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ADVANCED ENGINEERING CONCEPTS FOR TOMORROW'S AGRO-INDUSTRIAL SYSTEM IN THE ASIAN REGION

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ABSTRACT

The social-economic development of the various countries and, therefore, of the world agricultural market asks for a rationalization of the whole Agro-industrial System.

In order to help the economic competitiveness of the various products, to improve their quality and to protect the environments Agricultural Engineers have to follow holistic research approaches for the whole system.

The paper discusses the main problems that, in this view, Agricultural Engineers have to take into consideration.

Key Words: Competitiveness, Machinery, Advanced Technologies.

INTRODUCTION

1.1 - Agricultural Engineering is the application of the concepts, methodologies, analyses and design capabilities inherent to engineering itself to the processes and mechanisms related to biological systems and their derivatives (Garrett et Al., 1992).

These applications, consequently, take the form of a "service" rendered to the growth and development of vegetable and animal productions and to their storage and processing.

The present role of agricultural engineering is to help to minimize production costs, optimize produce quality, safeguard the health and safety of manpower and animals, protect the environment and increase the flexibility of farm production.

The different technologies have to be adapted to fit the various socio-economic, structural, pedo-climatic, production and market conditions of each country. This means that, though based on the application of common physical-mechanical principles, as well as on similar logic and operational schemes, each technology has to be appropriate to the local conditions and, particularly, to the evolutionary stage of the agro-industrial system of each country.

1.2 - It is therefore quite difficult to define, from a general worldwide point of view, which agricultural engineering technologies are required.

In fact, each country has a specific situation that make it impossible to define general solutions.

Consequently, the analysis must be limited to some general considerations as far as the existing situation and the future trends of the agricultural-industry systems are concerned.

As you can note, I have spoken up to now of agro-industry system and not only of agriculture. This is because in any country (with, of course, different stages of development) there is a strict link between the agricultural sub-system, the industry sub-system upstream for the production of technical means (machines, fertilizers, pesticides, seeds, etc.) and the industry sub-system downstream for agricultural produce processing, storage and distribution.

With this in mind, in fact, while in the industrialized countries the gross agricultural output is able to activate an upstream and downstream industrial activity 6-7 times its size, in the developing countries this ratio drops to a minimum of 1.5/1 and there are big differences from one country to another depending on the evolutionary stage of each.

In any case, what must be kept in mind is that every civilized country has to base its economy on a strong and productive agro-industrial system that involves all the allied facilities, from teaching to research, from services to government policies.

1.3 - Two more general points have to be taken into consideration:

- the progressive internationalization of the agricultural markets worldwide that requires greater competitiveness among the various countries;
- growth in the demand for environment protection.

This requires the management of the complexity of the system as a whole, as well as the conflicts within the systems themselves and with the external world.

This means meeting the need to produce at the lowest costs, assuring in the same time the highest standards of quality, a sufficient remuneration for farmers, protection of air, water and soil.

There is, then, a need for a complete rationalization of the whole system which requires an effort to carry out holistic engineering analyses in order to define government policies, agro-industrial goals and agricultural engineering requirements (figg. 1 and 2 - Pellizzi, 1992).

Consequently (Pellizzi, 1992) every effort must be made to:

- increase the farmer's knowledge, update management methods, evaluate the suitability of the various technologies to be applied individually or in combination, introduce rational management criteria;
- develop research & development programmes that combine an understanding of the system with the analysis and definition of its requirements and goals. To this end, advanced engineering technologies play a key role.

A recent analysis carried out on the impact of the GATT agreement on agriculture confirmed (Sharples et Al., 1992) the need for a substantial modification of the agro-industry system in the various countries. The prevailing thought is for a shifting of main staple crops (in particular cereals and oil-seed

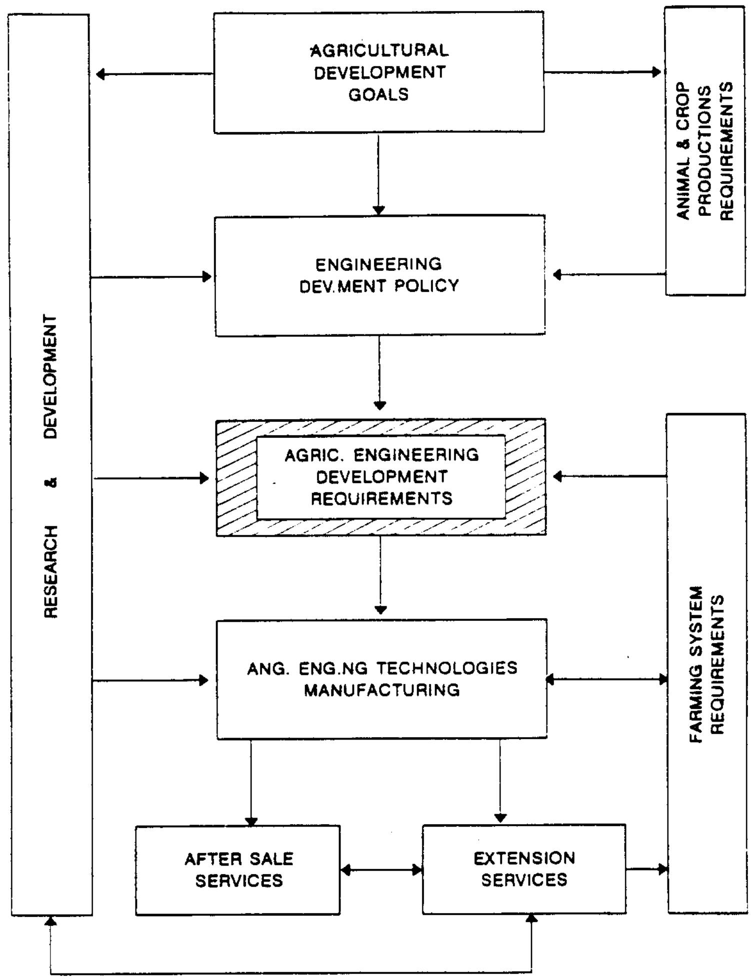

Fig.1 - Integration between Agricultural Goals, Agricultural Engineering Requirements and Ag.Engng Manufacturing facilities.

crops) as well as of some industrial sectors like agricultural machinery manufacturing, from industrialized high labour cost countries to those with lower labour costs.

This will be possible thanks in part to the development in the near future of biotechnologies (OECD, 1989) as well as new processing solutions (Peri et Al., 1988) that involve the break up of agricultural raw materials into their various basic components and their successive re-combination to create specific products able to meet the real requirements of the local populations. The impact on the world agro-industrial system organization and management will be very high and we as engineers are called upon cooperate in its interpretation and development.

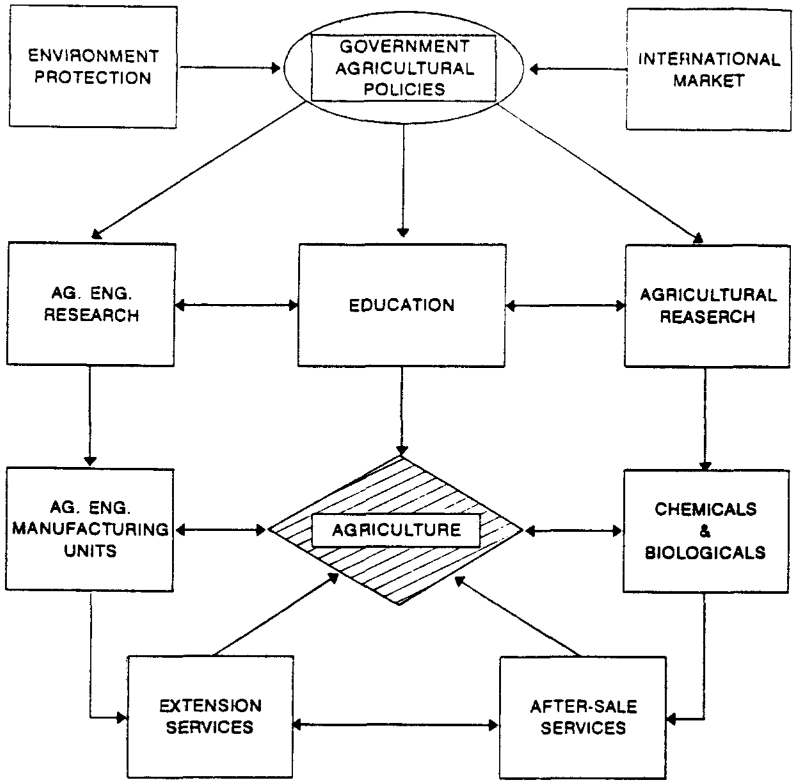

Fig.2 - A modern Agricultural System can be optimized, once the Governmental policies have been decided, taking care of all the allied problems.

IMPLICATIONS FOR MECHANISATION

2.1 - Bearing in mind the foregoing frame of reference, it is necessary, at this point, to carry out a short analysis of the present and future role of mechanical technologies applied to both agricultural and processing subsystems in the Asian Region.

In this context it is quite easy to get information on agricultural mechanisation (Kitani, 1990; Zia Ur Rahman, 1992), while it is very difficult to know the situation on the stage of development of agricultural produce processing in the various countries.

But if we really want to design a rational scheme of development for the whole system, we must carry out basic holistic analyses on both subsystems in order to evaluate their stage of development, the bottlenecks to eliminate, the needs for rationalization. Consequently we need to have a complete knowledge of both subsystems.

This must include the upstream sub-system of the manufacturing facilities for tractors and agricultural machines.

Countries like South Korea, Taiwan, China, Iran, Thailand, India and Pakistan where probably more than 75% (Zia Ur Rahman, 1992) of the main crop operations are mechanized, have to immediately carry out such a type of analyses in order to optimize their agro-industrial systems and to define the exact role the engineering technologies have to play in the near future.

The same could be applied, in the near future, to other less mechanization advanced countries like the Philippines, Indonesia, Sri Lanka and Bangladesh.

In fact, the trend is clear, and it is advisable to start examining these problems at their earlier stages in order to optimize the sub-systems (from both the technical and economic viewpoints) and to avoid the same mistakes made by the more advanced countries.

2.2 - The reasons for the introduction and development of mechanisation are also well known and frequently discussed: to increase food production and improve prevailing farming practices; to offset labour shortages; to increase timeliness in carrying out specific operations; to reduce losses and improve produce quality; to save land etc.

The same approach could be applied (Rijk, 1992) to the problems of the stages of mechanisation to be used, the reasons for the substitution of draught animal equipment, the fact that mechanisation has to be "demand driven" and not imposed. Very few people, however, have taken into consideration the need to perform some economic analyses (through simulation models) in order to establish the optimum level of labour productivity that has to be assured and then the level of mechanisation to be adopted.

This, of course, can be applied to both agricultural and industrial processing sub-systems.

In figs. 3 and 4 I have tried to do this with reference to field mechanisation for a rice area, updating an analysis I carried out in 1974 as FAO Consultant for the rice growing area in Iran on the Caspian Sea (Pellizzi et Al., 1974).

This analysis takes into consideration the following hypotheses: complete mechanisation of field operations through three different mechanisation levels based on tractors (with consistent and suitable implements) of 12 - 25 and 55 kW respectively assuring a labour productivity of 1.7 - 3.5 and 5 ha/100 Working hrs; two different costs of labour of 1 US$/hr (fig.3) and 5 US$/hr respectively (fig.4); pre-defined cultivated area of 20 ha or different areas that, at any rate, can optimize the global performance of tractors and implements from an economic point of view.

The total cost curbes obtained show the following:

- with a labour cost of 1 US$/hr, the minimum cost is obtainable at a labour productivity of about 1.5 ha/100 working hr (tractors of 10-12 kW). But if we take into consideration the possibility of using the mechanisation chains on cultivated areas that can make full use of their performance (useful yearly life and working capacity) a higher mechanisation level based on 25 kW tractors (3.5 ha/100 Working hr) increases the total cost by less than 5%. In case of labour shortage or a need for timeliness, it is then possible to utilize higher mechanisation levels;

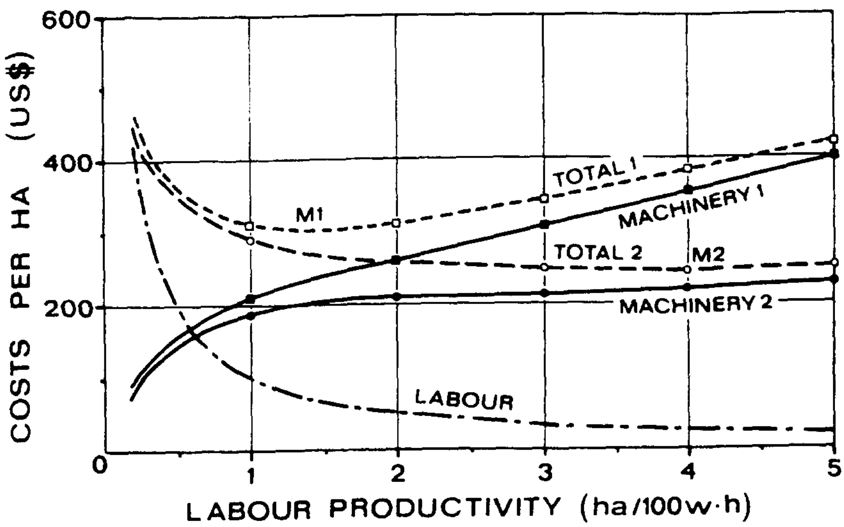

Fig.3 - Variation of the mechanisation costs vs. labour productivity in the hypothesis of a labour cost of 1 US$/hr. If the mechanisation is fully utilized it is convenient to make use of higher mechanisation levels.

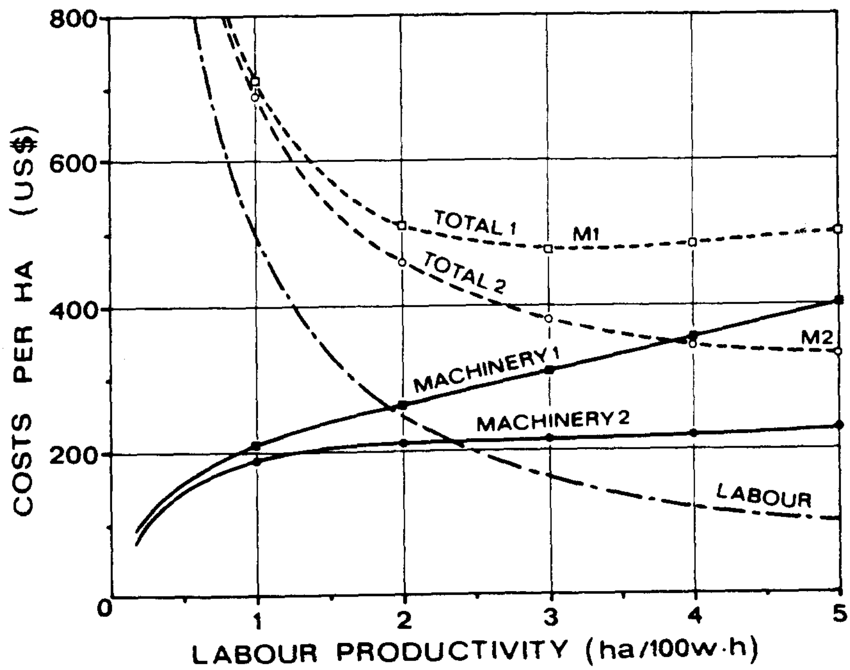

Fig.4 - Variation of the mechanisation costs vs. labour productivity in the hypothesis of a labour cost of 5 US$/hr. Total costs decrease with the increasing of productivity if the machines are fully exploited.

- with a labour cost of 5 US$/hr, the minimum cost is found at a labour productivity of about 5 ha/100 w.hr (based on 55 kW tractors) if we can organize the management of related mechanisation to make full use of its performance.

All this means (and it is important to note) that:

- with the increase of labour wages we have to use higher mechanisation levels;
- the best results are obtained through a mechanisation not based on specific farm sizes but managed through inter-farm or contracting solutions;
- in this type of calculations it is necessary to take into consideration the average development rate of the country, and then the average growth of labour wages and mechanisation costs during the usefull life of tractors and implements.

2.3 - Similar types of analysis, of course, must also be applied to the industrial processing sub-system in order to optimize the level of labour productivity and then the type of technologies to be used, as well as to a factory for the production of agricultural and/or processing equipment. In other words, this means following the peculiar criteria of marginality analyses (Kay, 1986).

Not until these preliminary evaluations, aiming to achieve the goal of minimizing the costs of production, have been carried out it is possible to start with the research and development of the specific technologies to be used following reductional (specific) engineering approaches.

Within this framework the goals that the new technologies have to achieve concern: *the reduction of produce losses, as well as fertilizers, herbicides and* seeds consumption; increasing the quality of products; improving the health and safety of workers and animals; protecting the physical soil parameters; reducting air and water pollution; managing the land for social recreational purposes; supplying farmers and/or farmers' associations with representative and decisional mathematical models for a proper management of farming and agricultural engineering systems etc.

On these perspectives it seems enough to recall the preeminent interest all over the world in the development of: low pressure tyres and rubber tracks to drastically reduce soil compaction and to permit to work in the fields even when the soil has a low bearing capacity, extending the time available for carrying out the various field operations; new solutions for chemicals distribution, with the goal of better checking their consumption, to reduce soil and water pollution and to increase produce quality; new low energy seed bed preparation practices; irrigation systems to reduce water consumption; stripper headers for cereals harvesting to reduce production losses and increase timeliness; energy saving, drying technologies etc.

A recent evaluation carried out by the European Community Club of Advanced Engineering for Agriculture (ECCAEA, 1989) confirms the possibility of reducing by 35-40% the mechanisation costs in comparison with the use of conventional technologies. This could mean, with reference to figs. 3 and 4, the possibility of reducing the global costs for mechanisation (including labour) to no more than 150 $/ha.

The future role of the agricultural engineer is, thus, to design and develop new technologies - machines and components - able to meet the above mentioned goals with his own capabilities, but also to investigate thorougly the possible application of all the allied facilities to mechanisation such as: sensors and vision systems for both mechanisation and fields in order to define the requirements of crops and optimize the use of fertilizers, herbicides and water as well as to improve environmental conditions of the animal housing; computerized active control systems for machinery; automation and robotics.

Within this framework, ECCAEA has underlined as of preminent importance in the near future:

- the monitoring of the environment, animals and machines through the appropriate use of sensors, vision systems and electrotechnologies;
- the development of information technologies.

At this point it is necessary to underline the need to perform preliminary marginality analyses, for each of these technologies, taking into account that the future will favour a growing need for dematerialization (Gruebler et Al. 1990) which means reduction of the role of materials used and energy embodied in favour of the use of immaterial and cultural resources, including information technologies.

At the same time the future need for specific agricultural professionals should be considered (Sevila et Al., 1991), such as:

- farmers supplying food and non-food products strictly linked to downstream industrial processing;

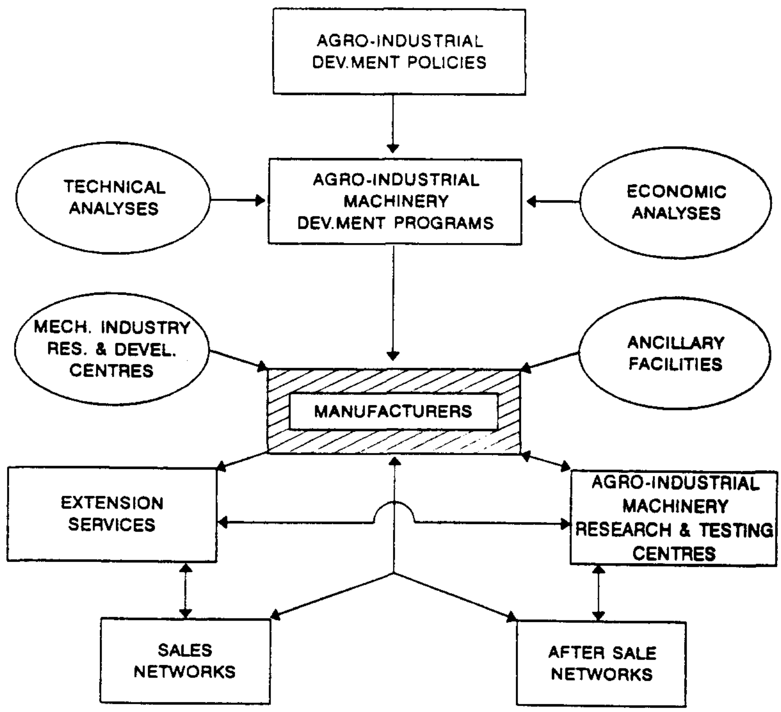

Fig.5 - The development of mechanisation requires the presence of local Manufacturers and allied Facilities but has to be defined on the basis of technical and economic analyses.

- farmers involved in the production of food and non-food speciality products with high value added;
- part-time farmers playing an irreplaceable social and environmental function;
- farmers providing maintenance and monitoring of rural leisure areas.

This will require widely differentiated, targetted agricultural and industrial structures and specific mechanisation technologies.

2.4 - All what we have pointed out will require a big effort to update the various agricultural-linked sub-systems as well as research & development, teaching and extention activity.

And, last but not least, we should bear in mind the fact that if one country wants to develop agro-industrial mechanisation from a national point of view, it must at the same time develop the allied facilities (fig.5 - Pellizzi, 1984) for local production of the various machines.

This means the development of ancillary and manufacturing industries together with efficient networks for repair and maintenance services as well as extention services for farmers as a link between research & development, manufacturers and end users.

In this connection there is a considerable discussion on the optimum production scale for a manufacturing industry. As far as tractors are concerned for example some estimates speak of a minimum of 10,000 units per year; in other cases the figures vary from 5,000 to 25,000 units per year.

It is very difficult to decide on this, due to the fact that everything depends not only on the specific situation but also on the existence of a strong enough ancillary network for production and component supply, as well as on the possibility of establishing joint-ventures with well established foreign industries. In Italy, for instance, there are 8 tractors manufacturers, each of which produces between 2,000 and 4,000 units per year, specifying that almost 70% of the components are purchased from specialized producers.

What I feel must be stressed is that each manufacturer or group of manufacturers must be directly involved in the market and must directly manage its own reapir & manintenance network.

CONCLUSIONS

What I have tried to communicate is the result of an in-depth multi-year analysis of the agricultural system, as well as of the role that engineering can (or must) play in its rational development.

In many cases international or bilateral assistance projects have failed their scope because they were based primarily on the interest of the donor countries to impose their experience and their mechanical production on the recipients. Luckily this trend seems to have ended and the various recipient Governments are, at present, more cautious in accepting this type of assistance.

However, in evaluating and deciding what to do in mechanisation and the application of engineering technologies, it is of primary importance to attentively follow the mechanisation trends in the more advanced countries, fully evaluating if and when and where they could be introduced in each situation.

But it is even more important to understand the tremendous development of the world agro-industrial situation and the consequences of changes in the world market in order to draw the proper conclusions on the role that the specific agro-industrial system has to play.

Within this framework, I believe that the exchange of information, the mobility of young professionals, the establishment of new coordinated and advanced university curricula at the international level could play an increasingly important role in the development of the sector. This is one of the main goals of CIGR for the near future: uniting all the people involved in agricultural engineering under one big worldwide umbrella.

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