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Industrial Processing of Rice

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THE IMPORTANCE OF THE RICE PROCESSING INDUSTRY AS AN AGRO-ALLIED INDUSTRY IN THE DEVELOPING COUNTRIES [1/]

by

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SUMMARY

THE IMPORTANCE OF THE RICE PROCESSING INDUSTRY AS AN AGRO-ALLIED INDUSTRY IN THE DEVELOPING COUNTRIES [1]

by

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A. INTRODUCTION: AN ASSESSMENT OF THE PROBLEM

In the introduction to this paper it is shown how important and urgent is the problem not only of providing the rice necessary for subsistence but also to raise the standards of living of the farmers who produce the rice by increasing the quality of the rice produced.

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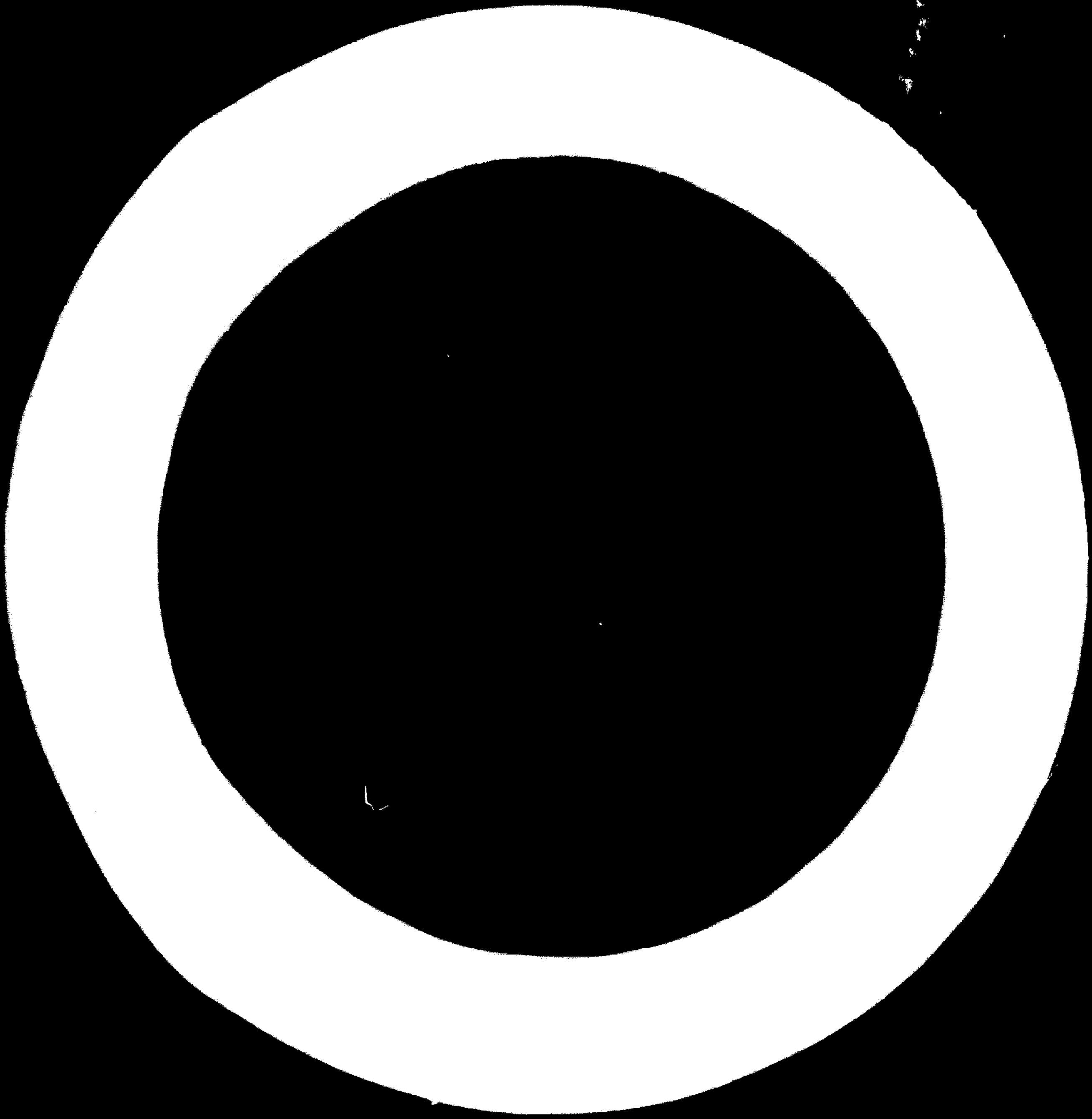

B. IMPORTANCE OF THE INDUSTRY

It is pointed out that ninety per cent of the world's rice is produced and consumed in the countries extending from Japan to Iran and the value of the paddy to be processed is much greater than that of any other crop required for other agrobased industries. Yet the rice processing industry has not received the attention its proper development deserves as up to 50% may be lost from harvest till it reaches the consumer. Statistics are given to highlight the number of farmers who produce the paddy crop, the monetary value, the economic importance and its contribution to the Gross National Product of various countries.

C. THE GREEN REVOLUTION AND ITS EFFECTS

With the progress of the Green Revolution and its associated increase in rice production, it is an urgent necessity to modernise the rice milling industry to cope with all the problems that accompany this revolution.

An increase in the production of paddy is no assurance of a corresponding increase in the quantity of rice. Storage and processing facilities have to be developed to cope with this extra quantity of rice to ensure that losses are kept to the minimum and that the maximum recovery of rice is obtained.

Bilateral and multilateral action for this modernisation must take place and this must be prefaced by pre-investment studies and pilot projects designed in a manner suited to local varieties and conditions.

D. RECOMMENDATIONS FOR MODERNISING OF THE INDUSTRY

Recommendations are made to ensure that modernisation takes place in an orderly and correct manner without encountering pitfalls due to too hasty action. These fall under the following headings:

Modernising of Existing Commercial Mills
Modernisation of Metallic Hullers
Hand Pounding Industry
Pre-Investment Study
Pilot Projects and Evaluation Studies

Financial Assistance for Modernisation and Training of Personnel
Manufacture of Modern Machinery
Advice to Industry and Development in Countries
Regulatory Measures of Countries
Co-ordination of Production with Processing Industry
Organization and Extension of Studies to other Food Crops
Research
Follow up Recommendations

E. PRESENT POSITION OF RICE PROCESSING AND SCOPE FOR IMPROVEMENT

Under this heading the whole rice processing industry is examined and details are given to enable more rice to be obtained of a higher quality. The various paragraphs are headed as follows:

(a) Production Methods

The best way to obtain the highest outturn of rice would be to grow fewer varieties with a potential outturn of over 80% of brown rice and over 70% of edible rice.

(b) Threshing Techniques

Mechanical threshing is advocated at a grain moisture level of 20 to 25% to reduce harvest and handling losses.

(c) Cleaning Operations

It is essential to clean paddy before transportation and milling to enhance productivity of rice mills. A modern cleaner is described.

(d) Drying Techniques

If controlled mechanical drying is practised, the milling quality will be improved and loss from birds and rodents reduced. Some information relative to mechanical drying is given and the operation of modern driers are described.

(e) Storage Methods

Modern storage methods will reduce damage to rice due to moisture and losses due to rodents and birds.

(f) Parboiling Techniques

Modern parboiling methods are described and compared with the existing methods.

(g) Milling Methods and Equipment

A description of the rice milling methods at present in use in various countries are given and it is noted that low milling outturn of 56-65% for raw and parboiled rice respectively is obtained and the value of the by-products is lower.
Ways and means of increasing the milling outturn are given.
The operation of modern machines described to suit various varieties of rice.

(h) Weighing, Special Treatments and Packaging

Modern methods are described.

(i) By-Products Utilisation

The by-products which can be obtained from rice milling are given and some idea of the value of bran oil is detailed when integrated with a modern rice milling complex.

(j) Handling and Transport

Efficiency of handling at modern mills can be improved by modern handling methods.

(k) Research and Development

Much research work is being undertaken in various countries to enhance the milling quality of rice.

(l) Sanitation and Infestation Control

Regulations are required to reduce health hazards due to food contamination.

(m) Integrated Systems in the Rice Processing Industry

A modern integrated rice processing system is described in order to enable an increase in production to be realized.

F. **TERMS OF REFERENCE OF THE PRE-INVESTMENT STUDY TEAM FOR A PILOT PROJECT FOR THE RICE PROCESSING INDUSTRY**

In order to find the answers to several questions relating to modernisation which arise from the diversity of opinions regarding the correct choice of components and procedure it is essential to first carry out a systematic pre-investment study with the following objectives:

(a) to demonstrate how modern techniques can ensure a higher outturn of rice;

(b) to analyse fully the prevailing local conditions;

(c) to investigate whether an investment in modernisation will be desirable and profitable.

(d) to determine the correct equipment and methods;

(e) to determine the correct capacity of the processing units;

(f) to work out the optimum combination of equipment;

(g) to work out a modern system with all its benefits;

(h) training of personnel for all requirements;

(i) best marketing procedure for the final product;

(j) to select a suitable location for the rice mill;

(k) to develop details of the rice mill taking into account the local supply of equipment;

(l) to use the information derived from the pilot plant to gain experience for a larger programme;

(m) to see how the development of the rice processing machinery manufacturing industry can be introduced.

G. **RESULTS OF PRE-INVESTMENT AND EVALUATION STUDIES IN INDIA A CASE OF AN INTEGRATED APPROACH TO MODERNISATION**

Some figures are given, taken from the evaluation of modern rice mill complexes in India, from which it appears that modern mills, even with their comparatively high capital requirements, are capable of yielding returns of about 12½-15% on the capital employed and that long term loans can be paid off within 8 years.

H. VALUE OF COLLABORATION

A plea for collaboration between countries regarding the information available concerning modern rice processing is given. The information which is given, however, should be modified to suit the conditions of each country and not merely copied. A strategy which leads to expansion involving the lowest possible capital-output ratio is of great importance, so that the return on investment is augmented by the maximum output which it facilitates.

J. BIBLIOGRAPHY

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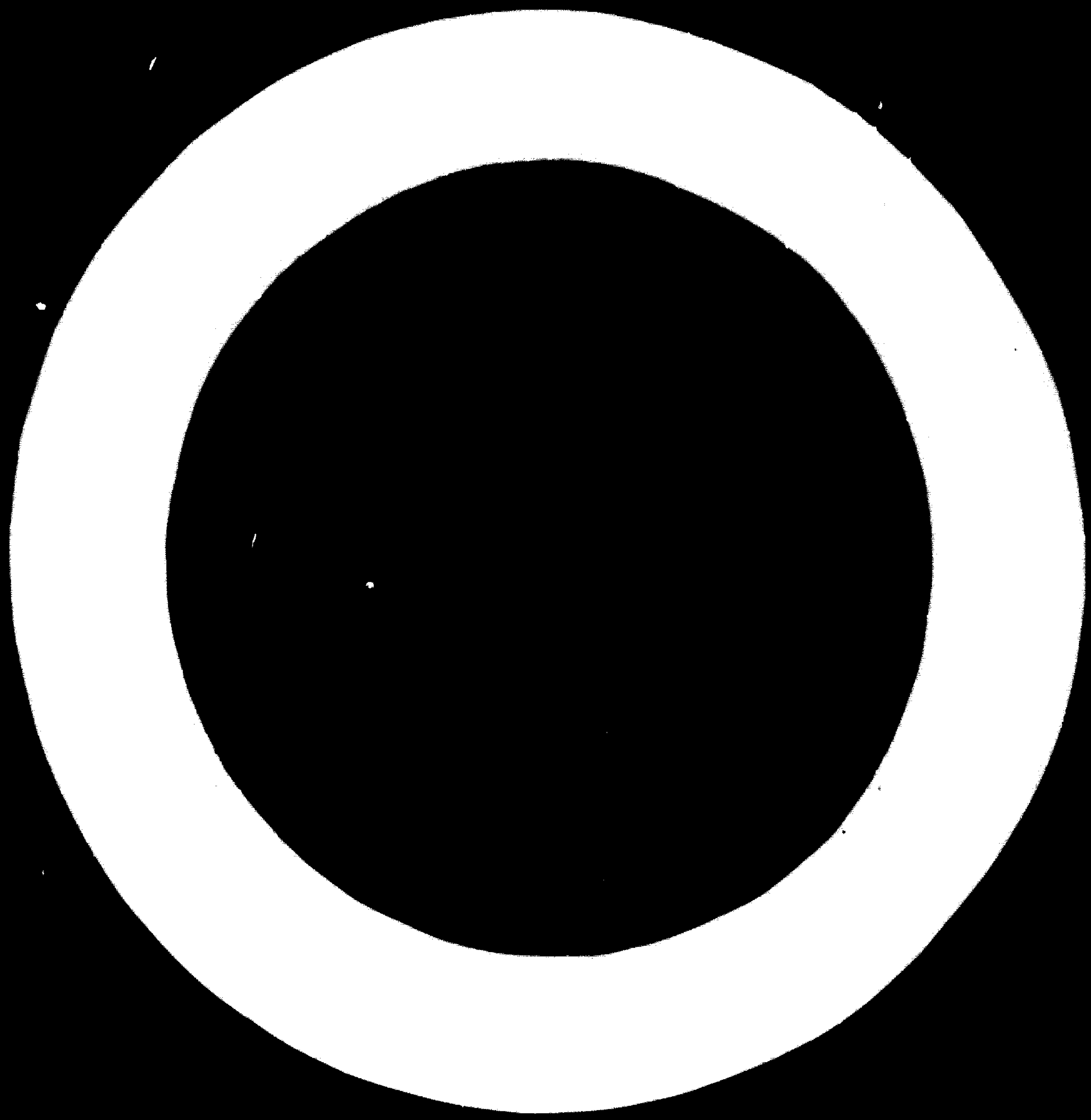

CONTENTS

A. INTRODUCTION: AN ASSESSMENT OF THE PROBLEM

1. Two thousand years ago, a Roman Philosopher, named Seneca, made the following observation: "A hungry People will not endure reason; they will not listen to justice; they will not even pray". Yet it is true today especially in the developing countries of the world where hunger and nakedness stifle progress and smother political stability. History shows that better living conditions, growth in industry and commerce are impossible where an abundant agriculture is lacking.

2. We are meeting here to look at and to highlight the importance of the Rice Processing Industry and to discuss the two-way battle directed on one side against the problem of food production in developing countries and on the other against public inertia in face of a developing crisis.

3. It is not just a problem of growing enough food to keep pace with human numbers. It is also one of quality. This indeed is at the heart of the whole question of progress for people of the developing nations. It is not enough that their children and grandchildren should be able to keep body and soul together on the same uncertain margins of malnutrition as so many must do now. They must be able to achieve fuller and better lives. Yet most nutritionists believe that the food quality between developed and developing nations is dangerously widening. Unless it can be closed, hundreds of millions of potentially valuable people will face life without hope or dignity that could well become one of despair.

4. Eighty per cent of all farmers in developing countries live on a subsistence level. Along with primitive farming go such other handicaps as poor marketing; wasteful storage; inadequate transport; lack of all-weather roads; out of date rice processing machinery incurring much loss; lack of financial capital and running like a thread through all of them, absence of incentive.

5. The greatest prospects for improving supplies of food lie in increasing the yields from cereals, crops which already dominate world protein production and preventing the losses which take place between harvesting, processing and marketing.

6. The breakthrough in the production and expansion of high yielding varieties of cereals has been called the "Green Revolution". And, like most other revolutions, it is throwing up its problems, some of them biological, some economic, some social.

B. IMPORTANCE OF THE INDUSTRY

7. Ninety per cent of the world's rice is produced and consumed in the countries extending from Japan to Iran and the monetary value of the paddy to be processed by the rice milling industry greatly exceeds that of any other crop required for agro-based industries being of the order of US$ 29 thousand million for a total quantity of 189 milli n metric tons of rice. Yet the rice processing industry has not received the attention its proper development deserves and it is estimated that losses may be up to 50% from harvest till it reaches the consumer.

8. To indicate the importance of rice in the finances of the various countries in Asia and the Far East, the statistics taken from the 1969 Statistical Yearbook of the United Nations show that rice contributes approximately 39% to the Gross National Product of Burma; approximately 15% to the Gross National Product of Thailand, India, Indonesia and Pakistan; approximately 7½% to the Gross National Product of the Republic of Korea and Ceylon and approximately 4% to the Gross National Product of the Philippines and Japan.

9. Further, if we take the percentage total consumption of rice compared to the total consumption of Cereals and Roots, it is found that this amounts to approximately 96% in Burma; approximately 60-70% in Ceylon, China (Taiwan), Japan, Pakistan and the Philippines and approximately 40-50% in Indonesia and India.

10. To give additional statistics to show the importance of the rice industry in relation to other agro-based industries, I give the following statistics for various countries taken from the United Nations Statistical Year Book 1969 and F.A.O. Production Year Book 1967. The intake of raw materials (i.e. paddy by the rice processing industry even exceeds the aggregate value of raw materials consumed by th following important agro-based industries - cotton, hemp, sugar, maize, wheat, tea, groundnuts, tobacco by approximately

US$ 70,000,000,000 or 80% in India. In Indonesia, it exceeds the aggregate value of the following important agro-based industries - tea, maize, coffee, cotton lint, sugar cane, groundnuts, tobacco, cocoa beans by approximately US$ 21,000,000,000 or 96%. In Nepal, it exceeds the following important agro-based industries - wheat, maize, sugar cane, tobacco by approximately US$ 250,000,000 or 75%. In Thailand, it exceeds the aggregate value of the following agro-based industries - maize, sugar cane, groundnuts, tobacco by approximately US$ 9,800,000,000 or 98%. In the Philippines, it exceeds the aggregate value of the following agro-based industries - maize, coffee, sugar cane, groundnuts, cocoa beans by approximately US$ 600,000,000 or 75%. In the Republic of Korea, it exceeds the aggregate value of the following agro-based industries - wheat, maize, hemp fibre, groundnuts, tobacco by US$ 600,000,000 or 88%. In Iran, it exceeds the aggregate value of the following agro-based industries - wheat, tea, maize, sugar cane, tobacco by approximately US$ 40,000,000 or 30%. In Ceylon, it exceeds the aggregate value of the following agro-based industries - tea, maize, cotton lint, sugar cane, groundnuts, tobacco, cocoa beans by US$ 190,000,000 or 93%.

11. In most of the countries of Asia, farm workers account for from 50% to 80% of the total population and in Nepal, this rises to 92% and in these countries, the rice growing area compared as a percentage of the total agrarian area varies from about 30% in Ceylon and the Philippines to up to 60% in Japan, Korea, Nepal and Indonesia.

12. The average land holding of rice growing farmers varies from as low as 0.4 hectars/household in Ceylon to up to 3-5 in Thailand.

13. The variety of natural conditions in which rice is grown necessarily leads to large differences in yields, but they are insufficient to explain the wide ratio of more than 3 to 1, between the highest and lowest national averages, i.e. yields in 100 kg/hectar from 19.8 in Nepal to 57.1 in Japan. A major factor must lie in the characteristics of the peasant system and the peasant farmer. *

14. Both maize and wheat approach the same level of production as rice in a normal year but if there are natural disasters, such as poor monsoon rains in India, floods in Indonesia, rice may fail to show an increase. A distinctive

feature of rice production is its geographical concentration and its subsistence nature, 90% is produced and consumed in Asia and the Far East. It forms the main part of the diet of half the world's population. The proportion entering into world trade, some 30%, is about the lowest of any major commodity. Half of this lies in Asia and the Far East itself. The future is hedged with uncertainties.

15. The present countries with a surplus, the "Rice-Bowl" countries - Burma, Cambodia, Laos and Thailand - with abundant rainfall and mainly natural, flat, flooded rice, produced two-thirds of the world's exports. Although their total production has increased by 50 per cent in the last twenty-five years, production per capita has actually declined by over 10 per cent. Rich in natural resources, but deficient in capital and modern skills, their agriculture is not very different from ancient times and has not greatly changed the peasant way of life.

C. THE GREEN REVOLUTION AND ITS EFFECTS

16. With the progress of the Green Revolution and increased rice production it is essential that the rice processing machinery is progressively modernised to keep pace. The insufficient, underproductive and under-economical types of rice processing machinery now widely used must be rapidly replaced by new and more efficient modern units suited to local conditions and practices.

17. For instance, in 1969 in most importing and exporting countries, better harvests were reaped. Crops in Ceylon, Indonesia, Malaysia and India reached new records. Main exporting countries in the region including Burma, Cambodia, China (Taiwan) and Thailand increased their output. For the Far Eastern countries, the total production was up by 5% in 1968 as compared to 1967. Further, the total paddy area in China (Taiwan) is now under high yielding varieties.

18. A break-through in rice production is rapidly taking place in several countries, as a result of the introduction of new high-yielding strains of paddy, together with the multiple cropping pattern and intensification and extension of improved agricultural practices. There is a pressing need to modernize the conventional rice-milling industry to cope with the following problems that accompany the Green Revolution:

(a) cultivation and harvesting in a shorter length of time and at the right stage of maturity;

(b) handling significantly larger volumes of crops;

(c) threshing, drying and transport of large quantities for safe storage;

(d) development of improved storage facilities;

(e) instituting proper procurement and price support policies;

(f) promotion of market development;

(g) establishment of consumer preferences for new varieties.

19. However, an increase in the production of paddy is no assurance of a corresponding increase in the quantity of rice. To ensure this, two types of facility will have to be developed simultaneously. The first is safe storage facilities for paddy and rice. The second is facilities for processing the future increase in rice production; this will involve the adoption of improved techniques and equipment to prevent avoidable losses, obtain the maximum recovery of rice, ensure improved quality and make full and efficient use of the by-products.

20. Above all, the rice processing industry must concern itself with improving the . rition of the poorer classes who depend on rice as their major source of food. It is, therefore, the region's most important industry, both economically and in terms of nutritional considerations.

21. Much of the existing rice-milling equipment and manufacturing facilities in the region consists of hullers and shellers of old design. Hence, modern facilities are needed in most of the countries.

22. Moreover, there is vast potential in the region for improving the entire post-harvest handling and processing of rice, from threshing and drying to storing, processing, packing and marketing, so as to derive an improved out-turn ratio a superior quality of milled product, cleaner by-products of great value, a lower cost per ton processed and handled, reduction of wastage and storage losses, and better èconomic return to the producers and processors.

23. The task of increasing the region's rice output is a vital one; it will involve a scientific break-through and relentless efforts will have to be made to sustain developmental action sufficiently extensive in scope and magnitude to bring about the desired results. It is essential to overcome or minimise the various difficulties at the earliest possible stage, so as to prevent them from growing into major impediments to future development.

24. Bilateral and multilateral action for this modernization must take place and this must be prefaced by pre-investment studies and pilot projects designed to demonstrate the feasibility and benefit of modernization that is carried out, in a manner suited to local varieties and conditions.

D. RECOMMENDATIONS FOR MODERNIZATION OF THE INDUSTRY

25. The following are recommendations which will be required to ensure that modernization takes place in an orderly and correct manner without encountering pitfalls due to too hasty action.

26. Modernization of existing commercial mills

The existing commercial mills of a capacity of one ton per hour and above should be improved by the installation of a combination of facilities comprising mechanical drying units, paddy cleaners, rubber roll huskers, husk separators, paddy and rice separators, improved whiteners, aspirating devices for recovering brokens from bran, graders for rice, and improved storage and handling facilities, to secure an increase in outturn of rice from paddy ranging from 4 to 10 per cent. There is scope for gradual modernization of existing units by the progressive introduction of components as desired. However, it is desirable that all new mills be of the integrated type complete with all modern facilities described above. An intermediate technology for milling parboiled paddy, which is less susceptible to breakage than raw paddy, would be to use precision-made under-runner disc shellers in place of rubber roll huskers. This would enhance the total rice outturn over that of traditional hullers and disc shellers, the recovery would generally still be around 1 per cent lower than that given by the rubber roll husker.

27. Modernization of metallic hullers

To improve recovery, the existing small huller units distributed all over the rural producing areas and consuming centres should be progressively replaced by self-contained small processing units of modern design of the same capacity.

28. Hand-pounding industry

A significant recent development is that the hand-pounding industry - which is regarded as labour-intensive and absorbs some of the surplus and idle labour in off-season periods and yields rice that is somewhat superior in nutritional value owing to under-polish, but with higher incidence of brokens - is being gradually replaced by the use of under-productive metal "hullers". A useful approach to dealing with the situation, and to checking the spread of these wasteful hullers, would be to introduce and popularize the more productive small self-contained units mentioned in the above paragraph.

29. Pre-investment study

The first step towards modernization should be a pre-investment study to formulate details of clear-cut action programmes and prepare project reports. Such a study should be undertaken by a group of three to four high-level international experts with experience in rice processing, and, preferably, in the formulation and implementation of similar schemes. The fields to be covered in the study should include rice-processing technology; plant engineering; nutrition and chemistry; milling; drying; parboiling; grain handling; silo; bulk and bag storage; processing and marketing economics; management and cost-benefit analysis. A separate team should be assigned to each of the countries in the ECAFE region for an initial period of six months, with a project leader to co-ordinate and guide the study and preparation of the report. The study could be sponsored by ECAFE, FAO and UNIDO. The team should work with the local government representatives in jointly developing a project and a systematic programme. Fuller details of the suggested terms of reference for the pre-investment study team required for a rice-processing industry pilot project are given in a later part of this paper.

30. Pilot projects and evaluation studies

Following the feasibility study, two to four pilot projects should be developed in each of the seven countries, with the establishment of integrated rice-processing and handling units capable of handling one to four tons per hour or more. These would work out the methodology of approach, demonstrate the benefit of modernization in quantitative and qualitative terms for each type at different locations and select the equipment and techniques for a larger programme. The project team should also investigate the various cost-benefit combinations for modernizing traditional commercial and village processing-units.

31. Financial assistance for modernization and training of personnel

During or after the initial external assistance programme assisted by the United Nations Agencies, the countries would need to explore the possibilities of training their own technical and managerial personnel, developing the supply o modern equipment and finding financial resources for modernization. This could be promoted by intra-regional co-operation in respect of training and technical assistance from Japan and India, and by financial assistance through the United Nations Development Programme, the World Bank, the Asian Development Bank or other bilateral arrangements. Research on processing local varieties and training facilities for mill operatives should also be developed by countries through intra-regional, bilateral or international collaboration.

32. Manufacture of modern machinery

With a view to encouraging the manufacture of modern rice-processing machines in countries, detailed studies must first be carried out to decide on the correct machines to be used. The suggestions given above would help in making the decision.

33. Advice to industry and development in countries

The countries interested should set up, with United Nations Development Programme or bilateral assistance, a grain processing advisory and consultancy cell to advise the industry on the choice of equipment, methods of operation, techniques of improving operational efficiency, quality and process control and related matters, as there is a great need for a reliable consultancy service able to promote a rapid modernization programme.

34. Regulatory measures of countries

By way of advance action towards the modernization of rice processing, governmental regulations should be introduced by countries, where they do not already exist, for instituting quality control and specifications for paddy and rice and establishing a suitable system for licensing rice mills and rice-milling machinery manufacturing units.

35. Co-ordination of production with processing industry

As the cultivation and harvesting practices for paddy production have such a great effect on the final processing of rice, other groups working on the modernization of these practices should co-ordinate their activities with the rice-processing groups.

36. Organization and extension of studies to other food crops

As processing of food crops is the most important agro-industry in the region both from the point of view of economic growth and nutrition and monetary value, it is recommended that ECAFE, FAO and UNIDO set up a new cell, headed by a high-level food processing expert, to initiate action on the conservation, processing and effective utilisation of all foods produced.

37. Research

International assistance might also be extended to interested countries to promote projects concerning research on rice-processing and related problems.

38. Follow-up of recommendations

It will be important for ECAFE, FAO and UNIDO to engage the services of a consultancy and advisory team, comprising two or three high-level international experts, to be stationed at headquarters and see to the implementation of the recommendations.

39. While massive aid by the developed nations will be essential if this most important problem is ever to be reduced to a manageable size, it will also require relentless efforts on the part of developing countries to sustain this action to make it sufficiently extensive in scope and magnitude to bring the desired result.

40. In time, this modernisation of the industry could not only make the region self-sufficient in rice but could also perhaps replace a considerable part of its present imports of wheat and wheat flour.

41. This development of regional self-sufficiency is a form of import substitution to which developing countries can look for an easing of their foreign exchange problems. The spread of the new high yielding cereals will make a substantial contribution in this field by enabling the developing world to begin reducing the cereal food imports which have become so heavy a burden in recent years.

42. With the increase of rice resources, it is also important to pursue all the opportunities that offer for increasing trade among the developing countries. If an effort is made to step up this trade, its expansion would mean both increased foreign exchange earnings and to some extent foreign exchange savings by the replacement of imports from outside the area. The developing world is certainly the market for agricultural products with the greatest potential for growth today.

E. PRESENT POSITION OF RICE PROCESSING AND SCOPE FOR IMPROVEMENT

(a) Production Methods

43. There are programmes in some countries to grow new varieties which have a higher yield and also take less time to ripen so that two or more crops can be grown each year.

44. Increasing attention is being paid to improving the water supply required for the rice crops and agricultural practices in order to increase the production of rice.

45. The ECAFE region is characterized by the large number of varieties grown. The paddy, as marketed, very often contains a mixture of different varieties and also impurities which have to be removed by cleaning.

46. The best way to obtain the highest outturn of rice would be to grow fewer varieties which are resistant to lodging and disease, with a potential outturn of over 80 per cent of brown rice and over 70 per cent of edible rice.

47. The choice of the time at which to harvest is also important for securing optimum maturity. The moisture content for best results ranges from 20 to 25 per cent.

(b) Threshing Techniques

48. The bulk of the paddy is now threshed from the straw by striking it against a solid object or spreading it upon a level floor on to which animals or tractors are driven. The paddy thus threshed contains a large incidence of impurities.

49. There is considerable scope for increasing the output of paddy by the use of pedal or power-operated threshing machines (suitable for local varieties and conditions) and this will help to speed up pre-processing operations.

50. If threshing takes place at a grain moisture content of 20 to 25 per cent it will cut down harvest and handling losses.

(c) Cleaning Operations

51. Farmers generally have no incentive to clean paddy before storing or marketing

52. The farmers should be encouraged to clean paddy before transportation as up to 5 per cent consists of impurities and thus cause wasteful expenditure in storage and transportation besides lowering milling efficiency and quality of rice products.

53. Field paddy brought into the rice mill contains various impurities such as straw, chaff, sand, dust, stones etc. Unless these impurities are removed before the husking and milling process, this will not only cause irregular flow in each process, accelerate wear of the rubber rolls and abrasive rolls but also some of the impurities will remain in the finished white rice.

54. The modern cleaner operates as follows: straw or other impurities which are larger in size than paddy will be removed when they drop on to a rotating sieve. The paddy falls through the rotating sieve, while the straws are conveyed on top of the sieve and fall out of the machine. Air suction from a fan removes dust, chaff etc. from the sample which falls on to a vibrating sieve through which air is blown to float out stones etc. heavier than paddy, leaving a cleaned sample of paddy to flow from the machine.

55. This is only one type, other types feature vibrating sieves only to separate medium sized impurities from the final paddy sample.

(d) Drying Techniques and Equipment

56. In some cases, where rain coincides with the harvest, the farmer is compelled to store and transport paddy in a wet condition. This results in heavy losses and even germination. Sun-drying is the next stage in most countries and, under these conditions of continuous wetting and drying in stacks and drying yards, sun-checks develop and render grain susceptible to damage. As a result, outturn of head rice is often reduced by 10 to 30%. At this stage, also, losses amounting to about 2 to 3% are caused by birds and rodents.

57. If controlled mechanical drying is practised, not only will the milling quality be improved but the losses caused by birds and rodents will also be eliminated.

58. Paddy needs to be stored at an optimum moisture content so that it does not deteriorate in quality. It has been found that this optimum moisture content for storage ranges from 12% to 14% depending on climatic conditions. Hence, the moisture content of the paddy must be brought down to this safe level. In fact, the need for drying of paddy is already known to farmers and they usually dry it in the sun. Scientific experiments show that drying should be uniform and slow. Fasty drying causes "sun checks" on paddy, which cause breakage during milling. Moisture content should therefore be brought down gradually under controlled conditions. Moist paddy very rapidly deteriorates in quality. This is true of all varieties and more significantly of the newer strains which have a short dormancy period. Indeed, it is observed that if after harvesting, drying is not immediately resorted to, some high yielding paddy varieties germinate within a short time. In order to take full advantage of high yielding varieties, post-harvest processing steps of drying should be thoroughly gone into.

59. A recent trend in harvesting practice is to undertake harvesting at a relatively high moisture content in order to prevent "shattering" losses in the field. It has been observed that losses due to shedding or shattering of grain in the field can be considerably reduced if paddy is harvested at 20% to 25% moisture content. Hence, after harvesting, the need arises for bringing down the moisture to the safe level to 12% to 14%. Wherever mechanical drying has been undertaken it has facilitated drying of large volumes of paddy, in relatively short periods of time. It has also given better results in the shape of an increase of head yields and total yield of rice.

60. Mechanical drying has one great advantage over other methods of drying, namely, that paddy can be dried in any season. This is particularly important when harvesting takes place during the rainy season. Considering the "field losses" eliminated by harvesting at a relatively high moisture content, immediately after maturity and the increase in rice yields from mechanically dried paddy, the cost of mechanical drying would more than pay for itself.

Other advantages of mechanical drying are that it reduces the time that paddy must stay in the field and provides shorter periods from planting to harvest; and facilitates larger volumes of paddy to be dried in one small area. Drying continues 24 hours a day whether rain or sunshine prevails.

61. Mechanical paddy drying can be divided into two general systems. One is the batch system, wherein paddy is placed in a bin, and hot air is slowly pushed through the "batch" of paddy until the desired moisture level of paddy is reached. The second type is referred to as the "continuous flow system", where a mechanical dryer is used in which a mass of paddy continuously moves down through the dryer and hot air is blown through the moving paddy, producing the drying.

62. Most commercial type paddy dryers use the continuous flow systems. This is done by blowing heated air through a constantly moving mass of paddy. The advantages of this method over other methods of drying are: 1) a shorter drying period is used with less danger of spoilage during wet weather; 2) larger volumes of paddy can be dried in less time. The disadvantages include higher capital investment in equipment and facilities, and more handling for the grain. In some cases it could mean a slightly higher drying cost per ton which is reduced as the volume of paddy increases.

63. Considerable research work has been done with continuous flow dryers, notably at the Louisiana State University, U.S.A. After many years of work in paddy processing, the staff at the L.S.U. developed a mechanical drying system. The dryer unit consists of a rectangular steel casing. Inside are arranged rows of inverted trough-shaped air channels, to guide the paddy downward in a zig-zag path. When paddy is fed on top of the dryer, it flows down between the troughs. Heated air is directed, into the inlet troughs, through the paddy, and out through the outlet troughs. A feed roll mechanism at the bottom of the dryer is rotated at a slow regulated speed by means of a small electric motor. The feed roll thus controls the rate of flow of paddy or in effect the time paddy stays in the dryer.

64. It is to be noted that hot air is fed from one side and escapes through the opposite end of the dryer. The troughs have open ends on one side and closed ends on the opposite side. Hot air is directed to pass through the

vertically flowing column of grain and to escape through the port openings on the opposite side. A very large volume of paddy is exposed to the hot air. The thickness of the grain layer through which air penetrates is controlled by the design as also the spacing of the metal troughs, both vertically and horizontally. As the grain passes down by gravity it tumbles and turns, thereby exposing all the grain to hot air for achieving best drying efficiency. Pre-cleaned paddy is fed into the dryers for more uniform and faster drying and to prevent foreign material from clogging the feed rolls. The entire drying may or may not be housed in a roofed structure. The outlet ports and top of the dryer may be protected with a hood, to keep out rain while drying.

65. The column type consists of two vertical columns of grain enclosed by mesh and situated on either side of a central chamber into which heated air is blown under pressure. This air penetrates through the gradually moving grain columns thereby reducing the moisture content of the paddy. The rate of feed outlet is controlled by a feed roll mechanism at the bottom of each column. By altering the speed of the mechanism the rate of drying can be changed. The third type of dryer also uses a central hot air chamber, but on either side there are a series of short alternately inclined plates or baffles arranged one below the other. As grain falls on these plates, it gets mixed as it turns, and the gap in between the plates is actually the portion through which heated air passes, penetrating through the grain.

66. In order to provide "heated air" for drying, fuel is burnt to raise the ambient air temperature. On continuous flow dryers, drying air temperatures may be as high as 160°F.

67. Heat may be supplied by the use of "direct burners" or indirect heat exchangers. Direct burners are used with gas or liquid fuels such as kerosene, diesel fuel or oil. The burner is placed at the entrance of the blower where the flame is mixed with the air entering the blower. It must operate with 100% combustion to prevent any unburnt products of combustion entering the dryer.

68. When using steam, husk or some fuel oils, an indirect heat exchanger may be employed. Here, the products of combustion are burnt in an inner cylinder, and are exhausted through a chimney. The air entering the blower passes around the inner cylinder, is heated up, and moves into the dryer. Heat exchangers are much less efficient than direct burners so they need more fuel but are necessary with some fuels.

69. The heat exchanger unit for use with fuel oils consists of an outer sheet metal tubing or shell about 3 ft. in diameter with an inner shell. Fuel oil is injected by means of a nozzle on the burner into the inner shell. The hot gases forming the products of combustion flow through the inner shell and out through a chimney. Fresh clean air is sucked in through the outer tube and as it passes inside this tube, it comes into contact with the hot inner shell and is heated. This design, therefore, contains two lengths of sheet metal tube, one an outer shell and the second an inner shell.

70. When operating the dryer blower and burner it is possible to control the rate of hot air produced and also its final temperature. By adjusting the fuel supply and the air to be mixed with the fuel, the combustion rate can also be controlled. Using a high grade fuel and properly choosing the burner it has been found by experience that considerable saving in fuel cost can be obtained.

71. Tempering of paddy between passes, serves primarily to equalize moisture in the kernel and permit faster drying with a minimum of breakage.

72. Most varieties temper adequately in 4 to 8 hours, depending upon paddy temperature, humidity and air movement through paddy. Tempering for long periods presents problems because paddy may become mouldy, sour or discoloured.

73. It must be kept in mind that parboiled paddy is received at the dryer at 35% to 40% moisture. This requires much more drying; thus longer drying periods are essential and drying cost will be obviously higher for parboiled paddy than for raw paddy.

74. Tempering periods between passes reduce the total drying time needed, thus allowing a greater throughput from the dryer and lower drying cost.

75. Paddy must be cooled before final storage to preserve quality. A pass through the dryer with blowers on and burners off cools paddy adequately.

76. If paddy temperature is high after drying, it is essential to cool paddy for final storage.

77. Storing dry paddy requires special precautions to prevent damage. Before the drying season starts, all storage bins and equipment should be cleaned thoroughly and treated with approved chemicals to kill insects and rodents.

78. Because paddy is alive for long periods, although at a very low level of animation, it requires oxygen and gives off heat as its respires. To keep paddy in good condition and prevent lowering of grade it must be kept cool and the air between the kernels changed occasionally. This is accomplished by moving grain through the dryer with fans on and burners off, moving paddy from bin to bin, by aeration in the bins. Grain temperatures must be watched carefully and if abnormal heating is detected, cooling must be resorted to.

(e) Storage Methods

79. Some of the storage facilities consist of ordinary warehouses which are neither rodent nor bird proof and the bags of paddy are stacked indiscriminately. Spilled grain lies everywhere and in general, the conditions are such as to increase the loss of grain. The moisture content of the grain is generally not checked before storage and losses due to fungi and micro-organisms are evident.

80. Modern bag-storage warehouses will reduce damage caused by moisture seeping through the floors and losses from rodents and birds.

81. The use of silo storage will protect the gain more effectively against insects, micro-organisms, birds, rodents, moisture and pilferage, and, at the same time, reduce handling charges and cost of bagging of the grain.

82. Silo storage entails substantial capital investments, although it is likely to be more economical in the long run in integrated systems.

83. The trend to automation continues. More and more storage facilities will be required to keep pace with expanding production and world trade and to extend the efficiencies of the mills.

84. In general, silos are now built in either concrete or steel. Both have advantages and disadvantages, only after a close study of the requirements and an investigation of cost can a sound recommendation be made. For storing up to about 120 tons of grain per unit, it is usually more economical to use the prefabricated type of all steel-bin. Some of the advantages of this type are ease of erection and lower weight to load-carrying ratio, thus reducing the cost of the foundation required.

85. In designing silos, the advice of specialists is indispensible. This includes the choice of material, the number and size of silo bins, the arrangement of intake, transport, cleaning and other equipment to meet local conditions. Paddy is prone to overheat when stored. This can be avoided by frequently turning it over, that is to say by transferring it by conveyors and elevators from one bin to another passing it via the preliminary cleaning plant in order to aerate and cool down the stock. In large silos, a temperature control system is commonly used to show temperatures at different bin levels and thus give warning when turning over and aeration are necessary.

86. Storage on the farm and at home can be improved if modern storage containers are introduced and popularized.

(f) Parboiling Techniques

87. Parboiling is practised in some countries, particularly in Ceylon, India and Nepal, and, to a lesser extent, in Thailand.

88. The method used involves two or three days of processing followed by drying in sunlight on the floor. The method usually produces discoloured rice with an objectionable odour accompanied by losses of the order of 1 to 2 per cent from birds and rodents and suncheck.

89. These losses can be avoided by adopting mechanical drying along with tempering in storage bins.

90. The latest parboiling methods can increase the nutrient value of rice and reduce breakage during processing. Gains of 2 to 4 per cent in outturn are possible, particularly in varieties that are susceptible to breakage. The discolouration and the objectionable odour are also eliminated.

91. The latest continuous parboiling processes which are being evolved are expected to increase this gain both in quality and recovery.

92. Improved parboiling techniques have been developed where these defects can be easily eliminated. According to these methods, paddy is soaked in hot water at about 70°C for a period of three to three-and-a-half hours. Moreover, the two steps of soaking and steaming are done in the same vessel and the steaming time is also reduced to three to five minutes. The short soaking time at the elevated temperature eliminates fermentation and reduces the chances of any off-flavour in the rice produced. After par-boiling, paddy is removed quickly from the tank and is ready for drying.

93. The size of the tank would naturally depend on the capacity of the boiler and the daily production in a particular mill. Using a set of four tanks, each of the capacity of 150 cubic feet, about 25 to 30 tons of paddy could be parboiled in an eight-hour working day.

94. According to the modern process developed, soaking of paddy is done either in batch or continuous soaker-steamer at elevated temperature (60-75°C) for two-and-a-half to three hours, followed by gelatinizing the rice grains by direct steaming for three to five minutes. The steamed paddy is then immediately cooled to the room temperature and dried in a continous dryer. When dried, it is subjected to conditioning and allowed to cool down slowly before milling.

95. The improved processes of parboiling have the following advantages over the existing process:

1. The total time required for the parboiling and drying of paddy is minimized from four days to four or five hours.
2. Proper soaking is achieved within two-and-a-half or three hours.
3. The soaking and steaming operations are done in a single equipment, continuously or batchwise.
4. There is no off-flavour in the finished rice.
5. Vitamin B_1 content, retained in the finished rice, is generally more than twice that of the raw white rice.
6. As drying is carried out continuously as a mechanical operation, this process is not dependent on the vagaries of the weather. In mechanical drying the floor space required for installing the equipment is only about 5 per cent of the space required for sun drying.
7. The breakage of head-rice is significantly less.
8. The overall cost of processing is less than that of the existing process.

(g) Milling Methods and Equipment

96. Rice-milling equipment in use in various countries range from crude hand-pounding equipment and small-scale village hullers to highly complex and capital-intensive units.

97. It is estimated that more than half of the rice crop is hand-pounded in Indonesia and about one-third in India. Hand-pounding is also substantial in Nepal, and, to a lesser extent, in Ceylon. It is noted that hand-pounding is gradually being replaced by under-productive hullers in many countries.

98. A significant feature is that the industry in Ceylon, Indonesia, Philippines, India and Nepal uses a large number of hullers with capacities ranging from 250 to 600 kg/h. The rice milling industry thus consists of far too many units of uneconomical size which are obsolete, poorly organized and inefficient. The majority of hullers are widely distributed in villages of the rice producing and consuming areas, close to the source of raw materials and in close contact with the growers. These hullers require only a small capital outlay and mostly work on a custom basis. They are wasteful, not merely because the milling outturn is low (about 56-65 per cent for raw and parboiled paddy respectively), but also because the value of the by-products is lower.

99. There are also commercial mills with a battery of two to six hullers for de-husking and whitening rice. One other type of commercial mill consists of an under-runner disc husker with huller combinations which reduces the mill outturn of whole white rice.

100. An avoidable breakage of brown rice occurs with the drastic dehusking operation in hullers and emery-coated under-runner disc huskers. An appreciable amount of brown rice also escapes, due to defective aspiration, and is lost in the piles of husk.

101. Some brokens also escape with the bran where there is no effective bran separator.

102. Under-running disc huskers, followed by aspiration to remove husk, paddy separators and whitening cones, are in use in large processing mills producing raw rice. The capacity is 1 to 4 t/h and these mills are usually located in market areas.

103. If paddy is not effectively cleaned before dehusking, small stones and dust cause excessive wear and defective operation of machines. Eventually, a portion of these impurities appears in the final product. The aspirators and graders in the conventional mills frequently do not effectively prevent unhusked paddy and broken grains from escaping in the final product.

104. Many mills operate with only one whitening process, whereas two or three whiteners reduce the broken rice and milling loss caused by a gradual change from brown rice to white rice.

105. If frequent stopping and starting has to take place in the mill operations, an increase of breakage and lower outturn also results.

106. Total rice recovery is thus never more than about 66 per cent, whereas most of the varieties of the paddy marketed are capable of yielding about 70 to 73 per cent polished white rice.

107. Modern milling techniques can be designed to suit varieties of paddy, whether in a raw or parboiled condition before milling. The use of grinding and friction whitening machines with an air-blow device, in correct stages in combination with an improved bran aspirator, can materially reduce loss of white rice.

108. The use of rubber roll huskers, in combination with precleaners in place of hullers and under-runner disc huskers, reduces the breakage of brown rice to the minimum and ensures a higher milling recovery.

109. In order to remove the bran layer from brown rice and change it into white rice, three different types of machine are used: 1) Pressure type and the same type with blower; 2) Abrasive roll type; 3) Combination equipment of abrasive roll type and pressure type with blower.

1) Pressure Type

110. This type was the main machine used for rice milling for a long time in Japan, but its place was taken by an improved type equipped with a blower. The pressure type originated from the Engelberg rice milling machine and was improved for milling Japanese rice at the beginning of the 1900s. It is a horizontal type machine with a chilled steel roll covered with a steel casing. The rice grains are milled by friction pressure between grains due to movement of

the roll in the casing. In Japan, this type is equipped with a weighted device at the outlet of the casing, regulating the flow and pressure on the grains to prevent breakage. In case of small scale milling, rice grains are circulated several times through the machine. This machine is unique for milling Japonica rice.

2) <u>Pressure Type with Blower</u>

111. This type was invented in 1930, and has been adopted by most of the mills after the war in Japan, becoming the main machine for milling at present. In this type, the horizontal roll mentioned above in the pressure type has a hollow centre shaft through which air is circulated by a separate blower in order to remove the rice bran produced during milling by blowing it out through the perforated casing. By this method the bran is removed, and a rise in temperature of rice during the milling is prevented resulting in increased milling efficiency and decrease of milling loss. The machines usually require from 2-15 HP. Both pressure type and the same type with blower are suitable for milling short grain varieties. But they increase broken rice in long grain varieties, because they put pressure upon the grain during the milling.

3) <u>Abrasive Roll Type</u>

112. There are two kinds of machines of this type, vertical and horizontal. In Japan, this type of machine is not used for milling of rice for edible use, being used mainly for milling of raw rice for brewing of "sake", a Japanese beverage. The machine has an abrasive roll within a steel casing. Rice grains are milled between the roll and casing by the high speed revolution of the former. As the milling is caused mainly by the high velocity of the roll, less pressure is put on the grains, decreasing the breakage of grains even in long varieties. In addition, this type has a high milling capacity. In Japan, the abrasive roll is not formed by hand, but it is formed from vitrified abrasive by a controlled and accurate process being different from the milling cones used in Asian countries. The machines are up to 10-50 HP.

4) Combination equipment of Abrasive Roll Type and Pressure Type with Blower

113. This type, the commercial name of which is "Compass" rice milling equipment, was developed in 1961. It is compactly designed so as to be suitable for many Japanese mills limited in mill space, being highly efficient and superior in milling ability. It may fairly be said that the expansion and industrialization of rice milling in Japan were promoted by the development of this equipment which is adopted by most of the rice mills at present.

114. This equipment is constructed by the combination of 1 to 3 units of the horizontal abrasive roll type and one or more units of horizontal pressure type with blowers to make use of the merits of the different milling functions of both types. This is the first arrangements which introduced the abrasive roll type into the milling of rice for edible use with the intention of giving high milling capacity to a compact equipment under various conditions of hardness of rice grains. The equipment requires 50-120 HP where it is composed of 3-4 units. The milling capacity of this type by single passing is 3 tons per hour at 50 HP; 4 tons per hour at 65-75 HP and 6 tons per hour at 120 HP using brown rice.

115. Rice milling facilities constructed by the combination of this type of equipment have been adopted recently in the model plants established in India.

116. This arrangement is also used in large scale modern rice mills in Japan.

117. The arrangement of machines in large scale rice mills is: cleaning and separation of raw rice; milling; polishing and finishing; mixing enrichment; measuring; packaging. There are two kinds of installation systems. One is the series system in which 8-10 units of the pressure type machines with blower are used. Brown rice is milled by passing the units successively. The other is the combination equipment of abrasive roll type and pressure with blower as mentioned above. The latter type is most commonly used in modern mills.

118. Equipment for the processes other than milling are: milling separator; grain aspirator and stone removing separator for cleaning and separation of raw rice; milled rice separator and stone removing separator for the polishing and finishing process. For measuring and packaging automatic packers using plastics are gradually being popularized. And for handling of packaged milled rice the palletization system is coming more into use.

119. The use of suitable graders of modern design will grade the final product into several fractions which can be recombined to produce the desired final grade by the use of belt conveyors.

120. Modern cleaners also control the amount of impurities escaping into the final product and reduce the amount of dirt and dust in the mill itself.

(h) Weighing, Special Treatments and Packaging

121. The rice produced can be enriched by the addition of vitamins, if so desired. For example, thiamine and riboflavine is added in Japan. This is included in about 30% of the rice sold there.

122. Refining and shining can be introduced into the processing of rice to improve the appearance of the final product.

123. Automatic packaging in 10-15 kg. polythene bags is also in use to meet the increased consumer demand for this type of packaging.

(i) By-Products Utilization

124. The bran that is produced in hullers is a mixture of husk and bran as there is no device to separate them.

125. Bran is a valuable by-product of rice milling and very little use is made of it for extraction of oil. Most of it is used for cattle feed and as fuel for raising steam in boilers.

126. In modern rice processing complexes, the utilization of bran for the production of rice bran oil can be developed and the extracted bran subsequently used for the manufacture of compound feed. In Japan, for instance, the rice bran oil industry produced 87,000 tons of oil in 1967.

127. If we take a bran oil plant which is integrated with the rice milling plant and utilizing 3 metric tons of bran per day for a 275-day year, a profit of about 15-20% can be expected on the enterprise. This would also include selling

de-oiled bran for cattle feed and also broken rice germ etc. The prices of raw materials and products are as follows:

Rice Bran	US$ 18.50/30 kgs.
De-oiled Bran	US$ 16.00/25 kgs.
Crude Oil	US$ 355/dm (181.5 kgs.)
Broken Rice	US$ 27.50/bag (30 kgs.)

The above profit calculation takes into account costs of solvents, fuel and power and expenses. If the bran is taken as 100%, the by-products (broken rice and grain) = 2% - 5%, the extracted crude oil 17% - 18.5% and de-oiled bran 74% - 76%.

128. If this oil bran extraction unit were combined with say/a 2 mton/hr. modern mill having a capacity of 14,400 mt. per year, the ratio of return on employed capital could be increased by as much as 2%.

129. In addition to rice bran, husk accounts for from 18 to 23 per cent of the paddy weight. Husk has no food value yet some millers grind husk and mix it with bran and sell it for livestock feeding. Some of the husk is burnt to raise steam in boilers. Efforts to use husk by turning it into wall board, concrete blocks, concentrated fuel and chemicals have not proved commercially successful. A potential use is its conversion into white ash and activated charcoal for industrial purposes.

(j) Handling and Transport

130. Rice is usually transported by head load and animal drawn cart in rural areas and by truck or rail in more developed areas. Modern bulk transport facilities are seldom found.

131. In most countries, handling consists of loading paddy, brown rice or white rice in gunny or paper bags, mostly by hand labour. In many instances, the sacks used are old and seldom fumigated, thus increasing the risk of infestation. The sacks are also often worn and damaged, resulting in loss due to spillage.

132. To improve the efficiency of modern mills, the bags of paddy, brown rice or white rice can be handled for example by the use of gravity roller bag conveyors, with pallets and fork lift trucks for bulk handling and mechanical conveyors for loading trucks and silos.

(k) Research and Development

133. In the Philippines, a beginning has been made to determine the losses caused by pests, rodents and micro-organisms by means of analysing the dirt and residues left in the mills.

134. Research work in connection with the continuous parboiled method and drying operation is in progress in India. Operational research to improve productivity in milling and the related processing operations is also being carried out in that country.

135. The dewatering of paddy by means of salt in solution, and also by parboiling in brine is being experimented with in India.

136. Even the use of salt to dry paddy, at farmer level, is being tried in India.

(l) Sanitation and Infestation Control

137. The rice mills, as well as the warehouses for paddy and rice, are usually heavily infested with insects, micro-organisms and rodents.

138. White rice and other food products are produced under highly insanitary conditions.

139. Effective governmental regulations covering preventive and control measures should be strictly enforced in order to protect consumers from the health hazards arising from this situation.

(m) Integrated Systems in the Rice Processing Industry

140. A modern integrated system would entail the use of the latest scientific engineering and technological knowledge for (1) reducing costs; (2) cutting down material losses; (3) achieving higher milling outturn; (4) improving institutional as well as marketing quality; (5) achieving production of cleaner products of greater value at less cost per metric ton of processing; (6) securing a better return to producers and processors; and (7) providing a combination of facilities for threshing, drying, handling, processing, storage, transport and packaging so as to facilitate an increase in production.

F. TERMS OF REFERENCE OF THE PRE-INVESTMENT STUDY TEAM FOR A PILOT PROJECT FOR THE RICE PROCESSING INDUSTRY

141. In order to find answers to the several questions relating to modernization which arise from the diversity of opinions regarding the correct choice of components and procedure, it is essential first to carry out a systematic pre-investment study with the following main objectives:

(a) To demonstrate how a higher outturn of rice can be obtained, and other benefits derived, from the adoption of modern pre-processing techniques, modern milling methods and equipment and the several components of storage, parboiling and drying of the integrated system.

(b) To analyse fully the prevailing local conditions, taking into account varieties of paddy grown; quantity in production; milling quality; pattern of marketing; storage practices; season of availability; marketable surplus; prices; utilization of labour; cost-benefit analysis; level of technology in other related fields; available services and their costs; consumer preferences; availability of technical personnel; organization and management; and details of existing mills.

(c) To investigate the economic and technical aspects and establish whether investment in modernization, under the given set of conditions, will be desirable and profitable.

(d) To determine the equipment and methods best suited to the varieties of paddy available locally.

(e) To work out the optimum capacity of the processing units.

(f) To work out the optimum combination of equipment for the modernization of existing commercial units and small village hulling units.

(g) To work out a modern system which does not upset the local rice-production, marketing and handling system but improves it so as to bring maximum economic benefits.

(h) To use the opportunity to train local personnel in technical design, operation and management.

(i) To work out the best method of marketing the final product.

(j) To select a suitable location, taking into consideration:

- (i) availability of paddy;
- (ii) environmental factors, socio-economic conditions and cost-benefit analysis.

(k) To develop blueprints, detailed designs and specifications of the mill building, storage structure and equipment for tenders. To develop the design and specification of equipment which can be supplied on the spot.

(l) To collect data and gain experience for a larg r programme, backed by government regulations, industry's co-operation and producers' participation.

(m) To explore the possibility of developing the rice-processing machinery manufacturing industry.

142. Such a study is considered to be most essential in order to avoid costly mistakes and to develop a systematic approach to rapid modernization.

G. RESULTS OF PRE-INVESTMENT AND EVALUATION STUDIES IN INDIA - A CASE OF AN INTEGRATED APPROACH TO MODERNIZATION

143. I would like to give you some figures which have been obtained by the Ministry of Food and Agriculture in India, who set up an evaluation committee for the modern rice mill complexes developed under their pilot projects. Of the four pilot projects studies, the capital expenditure ranges from US$ 334,000 to US$ 491,000 and two had a capacity of 4 tons per hour; one 2 tons per hour and one 1 ton per hour, all had parboiling and drying equipment which took from 1.6% to 6% of the total capital used. All units had silo storage with conveyors which consumed from 45% to 74% of the capital used. The mill machinery and other equipment took up from approx. 9% to 16% of the total capital. The silo storage for the 4 tons per hour mills had a capacity of 3,600 tons and 7,200 tons respectively, while the 2 tons per hour mill had 4,500 storage capacity and the one ton per hour mill 5,200 tons storage capacity. One 4 ton per hour mill was costed from January 1966 - June 1967, the other from January to September 1967 and the figures projected for full capacity on the basis of actual capacity during the period of study. One 4 ton per hour mill gave a ratio of return on employed capital of 15% and the other12.5%. The 2 tons per hour mill gave a ratio of 14.5% and the one ton per hour mill 15%.

144. These cost studies to assess the economic viability of the units which have been carried out and the preliminary results indicate that modern integrated units will reach the break-even point and start returning a profit after processing paddy to the extent of about 50% of their capacity.

145. The investment has varied in different mills on account of differences in:

(a) cost of imported equipment;

(b) capacity of the unit;

(c) capacity of the silo storage unit;

(d) capacity of the parboiling and drying units;

(e) availability of land, buildings and other management facilities.

146. It appears that the modern mills, even with their comparatively high capital requirements, are capable of yielding returns at the rate of about 12½% to 15% on the capital employed.

147. Cost studies have shown that modern mills, when worked to full capacity, will be able to pay off their long-term loans and all dues within eight years.

148. The output of rice and brokens on paddy delivered during the period of study, for rice, varied from 69 to 72.7% with brokens varying between 0.4% to 1.1%.

149. Further, the committee's report indicates that, in the case of raw paddy, an average increase in the outturn of rice of 2.5% over sheller mills and 6.5% over huller mills can be expected from the use of modern milling equipment alone.

150. From the information on the import and export of rice in the region during 1964-1966 indicates that there was a shortage.

151. If countries can adopt improvements in their processing methods, rice recovery from 153 million metric tons of paddy, at a minimum of 2½% would produce additional supplies of about 4 million metric tons in the ECAFE region alone.

152. Modernization is also necessary to infuse productivity into the paddy-rice system and ensure that the production of paddy is increased in proportion to the increase in rice produced.

H. VALUE OF COLLABORATION

153. The information now available from the use of these modern mills in various countries must be made easily available to all countries who are proposing to modernize the rice processing equipment. How and where this information is stored must be made known freely to everyone so that all facts and figures are obtained without difficulty.

154. In my view, interdependence is and ought to be as much the ideal of all countries, as self-sufficiency.

155. As Mahatma Ghandi said:

> "A man cannot become self-sufficient even in respect of all the various operations from the growing of cotton to the spinning of yarn. He has at some stage or other to take the aid of the members of his family. And if one may take the help from one's own family why not from one's neighbours? Or otherwise what is the significance of the great saying - 'The World is my Family'."

156. It is a widely accepted view that the greatest advantage for developing rice processing in the economically developing countries lies in the possibility of borrowing the technologies from advanced countries at a relatively low cost and without much difficulty. However, at the same time, the view seems widely accepted that in the case of rice processing this is difficult because of the different conditions that affect the borrowing of advanced technologies. I do not share the latter view, however, and would emphasise that the advantage of borrowing technology is the key factor for accelerating the rate of growth of all industries in the follower countries. Most of the difficulties in the international transfer of this technology do not prevent implementation of the strategy of borrowing advanced technologies, they only modify it.

157. Even in the case of manufacturing, most of the success stories tell us that an important feature of the process is the choice and modification of foreign technologies in order to fit them into the domestic economic situation, particularly in terms of the structure of factor prices. When a country has achieved this, it has built an appropriate system for developing its own technology.

158. What is important is first to identify the unique nature of the rice processing industry in each of the follower countries and second, to find the criteria for the choice and necessary modifications of the advanced technologies so that they may be fitted into the desirable pattern for transformation of the rice processing industry in each country.

159. If the above interpretation of the thesis of borrowed technology is accepted for the case of the rice processing industry, it offers theoretical support for the proposition that the positive aspects of Japan's experience, for instance, can be reproduced in other countries in Asia and the Far East.

160. The second point to be emphasized is that the term "reproduction" should not be taken to mean that technologies are borrowed outright without modification. Rather the term implies that the foreign experience becomes the basis

for guide lines in the choice of an appropriate strategy. As suggested above, this also requires invention and adaption on the part of the follower countries. In this occasion, Japan's experience is again relevant in both a positive and negative sense. In the transition period at the beginning of the Meiji Era, the government made an attempt to introduce "western" advanced methods of large scale farming. Agricultural machinery, implements and crop varieties were imported to Japan. The strategy was exactly to take full advantage of borrowed technologies developed in advanced countries. This was a failure except in Hokkiado, where conditions are more or less similar to those in Western countries. The so called "Meiji technology" that was evolved, has been aptly described as a combination of indigenous know-how and very selective borrowing from the west. Intimate knowledge of the best of traditional methods was thus the starting point for research and extension activities. In general, it is to be noted that appropriate borrowed technology in combination with indigenous achievements can be expected to contribute a great deal to establishing a country's own new system of improved technologies for transforming its traditional processing techniques.

161. In a number of countries in Asia and the Far East, the extent to which productivity and output can be increased by exploiting the international backlog of technological knowldgewill be influenced strongly by the measures taken to improve control over losses. It was, of course, for that reason that I urge that the limited capital available to the rice processing sector should be used chiefly for expansion and improvement of rice processing machinery as this is essential to increase rice yields.

162. The view has been advanced that for contemporary developing countries, a net transfer of resources into the rice processing sphere is likely to be required because of the massive investment which must be made in machinery facilities.

163. It may be noted, however, that the implications of the above view are sombre indeed. Rapid population growth not only accentuates the problem of food supply in developing countries, but also increases the requirements for capital to bring about the transformation of the economic structure that is a necessary condition for economic growth.

164. Regardless of one's view with respect to the net flow of resources between rice processing and the rest of the economy, it is clear that contemporary developing countries in Asia have a great stake in a strategy for technological progress that can achieve the expansion f rice output mainly through production and fuller utilization of the rice produced. The Japanese experience demonstrates that the intensification that will make this possible requires a substantial increase in current outputs and will in most instances depend on sizeable investments in expanded and improved machinery. But this simply emphasizes the great importance of a strategy that leads to a path of expansion involving the lowest possible capital-output ratio. Hence, the great importance, in the early phase of development, of fostering "minor" machinery usage for whose operation and maintenance local funds and avoidable losses can be mobilized through the inducement effect of central government outlays.

165. Similarly, the Japanes experience underscores the importance of simultaneous effort to promote loss reduction so that the return on investment in infra structure is augmented by the maximum output which it facilitates.

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[1] In order to compile this paper, the above references have been used.

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