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INTERNATIONAL FORUM ON APPROPRIATE INDUSTRIAL TECHNOLOGY

New Delhi/Anand, India 20–30 November 1978

WORKING GROUP No.4

APPROPRIATE TECHNOLOGY FOR THE PRODUCTION OF SUGAR

APPROPRIATE TECHNOLOGY FOR THE PRODUCTION OF SUGAR ,
Discussion Paper

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APPROPRIATE TECHNOLOGY FOR THE PRODUCTION OF SUGAR

Discussion Paper

Corrigendum

Page 6, paragraph 20, line 3: for "...100 ton VHS factory." read:
"...100 tonne/cane/hour VHS factory."

Page 6, paragraph 20, line 4: for "...10[illegible] tch factory)." read:
"...100 tch factory).".

Appropriate Technology for the Production of Sugar*

Issues and Considerations

Note prepared by the secretariat of UNIDO

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CONTENTS

Appropriate Technology for the Production of Sugar*

* This Note has been largely based on the background documentation on the subject, which is attached.

INTRODUCTION

1. Production of sugar occupies an important place in the industrialization programmes of many developing countries. Directly or in processed food, sugar furnishes as much as about one-seventh of total human energy intake particularly in developed countries. The use of sugar as an energy-giving part of the human diet is rather high in North America and Western Europe. But in most developing countries sugar consumption is relatively low. The forecast of consumption for the next 5 to 10 years indicates a higher rate of consumption in developing countries. Fluctuations in the world market price for sugar has in recent years caused severe difficulties for importing developing countries with foreign exchange restrictions and without the apparent benefits of bi-lateral sugar agreements as obtained by many developed countries.

2. As a result of these factors, many developing countries have placed the production of sugar in the high priority list for import substitution industries.

3. Sugar cane, a giant grass related to maize and sorghum, is cultivated in the tropical and sub-tropical regions of the world. Sugar beet, a member of the goosefoot family, grows best in cooler latitudes, but adapts itself to many climatic conditions, and in North America, is grown in Arizona and the Imperial Valley of California as well as in the Canadian provinces of Alberta, Manitoba and Quebec. The fact that a product practically identical in its refined state is obtainable from two altogether dissimilar plants has made possible the global dispersal of the industry. Sugar is now produced in over 100 countries, some producing only or primarily for domestic market while others, primarily for export, with annual national outputs ranging from less than 10,000 tons to more than 10 million tons of sugar.

4. Sugar manufacturing in developing countries is mostly based on cane. The general geo-climatic conditions of the world region, where most of the countries lie, are also favourable to the cultivation of sugar-cane. Technological options examined in this paper have been restricted to sugar production processes based on sugar-cane only.

I. PRODUCTION AND TRADE

5. From the available data on production and trade in sugar,[1] the following facts can be noticed:

(a) developed countries produce most of the beet sugar while developing countries produce most of the cane sugar;

(b) production of beet sugar has increased by about 6% since 1970-71 while that of cane sugar by about 16%;

(c) non-centrifugal sugar (like gur, panela, jaggery, etc.) accounts for over 10% of the total sugar production of about 94 million tons per annum;

(d) developed countries have a relatively high per capita consumption while developing countries have a relatively low consumption.

6. These available figures, however, give no indication of the distribution of sugar consumption by end use. But analysis of domestic and industrial consumption would again reveal a major distinction between developed and developing countries. In 1973, in the USA, approximately 70% of sucrose and other sweeteners were delivered as industrial sugar, i.e. for use in processed food and beverages. In 1975, sugar used for industrial purposes accounted for 4.3% of total consumption in Kenya and 6.1% in Ethiopia.

7. The generally low level of consumption in developing countries in association with the importance of domestic consumption or voluntary intake of sugar, rapid population increase, gradual improvement of the standard of living is expected to lead inevitably to a significant increase of demand for sugar. FAO projections to 1980 and 1985 suggest an average increase of 15.7% and 32.2% respectively over 1975 levels of world demand. When broken down by region, however, the increase in demand is heavily concentrated in the developing regions. In 1985, demand is projected to increase by 69% over 1975 levels in Asia, 57% in Africa, 58% in Near East, 55% in Far East and Oceania, and 41% in Latin America.

8. The above considerations are indicative of the need for major increases in sugar production to meet future demand in developing countries. Any evaluation of alternative technologies must also, therefore, take into account the imperatives of the time horizon within which the increased production capacity is expected to be built up.

1/ See background papers attached.

II. TECHNOLOGIES AND PRODUCTS

9. Existing sugar factories differ widely in size, although economies of scale have sustained a secular trend towards ever larger installations. Guided by the relative availability and costs of the factors of production in industrialized countries, sugar technology has developed in the direction of substituting capital for labour in these countries. Manpower requirements have been steadily reduced, but at an increasing capital cost. The capital cost of sugar factories has risen sharply and is estimated to be of the order of $ 1000 or more per tonne of sugar output for medium-sized vacuum pan plants.

10. During the last two decades or so, smaller plants using the open pan sulphitation (OPS) process have emerged in the developing countries. The survival of small plants based on this technology employing great deal of manual labour in batch-type operations side by side with large factories equipped with the most modern labour-saving apparatus and continuous production systems, is now being examined in many developing countries which have adopted employment-oriented industrial development strategies.

11. In its barest essentials, sugar processing consists of a series of liquid-solid separations to isolate the sucrose formed by photosynthesis in living plants. Four basic processes are involved: juice extraction, purification, evaporation and crystallization. These fundamental steps are at present carried out by various methods and over a spectrum of scales extending from tiny peasant-operated, animal-powered cottage enterprises to gigantic, highly automated factories. Different types of sugar are made. But most product characteristics admit of a choice of operating processes and are not uniquely determined by the size design and complexity of the equipment used. Characteristic of sugar manufacturing is a technological pluralism that reflects the historical development and wide geographical distribution of the industry.

12. The present day industrial practice of sugar making can be categorized into basically two methods, viz. (1) the Open Pan Process (OPS) and (2) the Vacuum Pan Process (VPS) each with internal variations. 1/

1/ These processes have been described in detail in the background papers of Technological Choices in Sugar Processing - ID/WG.282/55; Appropriate Technology for Production of Sugar and Other Sweetening Agents - ID/WG.282/13; Appropriate Technology in Production of Cane Sugar - ID/WG.282/28; Cane Sugar Production Techniques in Developing Countries - ID/WG.282/29.

[illegible]. Neither of the processes employed for production of various types of sugar is technologically monolithic although, on account of the very large differences in scale associated with the Open Pan Sulphitation and Vacuum Pan Technologies respectively, the number of hybrid technologies actually available is much more limited in practice than in principle. The use of cane preparation, cane carrier (conveyor), filter presses, mechanical driers etc. in OPS plants has been borrowed from Vacuum Pan technology. More generally, however, the use of Vacuum Pan equipment in small factories would be seriously uneconomic on account of their use well below their rated capacity (which determines their capital cost). In principle, OPS equipment could be used to produce any amount of sugar. However, if this were to be done in single locations, serious problems of organization and efficiency of labour would arise. Similarly, the traditional non-centrifugal sugar technology now includes certain features of OPS technology like use of power crushers, crystallization with stirring operation, improved firnace, etc. Although for the sake of product homogeneity, the discussion may be restricted mainly to Open Pan and Vacuum Pan technologies, the production of block sugar for specific rural needs also has its own relevance and justification for encouragement in specific situations.

[illegible]. Technological advances in the past 25 years have also enabled the Open Pan process to produce a near substitute to mill-white sugar produced by the highly sophisticated Vacuum Pan process. In fact the first product of OPS process (about 2/3rds of the total output) approaches the quality of plantation-white sugar made in Vacuum Pan factories. The invert sugars and non-sugars in the subsequent batches, although harmless, may give the product a dull and off-white colouration with less lustrous and uniform crystals than the VP product. Although OPS sugar may not be wholly substitutable for VPS sugar, particularly for use in food, soft-drink and pharmaceutical industries, it is pure enough to be an acceptable substitute for domestic consumption. The choice of the consumer for the mill-white sugar in preference to certain grades of OPS sugar should not be overlooked unless the latter has a price advantage.

CHOICE OF TECHNOLOGY - POLICY IMPLICATIONS

[illegible]. The sugar mill has been described as a "factory in the field". It intertwines in an intricate pattern with the agricultural structure of the area of its location. Depending on the technology adopted, its commanding presence in the rural environment can act either as a catalyst

for the regeneration and transformation of the rural region in which it is located or as a parasite which can sap its vitality and destroy its identity and character altogether.

[illegible]. Technological options involving a range of operating scales, from small-scale OPS factories of 100 ted to large-scale VPS factories of 20,000 ted capacities are now available. However, it is extremely important to evaluate the alternative technologies and plant capacities now available for their appropriateness not only in terms of their relative commercial viabilities but also, and more significantly, with regard to their compatability with the over-all development objectives of individual countries, which can be broadly described as economic development within the social dimensions of:

(a) reduction of inequalities:

(b) decentralization of economic power;

(c) integrated planning to secure balanced growth;

(d) mass participation.

[illegible]. Policy instruments will have to be refined and fashioned in a way that will facilitate the choice and operation of appropriate technology.

[illegible]. The [illegible] system [illegible] a relatively [illegible] marketing system where pricing and production efficiency factors, although of [illegible] importance for economic performance, are constrained and [illegible] in their movements by [illegible] of extraneous factors and considerations.

[illegible]. A common practice of comparing large (VPS) and small-scale (OPS) sugar processing technologies is to compare the relative output efficiency of a given capital input. A variant of this is to calculate the capital labour and other inputs required to produce a given quantity of sugar with alternative technologies. For example, on the simplified assumption that:

	OPS plant	VPS plant
Fixed capital cost	$ 250,000	$ 7,500,000
Number of workers	180	720
Sugar output	750 t	15,000 t

then

1 VPS factory = 30 OPS plants in terms of capital cost

= 20 OPS plants in terms of sugar output

Hence, the sugar output from a capital investment of $ 7,500,000 is

in 1 VPS factory - 15,000 t

in 30 OPS factories - 22,500 t

and, a capital investment of $ 7,500,000 generates employment for

in 1 VPS factory - 720 men

in 30 OPS factories - 5400 men

Conversely, to produce 15,000 tons of sugar, requires

by VPS technology - $ 7,500,000 - 720 men

by OPS technology - $ 5,000,000 - 3600 men [1]

. According to prevailing estimates, sugar output from twenty-eight 150 tcd OPS plants would exactly equal a single 100 ton VPS factory. The total discounted fixed capital cost of these units would amount to $ 14.28 million (as compared to $ 31.94 million for the 100teh factory). The factory employment in 28 OPS plants, would be 7364 as compared to 464 in 1 VPS factory. The capital requirement of 56 OPS plants is estimated at 52% of that of one 200 tcd plant with the cumulative potential of the latter. [2]

. Not only is the capital cost of establishing a number of small plants absolutely lower than that of building one larger factory of equivalent capacity, but it is also less lumpy which implies development of sugar production based on OPS technology can be phased and adjusted to the availability of cane, investible resources, manpower, and other scarce inputs.

. A question may therefore be asked whether it is economically more prudent to have small factories with much smaller initial and overhead costs (Pakistan - 1958) in areas where development of cane supplies would take a number of years than to have excess capacities in large-size factories for want of inputs. The OPS technology is particularly relevant to situations characterized by dispersed and insufficient cane supplies, small domestic markets dependent on imports, present inadequate infrastructures, capital constraints and high level of rural unemployment and under-employment. Characteristically, all these factors exist in varying degrees in all developing economies.

Secondly, decisions with regard to the scale of methods in the processing phase are intimately linked to decisions about how to secure the requisite quality and quantity of cane from the area in which the factory is sited. From this it follows that the ways in which the industry relates to the land and the population which sustains it, constitutes a crucial element in technology assessment. The current emphasis in development strategies is towards a redistribution of incomes, broadening of economic opportunities for the poorest members of the rural communities and balanced agricultural development.

1/ See Background Paper, Technological Choices in Sugar Processing, ID/WG.282/55.

2/ See Background Paper, Appropriate Technology in Production of Cane Sugar; ID/WG.282/28.

24. The central question to be addressed here is whether from a development point of view these goals are better served through mass participation in sugar industry as wage labourers (as in the case of plantation-based sugar industry) or as cane-growers (as in the case of sugar industry based on out-grower system).

25. From a strictly technical point of view it is essential for a sugar factory to secure a reliable supply of cane. This is more significant in the case of large-scale capital intensive VPS factories in view of the absolute dimension of the investment and the controlled cane requirement to ensure against capital wastages in terms of excess capacity. The 'solution' to this problem in many parts of the world, where sugar industry has been introduced has been to centralize control as fully as possible over both land and labour. Until the 19th century this approach was carried to its logical extreme with slaves and indentured labourers being used within the framework of a pure plantation economy. Historically, political and economic forces have, however, effectively liquidated this system and would certainly prevent its reconstruction. Nevertheless, plantations have survived in one form or another, and in the case of sugar industry they continue to hold certain attaction for the processes. But the theoretical advantages of the factory of centrally controlled production must also be compatible with the total situation in which it has to operate. It has been argued that the growing needs of a large-scale factory operating on a mixed-crop agricultural base tends to upset the existing balance leading ultimately to the emergence of a mono-crop economy based on sugar cane, in which the entire agricultural economy gets integrated directly or indirectly with the large-scale sugar factory in a subordinate and subservient rather than mutually complementary position. There are the dangers of a gradual alienation of the local population from traditional agriculture representing a balanced and largely self-sufficient food-cum-cash crop economy leading perhaps to the emergence of a class of landless labourers.

26. Perhaps the choice of system most appropriate in any local situation will depend on the type of land and population in a proposed project area. In areas of high population density and intensive cropping, as in Kenya, the outgrower system supporting a number of small-scale OPS plants, is more appropriate. On the other hand, in areas of low population density, with vast uncultivated lands, large-scale factories with a plantation base, preferably in the public sector, may be a more appropriate alternative.

7. Thirdly, growth of the sugar industry opens up a great deal of potential for integrated rural development provided, however, that the technology adopted is in harmony with the general level of technological development. To the extent that the technology of sugar production does not mesh with the level of development of its environment, there are fewer linkages of opportunities and the industry assumes the character of a parasite of the organized manufacturing sector on the rural economy. According to a study made [1] up to 85% of the equipments required for an OPS plant consisting of tanks, heating beds and furnaces can be fabricated locally with locally existent skills and materials in most of the developing countries. Sophistication of OPS technology is such as may be easily assimilated in the mainstream of technological development of the developing countries. The indigenous engineering capabilities might develop, initially, to service and repair the imported hardware and thereafter fabricate replacement spares and finally, even the basic hardwares themselves. Such linkages are, however, not possible in the case of large-scale VPS technology using highly sophisticated and automated processes and equipment. Not only would the basic equipment and spares in respect of large-scale VPS plants need to be imported indefinitely, the level of technological sophistication of large-scale VPS plants being what it is, but it would provide little or no opportunity for such linkages with domestic engineering capabilities.

8. Fourthly, rapid industrialization of the developing countries involving integrated and balanced regional development through dispersal of industries and broad-based entrepreneurship can be achieved more surely through small-scale, quick-yielding, less sophisticated and less capital-intensive technologies. Sugar industry based on OPS technology is clearly more capable of being dispersed regionally than one comprising a few large Vacuum Pan factories. The capital cost of establishing a new large-scale plantation-mill complex in a developing country has become almost prohibitive for the private enterprise. The time-profile between inception and completion of projects or until cane supplies are built up to match processing capacities has lengthened almost infinitely. On the other hand, by virtue of its small scale, it is possible to envisage situations where OPS sugar production may be the only way to produce sugar not only to substitute present imports but also to meet growing future needs. It is also compatible with domestic availability of investible resources, local enterprise, skill and engineering capabilities.

1/ See Background Paper, Project Report and Feasibility Study of Appropriate Technology on Mini-Sugar, ID/WG.282/32.

29. Machinery requirements for small-scale processing plants are already being manufactured in a number of developing countries and much of the equipment used can be locally fabricated by small workshops anywhere. Levels of skill and expertise required for the maintenance and repair of these small-scale plants are more or less available in the developing countries, or may, in any case, be easily acquired. The nature of cane production support required for the small-scale OPS plants harmonizes with the need for diversification of agriculture without involving any displacement of the agricultural population as a result of cane cropping. Small-scale OPS technology also blends well with the policy objective of dispersal of industry and entrepreneurship, and prevention of concentration of economic power in the hands of a few.

IV. POLICY OPTIONS

30. From the foregoing discussion it is apparent that choice of appropriate sugar technology involves consideration of a wide range of parameters. In addition to the differences in the product quality and labour requirements, ranking of the technological alternatives in this field is influenced by a large number of extraneous factors arising from the over-all development goals. Clearly there are a number of trade-offs and where the balance lies is determined by over-all policy approach and the specific circumstances. The small-scale OPS process would appear more appropriate to situations characterised by mixed agricultural cropping patterns, small domestic markets, inadequate infrastructure, capital scarcity, widespread unemployment and under-employment etc. It would, however, be misleading to suggest that the actual policy options would involve complete acceptance of one of the processes and a total rejection of the alternatives.

31. The time to start thinking about the appropriateness of different sugar processing technologies is at the outset of a sugar development programme and not at the evaluation stage of a particular project conceived in the conventional terms. The low capital cost per unit of output and employment, low level of technical, managerial and organizational skill requirements, the present level of the state-of the-art, its flexibility and adaptability to a wide spectrum of local conditions etc. obviously restricts the choice to OPS technology. But

policy instruments such as price, wage and fiscal regulations have to be fashioned in such a way that they facilitate both choice and operation of the technology. It cannot be expected to thrive if the market is allowed to be flooded with relatively cheap VPS sugar and if the price of non-centrifugal sugar is pegged at such a high level that it becomes more lucrative to discard the sulphitation apparatus, crystallizers and centrifuges and to produce inferior grades of sugar. Questions such as these rather than the analysis of often rather fanciful output and cost flow projections lie at the heart of the selection process of the appropriate sugar technology.

V. RESEARCH AND DEVELOPMENT

37. For the last hundred years, R & D in the sugar industry has been mainly concerned with the refinement of the basic processes and innovations in machinery and equipment particularly the transition from batch to continuous operations, introduction of measuring instruments and computerized process control systems and the automation of various phases. The aim has been to improve product quality, eliminate losses, increase throughput and reduce labour requirements. In fact, guided by the relative availability of the factors of production in industrialized countries, mainstream processing technology has developed in the direction of substituting capital for labour. The resultant capital-intensive, sophisticated large-scale technology, which was primarily oriented to an assured supply of cane based on plantation agriculture regimes, has now been reviewed in the changed circumstances of decentralized small-scale production units, capital and skilled manpower scarcity, and the needs for employment generation and dispersal of the industry and entrepreneurship in developing countries.

38. Until recently, however, little systematic R & D was undertaken on alternative processing technologies to meet the specific needs of the developing countries. The R & D efforts directed towards appropriate small-scale processing technology, which are mostly undertaken in developing countries so far, have been hardly in proportion to its share in total sugar production. From what is know about the relative efficiencies of the small and large-scale technologies, it is clear that the technological innovations should aim at improving the sugar recovery and fuel economy of the small-scale technologies and raising the quality of product while preserving the advantages of low capital and high employment intensity and modest

skill requirements. This is an area where the Working Group could present a concrete programme of action which could be taken up later by the countries and the international organizations like UNIDO as a part of their work programme. If the evolution of the small-scale technology is to proceed at a faster pace than hitherto and generate a range of feasibile alternatives to suit conditions in different countries, it must be provided with the same kinds of institutional and regulatory supports that have promoted world-wide diffusion of large-scale sugar processing technologies.

34. R & D efforts, for instance, need to be directed towards elimination of the known inadequacies of the small-scale technology with a view to (a) make it more adjustable to specific local situations of developing countries, particularly where labour availability and wage rates necessitate economy in labour input, (b) improve its productive efficiency and (c) improve the quality of its resultant product. More specifically, R & D should address itself to the following problems:

(a) increase of juice recovery rate;

(b) reduction of sucrose losses due to inversion and caramelization;

(c) reduction of fuel consumption.

35. While trying to find a solution to these problems, however, the need to preserve the present advantages of the OPS technology of relatively low capital cost per unit of investment and output will have to be kept constantly in view.

36. Simultaneously, the feasibility and economics of decentralization of some of the operations involved in the manufacture of crystalline sugar also need to be investigated. Integration of the dispersed traditional sector now producing block sugar variously called gut, panela, jaggery, etc. with the organized sector will improve the vitality of the traditional sector. In fact, neutral gur (pH 7.0) was made at one time in India for subsequent refining. In Thailand both non-centrifugal 'red' sugar and syrup are reprocessed in large sugar factories for production of mill-white sugar. In Venezuela small mills produce only syrup which is transported to conventional factories for further processing.

37. Apart from drawing up a programme of R & D for subsequent action, the Working Group may also want to devote its attention to the refinements and production adjustments in the VPS factory itself. For example, it is well known that valuable sucrose content is lost if the time between harvesting of sugar cane and its crushing is longer than 48 hours, assuming that the cane is cut when its maturity is at its peak. It is, however, known that

there are serious bottle-necks as there is a wide divergance in cutting the cane at the right time and its mil ng, which is also due to the cultivation system of sugar cane. One alternative may be to transport juice instead of cane provided the decentralized milling is reasonably efficient and also that technical break-throughs (solar cooling, for instance) is feasible to store the juice in a cooled condition for a longer time. While this has to be examined in terms of costs and available technologies, it may have the greater advantage of decentralizing sugar production system. Other systems to be noted in this connexion are the experiences in Thailand where both non-centifugal 'red' sugar and syrup are reprocessed in large sugar factories for production of mill-white sugar. In Venezuala, small mills produce only syrup which is transported to conventional factories for further processing.

VI. CONCLUSIONS

66. Intermediate small-scale sugar technology has advanced to a point where it represents a viable alternative to the large-scale technology. The inadequacies of the technology are not such as cannot be corrected through purposeful R&D efforts. It also blends well with the multiple objective development strategies of the developing countries involving rapid industrialization, balanced agricultural development, dispersal of industries, broadening of entrepreneurial base, expansion of employment opportunities, equitable distribution of wealth and income, raising of the standard of living of the rural poor and so on. The choice of sugar technology is, in the final analysis, therefore, a political option and has to be sustained directly and indirectly through public policy with regard to fiscal protections and incentives and price policies.

VII. ISSUES AND CONSIDERATIONS

67. In the prevailing circumstances of the developing countries, the small-scale DT technology for the production of crystalline sugar and the traditional technologies for the production of khandsari sugar and syrup which may be further processed in sugar mills, would appear to be more appropriate on account of their (a) low capital intensity, (b) high employment potential, (c) limited need for skilled manpower, (d) unlimited scope for linkages with other production sectors and more particularly with indigenous

engineering infrastructure and training facilities, (e) compatibility with existing land-use patterns, (f) adjustability of the scale of operation with actual needs in terms of both cane supplies and the nature and extent of demand for sugar, (g) short time-profile.

VIII. POLICY MEASURES

40. Choice and operation of appropriate technology would depend primarily on the policy measures adopted by the national governments to improve its relative viability and to encourage its application through suitable incentives and assistance.

41. Policy instruments such as price, wage and fiscal regulations would need to be fashioned in a way that would facilitate both choice and operation of appropriate technology. Pricing, fiscal and distribution policies would need to be so devised as would improve the competitiveness of small-scale technologies while, at the same time, create conditions for improving the efficiency and the quality of the small-scale product. An OPS plant, for example, cannot be expected to thrive if the market is swamped with relatively cheap vacuum pan sugar, or if price of non-centrifugal sugar is pegged at such a low level that it becomes more lucrative to discard sulphitation apparatus, crystallizers and centrifuges and produce an inferior grade of sugar. Adoption and operation of small-scale technology would need to be encouraged through a rational and co-ordinated scheme of fiscal and price incentives and subsidies. Even if price protection given to the small-scale sugar industry in the initial stages of development results in relatively higher price of sugar in the domestic market, it may be preferable for the community to sacrifice a bit of its present for a better future, provided, however, there is a built-in mechanism in such a policy to ensure that the price protection given to the industry does not perpetuate a high cost sugar economy.

42. The policy measures that would be needed may include the following:

(a) **The lending policies of public financial institutions would** need to be oriented to support government policy of encouraging establishment of small-scale units. Where small-scale units are set up in co-operative sector, the government would need to provide the seed capital and otherwise participate substantially in the share-capital of [illegible];

(b) while at least the basic equipments of small-scale plants would initially need to be imported, a phased programme would need to be taken up for their progressive manufacture within these countries; and

(c) it is simple, quicker as well as cheaper to increase sugar yield through better agricultural practices and proper co-ordination of harvest and transport operations. These would need adequate step-up of input supplies and extension services as well as proper linkages with rural transportation and communication policies.

14. Evaluation of the appropriateness of alternative technologies is made at the outset of a sugar development programme. A comprehensive national sugar policy should cover, on the production side, three interdependent units, viz. cane growing, cane transportation and cane processing; and on the distribution side, pricing and marketing.

15. Considering the share of small-scale and traditional processes in total world production of sugar, resources devoted to research and development problems of these processes are extremely meagre. This is so because **the R and D work in these fields which has been carried out so far is mainly undertaken in developing countries where financial and technical resources are characteristically inadequate.**

IX. PROGRAMME OF ACTION

16. The fact that the small-scale technology has maintained itself despite the mainstream technological development being in the direction of large-scale production, reflects its intrinsic excellence, particularly in relation to situations which characterise the developing countries. Given the same kind of R and D support that large-scale technology has received over the years, there is no reason why its techno-economic efficiency of the small-scale technology, too, cannot be improved further.

17. The basic small-scale sugar technology is already well known. However, its apparent inadequacies such as excessive fuel consumption in the process of juice purification and concentration leading to sucrose loss through inversion and caramelization and poor recovery would need immediate attention. Fragmented and scattered studies of the inherent technological inadequacies of the small-scale process undertaken in various countries would need to be co-ordinated and integrated for better impact. Another inadequacy of the small-scale process is with regard to its labour-intensity. This process would, therefore, need to be made more

adjustable to situations in developing countries characterised by the high cost of labour per unit of employment. The small-scale technology is at present oriented primarily to situations characterised by high unemployment and low wages. But there are many developing countries where the inverse relationship between employment and nominal wages render labour-intensive technologies somewhat uneconomic.

17. Considering the special relevance of small-scale sugar technology to almost all the developing countries, it would be both appropriate and necessary to have a collective R and D approach to the technological problems of the small-scale process, in which all cane-producing developing countries might participate under the aegis of a United Nations agency such as UNIDO. A central R and D institution structurally linked with national R and D centres, might undertake applied studies into the technological deficiencies of the small-scale process while the national institutions would address themselves to operational problems of local relevance and also to adaptive R and D. The R and D work now being undertaken in a fragmented manner in both developing and some developed countries could then be meaningfully integrated with those of the central R and D institution for better results. Such a central institution would also facilitate concentration of scarce and scattered R and D capabilities and resources for better and more purposeful application.

In preparing this Note, material contained in the following background papers have also been used:

1. Technological Choices in Sugar Processing - ID/WG.282/5
2. Appropriate Technology in Production of Cane Sugar - ID/WG.282/2*
3. Choice of Technology in the Sugar Industry - ID/WG.282/10
4. Project Report and Feasibility Study of Appropriate Technology on Mini-Sugar - ID/WG.282/12
5. Appropriate Technology for Production of Sugar and other Sweetening Agents - ID/WG.282/13
6. Cane Sugar Production Techniques in Developing Countries - ID/WG.282/2*
7. **Sociological Issues in the Design of Cane-growing Systems - ID/WG.247/1***
8. **Impact of Different Sugar Technologies on the Economic Environment - ID/WG.247/9***
9. **Economic Viability in African Conditions of the Large Scale Vacuum Pan Sugar Technology - ID/WG.247/10 ***
10. Economic Viability in African Conditions on the Small Scale Open Pan Sugar Technology - ID/WG.247/11 *

* available at the meeting

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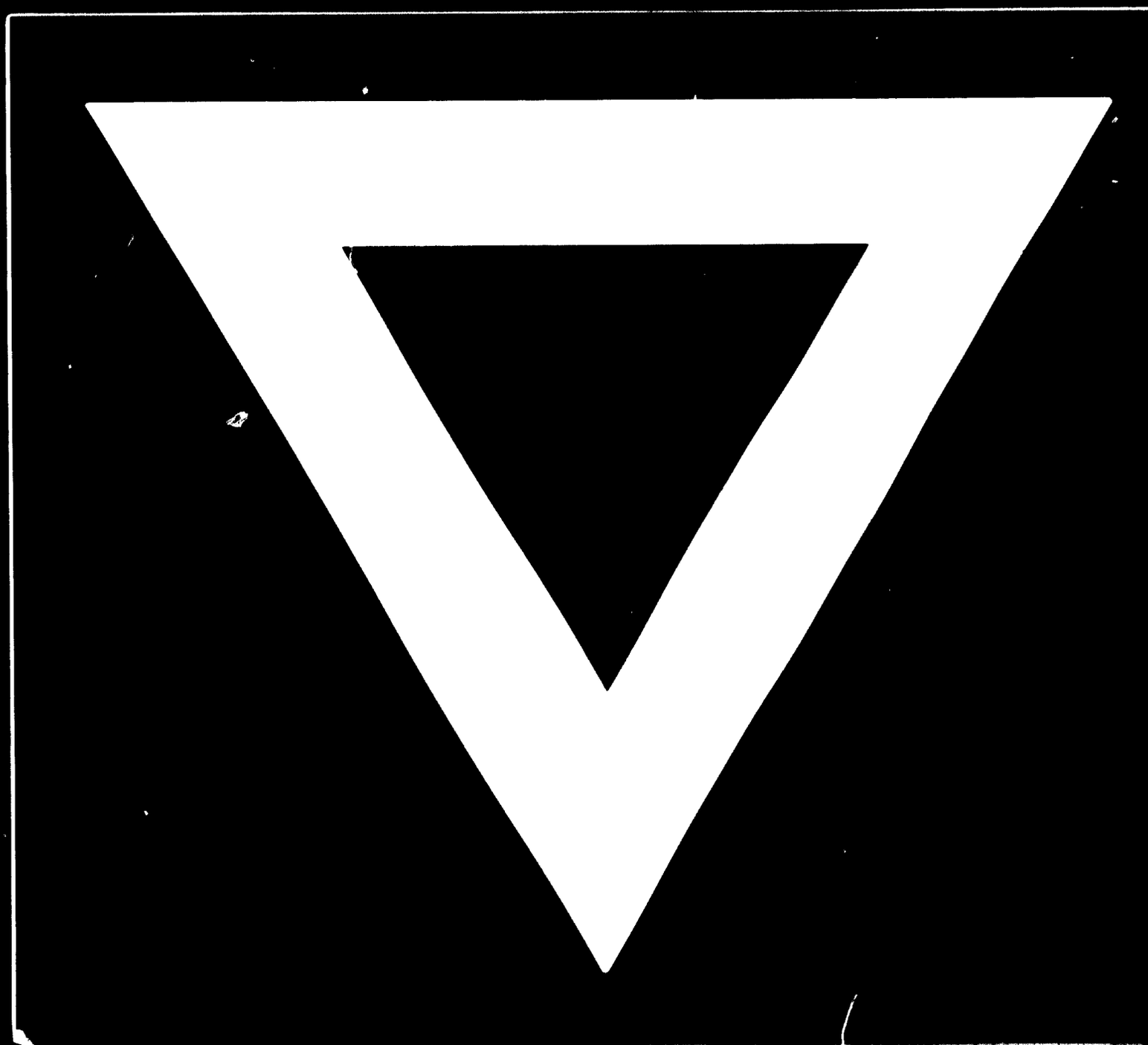

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