of machinery manufactured is likely to reduce and that does mean a reorientation, I suspect, in the agricultural machinery manufacturing industry in many countries.

Thirdly. may I just mention a fact which I think has more to do with design and development of equipment: if contracting continues to grow, and it is likely to be a very important component of mechanization in the future, clearly the quality of the product is likely to have to be improved and it may well be that design and development work in research centers should bear this in mind, for the contractor's machine, if he is going to be using it for 1000 hours or more per year, in order to be economical, it must not break down and therefore is likely to require more robust, more efficient and effective design and service ability and accessibility.

B.A. SNOBAR

Just one point. When the manufacturer specifies that a tractor should work for 10,000 hours I think they want this to happen, unless they are just giving a bright picture. You'd be surprised, in Jordan the latest study showed that the average working hours per year is about 1,100 and the number of years before the tractor breaks down (of course with maintenance and repair) is about fifteen years. We are talking of almost 1.5 times the number of hours that the manufacturers recommend. We are fulfilling the dream of the factories!

A. JONGEBREUR

Can you mention the real number of tractors in Jordan? Dr. Sutton referred also to the **Table 3** figures.

B.A. SNOBAR

Actually the number is about 5,500 and the annual sale is 200 tractors of different sizes. As far as I remember, we have about 12 marks of tractors in Jordan, for this market site - 200 tractors distributed among 12 marks. The lat-esttmake to come to Jordan was the Chinese one. We have Massey Ferguson, Ford, John Deere, Belarus, Ebro, Zetor - just mention it and we have it.

K.TH. RENIUS

One remark to the life of the tractor - you know that we are working in that area. A tractor's life should be 8-10,000 hours, not on average but related to B IO life, which means that 90% of the tractors should survive that figure. So you can explain why many tractors are lasting longer than 10,000 hours.

B.A. SNOBAR

I think that for private ownership, the owner treasures his tractor, he takes care of it when-ever it needs to he repaired or maintained. This is the difference between government ownership and private ownership. He just takes good care of it: oil change, instead of whatever the catalogue says, he goes half of it. He will pay eventually, by the time the tractor becomes obsolete - he will pay probably three times as much as the price of the tractor originally. He is really paying for repair, for maintenance, for taking care of it.

Y. SARIG

I would like to follow the footsteps of Dr. Sutton. I think that the role of the Club of Bologna is not to make recommendations whether to use contractors versus private ownership. I think we should reflect upon the picture that was given to us. If this is a general trend then I think what we should do is try to draw some conclusions and give some directives. For example, in addition to what Dr. Sutton said, I think that if the use of con-tractors will expand we probably can anticipate some changes in the design of machines. Machines can become more sophisticated because the contractors, unlike private owners, could operate more sophisticated machines and probably can derive better quality. This probably would reflect on some of the directives we can give to research institutions and possibly to manufacturers. Let me illustrate that with maybe a strong example. There has been a lot of talks and I am sure all of you are aware of the work that has been done in a very progressive way on developing robots for picking fruits. This is definitely not a job that a farmer could possibly buy robots for himself. this very sophisticated piece of equipment. But at the same time this is the only solution. if it will ever come to reality, that would pro-vide us with some means of harvesting fruits at their highest possible quality, on occasions where manual labour is not available.

A.U. KHAN

I have a few comments to make on this pre-sentation. First I wanted to go to this Table 1.1 am all for private or rental operations, but this gives a very unrealistic price because when we talk of a contract versus private ownership the cost is almost five times different, which is not a realistic situation because the individual who owns the machine also rents these machines quite often. Isn't that true?

B.A. SNOBAR

It is based on the hypothetical assumption that every farmer owning up to 20 hectares would buy the tractor. With this number, if everybody buys it then there is no room to hire tractors from neighbours and so on. This is number one.

Number two, you find out that those farmers that buy for themselves, before they go on and buy for themselves, they have to make sure that they will utilize mostly the tractor on their farm, otherwise they don't buy it. This means that he has to have enough reasons to buy for himself. He asks the question (if he is a farmer - but most contractors are not farmers): what would I get out of it?

A.U. KHAN

I find there is a sequence in contract operations. Initially, only the power-intensive operations get mechanized (land preparation first, then threshing, then harvesting, in that kind of a sequence), and this is happening in many developing countries. Then comes a second stage where the control-intensive operations start to become rented by contractors, such as seeding (and I think in Jordan I was pleased to see that this is starting to happen), spraying and things of this sort. But the prerequisite for the second stage is that part-time employment is available otherwise we have a situation where you are creating a lot of rich contractors and poor farmers, because if all the operations become rented then the farmer is sitting idle, wasting his time and losing money. I think this is an issue which is social but nevertheless has to be recognized, e.g. we are there to help the farmer maintain a better standard of living and keep earning. Until you have alternate employment, to recommend that we mechanize all the operations is not a realistic situation. We have to be very careful in what is recommended. I believe that unless you have a part-time employment, or some use for that time that will be freely available to the farmer, socially it is not a good thing to do to suggest that we mechanize.

Coming back, one attempt was made that the government should be out of this. I agree that it should be out of the regular hiring service. But the hiring services have also played a very crucial role in introducing new technology. This has happened in land preparation, initially; it is happening in harvesting, threshing - every country has gone through that phase. We always looked at the economic terms, but there was this other side: introducing new technology, transferring technology (and I think it is becoming important in spraying and the cultural operations). So I have a feeling that at this stage we should probably encourage the crop husbandry operations to be custom hired through governments; but we should of course tend to discourage land preparation and the traditional hiring, which has already passed onto the private sector. I am trying to make this final point because I think that to bluntly say that everything in government hands did not work out very well, I think there is a role of introducing new technology. We see that difference between Jordan and Egypt for example. Our contracting is only on land preparation and threshing. Land preparation and threshing and some harvesting has started to develop, but there is no contract operation for the cultural operation in between, and we would like to see the government get involved in that particular sector.

B.A. SNOBAR

What I meant, in my recommendation, was that for introductory operations of new technologies, that of course has to be handled by who ever should take the responsibility because this is not money-making, it is not an organization - this happens in the spraying of orchards of citrus, particularly. And then the private farmer is mainly getting loans to buy the equipment through government guarantee, then the government has nothing to do with their performance, how much salary they pay, incentives and all of these things, which are left up to the manager, who is appointed by the Prime Minister but he doesn't really interfere with his work. So this is the private - actually it could carry some of the transferred technology up to a level where the farmer cannot live without it, so that a private contractor has to come. This is what happens exactly with the cereal production. I mean, after ten years of running such services through private, the contractors all over now start to do this.

When we introduced the chisel plow, which is wider (3 m) and shallower and will do the job, the cost went down. And they liked it: it is not a turning plow, it conserves moisture, it has a lot of advantages. Now they won't accept any of the old contractors, coming to plow with small plows. So the contractor has to replace with chisel plows. Now for the Cintrel it had never been used in Jordan; prior to 1980 nobody ever, except in a research station - they used grangers. Now almost everybody want to plant with a Granger, because they want to fertilize as well and they know the importance of depth, the distribution, etc. Almost nobody sprayed for weeds: now everybody wants to spray for weeds, to conserve moisture. They looked around and with this new technology they are not paying much more and they are getting three times more net income as well. So they are happy with this. If you try to get them back to the old traditional way they would scream. If the government (my government in this organization) is not continuing to do this, then somebody else has to come into the picture, which is the private contractor.

A. RIJK

I also looked at **Table l** and I had the same feeling as Dr. Kahn: a five times difference between the privately owned machinery and the charge for the contractors. I think we are overlooking in this whole discussion some-thing very important (also in the previous paper). I experienced from the Netherlands - I am not sure it is the same in all countries, but I thought that in the UK this was the case as well - that the contractor business in general started in the Fifties, with farmers/contractors. Small farmers who decided to invest in machinery, they could not really financially operate profitably only on their own farm - they had 2-3 sons on the farm, the farm was too small - so they started to operate also in their neighbours' farms. I have seen this very clearly in the Netherlands. There were also very specialized contractors, that's true, who did not have land, who were non-farmers, but a lot of the smaller farmers bought equipment and as a sideline started operating on other farms. Dr. Jongebreur, correct me if I am wrong, but I grew up in an agricultural environment and had uncles working as contractors and so on, and I worked myself during my holidays to earn money, in the contractor business. This is also why it was so cheap, because these small farmers operated on very marginal costs, they didn't have fixed labour costs. The bigger contractors who were established as a real contractor business had always to compete with this small farmers. I think this is also what happened in the developing countries. In Thailand a farmer buys a hand tractor; he also does a lot next door. I think even in the government - India at some stage had a policy which I think was very good: they said "We should not only give credit to farmers who have enough land to buy a tractor, we should in particular help the small farmer who has very little land to buy a tractor and then with the tractor he can earn additional income as an extra opportunity to earn income". The same in Pakistan: a lot of tractors are being sold to farmers; if you see how many hectares they have you say "This cannot be financially attractive, on 3-4 hectares". But they work as contractors, many in the transport business even, which makes it attractive to own this machinery. I think this is one of the things we seem to have forgotten here. We talk about farmers and we talk about contractors and in many cases, particularly initially, it is a combination of farmer-contractor.

1 have a small comment on what Dr. Kahn said, ie. that the government has a role initially. I would like very much to disagree with it. Whenever you see the government involved in agricultural machinery in developing countries they mess it up. The IRRI thresher, Dr. Kahn, is a good example (the thresher you developed). The government never introduced that thresher, l think, in a country like Thailand. One or two prototypes from IRRI were brought in, they were demonstrated, farmers wanted them, manufacturers started making it. I remember what the government did in the 1950's: they brought in big McCormick's WD9 Diesels with big threshing machines from the United States and maybe as of today they are still standing because they thought they could thresh paddies with it - and of course it didn't work at all. I mean, that was the government's effort. Politicians got into it and all sorts of things happened. So I tend to disagree with the suggestion we should have governments even initiate something in mechanization.

A. JONGEBREUR

I think this remark will give rise to a lot of discussion all over this room, but we have only restricted time for a couple of questions. Maybe Dr. Snobar can give a very short answer on this question.

BA. SNOBAR

Really there is a mix up between contractors and farmers. You tell me if a farmer has five hectares and he decides to buy a machine and he was hiring it around to 30 people, working let's say 300 hours per season in order to do enough area, would you call this a contractor or a farmer? I would call him a contractor farming a small area.

A. RIJK

Three hundred hours is a part-time job, so I should still say he is a farmer.

B.A. SNOBAR

But what if he has another machine that will work another 300 hours and so on, so you would have a range of equipment? This is the thing. The contractor is really somebody who is utilizing his machine to the best possible, meaning working enough hours per season, to make up for the cost of the operation, but not to buy it. Then, if customers come along, I give them my services. This is not my definition of a contractor.

F. SANGIORGI

I would like to say that the problem of contracting, both in developing countries or in developed countries is a problem that can be better defined if we can make use of the new technologies. It is a problem of Geographic Information Systems. All the information can be gathered together - cost of manpower, availability of manpower, size of the fields etc. - and some type of figure can be utilized for making a good evaluation of the level of development or, we can say, the level of contracting that can be defined for a certain area. This afternoon we had quite interesting figures, i.e. the area where this type of machinery is utilized is more or less very small, let us say 10,000-15,000 hectares, so it can be easily defined, studied and well defined in different areas of the same country and so on. We have to consider it not at country level but at regional level. For this reason it would be interesting to discuss a bit more about this subject.

D.H. SUTTON

Just quickly, to try and put the remarks by Dr. Rijk and Dr. Kahn into perspective, on the involvement of government. I think there must be a role of government in promoting new technology, but it is how they go about it that's crucial. I would suggest that the evidence is overwhelmingly against government getting involved in operating equipment. In promoting, in providing incentives, in encouraging research and development, clearly no other organization can do it; but in actually operating it we have evidence coming out of our ears to show that it is not effective and it acts as a deterrent, because if government is involved in providing hire services, the private sector is deterred from coming in because they can't do it at a profit.

A. JONGEBREUR

Would you say the government has to have a strategy but must not carry out that strategy and leave it to the private companies?

D.H. SUTTON

Generally speaking, yes.

A.U. KHAN

I agree with Dr. Sutton's opinion. The government also has a great role to promote mechanization and to promote all these things. In the case of Japan the government did many things but the most effective way was they guarded the farming products' price. Then the farmer had a buying power, for the machinery, also another input. This is one of the roles of the government, to encourage mechanization.

A. JONGEBREUR

But that is an economic question you raise: the difference between the prices on farm and the difference on the contractor prices. If these papers show very clearly that contractor prices are lower, for optimizing the production cost I should say that contracting is a very import-ant point.

Y. KISHIDA

Of course to reduce the production cost a better utilization of machinery is essential. But we must also consider the production cost of the machinery or price of the machinery. Prof. Castelli's paper shows in some charts the "economical sizing". I don't know what kind of basic information he used but if we can produce a much cheaper machine which has a shorter life, in this case this figure could change. I would also like to recommend you are telling us the size of the machine, but the size of the machine, for example the horse-power, but if you look at recent developments with the new types of Diesel engines, the horsepower is the same but the size is maybe 40-50% of the former one. In this sense the price is highly reduced. I don't know whether size is a very fixed variable or not.

Also, in the future, in the case of Japan, many people are discussing of the possibility to develop smaller-sized robots, maybe 2-3 HP. If we can handle with such a machine at the same time 50 units, in this case we can have lower production costs.

A. JONGEBREUR

That is a new thing, which is not taken into account too much. It's quite new technology, I think.

Y. KISHIDA

But it's coming, very soon!

CLOSING SESSION

G. PELLIZZI

Ladies and Gentlemen I want to express my deep thanks to all of you, special thanks to all the key-note Speakers and to the three Chairmen of the Sessions.

I think that in addition to the technical quality of this Meeting there is a very important success, ie. that we can understand each other better and better and this seems to me to be a very important aspect to be taken into consideration. Thank you once again.

L. LEHOCZKY

May I, as the oldest of this Group, say some words of thanks to the organizing people - not only our President or our Secretary, Dr. Fiala - but all the others whom we didn't see or only heard, who did a wonderful work in the last months.

Please convey our thanks to all your people, and of course to UNACOMA for hosting us and, last but not least, to your Secretary, because he was a very nice guy and he helped us a lot, and as the last one (the "smallest"), to the President.

LIST OF PARTICIPANTS

Hugo VALENTI	Argentina
Irenilza DE ALENCAR NÄÄS	Brazil
Anthony C. WYLIE	Chile
Edmundo HETZ	Chile
Mao-Hua WANG	China P.R.
Gao YUANEN	China R.R.
Henry JIMENEZ	Colombia
Ali M. EL-HOSSARY	Egypt
Bernard CHÈZE	France
Karl Th. RENIUS	Germany
Jürgen HELLEBRAND	Germany
Heinz Dieter KUTZBACH	Germany
Laszlo LEHOCZKY	Hungary
Yoav SARIG	Israel
Giuseppe PELLIZZI	Italy
Enzo MANFREDI	Italy
Osamu KITANI	Japan
Yoshisuke KISHIDA	Japan
Hiroshi ITATANI	Japan
Masato SUZUKI	Japan
Bassam A. SNOBAR	Jordan
Arturo LARA LOPEZ	Mexico
Aad JONGEBREUR	Netherlands
H.L. MUSA	Nigeria
Luis MARQUEZ	Spain
Jaime ORTIZ CAÑAVATE	Spain
D.H. SUTTON	UK
David J. WHITE	UK
Brian D. WITNEY	UK
Richard O. HEGG	USA
Leonid KORMANOVSKY	Russia
Oleg MARCHENKO	Russia
Vladimir KRIAZHKOV	Russia
Adrianus RIJK	FAO
Pavel KIC	Czechoslovakia
Bernd SCHERER	Germany (LAV)
Franco SANGIORGI	Italy
Gennaro GIAMETTA	Italy
Tomohiko ICHIKAWA	Japan
Amir U. KHAN	Egypt
Dietrich ZAPS	Germany
Hans HERRMANN	Germany

Giorgio CASTELLI	Italy
Pietro PICCAROLO	Italy
Giovanni RIVA	Italy
Giovanni SARDI DE LETTO	Italy
Jerry SHARPLES	USA
Marco FIALA	Italy
Fabrizio MAZZETTO	Italy

REGIONAL FORUM
OF
ASIA AND OCEANIA
BANGKOK, DEC. 7, 1992

In the occasion of International Conference on Agricultural Engineering held in Bangkok at the beginning of December 1992, a special forum of the Club has been organized at the Asian Institute of Technology in cooperation with the Asian Association for Agricultural Engineering belonging to the CIGR Networking System.

During the forum 5 reports have been presented and discussed with the participation of over 120 scientists and technicians coming from the various Asia and Oceania Countries.
In the following pages all of these papers are reported.

The forum was jointly chaired by Prof. O. Kitani, Prof. G. Pellizzi and Prof. G. Singh.

PROSPECTS OF **AGRICULTURAL MECHANISATION** IN THE ASIAN REGION

A symposium organized by
the Asian Association for Agricultural Engineering
and
the Club of Bologna
(Regional Forum of Asia and Oceania)

ASIAN INSTITUTE OF TECHNOLOGY
BANGKOK, THAILAND

DECEMBER 7, 1992

Agricultural Mechanisation Policy and Strategy
Speaker: Dr. A. Rijk, Chief, Agricultural Engineering Services, FAO (Italy)

Impact of New Technologies on Farm Mechanisation Needs
Speaker: Dr. G.R. Quick, IRRI (Philippines)

Technical Transfer of Farm Mechanisation in China
Speaker: Prof. Hua Guozhu, CAAMS (China)

The Outline of Overseas Manufacturing by Kubota
Speaker: Mr. Koji Sahara, Kubota Corporation (Japan)

Agricultural Mechanisation in Asia: Present Status and Future Prospects
Speaker: Dr. Zia Ur Rahman, Project Manager, RNAM, ESCAP (Thailand)

Dr. Adrianus G. Rijk
Chief, Agricultural Engineering Service - FAO
Italy

AGRICULTURAL MECHANISATION POLICY AND STRATEGY

(The views expressed are the author's and do not necessarily reflect those of FAO or its Member Governments)

1. Introduction

Worldwide the agricultural mechanisation sub-sector has been in a prolonged slump, and there is little hope that in the near and medium future this situation will significantly improve. For example, during the last few years the annual investments in farm machinery in the U.S.A. are in real terms at the level of 1950. In Australia, tractor sales last year were a meagre 5000 units. Many North American and European manufacturers have merged or even gone out of business. Agricultural machinery exhibitions are poorly attended or their frequency reduced.

There are a number of reasons for this gloomy situation; the worldwide economic recession, the uncertainties for European farmers about the effect of the Common Agricultural Policy and the recent GATT negotiations, and the debt burden in many African and South American countries. Related to the latter is the effect of Structural Adjustment Policies in these countries which have eliminated the (indirect) subsidies for mechanisation through foreign exchange realignments and positive real interest rates on investments. (**Figures 1** and **2**)

In this gloomy picture, the only bright spot may be Asia. Many Asian countries continue to have high economic growth rates, while their industrial and service sector is rapidly expanding. This causes real wage rates to increase and subsequently causes a demand for mechanisation. The People's Republic of China's increased emphasis on free market economy enterprises, is likely to have an effect on demand for labour and, subsequently, mechanisation.

2. The role of agricultural mechanisation in Asia

Of all modern agricultural technologies, mechanisation has probably stimulated the most critical debate since it is often associated with rural unemployment and other adverse developments. On top of that there are many examples of failed mechanisation projects, especially in Africa. Consequently, the international aid community has become very reluctant to provide development assistance for mechanisation. Conflicting views on mechanisation have resulted in numerous studies and publications on the topic of mechanisation. Agricultural engineers were generally ill-prepared to argue against economists and sociologists' points of view. Most engineers tried to prove that the criticism was unjustified rather than admitting that numerous mistakes had been made with regard to mechanisation in developing countries.

Engineers should have emphasized these mistakes could be avoided if governments would implement realistic economic and fiscal policies, and formulate sound mechanisation policies and strategies. On the other hand the sociologists and economists often lacked the technical expertise required to make a realistic judgment, and usually did not explain how the development goals of increased food production could realistically be attained without providing additional farm power. It is now generally accepted that in order to achieve increased agricultural production, raise productivity or production, technological changes in the agricultural process are needed. Ad-equate and timely provided farm power (whether manual labour, draught animal technology, or mechanical power) is a crucial factor in the agricultural production process, as much as land, seed and water.

However, at "macro-level" discussions, most development specialists have adopted the popular notion that Asia is heavily populated with land being scarce, hence agricultural mechanisation is not to be pursued. However, not only in Africa and Latin America but also in Asia there are large regions where land is not- or under-utilized because labour is a limiting production factor. For example in Malaysia, and transmigration projects in Indonesia, lack of adequate farm power have been a principal cause for substantial capital investments in land development failing to achieve the expected benefits because lack of farm power leaves the land (partly) idle. Similarly, there are large areas in Asia where land and labour are under-utilized due to distinct seasonality and low rainfall, for ex-ample semi-arid areas in India, Barani areas in Pakistan, upland areas of Northeast Thailand, and on Flores in Indonesia. Mechanisation technology in these cases is required to eliminate labour shortage bottle-necks (usually for land preparation). This, in turn, will increase total employment because of additional labour requirements for crop care, harvest, and postharvest work. In Northern China, an effective cropping season of only 90-120 days, combined with harsh living and working conditions (average annual temperature below 0° C) and sparse population, large-scale mechanisation has successfully transformed the region in an important grain producing area.

Agricultural engineers have now the difficult task to reverse the negative attitude of socio-economist and the aid community into a more nuanced and positive one towards mechanisation. This is further made difficult by the fact that in the aid community, environmental concerns now appear to overshadow the concern for increased food production required to feed the increasing and often hungry third world population. Engineers need to emphasize that mechanisation not necessary means "tractors", but also pump-sets (to increase cropping intensity or to reduce risk), hand tools, draught animal equipment, more environmentally friendly and operator-safe pest control methods and devices, technologies which contribute to improvements in the post-harvest system, and complementary technology required to increase production, either through high yields or a larger cropped area. In fact, in particular the concern for the environment places a new demand on engineers to provide technology which supports sustainable agriculture, and is environmentally friendly.

When discussing agricultural technology, two major groups of technology can be distin-guished:

— **land-saving** technology (for example. fertilizer, irrigation, plant breeding);
— **labour-saving** technology (for example, new farming techniques, herbicides. mechanisation).

Depending on land and labour endowment. countries should follow a different technological strategy in achieving agricultural output growth. For example, because of land scarcity Japan emphasized yield raising technology and mechanisation played only a minor role up to the 1950s. Because of ample land available, the U.S.A. focused on mechanical technology even before 1880, rather than high yielding technology. Similarly, Thailand rapidly expanded its agricultural area during 1960-1980 rather than applying yield raising inputs. This strategy contributed to Thailand's impressive agricultural growth performance, made possible inter-alia by a demand driven highly efficient mechanisation system which the private sector gradually developed. This example also demonstrates that agricultural development is not synonymous with high crop yield.

As earlier mentioned, three levels of mechanisation technology are to be considered namely, handtool technology, draught animal technology, mechanical power technology. Within each level, degrees of sophistication can be distinguished. (**Table 1**). For example for threshing wheat, mechanical power technology includes treading by tractor, power thresher, combine harvester with bagging facility (manual handling), or combine harvester with grain tank (mechanized handling). The decision of which farm operation to mechanize, and the choice of technology level and degree of sophistication will have major implications in terms of capital investment, social impact, investments in institutional and infrastructural support and operation cost.

3. Medium-term prospects for the mechanisation sub-sector in Asia

Predicting the medium-term development for the mechanisation sub-sector is not easy. However, assuming that economic development in most Asian developing countries continue to be progressing, and that any remaining domestic distortions in the agricultural sector will give way to free market forces, a cautious qualitative assessment of what is likely to happen in the next five to ten years may be made. For this it is necessary to understand how mechanisation comes about.

In a free market economy, the driving force for adoption of new technology, including mechanisation is economic: mechanization comes about as a result of the farmer's attempt to increase or maintain net income. This is usually the case when wage rates rise relative to cost of machines **(Figure 3).**

Therefore, mechanisation is demand-driven and not to be imposed (as has been the case in centrally-planned economies and many aid projects). Real wage rates are likely to increase with agricultural labour supply becoming increasingly scarce in several Asian countries, such as South Korea, Thailand, Taiwan, and Malaysia. Draught animal technology is in these countries no longer a viable option. In other countries where labour scarcity is not an issue in the foreseeable future, for example Bangladesh, Sri Lanka, India, the Republic of China, machinery will be in demand mainly as a complementary input to crop intensification technology. Labour scarcity or cost of labour is often mentioned even in these countries as a justification for mechanisation. However, as long as the cost of labour is only a few dollars per day most mechanical technology will not be cost-reducing, although in areas with land scarcity or timeliness being crucial, simple tractor technology may be more economic than draught animals.

When making a prognosis about the development of the mechanisation sub-sector in Asia's developing countries, it is important to understand the process of mechanisation as it has occurred in high-income countries. Although there are exceptions, generally the following seven distinct stages can be identified in adoption of labour-saving (mechanisation) technology.

Stage I - Stationary power substitution. At this stage, mechanical power is substituted for human power used in stationary operations. Stationary operations are mechanized first because motive power sources required to move across the field are technically more complex and therefore have higher investment and operation costs.

Stage II - Motive power substitution. At this stage of mechanisation, substitution of mechanical power for brute muscle power takes place for field operations. It focuses on power-intensive field operations (for example, ploughing), and machinery is of relatively simple design, inexpensive, and easy to operate.

Stage III - Human control substitution. At this stage, the emphasis is on substitution for the human control functions (for example, transplanting and harvesting). Depending on the complexity of the control function and the degree of its mechanisation, machinery becomes increasingly complicated and costly. In developing countries this stage of mechanisation will, therefore, only be viable when real wage rates have increased already substantially.

Stage IV - Cropping system adaptation. This stage features the adaptation of the cropping system to the machine. For example, removing weeds in broadcast crops cannot be done with machines. Subsequently, row seeding may be introduced to facilitate mechanisation of weeding. Intercropping makes mechanized harvesting difficult and may be replaced by sequential cropping systems.

Stage V - Farming systems adaptation. The farming system is adapted to increase labour productivity and to benefit from economies of scale. An example of this is the rapid decline of mixed farming systems in Europe since the late 1960s when farmers specialized in capital-intensive dairy, poultry, hog, or crop production. At this stage, mechanisation also be-comes an important justification for investment in land development and land consolidation.

Stage VI - Plant adaptation. This stage features the adaptation of the plant and animal to the mechanisation system. Breeders increasingly take into account the suitability of new varieties for mechanized production.

Stage VII - Automation of agricultural production. This stage is progressing in countries with high labour costs and sophisticated demands on production and quality. Examples are automated sprinkler irrigation systems activated by soil moisture, and auto-mated and computerized rationing of concentrate feeding for individual dairy cows based on their milk production.

As a general rule, the more sophisticated mechanisation becomes, the higher investments must be made, not only in machinery but also in research, land consolidation and development, education, training, extension, and plant breeding. In most developing countries of Asia, mechanisation has still not advanced beyond Stage II.

For a specific country common sense may give an idea what the demand for mechanisation will look like in the next 10 years, at least in qualitative terms. For most Asian countries, there is little reason to expect mechanisation technology of relevance to Stage IV (Cropping System Adaptation) to become in demand during the next 10 years. Equally in countries (such as Nepal or Bhutan) where labourers manually hammer stones into gravel for road construction, or where water lifting is done with manually-operated scoops (for example, Bangladesh), it is premature to consider mechanized harvesting technology. Discussions concerning introduction of rice combine harvesters become irrelevant if a quick calculation indicates that depreciation cost alone on a per hectare basis exceeds the costs of manual harvest. Equally, an investment cost of 175,000 US$ of a modern top-of-the-line cotton harvester indicates that this machine is not justified in countries where rural labour's monthly wage cost is less than the depreciation cost per hour of this machine. In situations where labour is just not available to harvest the cotton timely, alternative solutions (e.g. migrationary labour, intermediate level of mechanisation, or other cropping patterns) ought to be considered first.

4. The effect of free trade on Asia's mechanisation sub-sector

Already for a long time, world agriculture has been highly distorted by the domestic policies of many countries, in particular by distorted incentives to producers. In recent years forces have been building up in many countries calling for reforming agriculture, as well as other industries. These forces have led many countries to support the current round of GATT negotiations on agriculture policies, with the purpose to reduce domestic policy distortions to agriculture as well as to reduce protectionist policies. In fact, many countries have already started to reform their domestic and trade policies, irrespective of what hap-pens in the GATT negotiations. A significant reduction in the policy distortions will have a major long run impact on the world's crop production and trade in farm machinery, both on the supply and demand side. The direct effect on the global supply of farm machinery is likely to be minimal. In general, only very few developing countries have established import tariffs or quotas to protect the domestic manufacture of agricultural machinery (usually tractors and prime movers) in an effort to develop their own industry, but overall these cases are few and often already being diminished as a result of Structural Adjustment Programmes aiming at removing inefficiencies in the industrial sector. A direct effect on the demand side may be much more significant but it is difficult to say whether it will be positive or negative for the global industry as a whole.

The agricultural policy reforms may cause a shift where crops are produced, while lowering support prices may have a significant impact on farm structure in some countries, particularly the EC and Japan. A possible scenario is that in the highly protectionist countries (EC, Japan, Taiwan, South Korea), demand for agricultural machinery will further stall and a process of increase in farm size will be accelerated in order to maintain acceptable incomes for the remaining farmers and to achieve higher utilization of machinery investments. Developing countries which sell farm produce in the world market, higher world market prices will be a boom for their agricultural sector and will result in capital investments (including machinery) in this sector. Just imagine what a tripling of the world market sugar price (at the expense of EC sugar-beet producers) could do to the Philip-pine or Cuban economy; a significant increase in the rice price (at the expense of Taiwanese, South Korean and Japanese farmers), may have a significant effect on the Thai, Myanmar, Vietnamese agricultural economy. Also the increased demand in labour for quota-controlled industries is likely to have an effect. For example the removal of quota systems for textile and garments industry may quickly cause this industry in low-income Asian countries to expand, causing a drain on the agricultural labour force.

The increased demand for mechanisation will stimulate Asia's domestic machinery manufacture, which is likely to result in increased investment in R&D and gain from economies-of-scale. This in turn may enable them to compete in the world market with, at least initially, some of the less complicated agricultural machinery, in particular those which require high labour input for their manufacture (for example, soil tillage implements). In fact there are already Thai agricultural machinery manufacturers who successfully compete in the export market. However, prima-facie the increase in demand for machinery from developing countries is unlikely to exceed the reduction in the highly protected agricultural markets in the short to medium term. At best we may expect no change in the global demand for agricultural machinery.

With regard to manufacturers of more sophisticated farm machinery, for example four wheel tractors, it will be difficult to penetrate the world market unless substantial volumes can be produced and an efficient marketing system is established in the importing country. Most likely this is only possible through foreign collaboration but given the depressed market and severe competition, few foreign companies will be willing to make investments in joint ventures. Although Indian tractor manufacturers have started to export to Australia and few other countries, the volume is still insignificant. On the other hand, western tractor designs have become increasingly complex and their hydraulic and electronic systems now require specialized skills which exceed those of a traditional mechanic. This is likely to have an adverse effect on the maintenance of the these sophisticated tractors in developing countries. Therefore, tractor manufacturers in developing countries, such as India, who produce a basic standard 1970's designed tractor of a good quality, may find their product becoming in demand in other developing countries because of simplicity, reliability and ease of repair and maintenance.

Assuming that a tractor factory is viable only if at least 25,000 units per year can be sold, some developing country manufacturers will find it difficult to survive once distortioned policies are removed and free trade is implemented. For example, in Pakistan, the annual demand for 20-25,000 tractors with little or no exports, does not justify four factories even though at first instance this government dominated industry appears profitable. How-ever, a comprehensive USAID supported study concluded that "As a whole, the (tractor) industry is operating at a considerable loss with nominal component and tractor prices being set at levels that do not provide for an economic rate of return on capital invested and assets employed". The distorted picture was, amongst others, created by the fact that state-owned factories supplied parts and components to the tractor factories at a loss.

5. The role of government versus the private sector

Many of the adverse experiences with agricultural mechanisation can be avoided if operations in need of mechanisation are carefully identified and the technology is properly priced, namely reflects the real costs of capital. A World Bank study reviewed the experience with agricultural mechanisation in developing countries and stressed the need to bring mechanisation policy in line with development objectives. The principle recommendations of this study were:

— to cause exchange rates and interest rates for agricultural machinery to reflect market conditions;
— to reduce inconsistencies in policies governing the import of machines, replacement parts, and implements;
— to reduce or eliminate bias against certain technology, particularly against draught animals;
— to reduce bias against small-scale firms;
— to implement industrial policies conductive to local adaptation, production and maintenance of machines.

Worldwide experience has shown that agricultural mechanisation is clearly an activity which should be left to the private sector as much as possible. If there are proper incentives, in a liberalized economy the private sector will satisfy the farmers' demand for mechanisation technology in an efficient and a sustainable manner as has been proven in the case of Thailand. The role of the government should be limited to establish clear and efficient policies, provide the proper incentives, and create an environment in which the private sector can flourish. The government will have an active role to play when it comes to education, training and extension, testing and evaluation, and research and development. The latter, however, should be in close collaboration with the private sector, in response to the realistic demands from the farmer.

More emphasis must be given to develop area-or country-specific mechanisation strategies and policies. These strategies must give answers to questions such as when or under what circumstances to mechanize? What will be the demand for mechanisation, what level of technology or degree of sophistication is required, and which policies are to be implemented to ensure that the technology is efficiently used, economically justified, and sustainable. This requires not only a good under-standing of the agricultural development process but also of the technical capabilities of machines and the managerial, economic and financial aspects involved. More education and training is required on this matter since this type of expertise is hardly available.

The Agricultural Engineering Service (AGSE) of the FAO has been assisting individual countries with the formulation of these mechanisation strategies and to provide advice on mechanisation policy. At present AGSE is involved in advising Eastern European governments on how to restructure their state managed mechanisation systems into efficient privatized systems. The experience obtained with this may be relevant to some Asian countries.

Figure 1- Changes in profitability of imported reapers induced by currency devaluation and rising interest rates in the Philippines, 1982-85. (Source: Juarez et al, 1988. The Development and Impact of Mechanical Reapers in the Philippines, IRRI, Los Baños)

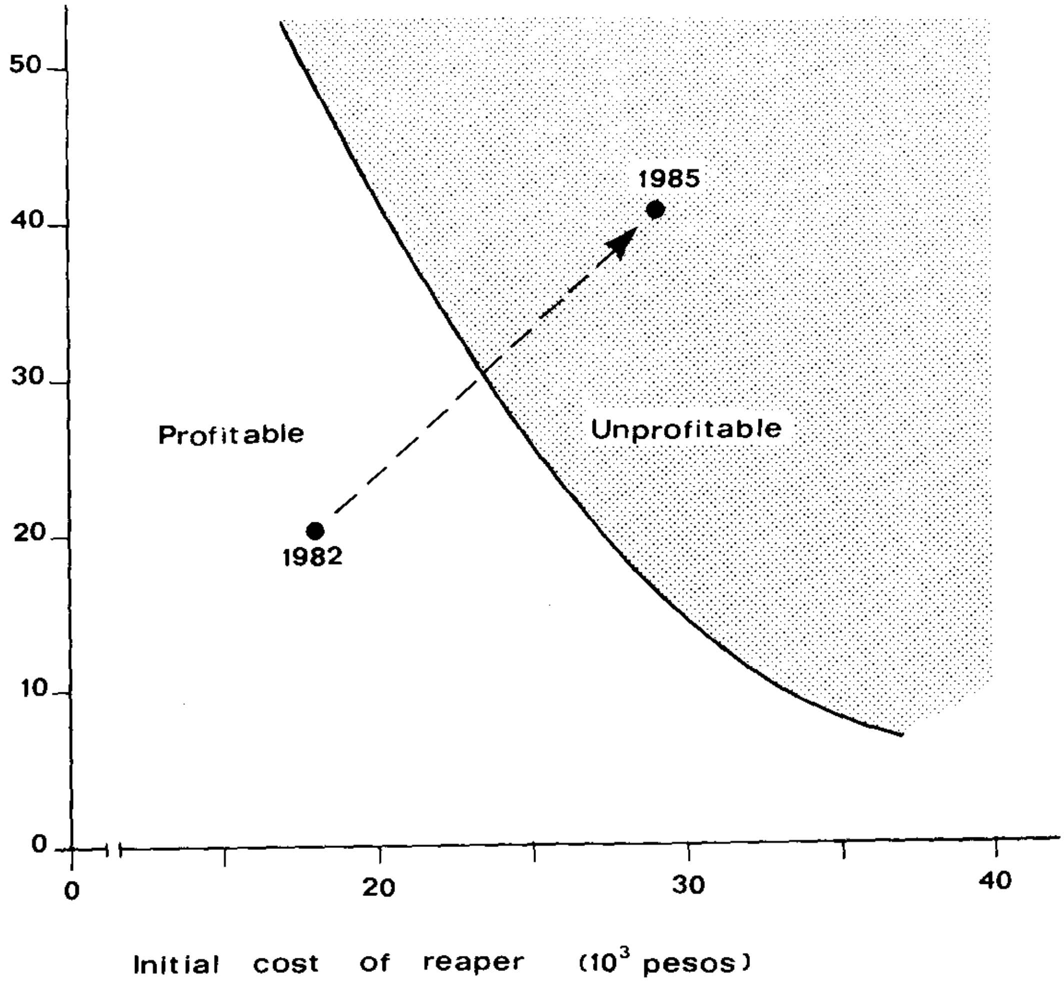

Figure 2 -Sales and price of imported and local reaper,Bataan and Pampanga,198255. (Source: Juarez et al. 1988. The Development and Impact of Mechanical Reapers in the Philippines, IRRI, Los Baños) (*) Sales of imported reaper cumulative for 1982-84. (**) Approximate sales for imported and local reapers as of April 1985.

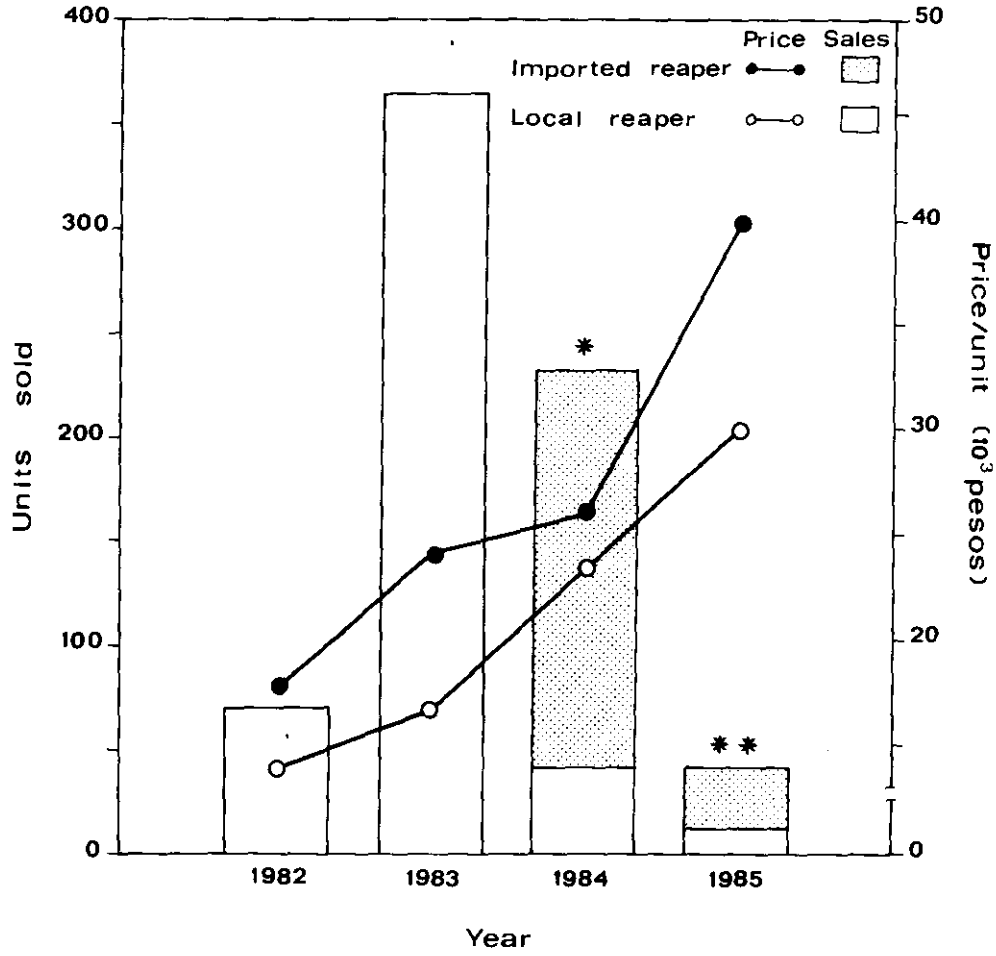

Figure 3 - Cost index of mechanical threshing versus farm labor wage rate (1977 = 100)

An example of sound mechanisation: Prior to 1975, paddy threshing in Thailand was done by hand even though mechanized threshers had been introduced earlier, but these machines did not come in demand. In 1975, an IRRI designed axial-flow thresher was introduced and demonstrated. Only after 1978, sales of these locally made axial-flow threshers rapidly increased, when the cost of mechanical threshing decreased rapidly as compared to the cost of labour. By 1986, 14,000 threshers were in use.

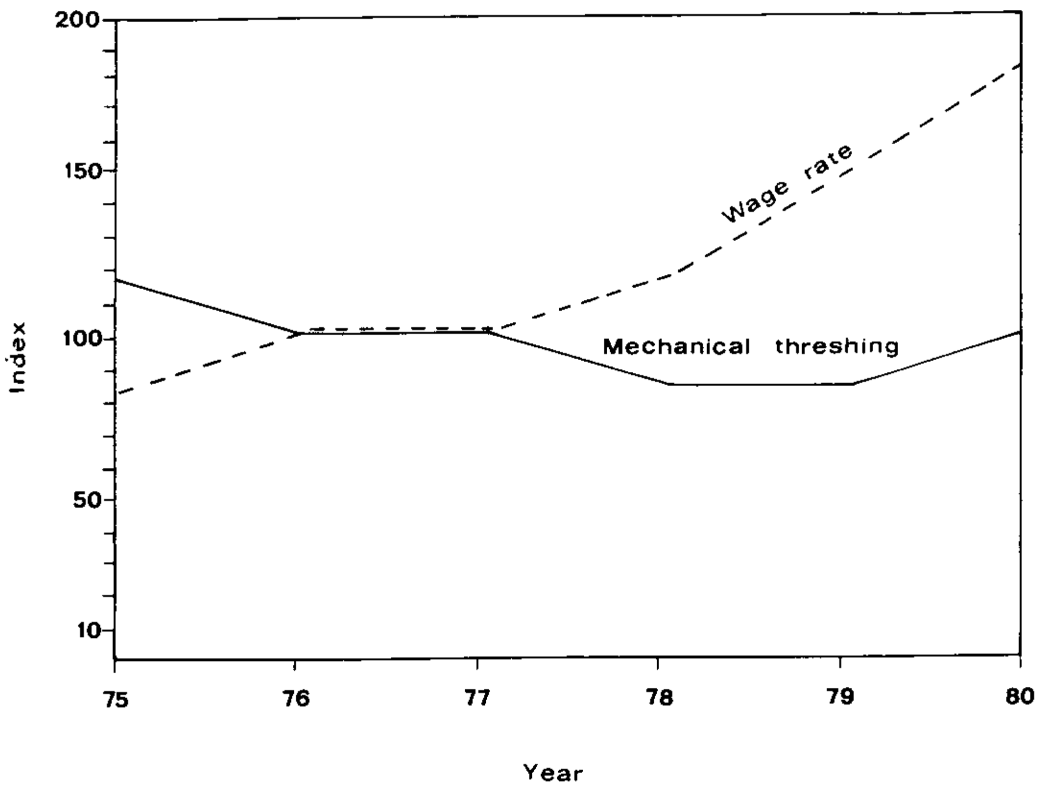

Table 1 - Levels of mechanisation technology with examples of degrees of sophistication for Thailand

FARM ACTIVITY	LEVEL OF MECHANISATION TECHNOLOGY (*) HANDTOOL	DRAFT ANIMAL POWER	MECHANICAL POWER
LAND CLEARING	axe hand saw	elephant for skidding and loading	tract-type tractor 4W tractor
LAND DEVELOPMENT	hoe	plow	4W tractor tract-type dozer
LAND PREPARATION	hoe	wooden plow comb. harrow steel plow rotary puddler	single-axle tractor power tiller two-axle tractor with various implements various implements
PLANTING	no tool (broadcasting) planting stick row marker hand-pushed seeder hand-operated transplanter	furrow opener (plow) seed drill	paddy transplanter seed drill
HARVESTING	finger-held knife sickle threshing basket pedal thresher	peanut lifter treading (threshing)	power reaper binder treading by tractor power thresher combine harvester
CROP HUSBANDRY	(weeding) hoe hand sprayer water can irrigation scoop	ridger interrow weeder	interrow weeder motor knapsack sprayer tractor boom sprayer spraying with aircraft diesel or electric irrigation pumps
CROP DRYING	sun drying		mechanical dryer (fuel)
CROP STORAGE	bag storage		bulk storage
PROCESSING	pestle and mortar flour grinding stone	sugarcane crusher	single pass rice mill multi-pass rice mill cassava chipper
HANDLING	carrying sack truck		elevator fork-truck
RURAL TRANSPORT	porter push cart rickshaw	pack animal bullock cart	motorized rickshaw power tiller with trailer two-axle tractor with trailer farm truck 4-10 wheel truck

(*) Within each operation and level of mechanisation technology, the degree of sophistication is presented vertically

Dr. G.R. Quick
International Rice Research Institute
Philippines

IMPACT OF NEW TECHNOLOGIES ON FARM MECHANISATION NEEDS TOWARDS 2000

1. Topical propositions, issues and potential solutions

Predicting anything for the year 2000 is hazardous, much more hazardous than for the year 2020 or beyond. The reason is that, with good management, many in this audience will still be around. Nevertheless, here are some topical propositions, issues, and potential solutions:

- engineering will be still very much needed for agriculture by the year 2000;
- engineering support for agriculture will probably be less than it is now in spite of the need;
- the tendency for inappropriate technologies to be foisted from remote societies unto unsuspecting and often initially-willing national agencies will diminish. This has often characterized past mechanisation systems and resulted in frustration, inequity, sometimes land degradation;
- there is a trend which should increase, towards indigenous technological development involving local manufacturers. This reduces dependence on imports and is likely to be a key area for future work by engineers and support by the donor community;
- we will need to be increasingly aware of the socioeconomic impact of the introduction of mechanisation and other new technologies;
- we will be most successful in surviving professionally if we can maintain an environmental interdisciplinary and ecological balance in our activities;
- there will not be any dramatic increase in the relative cost of fossil liquid fuels. If there is any significant shortfall in liquid fuels derived from oil, the gap will be gradually taken up by gas. Biomass fuels are not perceived as likely to play a major role in field agriculture, although they may become valuable for stationary applications;

— environmental degradation is going to assume increasing importance. The pressure on space may shrink the usage of draft animals, even though these are an important contribution in some societies;

— crop intensification will be essential to meet the food demands of proliferating populations. Crop intensification brings with it increased strain on ecosystems, especially fragile lands. Intensification also exacerbates pest problems. Reducing losses to pest especially by non-chemical methods will become an exercise in which engineers may play a valuable role. The role of chemicals may be threatened by the spread of the "Californian" anti-chemical attitude. That same state incidentally has banned straw burning, and this is a trend which will have interesting ramifications on crop management;

— reduction of losses, labor enhancement and improved efficiency and elevating worker dignity in farming operations will become imperatives. Mechanisation per se will not be a primary cause of labor displacement but will be a response of a rural community increasingly strapped for reliable labour and faced with declining profitability.

2. Lessons from western agriculture in regard to mechanisation

The Western world's farm equipment industry has taken a severe battering in the past decade. It reached its peak in terms of sale and dollar volume 20 or more years ago and has been steadily declining ever since. The situation in developing countries, however. is quite different. The needs are different and often quite specific to a region. The market is on the rise but highly variable in terms of unit sales. There is a likelihood that market demands will be addressed by a larger number of small entrepreneurs capable of making regional-specific designs free of freight and selling at low cost into their areas. At the same time they provide desirable services and back up. Engineers should play an important role in assisting such enterprise in the private sector. The heavy hand of government will not impede progress by such enterprises.

The shrinking market for tractors and machinery in the Western world has been partly cushioned by an increasingly sophisticated output of products of better quality, better appearance and greatly improved performance. There have been enormous improvements in the operator environment. A person operating a quarter million dollar machine has special skills and is worth cosseting to not take too many risks with such a valuable piece of equipment. On the other hand, he or she may spend long hours behind the wheel and the control functions are facilitated by providing a salubrious operator environment. The implications of these sweeping changes are that more work is done by fewer people. The quality of work is higher, the unit cost of energy are reduced, and efficiency is enhanced.

There has been a tremendous substitution of information for energy, resulting in unprecedented changes, for example conservation farming with greatly reduced tillage, the tolerance of residues in fields, so vital to protect the soil. The down side has sometimes been greater dependence on some chemicals, which are not always given a clean bill of health. That situation is changing. In the developing world, however, there is carelessness in the use of hazardous chemicals which have given the industry a bad name and this needs to be rectified. Again, a case of foisting technologies in an inappropriate way into a different cultural milieu.

The shrinking market in the West has meant that the farm equipment industry has excess plant capacity. That situation is probably being resolved (diversification, rationalization and complete scrapping of some factories. But in the meantime, there has been enormous attrition of skills and many engineers have been traumatized by loss of the career they set out to pursue and they have had to retrain them-selves. Perhaps in the developing world we can avoid this by forethought and astute planning. There may be certain advantages in not being at the forefront of a technology!

3. Unique features, impact and likely needs for the year 2000

One characteristic of the developing world is great dependence upon rice as the major source of nourishment. In Cambodia for ex-ample, rice makes up *78%* of total daily heat intake. But for the United States, rice is only 0.1% of daily need. The demand for rice is still increasing but it has to come from a diminishing resource base. A peculiar feature of rice is that it is a crop that is largely grown in water. Wet fields pose peculiar difficulties that in the past were resolved by applying large amount of hand labor. Furthermore a large proportion of the rice fields were distant from road access so trafficability and access have been key factors to be considered. Another critical point to consider is that farm and field sizes are small and are not likely to dramatically increase by year 2000, though there could be some rationalization and land reform programs are successful. But they do not al-ways mean that farm size will increase. Under the circumstances, the need for small equipment will not diminish. And traffic access and floatation problems will remain a high priority to get into fields and to get products out of fields.

Here is a list of likely equipment needs and developments:

— small tractors and harvesting equipment which do not bog in wet lands and can handle travel to remote sites on rugged terrain;

— equipment for minimum tillage and conservation farming;

— equipment to prepare land to minimize water use;

— indigenous small aircooled engines;
— equipment to place fertilizer and seed with precision yet not being to expensive;
— increased equipment reliability is essential as customer expectations and costs rise;
— pesticide applicator that minimize operator exposure to chemicals;
— residue retention equipment;
— improved thresher design for a range of circumstances;
— vermin and other pest-repelling equipment;
— equipment for value addition at the farm or in the rural community.

The lack of suitable credit facilities is a serious production constraint in most places. Added to that is the problem of sourcing quality steel and hardware for manufacturers in many developing countries. There was a larger gap between what national agencies should provide and farmers who are, with some justification, often suspicious of government agencies. The future challenges for engineers who stay around to serve the needs of agriculture in the *year* 2000 will be no less daunting than they are today.

Prof. Hua Guozhu
Chinese Academy of Agricultural Mechanisation Sciences
P.R. China

TECHNICAL EXTENSION OF FARM MECHANISATION IN CHINA

1. Introduction

China has a population of over 1.1 billion people, 80% of which lives in rural areas and is connected with agricultural activity. The main tasks to be performed in the development of agriculture and rural economy are to in-crease grain production, to develop a diversified economy and to raise farmers' income. Increasing grain production relies mainly on raising yields. The development of a diversified economy and increasing farmers' income depend on increasing the labour productivity of farmers. In these tasks, popularization and utilization of modern farm machinery and implement can play an important role. In China's rural area there has been a period for popularizing a new type of animal-drawn farm implements. At present we are developing power farming.

Figure 1 shows the development of farm power in China. From 1970-1989, mechanical and electric power increased by 12 times in the rural areas, while man-power and animal-power increased by 45% and 50% respectively. Manpower and animal-power in this period was jointly increased with mechanical and electric power. They are not mutually exclusive.

Tables 1 and **2** show the amount of farm power in use and the percentages of mechanisation in the main farm operations in 1990. In this year the total mechanical and electric power used amounted to 287.3 million kW.

It is mainly used for fighting natural calamities; doing irrigation, drainage and tillage work to increase farm productivity; carrying out agricultural production transport and farm processing practices to increase income.

The mechanisation percentages for irrigation, drainage, tillage, threshing and transport operations all exceeded 50% that year. More recently, stress of farm mechanisation has been shifted to new operations and new technology, such as: stalk ploughing into the field; nursery growing of rice seedlings; precision drilling; no-tillage sowing; applications of chemical fertilizers; aerial farming; fish pond oxygen enhancement. New efforts have also been concentrated on: small wind-driven generators; modification of Diesel engines, metal cleaning agents; etc.

Table 3 shows the new mechanized farm operations and their working quantity done in open fields in 1990. These operations are carried out with high efficiency and high speed to achieve farm seed-saving and fertilizer-saving.

2. Technical extension system of farm mechanisation

The main operational units of the present Chinese agricultural production are the farm households. The land possessed by a farm household averages 0.44 ha and the farm machinery possessed by them is mainly small sized, except for land tilling and combine harvesting where large and medium-sized machinery must be used due to operational scale.

The farm household is even incapable of bringing the small-sized farm machinery into full use. With a view to making full use of the farm machinery a dual operation system has been developed. Farm machinery is processed and operated both by farm holders and rural associations. Up to now, through practice the "dual operation" has developed into some operational formulas commonly used in rural China.

Farm holders purchase machines mainly for their own use, but in their free time the machines are used to do some jobs for other farm holders as a service to be repaid. Such farm holders use the free time of their machines to yield additional income which has been evaluated at over 13.3 million yuan in present China.

A farm holder purchases farm machines not only for his own use but also to do specialized farm operations (depending on the machine purchased) for other farm holders becoming at the same time a "contractor". This is with particular reference to: tillage, crop protection, transport, irrigation and drainage, farm processing etc.. The total amount of contractors reaches 1.3 million in China.

A rural collective purchases farm machines in order to offer specialized production service organizations to be engaged in a single item of mechanized farm operation. Such organizations total 117.6 thousand units in China.

A rural collective not only purchases farm machines to be used in various kinds of farm production operation services for farm holders but also for carrying out repair and maintenance work, spare supply and other multipurpose economic activities. These rural collectives are called township (or village) farm machinery (administrative and service) stations. Besides doing farm job for surrounding farm holders, they are also in charge of administrative functions, such as the arrangement of agricultural production, organizing and dispatching farm machine operations. In China there are: 51,224 township farm machinery (administrative service) stations; 296,000 village farm machinery (administrative service) stations.

The main task in order to bring about the technical extension of farm mechanisation is to transfer the suitable farm machines and the operational knowledge to farm holders and rural collectives in order to increase both their production and income. Farm holders who have carried out specialized farm operations for other farm holders are more familiar with modern farm machinery and therefore are more disposed to be taught the knowledge about the new machine.

Furthermore, they can often be expected to play an exemplary role in the technical extension of farm mechanisation.

In China, we have adopted different extension systems in the various periods of farm mechanisation. In the 1950s, the popularization of the new type of animal drawn equipment was mainly through agricultural technical extension stations, and in the same period over 500 new farm implement stations were established not only to do land cultivation work on behalf of the surrounding farm households but also to demonstrate the advantage of the new implement. In the 1960s and 1970s, due to the fact that the popularization of farm engines and the attached implements was largely at the beginning, large amounts of extension works were concentrated on the introduction, testing and improvement of the farm machinery. Therefore at provincial, prefectural and county levels farm implement research institutes were established to meet the needs and farm machinery extension services at this period were undertaken concurrently by the research institutes and the farm machinery evaluation centers. In the I980s, in order to popularize farm machinery and techniques to meet the agricultural requirements conscientiously, a complete extension system of farm mechanisation was gradually established.

Figure 2 shows the present technical extension system of farm mechanisation in China. In 1990 there were 1,753 provincial, prefectural, and county level farm machinery (development) extension stations (centers) with a staff totaling 13,043 of which 7,926 were scientific and technical personnel.

Under the Ministry of Agriculture, a National Development and Extension General Station of Farm Mechanisation has been established and charged with planning, coordinating, organizing and disseminating key items in the national technical extension of farm mechanisation, information exchange and international liaisons.

The provincial and prefectural farm machinery popularization stations are in charge of the local technical extension of farm mechanisation. Their concrete task is similar to that of the national general station. In 1982, in order to step up the extension of 7 items of mechanisation (i.e. mechanisation of growing rice seedlings, mechanized transplanting of rice, cage rearing of poultry for farm house-holds, fish farming in pools, etc.) 7 specialized extension liaison centers were established, headed by one provincial extension station and joined by the provincial and prefectural extension units and the agricultural and husbandry institutions concerned.

The specialized extension liaison centers are also responsible for organizing and carrying out the popularization, training and exchange of experiences with the financial assistance and guidance of related administrative departments.

County level farm machinery extension stations are at present the basic units which directly organize and carry out the planned items. Farm mechanisation technical extension below county level is largely done through township farm machinery (administrative and service) stations. In each of these stations there is a permanent or part-time staff whose task is to directly organize and guide the village farm machinery stations (teams), and to contact the farm machinery technical exemplary house-holds for carrying out tests, demonstrations and popularization operations. The farm machinery technical exemplary households are selected on the basis of their capability and economic and technical background.

Townships are the grass-root level of China's administrative structure and have the respons-ibility of directly organizing and guiding the economic activities of the townships, including the organization of the extension service. Farm machinery (mechanisation) re-search institutes, universities and colleges directly transfer and popularize their research results. Some of them undertake the popularization of some specialized projects in collaboration with the farm machinery extension units. New products made by farm machinery factories get to customers either through the technical extension units or the market.

In order to strengthen the regional farm mechanisation technical transfer and coordi-nation, the Ministry of Agriculture has planned to establish 5 regional farm machinery orga-nizations.

3. Method and support for the technical extension of farm mechanisation

The technical extension of farm mechanisation mainly works through the existing extension system. The method of extension has the following procedure: selection of proper items for extension, test, operational performance, demonstrations, marketing, personnel training, guidance and information feed-back.

Selection of items - The technical extension of farm mechanisation concerns both farm machinery and techniques except for some technical skills like all industrial products, including the appraised results of scientific research, technical innovation. new products produced by factories of farm machines or efficient farm machines that have been used in some other places.

All farm machines that are to be transferred in a large amount and over a large area should also ask the Ministry of Agriculture to grant a license.

The first task the farm machinery department has to do is to select the suitable and beneficial item to the needs of local agricultural production, and make suggestions according to the feasibility of customers, input it and submit it to the proper authority for approval.

Test, operational display and demonstration - Farm mechanisation technology has its distinctive regional adaptability, farm machinery that is supposed to be transferred needs to be tested, displayed in operation and demonstrated, to examine its adaptability to this area, giving propaganda and recommendations to customers.

Marketing, training, and guiding - Once the adaptability to local conditions has been confirmed, marketing and training of personnel can be carried out if customers promise to have it. In the practical use of the farm ma-chine, related guidance should be given to the customers.

Information feed back - Establish how matters stand in popularizing and utilizing the farm machine so as to determine the amount of production according to demand. If there is trouble in use, feed the information back to the unit concerned to improve it. The price of agricultural produce is relatively low in China, since the state gives subsidy to farmers to cover the deficit. Moreover the government treats the extension of agricultural techniques and farm mechanisation techniques as public welfare. The state offers standing expenses for the technical extension units. All expenses for purchasing prototypes, testing and demonstration activity, compensation of losses, personnel training and propaganda are paid by state special fund allotments. With a view to extending the source of funds, the following have been put into practice:

— farm machinery management departments collect a farm machine management service charge, 30% of which is used for technical extension;
— urging the extension units to carry out farm machine purchasing and marketing business on behalf of customers; to re-pair and train as services to customers. thus getting some income as their funds:
— do the best to strive for social support. such as to procure free loans for their circulation funds in popularization work.

Aiming to raise the cultural and technical capability of farmers we have found various ways to carry out technical extension propaganda and training activity for them. Recently rural scientific popularization networks with all kinds of specified technical associations as their core have been established extensively: rural scientific popularization stations, branches of agricultural colleges of correspondence courses or agricultural coaching stations have also been set up to disseminate scientific and technical knowledge and improve farmers' quality.

The "Bumper Harvest Plan" is an effective new high output method carried out since 1987 to increase farm productivity by the extension of agricultural techniques in China. Its main purpose is to replace the extension of a single item of high output technique with a complete set of multiple high output techniques with a new technique as its core, thus doing away with the low- effectiveness and high-difficulty in examining the practical high output effect of the single-item technique. In carrying out this new formula, stress should be laid on large-scale application and the pursuing of both high output and high income effect. In the bumper harvest plan farm mechanisation is an important component. It extends a set of comprehensive farm mechanisation techniques with a new one as its core, which not only closely combines the technique of farm mechanisation with agronomy, but also has a definite large extension area and specific high output and high income targets.

Since 1987, we have successively extended the comprehensive high output techniques of farm mechanisation for wheat, corn and rice; a complete set of mechanized cultivation techniques for stock, poultry, fish and shrimps; a complete set of mechanized output techniques for grain and cotton in low and middle yield land; high output techniques combining farm mechanisation with agronomy for grain and oil seed crops; complete sets of mechanized high output techniques for stock poultry, fish, shrimps, fruit and vegetable. All these have achieved good results. Table 4 shows the technical extension effect of the farm mechanisation items in the 1987-1991 Bumper Harvest Plan.

In **Table 4**, the complete set of comprehensive high output techniques for crop production consists of the popularization of cutting stalk ploughing into the field; precision drilling; mechanical plastic sheet covers for corn growth; nursery growing of rice seedlings; no-tillage sowing in paddy fields; deep application of fertilizers, as well as deep ploughing, mechanical irrigation-drainage and harvesting. In farm household poultry farming, it consists of the large area popularization of cage rearing; mechanized mix feeding; fish and shrimp breeding in ponds with mechanical oxygen enhancement; and feeding with pellet baits, etc.

Owing to the large area application, production has increased remarkably. From 1987-1991, the mechanized high output techniques were extended to an area of 1,704 million ha, and grain production increased by 1,518 million ton. The high output mechanized technique in the cultivation of fish and shrimps was popularized in an area of 15.6 kha, resulting in an increase of fish and shrimp production of 41.3 million ton. In 1991, the state allotment of funds used in popularization of new techniques amounted to 2 million yuan, so farmers and the local government took concerted action and invested a fund of 108 million yuan and the total economic benefit from increasing production and cutting down expenditure amounted to about 320 million yuan.

Some new forms in the technical transfer of farm mechanisation. Along with the development in implementing the reform and open-door policy, farm machinery has entered the rural market as commodities go into the market for transfer. Under such circumstances, some new forms in the technical transfer of farm mechanisation have been established:

— farmers or rural collectives buy research results on the market from the farm machinery research units or the related universities and colleges. The technical transfer is effected by signing contracts, and the extension of new techniques is carried out according to the stipulation in the contracts;

— new products from factories are sold on the market. Farmers or rural collectives purchase what they like by selection on the market. Factories or sales departments should do the before hand recommendation and after-sales service for their products. Tractor, transporter and truck drivers must be trained in specialized training schools;

— technical groups contract for agricultural production of the farmers. Technicians of farm mechanisation combining with agronomical technicians form a group, to contract for the comprehensive new technical service work in an agricultural production unit. This group guarantees the fulfilment of the duty defined on the contract agreement, and close cooperation with the farmers to accomplish the complete high output and high income plan stipulated in the contract.

4. Conclusions

China has a large population with little land per capita. To increase its grain output and raise the income for farm households it must urgently develop and spread farm mechanisation. Farm mechanisation in China is required mainly for raising the yield and the labour productivity of farmers and should give priority to those farm operations that are difficult to complete in their farm season but on which it is easy to earn some money. such as tillage, irrigation and drainage, plant protection, threshing (low power capacity of man and animals makes it difficult to catch their seasons), transport and processing (easy to make some money on).

The technical extension of farm mechanisation is done mainly relying on governmental organization. In China, we have established a comparatively better extension system and popularization procedure. In order to find some fund resources for farm mechanisation technical extension we have worked out some back-up measures.

The "Bumper Harvest Plan" for technical extension features the extension of complete set of multiple high output techniques with new ones as its core. In carrying out this plan stress should be laid on large-scale application and pursuing of both high output and high income effect. The advantages of it are that the state gives less input and the farmers are willing to pay the rest resulting in a great economic benefit either from increasing production or from cutting down expenditure.

In complying with the development of the economy, both new farm machinery products from factories and scientific research results have entered the market for sale, and farms or rural collectives begin to be able to purchase what they like by free selection while technical groups begin to contract for agricultural production. These new methods seem to be more flexible and promising.

References

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[2] Ministry of agriculture, 1991. Annual statistics report on farm mechanisation administration in 1990.

[3] Ministry of agriculture, animal husbandry and fishery, 1983. Administrative measures for farm mechanisation extension (trail edition).

[4] Li Fuging,1991,"Speech at the conclusive meeting on farm mechanisation items of Bumper Harvest Plan", Nongye Tuiguang, 1991. 1 (36)

Figure 1 - Increase of rural manpower, animal power, farm mechanisation and electric power

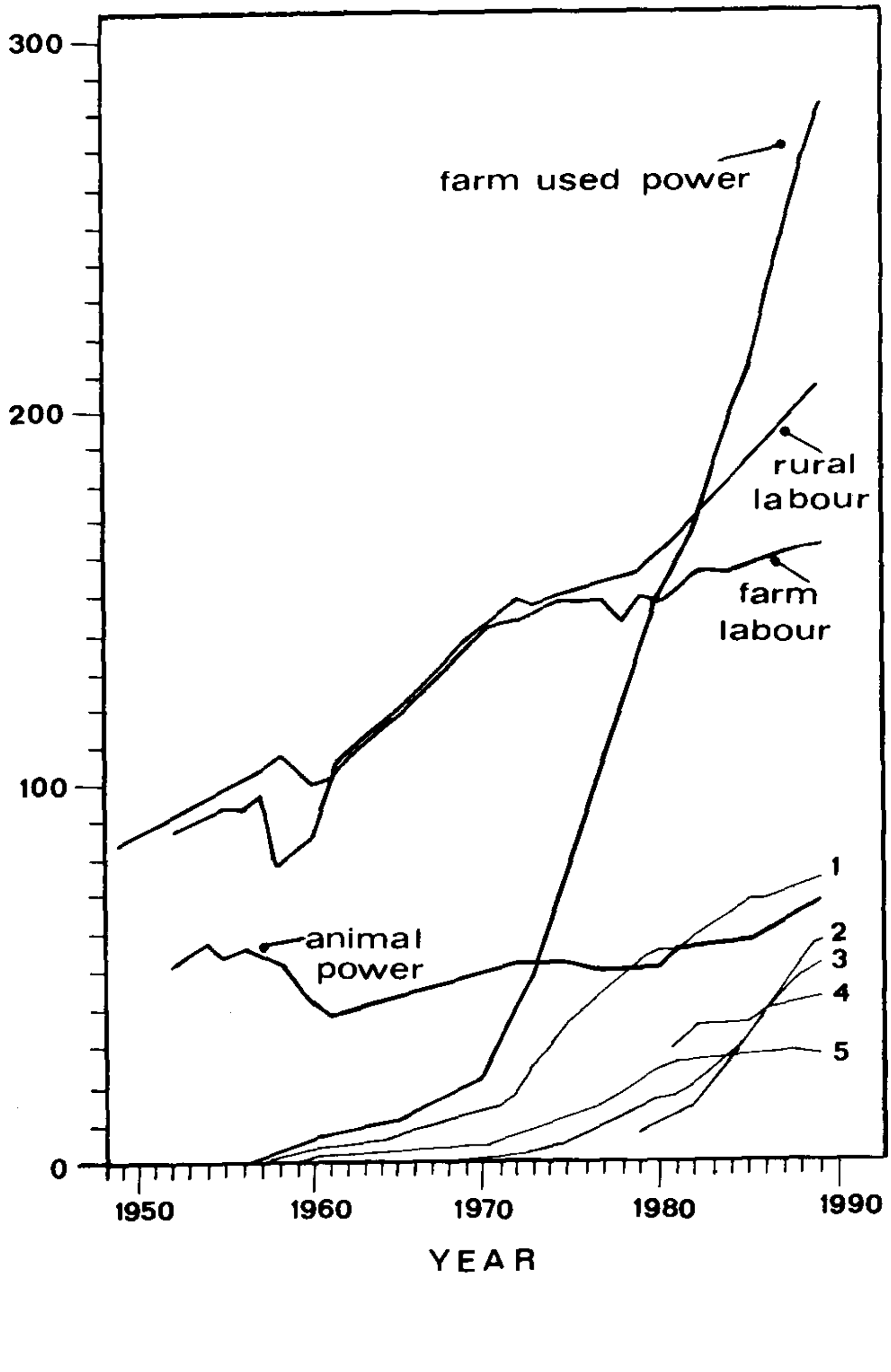

Figure 2 - Technical extension system of farm mechanisation

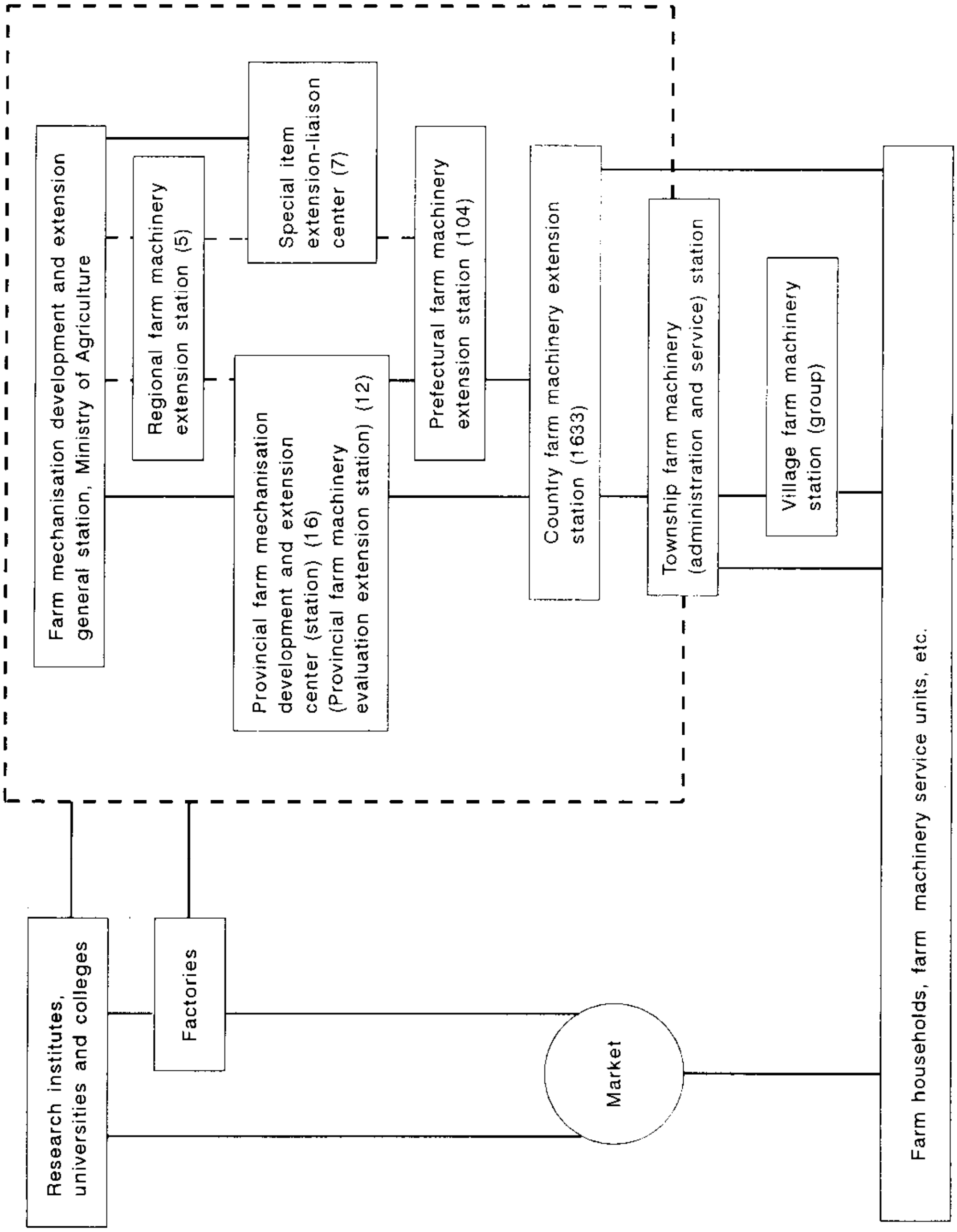

Table 1 - Farm power used in 1990

<table>
<tr><th colspan="2">NAME OF POWER</th><th>UNIT
(10³)</th><th>POWER CAPACITY
(10⁶ kW)</th><th>POWER PERCENTAGE
(%)</th></tr>
<tr><td colspan="2">Total mechanical and electric power</td><td></td><td>287.3</td><td>100</td></tr>
<tr><td colspan="2">Irrigation and drainage power</td><td>8483</td><td>71.4</td><td>24.9</td></tr>
<tr><td rowspan="2">Tillage power</td><td>large-sized tractor (≥ 14.7 kW)</td><td>814</td><td>27.5</td><td rowspan="2">31,3</td></tr>
<tr><td>small-sized tractor (< 14.7 kW)</td><td>6980</td><td>62.3</td></tr>
<tr><td rowspan="3">Transportation power</td><td>truck</td><td>601</td><td>45.8</td><td rowspan="3">18.5</td></tr>
<tr><td>motor boat</td><td>351</td><td>3.7</td></tr>
<tr><td>farm transporter</td><td>232</td><td>3.5</td></tr>
<tr><td colspan="2">Farm produce processing power</td><td></td><td>43.5</td><td>15.2</td></tr>
<tr><td colspan="2">Fishing vessel power</td><td>318</td><td>6.8</td><td>2.4</td></tr>
</table>

Table 2 - Percentages of mechanisation in the main farm operations in 1990

OPERATION	QUANTITY OF WORK	PERCENTAGE OF MECHANISATION (%)
Tillage	48.3 Mha	51
Sowing	21.6 Mha	15
Plant protection	13.7 Mha	
Harvesting	11.0 Mha	7
Irrigation and drainage	27.2 Mha	56
Threshing	230.4 Mton	54.6
Processing	872.6 Mton	
Farm transportation	7069.0 Mton. km	

Table 3 - New mechanized farm operations popularized in 1990

FARM OPERATION	WORKING QUANTITY (10^3 ha)	MAIN FUNCTION
Terrace building against the slope	8.7	high efficiency
Non-tillage sowing	128.6	seasonable aid
Factory growing of rice seedling	58.0	saving of seed and seedling bed, seasonable aid
Precision drilling	491.7	seed-saving, seasonable aid
Deep application of fertilizers	249.7	raising of fertilizer effect
Cutting stalks to return them to field	492.8	raising of land fertility
Mechanized plastic sheet covering	60.1	high efficiency

Table 4 - Technical extension effect of farm mechanisation items in 1987-1991.

AG. PRODUCT.			YEAR				
			1987	1988	1989	1990	1991
Grain crop	area	(Mha)	1.75	3.02	3.23		9.04
	increased production	(kt)	2.0	2.5	4.5		6.2
Oil-seed crop and cotton	area	(Mha)		cotton 0.87			oil seed 0.10
	increased production	(kt)		253.6			114.0
Stock and poultry raising	raising amount	(10^6head)	poultry 14.98	poultry 19.40	poultry 23.62		poultry 25.30
	increased production	(kt)	egg egg 16.8	meat and 361.0	egg 39.8		
Fish and shrimp cultivation	area	(kha)	62.0	79.3			14.3
	increased production	(kt)	19.6	195.2			21.7
Benefit from income and cutting down expenditure		(100 million yuan)	3.4	3.2			

Mr. Sahara Koji Kubota Corporation
Japan

THE ACTUAL STATE OF TECHNICAL TRANSFER IN KUBOTA CORPORATION

1. Introduction of the farm machinery division in Kubota

Kubota was founded as a cast-iron manufacturer in 1889. Since then Kubota has diversified and developed, especially in the machinery field, for about 100 years. Kubota is now expanding into the field of electronics - such as computer, automated vending machine - and of environmental purification equipment, such as garbage incineration plants and water purification plants. Our farm machinery division started in production of Diesel engine in 1922 and since then for 70 years Kubota, as a top-maker in Japan, has been manufacturing various type of farm machinery.

We are supplying our products to domestic market and overseas market and we are manufacturing our products in more than 10 countries and contributing to mechanisation of the world farming.

We could say that Kubota manufactures almost all types of farm machinery. The main products are as follows:

- Engine: vertical Diesel engine, horizontal Diesel engine, air-cooled gasoline engine;
- Tractor: for farm, horticulture, mowing, light public works;
- Harvester: for rice, wheat, vegetable;
- Planter: for rice, wheat, vegetable;
- Walk-type farm and horticulture machine: tiller, reaper, binder;
- Farm facilities: drying facilities, storing facilities.

Total domestic production amount of our farm machinery division is 2.5 billion US$ while the overseas production amount is 250 million US$. The 75% of production is for the domestic market and the 25% is for the overseas market use. Those produced in overseas are almost for the use of overseas market.

2. Technical transfer and popularization of farm machinery

We are apt to think of the transfer of "manufacturing techniques when we speak of technical transfer. However from the point of view of the contribution to popularization of farm machinery, the technical trainings of right knowledge, proper use, maintenance and repairing techniques of the products should be preferentially alluded.

Therefore I would like to divide the content of technical transfer which we have performed into the following three fields:

- technical transfer of right knowledge, proper use, maintenance and repairing of farm machinery;
- technical transfer of production techniques;
- technical transfer of development techniques.

3. Technical transfer of right knowledge, proper use and maintenance and repairing of farm machinery

The contents of techniques in this field are:

- techniques to understand the feature and structure of the products and to use the products safely and economically;
- techniques to repair and adjust the products properly.

The means of transferring of these techniques are:

—Trainings at Kubota training centers:

  - Kubota has more than 10 training centers in Japan and furnishes technical trainings. Also in Osaka we have a training center with accommodations for overseas trainees and provide the training in English;

- this training center for overseas trainees is 30 years old and the people trained here is about 1,000;
- these trainees graduated at this center have become key-persons of popularization of farm machinery in each of their countries or areas;

- Training at our overseas factories and sales companies:
  - although each of our overseas factories or sales companies makes plans and performs its technical trainings by itself, Kubota occasionally supports these trainings by giving advices of training programs, dispatching instructors, sending training materials and so on;
  - in both of Thailand and Indonesia we have permanent training centers included into the factory; instructors are fully employed in order to provide technical trainings any time;
  - especially in Indonesia the training activity at the factory has become a part of curriculum of the high-school in that district and this training course is highly appreciated by the local people;

- Trainings by the Japanese governmental body such as JICA or others;
- Trainings held by tour service teams visiting local areas:
  - we dispatch our technical teams periodically to local areas where sales and service activities are not sufficiently organized. The teachers involved supply information on proper use, maintenance and repairing of the product, carrying out servicing or repairing activities.

Though the content of techniques to be transferred varies depending on the trainees themselves or the purpose of the trainings, the content of our trainings is generally as follows:

- roomlectures of the features and structure of the products;
- disassembly, assembly and adjustment of the products;
- operating practice in the field.

4. Outline of overseas manufacturing

4.1. General outlines

Kubota has performed development, manufacturing and sales of farm machinery as its company policy. Consequently Kubota has to supply the products with high quality and performance at a reasonable price to farmers, in order to contribute to the mechanisation of the world farming.

Concerning the overseas manufacturing, Kubota policy is that the products should be manufactured near the place of their main markets.

In 1960 we started manufacturing of Diesel engines and power tillers in Brazil and, at the same time, we performed the technical transfer of the development and manufacturing of these products and the techniques of manufacturing of cast-iron for the product components.

Successively, we started our overseas manufacturing in Taiwan, Thailand, Indonesia, USA, Spain and Germany.

4.2. The manufacturing in Indonesia

In Indonesia Kubota started the manufacturing of horizontal Diesel engines in 1973 and, at present, is manufacturing 10 models from 3.3 kW to 19.8 kW as well as locally developed power tillers.

The total demand of Diesel engines for farm use, including boat use, is 60,000 to 80,000 units per year. Approximately 50% of them (40,000 units) are manufactured in Indonesia, shared by 2 companies.

Consequently, the production volume per company comes to about 20,000 units. Therefore, we could not take up for large investment due to low volume. Under such circumstances we have not been able to make a remarkable progress in localization of the products.

But taking into account that industrialization in Indonesia is rapidly developing and partner industries are expanding too, we expect to increase our location.

4.3. The manufacturing in Thailand

In Thailand Kubota started the manufacturing of horizontal Diesel engines in 1980 and now we are manufacturing 4 models from 5.5 kW to 8.8 kW as well as power tillers locally developed. The production volume of Diesel engines is over 120,000 units per year.

The total demand of Diesel engines in Thailand was 60,000 units per year in the 1970's. In 1980's the total demand was expanded to 100,000 units along with the popularization of power tillers and at present is expanding to 150,000-170,000 units per year.

The manufacturing of Diesel engine in Thai-land is one of our most successful business. We deem the reason of the success is founded on the management ability of Thai partners and their management policy that first priority should be given to the quality. We intend to keep this policy of "Quality is the first" hereafter. In Thai factory QC-circles and other QC-activity are practiced very actively and their activity level is almost the same as in Japan. Kubota holds meetings on QC-circles in Japan every year inviting them in order to exchange opinions.

At present farm mechanisation in Thailand is under progress in the fields of cultivating, harvesting and transport and the popularization of our compact and light Diesel engines gives a large contribute to farm mechanisation.

Kubota intends to cooperate with the Thai partner in the developing and manufacturing not only for Diesel engines but also for less mechanized fields.

4.4. The manufacturing in other South East Asian Countries

Kubota has attempted overseas manufacturing in Vietnam, Bangladesh and Myanmar. However in these countries, due to the political or economical reasons, we cannot say we have been operating smoothly. Therefore, we have not yet reached the level which we claim to really contribute to the mechanisation.

However, we believe that in these countries the popularization of farm machinery will be rapidly progressed in the near future. In fact, the increasing of productivity, the enlarging of harvesting technologies and the lowering of labor forces are the common needs of the world farmers and at that time our overseas manufacturing of Diesel engines would contribute to the mechanisation of farming.

5. The objections and problems in overseas manufacturing and technical transfer

5.1. Enforcement or incentives are needed to promote the overseas manufacturing

Overseas manufacturing is not always favourable costwise comparing with the imported CBU (Completely Built Units) goods.

Overseas manufacturing needs a considerably large investment and the depreciation of the investment becomes a large burden to the production cost, especially if the production volume is not enough.

The wider the scope of the technical transfer is, the larger becomes the investment amount for the equipment.

In order to make progress in overseas manufacturing in such risky condition of investment for equipment as stated above, some incentives for taking up overseas manufacturing, continuity and consistency in the economic policy of the government are quite needed.

In many countries import-ban or limitation of importation of CBU and incentives to the taxes are introduced to support manufacturing companies.

5.2. Farm machinery manufacturers difficulties in transferring techniques due to limitation of our own techniques

For the manufacturing of machinery the techniques which a farm machinery manufacturer possesses is not sufficient to perform localization (i.e. we have not all techniques to produce farm machinery products only by ourselves). The localization of machinery needs support of considerably wide range of industries' support.

The techniques which farm machinery manufacturers are able to transfer are mainly limited to those possessed at home (such as designing assembly and inspection techniques and a very limited part of manufacturing techniques of components).

Generally speaking, it is difficult for farm machinery manufacturers to transfer the techniques of parts manufactured by specialists or standardized parts sold on market. In our case of Thailand, the technical transfer by parts makers of car industry have been per-formed in parallel with our technical helping us very much for our location.

Therefore it is a key obstacle for us to transfer the techniques of components as well as of forging and casting.

5.3. Settlement and development of technical transfer

In order to settle and develop the techniques transferred, an appointment of excellent personnel and a reasonable service period of this personnel are desired in the overseas manu-facturing companies. An example of unsettlement of the techniques transferred is the retirement of the trained personnel.

In the case that local partner is a large enterprise, the parent company moves the personnel to other group company or division due to their system of personnel rotation or other reason.

5.4. Conscious gap between transferor and transferee toward the way of technical transfer

Namely, transferee generally wishes to be transferred as much techniques as possible at one time. On the contrary, the transferor intends to transfer step by step, confirming the quality of the products manufactured by the transferee. In many cases this kind of conscious gaps happen to become a problem. We solve this problem by mutual discussion and understandings between our local partner and ourselves.

6. Transfer of the techniques of development

It is naturally better for us to have only a central development place of techniques; therefore we used to develop the machinery in Japan.

However, in accordance with advancement of localization, the machinery manufactured in the different countries are shifted from Diesel engines up to the farm machinery (like power tillers or harvesters) which requires study and research on local needs. Therefore the development is required to be performed near the market of the products to be developed.

Transfer of techniques of development is, at present, performed by trainings in Japan for the overseas trainees and by our engineers dispatched in each country.

7. Conclusions

Kubota has contributed to the mechanisation of the world farming as its company policy supplying farm machinery with high quality in reasonable prices. We have promoted localization of farm machinery and performed transfer of the techniques in various countries and we intend to cooper with the needs of technical transfer progressively.

However the needs for farm machinery have been diversified in accordance with the mechanisation of farming which requires a large amount of investment and is becoming a factor of cost production. Therefore we see some cases that localization of farm machinery have become restraint to mechanisation of farming.

We are near a new era: especially in South East Asia we have to select localization or importation in accordance with the aim of the farming, abolishing the idea that localization should be performed at any rate.

Dr. Zia Ur Rahman
Regional Network for Agricultural Machinery
Thailand

AGRICULTURAL MECHANISATION IN ASIA. PRESENT STATUS AND FUTURE PROSPECTS

(Opinions expressed in this article do not necessarily reflect the views of the United Nations)

1. Introduction

According to various educated estimates, the population of the Asian Pacific Region will double itself from the present 2.7 to 5.4 billion within the first quarter of the next century. The food production in the region must keep up with this increase to avoid the specter of hunger and starvation currently unfolding in Africa. The challenge for planners economists, agriculturists and engineers becomes more formidable in view of the fact that the avail-able land and water resources in the region are already exploited to the maximum and no significant increase in these resources is possible without enormous inputs of energy. The only viable alternative to increase food production is to improve prevailing farming practices along with the use of better seeds and more efficient utilization of fertilizer and other inputs. The use of agricultural machinery takes on a pivotal role in all of these. For instance, despite the introduction of hybrid seeds for wheat and rice and resulting increases in outputs, the yields in most of the countries have stabilized at a level far below the potential. Appropriate machines are needed for accurate application of seeds and fertilizer, and to preserve scarce soil and water resources. These are among the main reasons because most of the governments in Asia are promoting agricultural mechanisation, despite apparent surpluses in labor force and employment generation problems.

2. Historical background

The history of agricultural mechanisation in Asia is relatively recent. Until the fifties, the traditional methods of employing manual and animal power were used in all crop production operations in all the Asian countries. The three main regions of Asia considered in this article, i.e., South, South East and North East, expe-rienced somewhat different developments in agricultural mechanisation. In the North East, Japan was the first to mechanize as a result of rapid industrialization immediately after the Second World War. The Republic of Korea and Taiwan Province of China, followed suit due to their own industrialization and access to technologies from Japan. The iron buffalo, or the 2-wheel tractor developed in Japan, be-came the mainstay of agriculture in these countries, to be replaced later by 4-wheel tractors.

In South Asia, a few 4-wheel tractors were introduced in India and Pakistan in the fifties but mechanisation took off only in the late seventies when there was large scale migration of rural labor to the Middle East. In the Southeast Asian countries, Thailand made considerable progress in the eighties by introducing small machines such as 2-wheel tractors, seeders, stationary threshers and water lifting devices - again due to the shift of rural labour to the industrial sector. Another country, Malaysia, introduced large tractors and combines in the seventies and eighties to increase production of rice in a large area added to its arable land under the MUDA Agricultural Development Authority.

It is interesting to note here that in all the countries mentioned above the government policies of actively promoting mechanisation played a very significant role. This is somewhat at variance with the way agricultural mechanisation evolved in North America (and Europe) in the last century where market conditions were allowed to determine the priorities without much government interference.

3. Why mechanisation?

It is also interesting to note that farmers, whether they are from North America, Europe or Asia, would choose to mechanize agriculture only if it entails substantial economic advantage over the traditional practices. They, particularly those in Asia, have little or no understanding of national food security problems, but they do understand the concept of profit and loss. In addition, they would mechanize those operations first which save a lot of time and are carried out with relatively simple devices such as ploughing and threshing. Next in adoption are crop protection devices and fertilizer spreaders followed by reapers for cereal crops. The transplanting machines for rice and other crops (vegetables) are the last to be adopted - in fact only Japan, Republic of Korea and Taiwan Province of China have successfully introduced trans-planters for rice. Other Asian countries are looking for simpler and less expensive solutions.

There are other related reasons for mechanisation which are briefly discussed below.

3.1 Shortage of labour

Shortage of labour, whether it exists throughout the year or occurs at the peak time of an operation, translates into higher wages for rural workers. Once these wages cross the break-even threshold, farmers begin to buy machines. The labour shortage can be caused by migration of rural labour to cities or other countries; increased demand at peak sowing, transplanting, harvesting or threshing times: necessity to handle increased volume of crops caused by use of better seeds or increased cropping intensity; or simply by the current change in the social attitudes of the rural population, i.e., those exposed to cities or other countries seldom go back to farming in rural areas, much less to traditional or dirt farming.

3.2. Machines provide concentrated power where needed

In the traditional method of farming, ploughing, transplanting, harvesting and threshing are tedious and time-consuming operations. Machines can compress the time required for these operations to a fraction of that taken by traditional methods. The use of land preparation and harvesting machines has made it possible for farmers in the Punjab provinces of India and Pakistan to practice wheat-rice rotation, whereas earlier only one or the other crop could be sown in a year. Machines have also made it possible for farmers of some areas in the Philippines (where water is available) to grow up to three crops of rice in a year. Furthermore, because of high concentration of power in machines, it is possible to carry out such operations as deep chisel plowing to conserve moisture. Animals just cannot deliver the kind of horse power needed for such operations. Machines allow the farmer to cover greater areas in a shorter time thus allowing him better control over timing of different operations. Thus timeliness of sowing and harvesting alone can increase yields by over 15%, due to better crop stand and reduced losses.

3.3 Government policies

As mentioned earlier, government policies have a profound effect on the extent and direction of agricultural mechanisation. Some factors directly related to these policies which determine the affordability of farmers to buy agricultural machinery are:

— availability of soft loans;

- — commodity prices and those of inputs, i.e., net profitability from a crop;
- — availability of appropriate and reasonably priced machines, preferably of local origin with adequate arrangements for maintenance facilities and spares;
- — low tariffs on imported machines;
- — timely provision of inputs, i.e., water, seed, fertilizer, etc. (More machines are bought following bumper crops than under any other conditions.);
- — general state of a country's economy.

In general, the experience in Asian countries shows that agricultural mechanisation proceeds with minimum problems and at an accelerated rate if the government policies are clearly enunciated and address themselves equitably to all the inter-related multi-sectoral issues involved.

4. Present status of agricultural mechanisation

Table 1 gives the average percentage increase in agricultural machinery population in seven Asian countries. The table shows that the use of agricultural machinery has been on the in-crease since the early seventies in all the countries included in this table. Some of the high percentage increases in the 1971-80 decade are due to initial introduction and rapid growth in the population of machines. The figures in this table can be interpreted more meaning fully by reading them in conjunction with those in **Table 2** which gives the absolute population of these machines in 1990 - in all 11 countries participating in RNAM.

In their present state of agricultural mechanisation, the countries of Asia may be classified under three categories, i.e., advanced mechanisation, mixed mechanisation and low mechanisation countries. The advanced mechanisation countries would include Japan, Taiwan Province of China and the Republic of Korea. These countries have mechanized at least 75% of the major crop production operations such as land preparation, transplanting, crop protecting and harvesting including threshing. The Republic of Korea is planning to mechanize 100% of rice farming by 1996. The sale of agricultural machinery in that country reached 860 million US$ in 1990, an increase of 30% over 1989 sales which includes 177 million US$ worth of imports, mostly from the USA and Japan. The larger increases in tractors (70%), combines (81%) and cultivators (138%) indicate that the Republic of Korea is well on its way to achieving the goal of 26 operational hours per hectare for rice production in the 1990s. This compares with 92 hours with power tillers and threshers in the eighties and 515 hours with animal and animal power in the sixties - all according to a well thought out plan being executed meticulously.

The second category, i.e. mixed mechanisation, involves widespread use of machines with a substantial amount of farming still being done with animal and manual power. China. India, Islamic Republic of Iran, Pakistan and Thailand come under this category. In these countries - on the basis of studies conducted by RNAM counterpart National Institutes - more than 50% of land preparation, crop protection and threshing operations are mechanized. The bulk of transplanting (rice) and harvesting (of all crops) operations are being carried out manually. All these countries possess capabilities to produce agricultural machinery locally, while they, with the exception of China and India, import substantial amounts of machinery, mostly from Europe and North America. If the current trends continue, Thailand and Iran will be the first to promote themselves to the advanced mechanisation category, followed by China, India and Pakistan.

In the low mechanisation countries, the most advanced is Sri Lanka followed by the Philippines, Nepal, Indonesia and Bangladesh. In these countries less than 50% of any crop production operation is mechanized. Major impediments to agricultural mechanisation in these countries are: low buying power of farmers, abundance of rural labor and hence low wages, very small land holdings, high cost of imported machines, substandard quality of locally manufactured machines and government policies not conducive to mechanising agriculture. To a lesser degree, the mixed mechanisation countries are facing the same problems.

5. Technical cooperation among countries in agricultural mechanisation

In order to bridge the gaps in the use of agricultural machinery, eight countries of Asia formed a network in 1977 called the Regional Network for Agricultural Machinery (RNAM) under the aegis of the United Nations Economic and Social Commission for Asia and the Pacific. The original eight countries, i.e. India, Indonesia, Iran, Pakistan, Philippines, Republic of Korea, Sri Lanka and Thailand were joined by Bangladesh and Nepal in 1987 and the Peoples Republic of China in 1990. The mandate of the network is to carry out extensive exchange of hardware and information on selection, design and development, adaptation, local manufacture and extension of agricultural machinery. The Network is emphasizing the increased participation of women and manufacturers of agricultural machinery in its activities during the current phase of its operation, 1992-1996.

As a result of these activities, an investment of 41 million US$ was made during the period 1984-90 by ten participating countries (China not included in this study) to strengthen the national agricultural mechanisation infrastructure. The RNAM counterpart national institutes designed 130 agricultural machines and exchanged nearly 70 units among themselves out of which over 100 are already commercialized, involving 533 small and medium scale manufacturers and an investment of US$ 80 million. To date, over 500 engineers, other individuals and local manufacturers have been trained through 22 regional courses, 24 workshops and 30 study tours, the majority of them in the RNAM participating countries. The project continues to assist the countries in bridging the gaps still existing to improve the working conditions and income of farmers in Asia.

6. Future prospects

The trends in the recent past indicate that the use of agricultural machinery in most of the Asian countries will continue to rise for quite some time as there is great potential for agricultural mechanization in them. As in the past, there will be a mix of locally produced and imported machinery. Table 3 gives the projected yearly demand of machinery from 1992 to 1995 for the eleven RNAM member countries.

Keeping in view that the income of Asian farmers will not increase drastically in the near future, they will continue to demand simple, inexpensive but reliable machines. Thus the manufacturers of agricultural machinery have a challenge to produce machines which per-form their intended functions efficiently and are at the same time affordable to the Asian farmers. This necessitates not only continuing exchange of technologies among developing countries but also transfer of appropriate technologies from the developed countries to the developing countries of Asia.

Table 1 - Average yearly percentage increase in use of agricultural machinery for selected Asian countries (Source: RNAM National Institutes)

		COUNTRY						
MACHINE	PERIOD	INDIA	INDONESIA	PAKISTAN	PHILIPPINES	SOUTH KOREA	SRI-LANKA	THAILAND
4W Tractors	1971-80	19	170	11	10	60	30	22
	1981-90	10	15	18	26	64	2	10
Power Tillers	1971-80	11	30	90	25	70	NA	14
	1981-90	17	10	9	66	13	NA	14
Pumps	1971-80	15	25	6	33	12	30	8
	1981-90	17	NA	6	21	15	16	7
Sprayers	1971-80	9	74	95	26.8	17	24	2
	1981-90	36	11	60	86	227	36	4
Reapers/Harvesters	1971-80	30	-	50	-	NA	NA	NA
	1981-90	26	-	33	12	NA	NA	NA
Shellers/Threshers	1971-80	14	75	106	28	38	NA	30
	1981-90	23	23	19	4.3	5	NA	13

Table 2 - Agricultural mechanisation statistics in the RNAM participating Countries, 1990 (Source: RNAM National Institutes)

	COUNTRY										
	BANGLADESH	INDIA	INDONESIA	ISLAMIC	NEPAL	PAKISTAN	P.R. CHINA	PHILIPPINES	S. KOREA	SRI LANKA	THAILAND
Total population (M)	105.30	830.00	179.14	55.00	16.35	110.00	1,112.00	61.50	42.38	16.59	54.53
Farming population (%)	73.00	70.00	55.80	45.00	92.00	49.20	79.54	57.00	16.00	45.02	62.88
Total area (M ha)	14.79	328.78	191.94	165.00	14.11	80.00	960	30.00	9.92	6.54	51.40
Cultivated area (M ha)	8.85	142.90	31.49	17.00	3.13	20.80	95.67	13.40	2.12	2.90	23.11
Average farm size (ha)	0.88	2.00	1.77	6.02	1.31	4.68	NA	2.84	1.20	0.79	4.51
Major crops	Rice Wheat Jute Sugarcane/ Oilseeds	Wheat Rice Sorghum Pearl Millet/ Oilseeds	Rice Soybean Corn Cassava	Wheat Barley Rice Cotton	Rice Corn Wheat Millet	Wheat Rice Cotton Sugarcane	Rice Wheat Cotton Corn Sugarcane	Rice Corn Coconut Sugarcane	Rice Barley Vegetables Soybean Redbean	Rice Tea Coconut Rubber	Rice Corn Sugarcane Soybean
Average rice yield (t/ha)	1.49	1.68	4.04	2.81	2.26	2.50	5.36	2.64	4.70	3.42	2.14
Average farm labour wage (US $/day)	0.90	1.25	1.62	57.00	1.00	2.00	5.27	2.00	21.00	1.20	2.00
Installed power (HP/ha) (*)	0.40	1.0	0.41	0.7	0.3	1.02	3.88	0.52	4.11	0.58	0.79
Machinery population											
2W-Power tillers	10,000	90,000	16,804	65,000	1,000	4,800	6,533,600	32,226	739,098	24,000	582,753
4W-Tractors	5,000	950,000	4,316	215,000	6,000	231,567	847,177	5,804	31,318	15,000	45,544
Reapers	NA	7,000	NA	12,500	0	6,000	209,631	587	49,816	250	100
Combine harvesters	NA	4,500	NA	5,000	0	1,268	36,800	NA	2,882	NA	10
Threshers	1,000	2,000,000	103,019	10,000	10,000	101,200	4,526,000	32,618	284,837	9,000	37,028
Irrigation pumps	220,000	15,000,000	NA	NA	23,000	288,453	1,620,000	107,139	326,476	52,000	851,340
Seeders	NA	15,000,000	NA	1,500	0	18,000	118,000	242	4,473	950	11,200
Sprayers	10,000	3,500,000	905,062	128,525	NA	295,855	313,000	885,654	450,844	125,000	2,270,000
Rice transplanters	NA	1,200	NA	NA	0	95	15,047	367	111,937	2,050	NA

(*) estimated based on availability of human, animal and mechanical power, including pumps

NA: information not available

Table 3 - Average annual demand of agricultural machinery in the RNAM participating countries, 1992-1995 [Source: RNAM National Institutes]

	COUNTRY											
MACHINE	BANGLADESH	INDIA	INDONESIA	ISL.R. IRAN	NEPAL	PAKISTAN	P.R. OF CHINA	PHILIPPINES	R. OF KOREA	SRI LANKA	THAILAND	TOTAL
4W-Tractors	700 *	131,700	600 *	15,000	800 *	31,100 *	84,000	400	8,400	2,000 *	6,200	280,900
2W-Power tillers	4,300	5,400	80,000	10,000	400 *	1,700 *	1,100,000	2,800	90,000	8,600 *	76,000	1,379,200
Seeders and transplanters	100	211,300	NA	300	7,700 *	14,100	32,500	300	34,600	700 *	2,800	304,400
Reapers/winnowers	NA	1,600 *	10,200	6,700	NA	3,700	48,700 *	100	13,000	60 *	20 *	84,080
Threshers and shellers	300	206,700	34,500	4,900	2,700 *	22,500	1,215,800 *	3,300	7,800	2,400 *	3,500	1,504,400
Combine harvesters	NA	600	NA	600	NA	600	8,400	NA	11,900	NA	10	22,110
Irrigation pumps	30,000	4,029,400 *	4,100 *	17,000	6,200 *	77,500 *	1,920,000	1,000	9,000	14,000 *	109,000	6,217,200
TOTAL	35,400	4,586,700	129,400	54,500	17,800	151,200	4,409,400	7,900	174,700	27,760	197,530	9,792,290

(*) Computed estimates

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