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SRI LANKA ASSOCIATION
FOR THE ADVANCEMENT OF SCIENCE

PART II

PROCEEDINGS

of the

THIRTY SECOND
ANNUAL SESSION

December, 1976

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FOR THE
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CONTENTS—PART II

INAUGURAL ADDRESS

by

PIETER KEUNEMAN M.P.
Minister of Housing and Construction

Mr. President! Ladies and Gentlemen!

The last time I addressed your Association was in 1970, shortly after the United Front Government was formed. I have now been asked to perform the same task in the final year of our Governments' term of office. Let me thank you all for your kind invitation and for, the honour you have done me.

In the last six years, I have watched with interest the steady progress made by your association. The Sri Lanka Association for the Advancement of Science is to-day one of the oldest, most firmly established and prestigious learned Societies in our Country Its ranks unite most of those in Sri Lanka who work in the natural, physical, social and applied sciences.

I am happy that the new National Academy of Science will be inaugurated during your 32nd Annual Sessions. The work of your Association over the years and the many important contributions made by its members have played a decisive part in this development.

It is also a great pleasure to meet once again your Chief Guest, Professor Otto Koenigsberger. He is an old and valued friend of our country, and especially of my Ministry. May I welcome him once again to Sri Lanka and hope that he will enjoy his present visit as much as we will undoubtedly profit from it.

The central theme of your 32nd Sessions - namely, physical planning and development – is a most appropriate and timely one. I am happy to note that your Association seeks to link science with the practical tasks of nation-building. The large numbers of seminars and public lectures which you have organised on this and allied themes in the recent past, including

the Special International Session with scientists of other non-aligned countries which you held in the middle of this year, have helped to sharpen and deepen the consciousness of both the general public and the Scientific Community about the importance of these matters.

It is no longer necessary in Sri Lanka to argue the importance and value of planned development. Since 1948, we have had several plans – both economic and physical. But looking back and speaking frankly, we have to admit that most of these plans never got off the ground. They have contributed more to the nations' archives than to its socio-economic growth. Where there have been successes, they have been mainly confined to the planning of limited projects.

The big question that we must all consider and answer is: why? Some have argued that the fault lies with our planners. But although there are many faults that can be laid at their door, it is by no means fair to make them scapegoats. We have many talented and dedicated persons among our planners. We have to ask ourselves whether we are making the best use of their talents.

Of course, there are considerations of a fundamental nature that have to be examined, such as the constraints that a mixed economy places on purposeful planning. The concept of economic planning has been borrowed from the socialist countries where it has been used to great advantage in order to ensure crisis – free growth. In the socialist countries where the means of production, distribution and exchange are socially owned the control and deployment of natural resources according to a central plan and the integration of natural, regional and physical plans are much easier than in a mixed economy, where resources are in diverse hands with conflicting interests.

This is one of the main reasons why all our economic plans in Sri Lanka since 1948, irrespective of whether we have called them plans or programmes, have been, in essence, *investment* plans. Even here they have been mainly plans for public sector investment. Lacking effective direction and control over the private sector, the planners, where they have fixed targets for

the private sector at all, have based these targets more on wishes, hopes and exhortations rather than on accurate estimates of how the resources in this sector can be mobilised to ensure maximum performance.

A mixed economy can create problems in Physical Planning too. Let me give you an example from the work of my own Ministry. Our plans for promoting house building for the low and middle income groups are being thwarted by the uncontrolled inflation and rising prices of private urban land. This has made it necessary for the Cabinet to set up a special inter-Ministerial Committee to study this matter.

Does all this mean that we cannot have effective plans until a fully socialist society is achieved? On the contrary despite some fundamental constraints on the planning process in a mixed economy, there is much that can be done to make better use of such facilities as exist.

This is vital if we are to limit, even in a restricted way, the glaring socio-economic distortions that have resulted from unplanned growth. For example, physical planners working in our metropolis of Colombo have to take into account the facts that the so-called "development" achieved through income and price structures have resulted in large-scale urban slums alongside affluent dwellings within the same city, that residential land-use patterns are so unequal that population densities vary from between 25 persons per acre in some localities and 900 persons per acre in others, that there are 1277 acres of excellent buildable land in Colombo (excluding parks and playgrounds) lying vacant and unused owing to uncontrolled ribbon development allowed in earlier times, that one out of every three houses is unfit for human habitation; and that large areas of our capital are still unsewered, while the general sewage system is over half a century old and almost bursting at the seams.

The need for greater co-ordination and integration between the work of the economic and the physical planners has begun to be realised. But to my mind, the extent of this realisation is still far from adequate. Of course, there are distinctive features in the work of the economic and the physical planners that make

integration no simple matter. For instance, while economic planning is primarily concerned with the flow of new resources, physical planning is concerned with the optimal spatial arrangements based on the existing physical stock. Equally, physical plans are prepared for relatively long periods such as 20 to 30 years, while economic plans have generally been for shorter periods of 5, 6 or 10 years.

However, such difficulties do not negate the need for the closest integration between economic and physical plans. The lack of such co-ordination often results in both the economic and the physical plans being abandoned. For instance it is not unusual for the physical planners to commence their work *after* the economic planners have finalised their's. As a result, there are long delays in finalising physical plans. But neither the Government nor other public authorities or private entrepreneurs can remain passive during this period. They often start and complete projects which sometimes contradict and often complicate what the physical planners had in mind. And by the time the physical plan is ready, it is still-born.

However, it is encouraging to note the greater emphasis and importance that is now being given in the planning process to the work of the physical planners. Our investment—oriented economic plans have generally stopped short at the questions of where, how and by whom. This is where the physical planner has to step in. He is at the terminal point of the development chain. It is he who has to transform political decisions into benefits for ordinary people. Ultimately, it is the physical planner who marshals and regulates resources for development. This is the key role that the physical planner has to play in national development

There are many preliminary steps that have to be taken before the physical planners can effectively play the role expected of them. In the interests of greater integration, economic planning units should be supported by complementary physical planning units at all levels. These units should advise on the physical implications of major economic development proposals.

A complete overhaul of the legal structure for physical planning is also called for. At the moment, the enabling law for town and country planning in Sri Lanka is an Ordinance of 1946 which is itself based in very great measure on a British Act of 1932. The other relevant Law – the Housing and Town Improvement Ordinance–is equally outdated. Not only do both these laws seek to transplant in Sri Lanka institutions and practices that existed in Great Britain several decades ago, but they also take no account of the profound political, social and economic changes in Sri Lanka since these laws were enacted, including sweeping changes in the patterns of ownership of land and house property.

Thirdly, the supply of qualified persons who can undertake physical planning, especially at regional and district levels, must be speedily increased. In this connection, the work now being done in the town planning course of studies at the Katubedde Campus is most valuable.

I would also urge close study by our physical planners of the conclusions and recommendations of the U. N. Habitat Conference at Vancouver earlier this year. I was fortunate enough to lead the Sri Lanka delegation to this important conference and can testify to the importance for our country's development of many of its recommendations, not to speak of the rich experience the Conference provided of work done in this field in other lands. There are valuable lessons that our physical planners can learn from the Habitat Conference in regard to national priorities, the regulation of the urban rural balance, the preservation of eco-systems, the conversion of waste into resources, the patterns of human re-settlement policies so that the dis-advantages experienced by scattered populations in rural areas and the unequal development between different regions of the country can be overcome. Professor Koenigsberger, who will be speaking to you about the Habitat Conference, will undoubtedly spell out its lessons in greater detail.

Development is, of course, not a matter for the planners alone. The people and their elected representatives, including their governments, have vital roles to play. The active participations of the people in the preparations and implementation of

plans, especially in such areas which directly affect their daily lives, is vital to the success of any plan. So too is the active association at all stages, of the peoples representatives and leaders in the planning process.

This not only guarantees that plans, both economic and physical, correspond to the wishes and aspiration of the people but it also ensures the co-operation of those who make the decisions in the fight to overcome obstacles in the way.

Wherever we turn. we meet contradictions that underline the need for better planning, both economic and physical. Despite recurrent droughts, few countries are as spendthrift in its use of water as Sri Lanka. Over 6 million acres are under forest, while the construction industry complains of a lack of timber. At the same time, the number of trees felled each year exceeds the number replanted by 3 million. One-third of our hospital beds are occupied by patients who would never be there if we had paid sufficient attention to the provision of clean water and basic sanitary facilities. One need not go on to labour a point that should be clear to all.

I am sure that the discussions at your 32nd Sessions will go into these and other problems of physical planning and development in greater depth and thus help towards finding solutions of the urgent problems that face our country in this regard. I Wish your deliberations every success, I am confident that your 32nd sessions will add to the many worthy contributions that the S.L.A.A.S. has already made towards the advance of our country and its people

GENERAL PRESIDENT'S ADDRESS

PHYSICAL PLANNING AND NATIONAL DEVELOPMENT

by

JUSTIN SAMARASEKERA

Historical Background

If we look deep into our history for evidence of planning, we see the early Indo Aryan settlers who came to Sri Lanka about the 6th Century B. C. settling down in the plains of the North Central Province, which we refer to as the dry zone, establishing centers of civilisation, opening up the land, building tanks (reservoirs) for storing of water and canals for irrigation. The population increased steadily spreading further inland.

Anuradhapura where the first major tank (reservoir) was built became the central settlement and soon grew into a city.

By the 3rd Century B.C. these early settlers in their quest for greater and improved agricultural production, realised the importance of water and concentrated their efforts on the construction of reservoirs and canals From small beginning by the 3rd Century B.C. these early settlers and the indigenous population had made remarkable advances in the science and practice of irrigation engineering and many large reservoirs such as the Minneriya Tank, the Kavudula tank were built. The Minneriya reservoir submerged 4,570 acres and now it irrigates 4000 acres of cultivated land. The Kalawewa tank submerged ten square miles and its waters were conveyed to Tissawewa at Anuradhapura along the Yoda ganga, an artificial canal 54 miles long.

By the 2nd decade of the 7th century a whole network of irrigation works consisting of reservoirs, canals and river diversions were functioning :-

River Diversion Schemes

1 Hattota-Amuna dam on the Kaluganga – canal to Ambun Ganga, Alahera dam — Alahera Canal — Branch canal to Giritale tank, main canal to Minneriya tank — Canal — Kavudulla tank — Canal — Kantale tank ; total length of canal 95 miles.

2 Dam on Mahavati Ganga — Pabbatuna Canal, extended by Dhatusena; length of canal approx. 30 miles.

3 Manimekhala (Minipe) dam on Mahaweli Ganga — Minipe Canal, length 17 miles.

4 Dam on Malvatuoya — Giant's tank — length 17 miles.

Storage Reservoir Schemes

1 Kalavapi (Kalaveva) — Jaya Ganga — Tissaveva; length of canal 54 miles.

2 Jaya Ganga — Branch canal — Naccaduwa tank — Canal — Nuwaraveva — Canal — Mahagalkadavala tank; length of canal 20 miles.

3 Mahakanadarawa tank.

4 Hurulewewa.

5 Tannemuruppukulam.

6 Tissamaharama tank.

The total length of major canals was over 250 miles. This is an extraordinary achievement and any of these projects if undertaken now in 20th Century Sri Lanka, would be considered major works. We can only admire the skill and energies of these people as we to date enjoy the results of their labours. It is however a pity thas we are unable to discover how these Engineers and technicians set about their work and what techniques and mathematical formulas they employed.

The next development period was the Polonnaruwa era 12th to the 13th Century. The construction of the Parakrama Samudra submerging an area of 5,940 acres and irrigating 10,200

acres and the major task of repairing and restoring 163 dams, 3910 canals, 163 major tanks and 2376 minor tanks destroyed during the Chola invasion was accomplished during this period.

The Raja Rata civilization is by far the most glorious in Sri Lanka's history. Its benefits are still being enjoyed by us in the 20th Century. The intricate system of storage of rain water in small village tanks, major tanks and the distribution and feed systems from rivers to reservoirs and from reservoir to reservoir and thence the fields near and far through channels is really a great achievement. It is an achievement not only for the period in which it was accomplished between the 3rd Century B.C. and the 4th Century A. D. but also for today in the latter part of the 20th Century. If done today these would be acclaimed for their technological skill and social and economic values. It is interesting in a study such as this to consider the social and physical features of this development and the planning methods adopted. We see about the 5th Century a very early settlement or a series of settlements with a central market at Upatissagama which served as the capital for 60 years, before Anuradhapura became the chief city. Anuradhapura itself developed as a settlement around a tank (reservoir) and soon became the central exchange and barter centre for other settlements situated around it. It very soon grew into a city and the Administrative Centre for the for the whole island.

The administration was on a hierachial system with the King at the top. The King appointed princes of his choice to govern the different regions. The Southern region being the most important. The regional administration was similarly structured with chiefs in charge of various activities such as the maintenance of tanks and canals, Mining for metals and precious stones, trade and taxes at the civil administration and the other of military affairs.

The physical layout of the 4th Century city during Pandukahabaya's reign is outlined as follows by Roland Silva quoting from the Mahavamsa. 16

"The royal residence of the King was within the city where he lived with Queen Cittaraja. Although only the south and

west gates of the city are mentioned it could be assumed that if followed the conventional plan current to Indian traditions of the periods shown on the city of Ayojjha. The basic units of this 4th Century B.C Pandukabhaya town of Anuradhapura could be listed under the following regions or zones :

I	Palace area	
II	Shrines to the Gods	(a) Palace Temple
		(b) A chapel to the Queens of the West
		(c) Banyan shrine to God Kuvera
		(d) Palmyrah palm to the God Hunters
		(e) Chapel of the Jain asectic Kumbahanda.
III	Four gateways and the city walls	
IV	Traders' shops	
V	Hospital and maternity home	
VI	Two cemeteries	
VII	Traders settlements	
VIII	Agricultural settlements	(a) Abhayavapi (Basavakkulam)
		(b) Camanivapi (Bulankulam)
		(c) Jayavapi (Tissavave)
		(d) Nuvaravava
		(e) Puliyankulam
IX	City workers' settlements	
X	Hunters' Settlements	
XI	Asectic settlements	(a) North of Gamanivapi
		(b) Jain asectic headed by Netiy
		(c) Jain asectic headed by Giri
		(d) Asectics of herstical beliefs
		(e) Wandering Mendicants
		(f) Kjivakas
		(g) Brahmanas

XII	Villas for the ladies and nobles	(a) Stepmother of the King (b) Noble Kalavela (c) Noble Chittaraja
XIII	Streets for commnni-cation	
XIV	Sewers for disposal of waste	
XV	Reservoirs for town and agricultural water supply	(a) Jayavapi (b) Abhayavapi (c) Gaminivapi

Within the walls of the inner city were only the Palace, the administration of the trade centre and a few selected shrines meant for the use of the royal household. All other neelagam buildings were outside the walled city and at a specified distance. 500 dunus (laid down by the Vinaya). Thus there was the inner ring and the outer ring of settlements, Monasteries and shrines with parks and forest reserves filling up the gaps.

The development efforts and the physical planning features of the medieval period of Sri Lanka are not as impressive as those of the earlier periods. This is understandable as the sea fairers in search of trade, adventure and colonial ambitions had by now established beach heads on our south western and north western coasts and were having ideas of favourable trade conquest and domination. The population had divided interests and loyalties. The coastal people were flirting with the foreigners for economic advantage and the highland and inland people were dedicated to supporting a Kingship system with progressively diminishing power and authority.

We, however, find good examples of village developments around a focal shrine. A few good examples of the past 14th Century developments are Ambakka, Lankatilaka, Gadaldeniya, Ratnapura, Uggalalutnuvara and Devinuvara. These vary in size but they all portray the socio-economic development with Buddhist-Hindu mixture of cultural values and a quaint aesthetic quality. 16

The collapse of the Rajarata civilization is attributed to several causes such as the Chola invasion (from South India) which damaged the tanks and dams that formed the infrastructure of this civilization. The disintegration of the administrative and social structure and to the incidence of Malaria. There is no doubt that all or several of these causes contributed to the collapse and sapped the energy of these industrious people. The virulence of the Malaria disease as it first struck the population must necessarily have depleted and weekened the population resulting in mass migration to the Central and Coastal regions in which development occured in the Medieval and Colonial periods that followed. 5.

It is interesting to note that several other agricultural civilizations in South East Asia notably in Cambodia, Northern Siam and the dry zone areas of Burma rose and fell over the same period in history as the Dry Zone Rajarata civilization of Sri Lanka 4 & 5.

Portuguese and Dutch period and the development that occured during that period.

About 700 A D. Muslim traders had established six settlements and trading posts in Ceylon. One of these was on the West Coast of 'Kolomba' or 'Kolontota' at the mouth of the Kolom Ganga a tributary of the Kelani Gange which is now extinct and said to have entered the sea in the Pettah Bay. 3.

The Portuguese came in 1508 A. D. and set up a garrisoned factory close to the Muslim settlement. The Portuguese chose 'Colombo' for their activities as the shallow favourable bay afforded shelter to their sailing vessels and for the proximity to Kotte the then Capital City and the seat of the Kingdom. They were thus able to have a safe haven for their ships and maintain friendly relations with the King for purposes of trade.

During the Dutch period 1658-1725 foreign trade developed mainly in cinnamon. In and around the parts of Colombo they had organised processing points where the cinnamon was cleaned, refined and packed for export. Cinnamon which was once harvested in its wild state was now being cultivated and the Dutch

carried out considerable development in this region by establishing agricultural settlements and building a system of navigable canals connected to the rivers and a system of arterial roads radiating out of Colombo to facilitate their trade.

The Beira Lake (getting its name from the Dutch Engineer, De Beer who improved it) was a part and perhaps the focal point of the river, canal, lake, system developed by the Dutch. The Beira Lake was an inland harbour for their produce transport vessels.

The British Period and Development Activity.

The major development activity of the British period 1800 to independence in 1947 was in transportation, building of canals. Roads and Railways were undertoken during this period with varying emphasis of each mode of transport during each development period. The main purpose was to facilitate the transport of produce to the ports. This in turn developed trade and commerce and linked the various regions of the country to the Principal parts and also to each other. 1.

The following events are of interest to this study :—

The Colombo/Kandy road was built by the British in the 1820s to facilitate military activity. During this period roads were also constructed from Ambepussa to Kurunegala, Kurunegala to Matale and Matale to Kandy. At this period in history the roads from Colombo to Galle and Matara and the road from Colombo to Mannar and Puttalam and the road to Batticaloa were dirt tracks which could be used by carts only during dry weather. With the success of coffee cultivation these were gradually improved to serve commercial purposes. There was a growing clamour for more and more roads to connect the plantations to main trunk roads and also to provide access between plantations. To find the finance for road building the Government introduced the Roads Ordinance of 1848 whereby each male between the age of 15 and 55 had to perform six days free labour on road construction each year or pay 3 shillings in lieu. A very interesting corruption of the Raja Kariya system — service to the State of the Sinhala Kingdom. The indigenous people called it the body "anga badda" a dehumanizing term meaning a tax for having a

body. It was fashionable to pay 3 shillings in lieu. Earlier it was fashionable to do Raja Kariya vide the village peasantry when people meet 'baharak de' and the peasantry replying 'Raja Kariakata'.

The government introduced export duty in 1856 to enable it to repay the loans raised in London to build the Railways in Ceylon. The Railway line from Colombo to Kandy was completed in 1867.

The development of roads and railways gave employment outside the agricultural sector and gave rise to commercial activity which too increased employment in commercial enterprises. This in turn gave rise to the growth of cities and attracted population from the rural areas. Inspite of the road and railway development inland navigation using canals was still popular and in 1880 as much as 167 miles of canal were in use mainly in the Western and North Western provinces. It is said that 24,000 tons of goods come down from Ratnapura to Kalutara along the Kaluganga annually. Two thirds of these goods were despatched from Kalutara to Colombo along the canals. 1.

During the period 1865 - 1900 road construction made considerable headway and for the first time roads were being conceived as links with railways. By 1925 the Railway and the Road systems were fully developed connecting Jaffna, Batticaloa, Puttalam, Ratnapura, Nuwara Eliya to Colombo. By this time National Development considerations and human settlement problems and agricultural advancement of the remote areas and their access to the transport network came into the picture.

Motor *transportation* came in the 1920s and grew into an industry getting considerable patronage from the plantation sector. By 1930 the number of lorries ammounted to about 2960. They were now competing with the Railway and causing concern. Two Commissions one in 1936 and another in 1948 considered these problems and sections of the railways were scrapped. The 1948 commission recommened that government should encourage both railway and motor transport in the development of Colombo, and the hinterland surrounding it progressed at a pace during

the British period and the produce from the successful coffee plantations in the letter part of the 19th Century brought progress and prosperity to Colombo. About 30 Commercial firms were established for processing, packing and trading the coffee. Roads, Railways and postal services were started and developed. Tea plantations took the place of coffee after the coffee blithe. Rubber and Coconut followed and the commercial prosperity made Colombo the principal city of the island. 1.

The City of Colombo

The unplanned growth of the city and the suburbs of Colombo created problems of health and sanitation and the first attempt at controlled development came in the form of the Housing and Town Improvement Ordinance No. 19 of 1915. 2

The main features of this Bill were :

1 No building was to be erected unless roads existed to service it;

2 No building was to exceed in height the width of the road servicing it;

3 Minimum living room areas were specified with minimum provision for light and ventilation;

4 Open spaces were to be provided in the rear of buildings as a common channel for ventilation between continuous rows of houses.

In 1921 the first serious attempt at a comprehensive city plan was drafted by Patrick Geddes one of the earliest British Planners, who after considerable experience of work on Indian cities, drew up his planning scheme for the *'Greater Colombo'*. His concept was that of a Garden City preserving the rural spirit in the grandeur of a metropolitan development. A city catering for the concentration of functions that occur in a City. An artificial graving dock for the repair of ships situated in the low-lying reaches of Colombo with an excess canal to the Harbour. The Galle Face promanade and a marine drive, Zoological Gardens, a Marine Acquarium, a Horticultural Society and a Museum were planned. 2.

The next attempt at a planning study of Colombo was made by Lanchester who came here in the late 20s. He did a limited study of the Reclamation of the lands around the lake. His recommendations were implemented.

In 1938 Mr. Oliver Weerasinghe, Architect and Town Planner started the Town Planning Division of the Department of Local Government. On his recommendation in 1939 the Colombo Municipality got down Prof. Clifford Holiday to study the Planning problems of the City. He presented his proposal in a memorandum entitled 'City of Colombo Memorandum on Town Planning'.

It is apparent that this was a prelude to the establishment of the Town and Country Department the establishment of which was one of his chief recommendations. In this memorandum he stated the rules, aims and method of town planning, which were later incorporated in the Town and Country Planning Act. No. 13 of 1946.

The Department so established in 1946 with a small staff and meagre resources started to prepare the outlines for the physical planning of Ceylonese towns.

Foremost in their list was a study of the Physical Planning problems of the City of Colombo For this task they obtained the services of Sir Patrick Abercrombie in 1948.

The Abercrombie-Weerasinghe proposals for the Regional Plan of Colombo followed. This proposal covered an area of approximately 220 square miles with the City of Colombo as the focus. It extended up to Ja-ela to the North, Moratuwa to the South 14 miles inland to the East and had the Coastline as the Western boundary. 2.

There were five major proposals in this Regional Plan.

1 To resettle about 7,000 working class families and 2,000 middle class families who cannot be provided with accommodation in the city. This movement will account for about 100,000 people for whom accommodation is to be found in the Region.

2 To develop three new towns, those of Ragama to the north, Ratmalana to the South and Homagama to the east of the city respectively, as satellites to the central urban mass of Colombo, but independent as regards employment. Each town is to accommodate about 35,000 people.

3 To decentralise certain government departments industries, institutions from the city to these satellite towns and the Region.

4 Regional zoning into, urban, semi-urban, satellite town and rural areas in order that appropriate regulations may be framed under Town and Country Ordinance to control the disposal and use of land in each zone, and to secure that uniform action throughout the Region is taken particularly to prevent a straggling growth taking place in the semi-urban zones and in the neighbourhood of the new towns. In the urban zone is found high building and mixed uses so that restrictions are urgent. In the semi-urban zone, it is necessary to avoid the evils of haphazard building development. In the rural zone of villages, gardens, agricultural lands and shrub the aim is to preserve the amenities of the countryside and integrate this area to a regional planning authority.

5 The planning and reservation of land for the construction of a 'ring-road' within a distance about 12 miles from Colombo.

General Policy and Planning Schemes

The policy in this proposal was to carry out planned development of satellite towns within the Region to accommodate the overflow people from crowded city areas. Secondly, to plan new towns, expansion of small towns, housing estates and co-operative housing schemes in the Region. An experiment in this respect is the development of Ratmalana, Ragama and Homagama.

It is interesting to contemplate why the Abercrombie-Weerasinghe proposal for the Colombo Regional Plan was not fully implemented. Was it a lack of Political and Administrative

will, or was it that the moving of people with residential and commercial interests in the City itself into Satellites was impracticable? What is evident however is a natural spread of the population into these suburban areas with insufficient planning controls for their healthy development.

The Greater Colombo area Development proposals are now being prepared by the Physical Planning division of the Ministry of Local Government (The Successor to the former Department of Town & Country Planning) with United Nations Development aid, in the form of, a Team of experts on many developoment aspects. It is to be hoped that this team of local and foreign planners co-ordinated by Prof. Neville Gunaratne will take these lessons and experience of history into consideration.

Development & Planning

The first stage in the direction of post Independence development planning occured in 1963 with the establishment of the Planning Secretariat. It consisted of a small group of Economists with a senior Civil Servant as its head. Mr. Godfrey Gunatilleke whose talk I use as referenee here describes the function of this Planning Secretariat as a decorative element of the cabinet to which it was then attached and its activities peripheral and marginal. 7.

One could not even in retrospect expected it to have a more dynamic impact on the government or the people of the time. We in Ceylon were then well off, with a population of 8.3 million. External assets of 1000 million at that period of time. Our Tea, Rubber and Coconut export prices were good and our Rupee was about 4/70 to the U. S. Dollar, Rs. 1/20 to the Deutsch Mark, Rs. 8/13 to the Japanese Yen and Rs. 13/30 to the British Pound Sterling.

The first economic planning document came out in 1954 and it was called the *'Six Year Programme of Investment'* The Ceylon Government was inspired by the first Five Year Plan of Investment of the Indian Government and ordered the preparation of a similar document.

This document projected the Government investment programme over the period 1955 to 1960 giving in detail the projects and the schemes it intended to finance. Although it lacked the sophistication of analytical studies of the economy and its growth pattern, it was the first attempt to take a forward look and make a projection of Government expenditure on development. With this the economic planners came into the forefront and were being consulted and took a part in decision-making. However by the time this plan was printed and made available for public scrutiny a new Government came into power in 1956.

This Government took a greater interest in planning and set up the National Planning Council and the Planning Secretariat to prepare the Ten Year Plan. The Planning organisation was expanded for this purpose and it now had people with expertise in different specialized sectors. The National Planning Council and the Planning Secretariat functioned till 1960 when it was made into the National Planning Department under the Prime Minister. This Department was then asked to produce the three year implementation programme which really carried forward the work of the Ten Year Plan in a short-term Programme. This came out in 1962. With the change of Government in 1965 the Ministry of Planning and Economic Affairs was set up under the Prime Minister. This position remained unchanged after the change of Government in 1970 except for the emphasis given to employment by naming it the Ministry of Planning & Employment and, also the transfer of the Department of Census and Statistics from the Ministry of Finance to the Minister of Planning. 6.

The present Five Year Plan came out in 1971. The Ministry of Planning today is a very august body which employs persons with training in many specialized disciplines including Engineering and Physical Planning. This is an indication of the emphasis laid on the application of Science and Technology alongside Economics and Sociology in the development of the whole country.

Both the Ten Year Plan which came out in 1964 and the current Five Year Plan of 1971 are excellent documents which

have analysed and taken into account the socio-economic situation of the country and chartered a course of development and programme of expenditure keeping the factors of employment, generation foremost and foreign expenditure under very strict control. One could say that the current Five Year Plan is more geared to implementation than the earlier Ten Year Plan or the still earlier Six Year Plan.

The overall economic policies of the current Five Year Plan 1972-76 aimed at improving the quality of life of the people. Its main recommendations are summarized in the Colombo Master Plan Project working paper W. P. 19 as follows:- 15.

1 To carry through the structural changes in the economy necessary for long-term growth.

2 To implement the short-term measures necessary to correct the major imbalances in the economy in respect of the balance of payments and unemployment.

3 To eliminate the social tensions by the curtailment of wasteful consumption and by income redistribution.

4 To raise living standards of low income groups by improving housing facilities, sanitary facilities, and the nutritional standards.

5 To take measures to regenerate rural society and make it more attractive to the young by modernising agriculture and siting agro-based industries in rural areas.

The main thrust of the Government's policy is towards the creation of jobs through agricultural development where the largest proportion of the 'project' budget' is concentrated.

A Global View of Development:

In a shrinking world with amazingly improved transportation and communication, any Nation taking a good look at itself, should be able to place its problems first in the National context. In the global review one should appreciate the regional position of one's own country and the socio-economic forces that are evolving continously.

"Today the world divides most naturally into three sectors, which may be called the Capitalist, Socialist and former Colonial sectors, now rapidly becoming a neutral block of States no longer part of the 'Free World'. In this context our partnership in the Non-Aligned Movement is very significant.

The Capitalist world has developed industrially and economically drawing its raw materials from the former colonial sector (to which we belong) and exhibited over the last two decades an astonishing industrial growth. 8.

The rent control of this Industrial complex though by no means unified is centered in about fifty great Financial and Industrial Trusts controlled by not very much more than double that number of persons, of which the dominating interests are in the United States.

The Socialist sector is represented by the USSR, a number of East European countries and by China forming one third of the world population. This sector, the members of which have reached different stages on the road to classless Communism are themselves undergoing extremely rapid industrialisation but in contrast to the centralising tendency of the capitalist sector is doing so in a planned manner that raises the industrial production in all areas. In fact they attempt to raise the Industrial and the Agricultural production throughout the country.

This is done naturally by the centrally controlled administration to spread the benefits of production throughout the country and among the whole mass of people. This by itself prevents the over-concentration of people and activities in the cities and wards off the problems of over-crowding and polution.

The 'Habitat' conference organised by the United Nations in June this year, was on Human Settlement and the focus was on over-crowded cities both Western and Eastern. Over built cities with a very high concentration of activity bursting at its seams smothered by polution and creating unsurmountable problems to city adminstrations in coping with the cost of maintenance of the services.

The plight of cities in the former Colonial countries is more pathetic. The crowding into cities is due to growth of population, landlessness and lack of employment in the villages. These cities exhibit a sleek glossy development imitating the western cities in the centre and an outer fringe of ever-increasing blithe and almost inhuman sanitary and living conditions in slums.

A notable absentee at Habitat was China. Was it that she considered that settlement problems in the world today are the direct result of free enterprise?

It was significant that although China was absent at the Habitat Conference and Forum it made a very good impact by running well documented and illustrated China programmes through friends of China organisations, highlighting the extensive development in the remote villages by co-operative efforts, local discussion on and enterprise of the village communities themselves.

With sheer determination, experiment, innovation and a spirit of self-reliance, initial failures lessons learnt from such failures and a firm resolve, they, with no help from the city or sophisticated technical expertise, have built dams, aquaducts, roads, and converted waste land into arable lands. In this China programmes there was no mention of the Cities. It was all rural and village development activity.

The Development of Cities

Cities grew from trading posts and harbours where people from outlying settlements bring produce for exchange and warehousing before shipment. With this type of trading activity increasing in volume a city grows to cater to the numerous services and functions connected with trade, finance, management and anciliary support services of a heterogenous and cosmopolitan population. In their ultimate development they grew into meta-physical exchanges where little or no goods are traded or warehoused but where the philosophy of trade, finance wealth values are discussed and ideas developed. 9.

Much of the problems that afflict large cities emanated from earlier unplanned national development. Development that occured mainly due to the growth of commerce and industry through private enterprise, wherein the national welfare was secondary to private interest. Concentration of development activity in the city created the Urban, Rural imbalance. This attracted people into the cities in search of a better livelihood resulting in over-population, under employment, the growth of slums with all the attendent problems of health, sanitation, environmental deterioration and polution

We could therefore say to plan for tomorrow's healthier and orderly cities we should develop our villages today.

In Sri Lanka we find that the policy of decentralisation and the development measures adopted during the last three decades namely, the restoration of irrigation facilities in the North Central province, the building of new storage reservoirs and the distribution systems such as at Gal Oya and Uda Walawe, the action taken already to divert the river Mahaveli to serve the water-starved, but fertile lands of the North Central province, the shifting of the University to Peradeniya (now one of the five Campuses of the University of Sri Lanka), the distribution of Health and Education facilities in the form of schools and hospitals in the districts and also rural electrification has reduced the rate of urbanisation. In fact there is evidence that in recent times these counter magnets have drawn youth from the city to these parts where development is occuring.

Environment and Natural Resources : 11

Concern about the environ is recent. Action to manage the environment in a unified manner is hardly a decade old in most countries.

Environmental management consists broadly of:-

(a) Polution Control

(b) Resource Utilisation and Conservation

(c) Landscape Preservation

(a) Polution is of land, air, water and sound. In the industrialised West air and water polution are their main concern. In Sri Lanka, due to low industrialisation and the low use of motor vehicle air polution though present in cities and around certain factories such as cement and flour milling, is not a great problem. 11.

Land and water polution is our main concern. Much of it is due to under development and often to lack of enforcement of laws and regulations by the authorities. Land and water are both poluted with fecal matter, household waste. Polution from agro-chemicals, fertiliser, leaching and industry are not very noticeable except in a few instances as the paper factory at Valaichenai. Use of the stream and river beds and beaches for defication and ablution has grown into our people It is a habit that will be difficult to eradicate. It has however to be done as a matter of urgency as besides its adverse effects on tourism, it is creating a major health hazard. A larger percentage of beds in our hospitals are occupied by persons ,with bowel, intestinal and liver diseases caused by use of poluted water and infected food. This is a drain on our hard pressed health services and affects our manpower.

Sound polution is not of great concern yet.

(b) Resource utilisation and Conservation is of vital concern to us as in any other national economy. It is the base for any and all development. The report of the sub-committee on Environmental Management in Sri Lanka appointed by the Ministry of Planning and Employment lists our natural resources as :—

1. Soil
2. Water
3. Energy
4. Forests
5. Faun and Flora
6. Living Aquatic Resources
7. Minerals

While these are resources to be used and conserved we have a positive advantage being an island country with a natural sea front as invialable and undisputable boundaries. Our geographical location in the tropical waters of the Indian Ocean is of great advantage. Let us take stock of these resources.

Regarding Soil – I could do no better than quote from the Sub Committee report "The most important use of soil as a resource is in agriculture." The economy of Sri Lanka is still largely agricultural. A large part of the gross national product and nine-tenths of the foreign exchange earnings are obtained from agriculture. Sound information of the nature, extent and distribution of the socils and their management for optimum crop production is, therefore of utmost importance. 11.

Water - It is estimated that we get 6.25 feet average of water falling on this island annually. The highest global precipitation is a little over 8 feet. We therefore have much more than the global average. Storage, control, utilisation and the management of this resource in which we are richly endowed is vital to our economic development and well being.

In the eyes of people from water scarce parts of the world, we as a country misuse and waste this precious resource. Recent droughts and water cuts have made us acutely aware of this. Let us not forget this lesson and let us learn to conserve our water and keep it free from polution. Many countries have moved fast during recent times to reduce and eventually eliminate polution of their water bodies.

In U. S. A. a new permit program was brought in by the Federal Government in 1972. It is administered by the Environment Protection Agency E. P. A. The E. P. A. is required to establish national affluent limitations and national performance standards for sources of water polution including, factories, power plants, sewarage treatment plants and animal feed lots. An affluent limitation is the maximum amount of pollutant that any one may discharge into a water body.

This law requires industries to use the 'best practicable' technology to control water polution by July 1 1977 and the best available by July 1983.

Secondary treatment of sewage using the biological process is a must. Upto 90 percent of the organic matter in sewage is removed by making use of the bacteria in it. The principal methods are by filter, in which the waste passes through a thick

bed of stones and by the activated sludge process, wherein organic matter, pumped into ariation tank is broken down by the addition of air and bacteria-laden sludge. The solids are removed to a sedimentation tank and the affluent is chlorinated.

Considering the deterioration of the quality of water in our water bodies and the resultant damage to the health and well being of the population, it has caused, we need to review our laws for prevention of polution and bring in a new and effective set of regulations on a national scale making it mandatory for all local bodies, corporations and private companies as well as individuals to conform.

Storage, conservation, utilisation and management of our water resources was the backbone of the Rajarata Civilization – – it is so new and it will be the primary factor in any development strategy of the future.

Energy

Energy is essential for national development. Without energy, one cannot plan for the surplus production needed for development. Most of the machinery and equipment developed to assist man in production are those that consume the fast diminishing non-renewable store of fossil fuels in the world. Hydro-power is the next source of energy available to us It is renewable but limited. It is not yet fully developed. In Sri Lanka upto date we have developed only about 300 MW of power out of a possible 1500 MW. Our major power resource at present and for many more years to come will be the hydro-potential of our rivers. Power studies conducted on the power potential of these rivers, namely; Mahaveli, Kelani, Walawe, Kala, Gin, Nilwala and Maha Oya give this potential as between 1,500 - 1,800 MW. We have therefore still a long way to go in the exploitation of this resource as 60 to 75% of the potential is yet to be developed. 11.

The world is fast moving into the production of nuclear energy. The production of this needs highly sophisticated technology and is beyond the capability both technically and financially of small nations like Sri Lanka. Further the risks of accidents and the irreparable damage it could cause to the

environment is now being increasingly pressed the world over as a lobby against the development of nuclear energy. The world over people are now turning to the other known but yet largely unexploited sources of Energy, Solar, Wind, Tidal, Geothermal and Bio-gas. More and more funds are directed towards research in these fields. Of these solar as a limitless resource is the most challenging. Most of the serious research into solar energy in the world is not more than a few years old. Bio-conversion of solar energy is one of the fields into which research is directed. It is said that a hundred years ago 90% of the commercial energy consumed by the United States came from firewood. Today 90% of the people in the poor countries such as ours use firewood for cooking and heating. Trees are still the best known converters of solar energy. At a recent Seminar on Energy, Dr. Devanadan of the Tea Research Institute worked out the figures of cost of the production of alcohol from wood, suitable for use as a motor fuel in place of petrol and showed the cost comparable to the prices we pay now for petrol. There are projects in the U. S. to produce energy from agricultural waste and garbage. Some of these are already operating tn Baltimore. This plant is said to provide much of the heating needed in the city centre. Saudi Arabia and a number of Arab countries with oil wealth are making massive investments on the harnessing of solar energy. They hope to make the desert bloom with this energy source. 12. 13.

The governments of Niger, Mauritania, Senegal and Upper Volta are operating solar pumps in an attempt to stem desert encroachment.

The reliance on solar as the energy of the future is such that some feel that with a world energy policy the poverty of the global South could be soon overcome by exploiting the greater solar flux in this region with the technology of the North and this development could help both the under-developed global South as well as the industrial global North. 12. 13.

A village energy centre is being established in Hambantota in Sri Lanka as a pilot projecet for the South East Asian Region with United Nations assistance Perhaps this is our opportunity in Sri Lanka to make the fullest use of this not only to exploit

the results of this research but also to use this project as a prototype and develop, similar projects at other locations with the objective of accelerating Science and Technical Education throughout the country. What better opportunity have we, to get our youth enthused in Science & Technology, than this which is both village-based as well as future oriented and evolving.

Perhaps we should within the next year have a national debate on many forums on an Energy Policy for Sri Lanka. *Any development plan of the future should make a statement on Energy and base much of its strategy on such a declared Energy Policy*

Forests, Flora & Fauna

We have in the past thoughtlessly denuded our forests in a mad rush of slash and burn clearings for chena cultivation. This was encouraged in the name of a food drive. We are now sader and wiser. Recent occurances of droughts, sudden showers, flash floods and quick run-off with soil erosion have brought us to this realisation. Forests serve as the first reservoir of the water that falls on the land due to precipitation. The area now under forests is said to be 9%. Whatever should be the proper percentage area that should go into strict reserve the present 9% appears to be alarmingly low. We need a deeper multidisciplinary study not only to work out the actual are a that should remain as forest cover but also to decide the precise distribution of forests over the island to yield the maximum benefit.

Plants, animal and man are ecologically inter-dependent. Man as the conscious moulder of the natural environment into the built environment where human settlements occur has to take the responsibility, to maintain the ecological balance. As the world population goes on increasing exponentially, man has to take the management of the built as well as the natural environment more seriously as with this growth of population which is doubling itself in increasingly shorter periods, (the next doubling will be in 25 years,) it is now a matter of maintaining the balance in the interest of human ecology.

The natural environment on the cradle of man is what man needs to maintain his mental equilibrium. The built environment and the human interaction that occurs within it, its complexity and pace, taxes his brains and takes toll of his nervous and digestive systems very fast. In such states of stress man needs to return to the natural environment to regain his mental balance and to sooth his nerves Our holiday resorts are in natural settings – – by the sea with inviting beaches In the hill country with forests, flowing streams and gushing waterfalls, in jungles where the flora and the fauna are yet unaffected by man, and where he was once only a part of the ecosystem and not its controller.

This appreciation of the natural environment is reflected in our desire for landscaping and the introduction into the built environment of the spirit of the natural environment often expressed in terms of plants, rockeries, sand streches, flowing waters, animals birds and fish.

As human settlement tend to cluster together and get more and more removed from the natural environment, we find the need to get our children to appreciate the inter-dependence of man, plant and animal. This plus our need to be soothed in and vested in unspoiled nature, drives us to create nature reserves between human settlements. Reserves which are allowed to grow into natural forest that provide the habitat for animal and bird.

Fish as a Source of Food:

As the pressure increases for production of food particularly proteins of which the populations of most poor countries are deficient, people turn to fish as a major source of protein supply. Our geographic location giving us a long coast line with coral reefs and quite a few fishing harbours make our potential in this resource considerable. 11.

The shallow lagoons, saline marshes and the mangrove swamps of our coastal belt provide ideal breeding grounds for prawns and crab. Our lagoons and estuaries are also the

breeding ground of an abundant supply of highly edible fish. Their exploitation however has been hitherto unplanned with no thought or programme for conservation.

Aqua culture is the technology of fish breeding conservation and exploitation. As we now fish in our lagoons and brackish water marshes flats, lagoons and estuaries, we harvest the fully grown, the partially grown and the small fish with no concern about breeding or selection of the size we catch. The technology of breeding, batching, and harvesting only the fully grown specimens is known and much more research is now being done in improving the techniques in this field, We will soon have to adopt these techniques of aquaculture and conserve this resource with breeding and selective harvesting.

Fresh water fish in the newly cultivated breeds such as Tilapia, Carp, and Giant Gouramy have now multiplied in our waters and provide a very good course of edible fish. Some prejudice still exists towards fresh water fish in favour of sea fish, but these cultivated varieties now easily available inland in its fresh state is fast becoming an acceptable item of food. The breeding of fry in the paddy fields is another form of fish supply that is now being cultivated. This is said to serve a useful purpose in the early growth of the paddy plant as well as being an item of food in itself. We will have to depend more and more on our inland fresh water fisheries in the future to supplement the supply from the sea.

Minerals :

We are not by any means a minerally rich country. At least we do not depend very largely on income from our mineral resources. Yet we need to survey exploit and improve our methods of entration and refining and also in the case of mineral sands and lime stone adopt conservation methods to ward off the ill-effects of coastal erosion. Our main mineral resources are, graphite, limestone, beach sands, clay, vein quartz, silica sands, feldspar, mica, rock aggregate and sand for construction.

Housing & National Development:

Housing occupies a cardinal position in National Development. It is one of the major concerns of physical planning. In Sri Lanka the housing problem is viewed sectorally.

- ☐ Urban
- ☐ Plantation
- ☐ Rural

They have all to be considered as settlement problems and their solution should be guided by national considerations in the first place and sectoral considerations should come next.

The current urban rural balance in Sri Lanka is not too bad. Our latest figures shows only 23% of the population in the urban sector. The projection for the year 2001 is 30%.

No one has defined what the correet urban rural balance should be for any particular socio-economic setting. All we know is the higher the urban concentration the sicker is that society. The high urban concentration was hitherto a phenomena in industrially developed countries. It is now becoming a phenomena in developing countries as well

In 1950 there were 50 cities with over a million inhabitants each totalling 130 million in the developed regions of the world and only 25 cities of the same order with an aggregate population of 50 million in the developing regions.

Current projections show that by 1985 there will be 126 such cities with 340 million population in the developed world and 147 such cities with a total population of 465 million in the developing world It is going to be a very sick world.

I quote these figures purely to show that our population concentration in the urbon areas now and the projection for the immediate future are not too bad. Let us however not forget the fact that our cities are in a crisis. In Colombo the sewers are at bursting point. The water supply is insufficient, the waste disposal systems are breaking down and the health of the population is already affected. Unemployment and underemployed

are rampant and 50% of our city population does not get sufficient food. However, we need to take meaningful steps now to exploit this favourable urban rural situation in the interest of balanced development.

Rural Housing

Rural housing is not very much of a problem as the cost and the technique of construction fit into the socio-economic and cultural setting of the community. The problems we have to address our minds to in this sector are environmental sanitation with simple systems for disposal of human and household waste, proper soil drainage and the encouragement of improved traditional building. The cadjan roofed hut with wattle and daub, sun dried brick, or brick in mud walls are environmentally suitable. This can be added on to improve on or demolished with no great cost or loss. This is because all the labour and material inputs are village based.

We however need planning guidance at village level, and this should be an integrated exercise which will give them, the basic knowledge in building simply, with elementary sanitary facilities. What is of utmost importance is the creation of an awareness in these rural folk of social hygiene and its unseen benefits in improved individual and community health and agricultural and industrial production.

The infrastructural development needed in the rural areas is small, yet this has to be well thought out in the interest of a sustained and healthy growth.

Integrated planning guidance has been lacking in the past in our settlements. We learn from experience. In the planning of these settlements in the past, Architects and Planners, and the Health Officer did not participate. It was mainly an Irrigation Engineer's and Surveyor's exercise. As we now plan the Human Settlements in the plains watered by our river valley projects, let us integrate this planning process and bring together under a single envirnmental development officer, the physical planning method, the health standards and the Civil and Sanitary engineering action and guidance.

Urban Housing & Regional Planning :

Urban housing due to its great concentration in limited areas creates more complex problems than in the rural setting. In fact the greater the concentration and density the more acute is the problem. The solutions are two-fold.

One curative is through detailed study and an almost surgical operation in clearing, renewing and revitalising areas of blithe through action planning and complete renewal of the infrastructure consisting of roads, drains, human and household waste disposal systems creating of large green areas, play areas, marketing and utility services and then providing high density housing to suit the situation.

The second is by preventative action in the fast growing areas whereby timely introduction of planning method controls you provide environmentally desirable and essential features.

In the Urban setting *land is the all pervading problem.* In the development race infrastructural development by public action, puts up land prices and as the developer and the speculator chases after scarce city land, up goes the prices, and compensation to be paid for land acquisition for further infrastructural development. The vicious chain that leaves city administrations poverty stricken and condeming the cities to eventual environmental decay and obsolescence.

We are conscious of the number of laws brought in to the Statute by the Minister of Housing & Construction during the last few years to curb the actions of the speculator and the Landlords in the sphere of housing property and land for house building. This by itself is not sufficient, in fact it can in time affect the urban environment adversely if they are not followed by a very broad policy on urban land where land use dictated by physical planning considerations can be predetermined and frozen for such purposes as are in the best interest of the community.

How else can city corporations or specially constituted development authorities for urban areas carry out the purposes or intentions of the best laid out physical plans.

This problem of land is the one that plagues all city corporations. Land for open spaces, land for green areas, land for children's parks and play areas, and nature reserves cannot be paid for at building land prices. Many strategies such as the creation of land banks through which the price at which the land is purchased and the price at which it is leased or sold for use are controlled so as to relieve hardships to both the vendor and the genuine developer, conforming to planning controls have been tried in different countries and situations. What is needed is an effective means by which land use can be controlled, in the interest of the community without leaving room for runaway inflation, when public action is taken on physical planning proposals.

Conclusion:

Economic planning today is a multi-disciplinary exercise involving a whole host of specialists in various disciplines.

In the Physical planning sphere too a similarly large array of disciplines are mustered together. Some of them being the same as in economic planning. They are both attempting to solve the same problem but from two different angles.

It is therefore very necessary to have greater interaction between these planning bodies. An economic plan drawn up with greater appreciation of physical planning ideals can be ever more dynamic than the one without. Further in such an atmosphere of complimentary activity the physical planning process can be contiguous with the economic planning process.

Most plans fail because they take time to implement. Society is continually changing and unless we speed up plan implementation, our plans will remain on paper more as good intentions than working models.

Planning both Economic and Physical is highly specialised and an extremely sophisticated activity understood and practised by a few intellectual elite. Yet these plans are for people and have to be implemented by the participation of the large mass of people. For plan implementation peoples participation is essential. For peoples participation there must be understanding. Understanding can come only out of communication and dialogue.

The missing link that frustrates plan implementation is therefore this communications gap between this elitist few at the top and the large mass of people who have to implement them.

Sri Lanka literacy rate is 78%. This has a great potential for development. This also shows that the receptivity is there, what we need is effective communications systems, conventional as well as vernacular village based personnel face to face interaction.

We need more discussion of development issues, the type of programme that we conducted this year in Colombo for our own education. This can be taken to other regions, towns and villages and I am sure there will be great response and interest as the survival of the Village and therefore the country depends on the correct understanding of these issues.

Physical Planning when it was first identified as a separate discipline was called Town Planning. The concentration is still on Urban and Metropolitan problems. We mentioned earlier that a world survey revealed that in 1920 only 19% of the world population were in Cities. Now 39% are in Cities and by the turn of the century 51% are expected to be in Cities.

We might very well ask ourselves the question; Where are we heading with all our sophisticated planning, both Economic and Physical ? Should we not reorientate our attitudes to face the village, understand the villagers and their aspirations ? Should we not therefore learn the language of the village and go down to the village with simple planning models both physical and economic ?

What we need therefore are another generation of planners let's call them Development Planning Officers not of the highly specialised sort in the two centres of planning, but general practitioners who will know the planning method and understand the strategies in the master plan; and apply them to the regions and areas in which they work. This person will also serve to feed back to the top the experienced gained at the Village level.

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CHIEF GUEST'S ADDRESS

ACTION PLANNING IN SRI LANKA

by

OTTO KOENIGSBERGER

Planning is many things to many men. It is a way of thinking, a skill, an art, a profession, a discipline and above all, an applied science. To be precise, one should perhaps say: planning is the application of many sciences - natural, engineering, biological and social sciences - to the efficient management of change and the improvement of the human environment.

Unfortunately, as an applied science, planning is still far behind the physical, engineering and biological sciences:

— our mechanical sciences have advanced far enough to send missiles to the Moon or Mars, while our planning science is still far from solving the traffic problems of our great cities;

— We build aircraft that fly faster than sound, but we cannot organise our airports so as to handle a few hundred passengers without discomfort or delay;

— We can accelerate and boost agricultural production, but the problems of distribution are stilll argely unsolved. We still experience shortages and even starvation in one country or province simultaneously with glut in another.

The worst is that time is not on our side The human population of the world is increasing and will continue to increase for many decades. The planner knows that his problems increase in size and complexity while he searches for solutions The cautious academic approach is not for him. He must study, research and learn while he acts.

If he has to act - or advise on decisions in a poor country, he, or rather his country cannot afford mistakes, neither can it

afford to wait until an ideal solution has been found. This formidable dilemma is seldom appreciated by the critics of the profession.

As planning is an applied science, planning approaches and methods must be determined by planning goals and objectives.

In developed countries, the objectives of planning are not always stated explicitly. Goals such as conservation, the protection of the physical and economic environment, the fair distribution of scarce resources such as land or water, greater equity in the distribution of the fruits of development and a few other objectives of this type are so much taken for granted that they are rarely spelled out in Western plans.

In developing countries, on the other hand, the purpose of a plan and with it the task of the planner is normally much more clearly circumscribed. It is the full development of a country's (region's city's, locality's) physical and human resources. This it usually presumed to include specifically stated subsidiary goals, such as improved distribution, greater equality of opportunity and enhancement of the quality of life for hitherto disadvantaged sections of the population.

If the purpose of planning is development, the first question must be: who is the developer? The nature of the planner's task will vary substantially with the answer to this question- He must know whether his plans are to be implemented by a host of private developers or by a few powerful public sector agencies. In the first case, the planner can influence development only indirectly through attempts to control or stimulate the actions of private investors. In the second, his influence can be much more direct through the guidance of public investment and the co-ordination of the development strategies of government departments and public development agencies. In other words, the nature of development planing must fit the political character of the country for which it is intended. In a purely capitalist country, it will consist mainly of "masterplans" or "development plans" intended as a basis for the control of private investment. In purely socialist economies, it will be a matter of "action plans" to guide the actions of public sector developers.

Few countries, if any, are purely capitalist with zero public sector investment in development or purely socialist with no private development activity whatsoever. Most countries have

mixed economies and therefore need a mixture of control planning (master planning) and action planning. Determining the mixture is an essential prerequisite for the adoption of a particular planning system such as the choice of the right planning methods.

Table I is an attempt to facilitate this task. It contains a sample of 20 countries ordered acccording to the division of development initiative between the public and private sectors of the economy. It begins with the People's Republic of China where the role of individual private investors is negligible and ends with Switzerland where public sector development is strictly confined to infrastructure investment. Between these two extremes are 18 countries with mixed economies according to the declining role of the public sector as developer and the increasing private sector development monopoly. The countries at the top of the scale need mainly "action planning" and very little "control planning". The reverse is true for those nearer the bottom. The countries in the middle need a good dose of both.

Table I

Twenty Countries ordered According to Percentage of Public Sector Leadership in Development

1.	China (People's Republic)
2.	Romania
3.	Poland
4	Yugoslavia
5.	Mozambique
6.	Sri Lanka
7.	Zambia
8.	Ghana
9.	Singapore
10.	Syria
11.	Egypt
12.	Mexico
13.	Upper Volta
14.	Malta
15.	Somalia
16.	Israel
17.	Bangladesh
18	U. K.
19.	U. S. A.
20.	Switzerland

Table II

The same Twenty Countries in Order of Poverty (GNP Per Capita)

1.	Upper Volta
2.	Somalia
3.	Bangladesh
4.	Sri Lanka
5.	China (People's Republic)
6.	Egypt
7.	Mozambique
8.	Syria
9.	Ghana
10.	Zambia
11.	Yugoslavia
12.	Mexico
13.	Malta
14.	Singapore
15.	Romania
16.	Poland
17.	Israel
18.	U K,
19.	Switzerland
20.	U. S. A.

*Table 1 is based on "guesstimates" of the author. It is hoped that its publication in this rough form will stimulate the World Bank or other centres concerned with comparative economic studies to calculate the public/private sector ratios in development initiative more exactly and for a larger number of countries.

The choice of the right planning system is assisted further by another scale which is depicted in Table II (placed conveniently next to Table I to facilitate comparison). The same sample of 20 countries is ordered according to their per capita GNP, beginning with Upper Volta, the poorest of the group and ending with USA as the richest **) This juxtaposition shows clearly that the countries that expect most initiative and leadership from their governments are by no means among the richest. Fortunately, they are not among the poorest either.

A very poor country cannot plan. It is in the situation of a very poor person who has to spend all his energies on survival and cannot think much of the future. A very rich country need not plan - or believes it need not plan. Most of its people are doing fine and are averse to change, however efficiently managed. It is the middle income range of countries that must and can plan to make the most of limited resources. SRI LANKA clearly belongs to this middle range. It is in the upper half of the poverty scale (Tabale II) and cannot afford the luxury of a "no-plan economy". The fact that it is fairly high up in Table I indicates that the people of SRI LANKA are conscious of this situation and expect and demand a high degree of planned public sector initiative in development.

What is not equally well understood is the severe restraint which poverty imposes on public sector development activities. If people are poor, their governments are even poorer. There can be poor governments of rich countries, but not rich governments of poor countries. In SRI LANKA and its neighbours on the poverty scale, public sector initiative in development must therefore mean planning for the most effective use of limited public sector resource. Public sector agencies must concentrate on tasks that people cannot do for themselves. In the case of housing - to use a familiar example - this would mean concentration on land acquisition and utilities, but leaving the construction of houses to families, individuals, or voluntary associations of individuals.

SRI LANKA clearly needs much more "Action Planning" than "Control Planning". Yet action planning in SRI LANKA

**Based on the World Bank publication TRENDS IN DEVELOPING OUNTRIES, 1973

means planning for joint development action by the public and private sectors, each doing what it is most fit to do. Control is not redundant, but it can be minimised through vigorous public sector initiative and leadership in development. To paraphrase Jawarhalal Nehru's words at the opening meeting of the Indian Planning Commission in 1950: the task that faces us is immense. It is far too big to be handled by either the public or the private sector alone. Let us not waste time on idealogical debates, but plan for each sector to do what it can do best. For a non – aligned country like SRI LANKA this seems to be as appropriate in 1976 as it was for India in 1950.

SECTION A – MEDICAL AND VETERINARY SCIENCES

VIRUSES, HUMANS AND SOME QUESTIONS OF PHILOSOPHY

by

TISSA VITARANA
(President, Section A)

All of us human are acquainted with viruses, from direct and at times painful experience, if not from newspapers and medical literature. You may wonder what philosophy has got to do with our relation with viruses. No doubt in the absence of any specific treatment for most virus diseases we are compelled to take things philosophically. There is no other course open to us. But does the matter end there? As scientists, not as patients, how do any questions of philosophy arise or concern us?

We all have our own view of the nature of the world and of mankinds' place and destiny in it – our world outlook. A world outlook when it is defined and systematised is a philosophy. The theoretical formulation of such a philosophy is dependent on the application of a method of reasoning or logic to the facts of nature and of human society. As we all know eliciting the facts of nature and of society are the basic objectives of science and logic is itself a science. "Logic is in fact the science of the thought process". Therefore, quite clearly, science influences philosophy just as much as philosophy influences science.

But here it is not my intention to go into the vexed questions of idealist and materialist philosophy; although our very scientific activity itself presupposes the existence of a material world and the question should not arise, there are still some among us who cling to an idealist negation of such a material world. Amongst those who accept the existence of a material world a large number, the great majority in fact, do so in a mechanical way viewing the world as a machine made up of

separate component parts. These components have well defined boundaries and fixed properties by which they are identified and classified. Such a system of classification is common to all science. The motion of these components is largely attributed to external factors, that is to reaction between each other or to some outside agency. But every machine need to be created and this too needs an external agency, a creator. In this way idealism is accommodated in the mechanistic materialism that permitted science to develop and flourish in the last few centuries.

To us scientists what is pertinent is a method of reasoning or logic. And logic as we stated earlier is itself a science- Logicians investigate the thought processes going on in human heads, study their form and inter-relations and formulate the laws of these thought processes. Like all science, logic has not remained static, it has changed and evolved. There have been two main stages in the development of logic, Formal Logic and Dialectics. In fact one may say that Dialectics grew out of Formal Logic and was dependent on it in the same way that Newton's Laws permitted the development of Physics to the point where Einstein's Theory of Relativity became not only applicable but necessary.

Formal Logic was the first great system of scientific knowledge of the thought process and originated with the early Greek thinkers. Aristotle, who "collected, classified, criticised and systematised" this knowledge, may be considered to be the creator of Formal Logic. It has held sway in the realm of thought for over 2000 years and still does so today in everyday life as "common sense". It was Formal Logic that helped to clear the mysticism and superstition of earlier societies and usher in the era of science. And it is on the basis of Formal Logic that modern science has developed to the point where man can master nature. It could be said that Formal Logic has continued to dominate the field of logic even during the philosophical era of Mechanistic Materialism.

FORMAL LOGIC (See Appendix 1)

What then is Formal Logic? In common sense terms it may be summed up as "each thing is what it is and not another

thing". There are three basic Laws of Formal Logic The first and most important is the *Law of Identity* which states that "a thing is always equal to or identical with itself" or in algebraic terms A=A. This law asserts that under all conditions a thing remains one and the same. The smallpox virus is the smallpox virus and nothing else and remains so. The axiom "matter can neither be created nor destroyed" is a corollary to this

The law of Contradiction- this states that one thing is not another i.e. A is not B or as it is better stated, A is not non-A. In reality it excludes difference from a thing e g. A smallpox virus is not an influenza virus or a mumps virus or a human being.

The law of the Excluded Middle- flows from the other two and states that "everything is and must be one or other two mutually exclusive things". So that A is either B or it is not B, it cannot be both – that is, B and not B. The smallpox virus must be either the same as other viruses or be different from them, but it cannot be both at the same time.

These are the fundamental laws on which the rest of formal logic is founded. Without applying them consciously or unconsciously everyday life would be impossible for us. We identify and recognize objects and persons on this basis. In all scientific investigation correct classification depends on the contrasting of likeness with difference. For instance in the field of virology organisms were grouped together on the basis of their similarities and separated on their differences by applying formal logic Though the task is not yet complete, sophisticated tools like the electron microscope and ultracentrifuge have helped in this.

It is basically the Law of Indentity that enables us "to recognise likenesses amidst diversity, permanence and continuity amidst changes, and to uncover the real bonds of unity between them". That is why mankind still continues to act or think in accordance with this basic law enunciated by Aristotle.

Dialectics

Credit is generally given to the German Professor George Hegel (1770 - 1831) for the development of Dialectics, a revolution in logic. In his own words he set out to devise a logic "adequate to the loftly development of the sciences" and necessary "for securing scientific progress".

But it is time that scientific recognition be given to that supreme dialectician from India who lived over 2500 years ago, the Buddha. He gave a dialectical interpretation to world phenomena with emphasis on the mind.

Hegel however was an idealist and it was left to Karl Marx and Friedrich Engels to associate dialectics and materialism. Their main achievement was the application of dialectics to society and social relations.

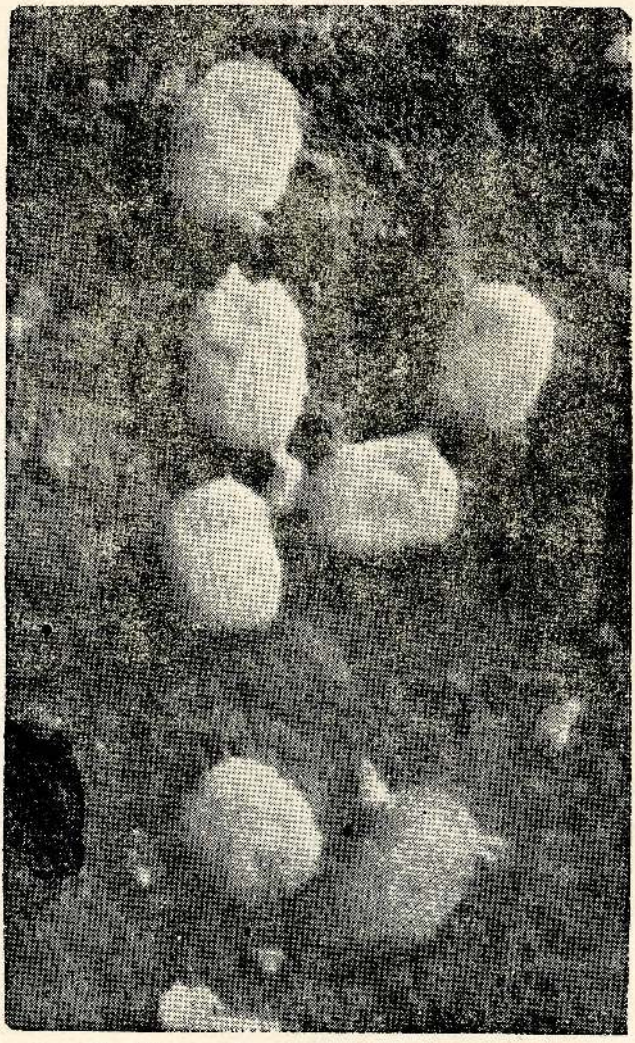
The more important aspects of dialectics have been given in brief point form in the sheet of paper supplied to you (see Appendix 2). Reference to it will be made as we go on.

Viruses and humans

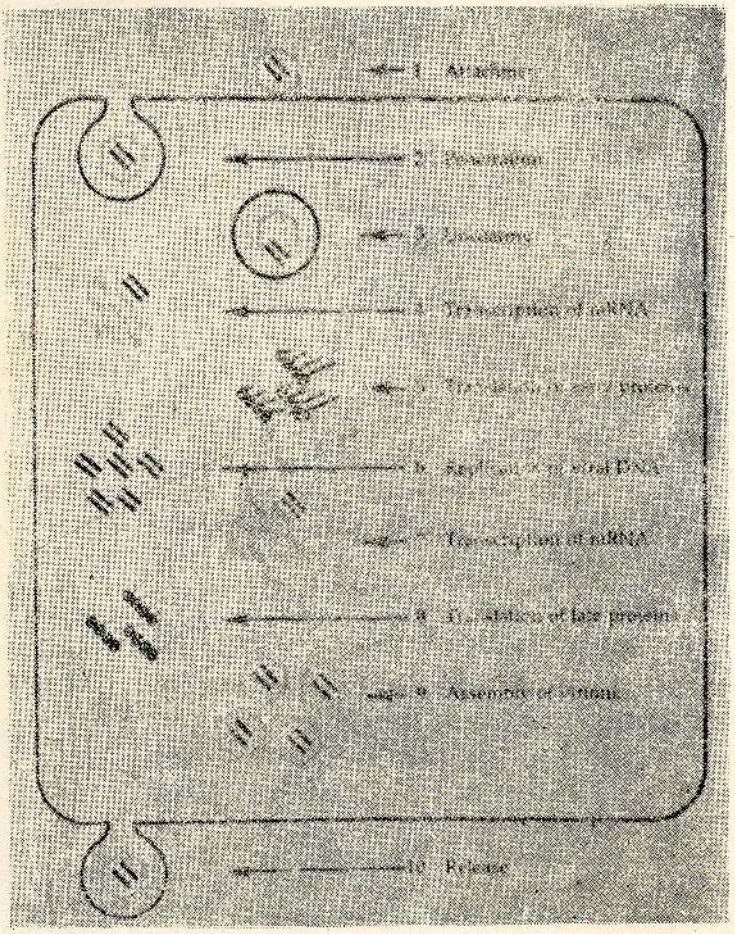
Now let us examine viruses and humans and their interrelations a little carefully to see whether formal logic accords with some of the realities uncovered by science. *Figures 1 and 2* show two easily identifiable and distinct things, a human being suffering from smallpox and the virus responsible whose differences in size as well as structure and function exceeds that between the proverbial elephant and ant. In terms of Formal Logic, one is A and the other B or non-A. But if one were to say that the human made that virus and that every single component of the virus originated in that humans' body and that the virus could not exist without the human many of you may be surprised. But it is true nevertheless, and at once it throws the validity of the Laws of Formal Logic into question.

Figure 3 shows the process of multiplication of such a virus. All that happens is that the virus genetic or hereditary material (the nucleic acid) gets into the human cell, and acting as a template, directs the cell to produce replicas of itself. Unlike

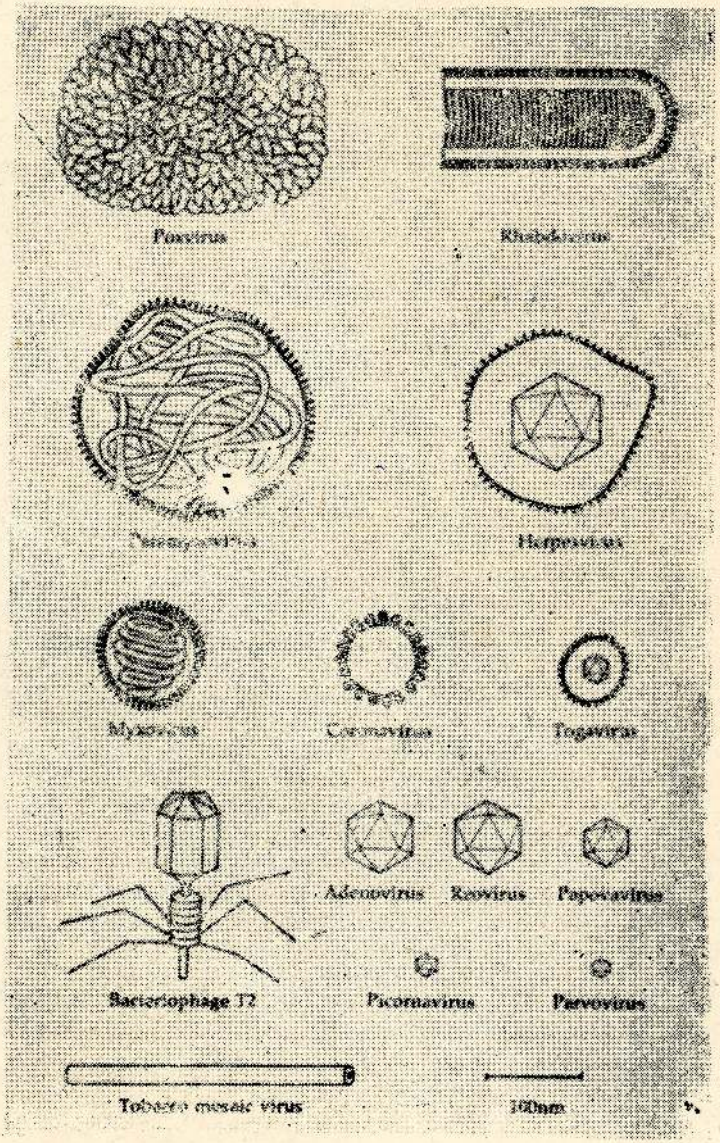
1. Smallpox patient.



2. Smallpox virus (magnified 60,000 times).



3. **Multiplication of a virus in an animal cell – different stages.**



4. **Some viruses–to show differences in size, shape and structure**

with all other living things whether they be bacteria or animals or plants the progeny do not arise by a division of a parent cell into two and so on. In the case of a virus, the whole operation of producing several hundred complete virus particles is performed by the host cell using its own resources. A virus is unable to multiply on its own.

Lest you begin to think that it is that unique creature man playing God, let me assure you that this role is played with equal facility by other animals, by plants and even by bacteria.

Figure 4 gives some indication of the wide variety of viruses that exist. They have been classified on the basis of structure and properties applying Formal Logic. But even where no differences in structure or properties exist, it is still found that there are types of a given virus that differ in the protective immune response they evoke in the host and are therefore called antigenic types.

Thus, there are 4 types of Dengue virus that all produce an identical illness. Similarly, there are 3 antigenic types of Poliovirus. However infection by one type does not protect the person against the other types. But this contradicts the law of contradiction and the other laws of Formal Logic which "exclude difference from a thing". In the case of small pox the difference is of another order. There is only one antigenic type but two varieties of illness, a severe form (Variola major) and a milder form (variole minor).

Then let us look at vaccines themselves. The vaccine against small pox is a live virus, vaccinia, which is antigenically identical with the small pox virus but without its disease producing ability. In fact, it has been one of the most successful vaccines known and should receive a major share of the credit for one of the greatest achievements of medical science that is just being accomplished, the total eradication of the virus of small pox from our world. But why did the health authorities in Britain, for instance, stop its use altogether, not even for primary vaccination, well before small pox was eliminated from this globe? The reason is that there were some deaths every year from vaccination, mainly as a result of encephalitis, and

although small in number it still outweighed the risk from the sudden introduction of small pox into a non-immune population. Here one finds the amazing contradiction of a vaccine of proven value in a disease situation being itself a hazard in a different, non-disease, environment. This example clearly demonstrates three points:

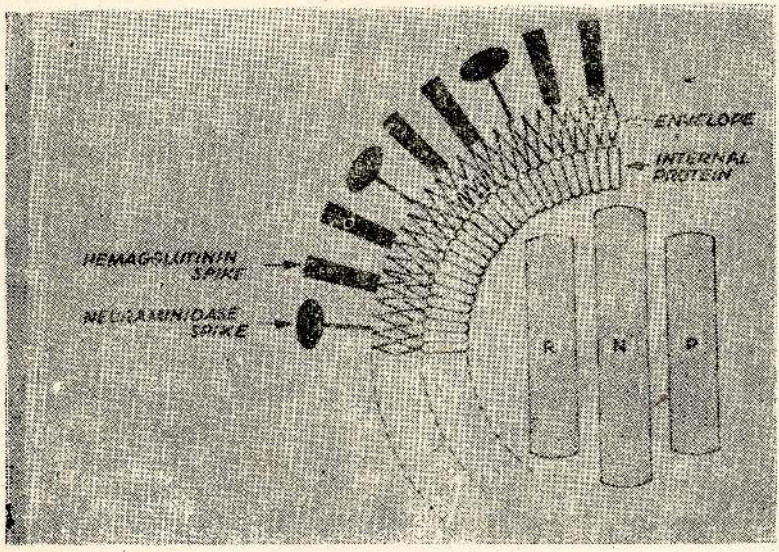
(1) that a thing is not homogeneous and not only has difference within it but also positive and negative aspects, good and bad;

(2) that under certain conditions one aspect may be dominant and under different conditions the other aspect;

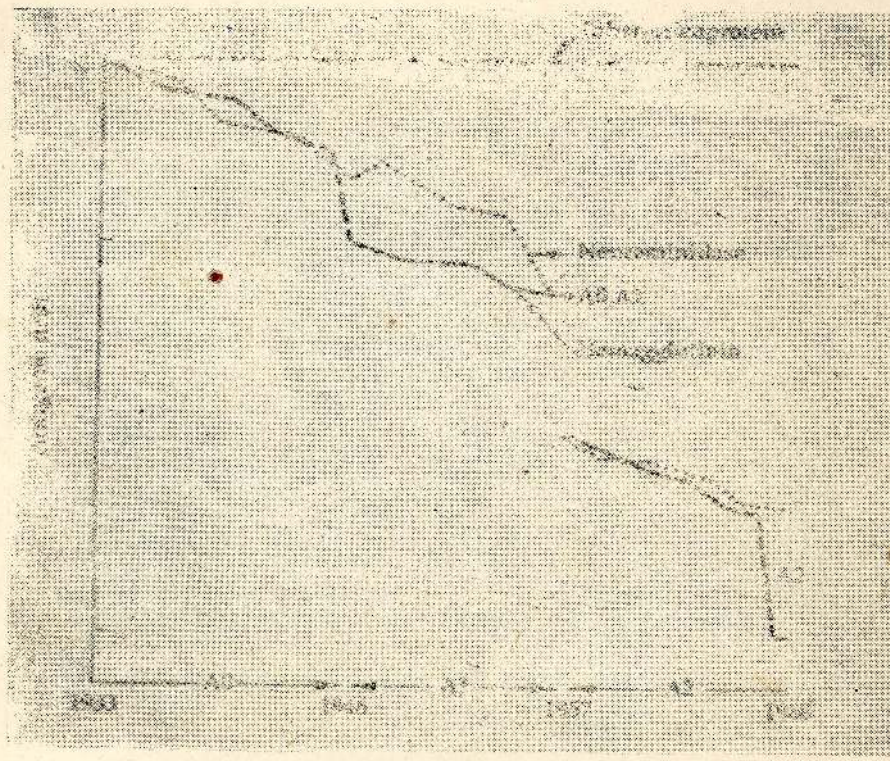
(3) that here we have an instance of a thing, under appropriate conditions turning into its opposite. These are impossible according to Formal Logic but well in harmony with points 6, 8 and 12 of Dialectics (see Appendix 2),

Another live vaccine is that against poliomyelities (Sabin vaccine). It too shows signs of turning into its opposite There is some evidence now that the vaccine virus may cause paralytic disease, epecially the type 3 vaccine strain, in adults, although the risk is very low indeed.

How is this change to virulence of these vaccine viruses brought about. In the case of small pox vaccination, it appears to be a peculiarity of some human hosts and more about this aspect later. But in the case of polio a back-mutation, that is a heritable change in its genetic configuration or nucleic acid, restoring the original virulence is possible. This raises the whole question of genetic change which is contrary to the Laws of Formal Logic which do not permit A to turn into B or for difference to arise in A. This is not mere adaptive change brought about by the environment, which formal logic would permit, but changes in the nucleic acid that pass on from generation, to generation and are therefore stable. In fact, the whole of Darwin's theory of evolution depends on genetic change within the organism with the environment having a selective effect (natural selection). Therefore the process of change or evolution is an



5. Influenza virus – part of cross-section (diagramnostic). R N P = Ribonucleoprotein.



6. Antigenic change of Influenza A virus from 1933 to 1968. There was a marked change of the Hemagglutinin (- - - - -) alone in 1946 and 1968. But in 1957 both hemagglutinin and neuraminidase (.....) changed significantly causing an antigenic "shift". The Ribonucleoprotein antigen has not changed in this period.

internal process occurring within an organism. This is something that formal logic fails to grasp, but is clearly appreciated in point 4 of Dialectics (see Appendix 2).

There is another instance of change in a virus that is of importance to us all and which medical science has not fully understood. This concerns the influenza virus *(see Figure 5)* which is divided into 3 types A, B and C having different inner nucleoprotein antigens. For some reason, influenza virus C remains antigenically stable but the others, specially A show progressive antigenic variation due to changes in the surface antigens the haemagglutinin (H) and / or neuraminidase (N). These variations are of two types *(see Figure 6)*.

(1) a gradual minimal change usually involving one surface antigen referred to as antigenic 'drift', which may occur even once a year e.g. the Hong Kong ($H_3 N_2$) sub type of Influenza A showed 3 variants in 3 successive years (1971, 72, 73), and

(2) a sudden major antigenic change, usually involving both surface antigens H and N, called an antigenic "*shift*". The former may be a result of a mutation or of a re-arrangement of surface antigens and leads to minor epidemics. The latter 'shift' is too extensive to be explained in this way and is believed to be a result of an exchange of nucleic acid (recombination) between human and animal influenza A viruses when they infect the same cell. An alternative explanation is that it is entirely due to infection of a human being by an animal virus. Whatever the true explanation may be the outcome is that a 'shift' occurs about once in 10 years and is accompanied by a major worldwide epidemic or pandemic. It was the fear of a repetition of the 1918 pandemic which was thought to be due an influenza virus related to a swine virus, and which killed more people in a few months than died in the entire first World War, that led to the vaccination of the entire population of the USA earlier this year. This measure appears to have been successful so far in preventing the spread of this new influenza virus that was first detected in the USA.

Here we have witnessed not only the existence of several different variants of one virus, the influenza virus, but its tendency to rapidly change into new forms and these new forms tend to displace the older forms from the community. In fact no sooner does the community develop immunity to one virus another replaces it – a type of natural selection. They all produce the same clinical illness, influenza, but the greater the antigenic change in the virus the greater the severity of the illness and the more its spread in the community. These phenomena clearly contradict all the laws of Formal Logic. But in terms of dialectics this is easily understood (e.g. points 1 2, 3 and 6 in Appendix 2). Here the influenza virus is not viewed as something static with well-defined fixed properties but rather as a changing process. It is not viewed in isolation but in relation to other things, and here to humans in particular, and then not to one human but to human beings in general. In fact, this relationship is itself a changing process with one acting on the other as we have seen. In this interaction the virus which is the parasite, and the human, the host, are fundamental opposites (point 8 in Appendix 2) and further there is a unity of these opposites (point 9 in the sheet). They can be fully understood together only in terms of their inter-relations.

Dynamics of disease due to Viruses

Let us now consider the production of disease by a virus. According to the Germ Theory, disease is a result of such a virus entering the human body If no virus enters then there is no disease. This seems to fit the laws of Formal Logic very well. However, if a rabid dog bites one of us and saliva enters the body will that person invariably get rabies. The answer is no. In fact on an average there is only a 20% chance of that person getting this disease or in other words, if 10 people are bitten 8 will not get rabies even if they are given just distilled water as a prophylactic. When one remembers that quite a few bites are due to dogs that are not rabid, one can see the profitable possibilities open to a person who claims to cure the disease. This is because the lay public, on the basis of common sense or Formal Logic, assumes that everone who is bitten by a rabid dog will get rabies

The question that immediately arises is can one virus produce disease or are a million necessary? In fact it is not an all or none (quantal) relationship but a quantitative one. For a particular virus with a known virulence and a group of people or animals with a known susceptibility to infection one can determine the minimal quantity of virus that will produce disease e.g. a million. In practice, it is found to vary widely in nature. Why is this?

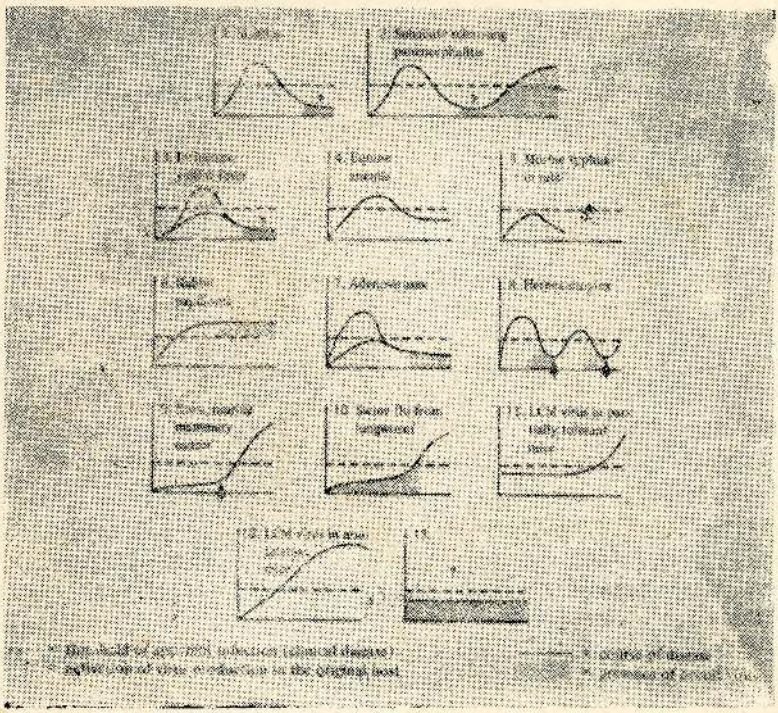
There are a very large number of variables involved some affecting the virus and others the human host. On the side of the viruses it is found that many may infect the human body without producing disease. In fact one such group of viruses was named enterocytopathic human orphans (ECHO) because they lacked a disease. But though this was generally true, in certain individuals some ECHO viruses were found to produce skin rashes and even meningitis or encephalitis. Then for a given type of polio virus it is found that some strains are more virulent than others but for all of them more than 90% of infections do not cause any illness (sub-clinical). In fact, besides the Echo viruses, all the other enteroviruses (this includes the Polio and Coxsackie viruses) grow well in the human bowel but do not cause any disturbance in bowel function But if they happen to invade the central nervous system we know the disastrous consequences that may follow.

Evidently there are many variables on the side of the host that determine the outcome. Nearly 20 years ago Sabin found that a strain of yellow fever virus which would produce 100% deaths in one strain of mice had no effect on another strain of mice even when they were given a 10,000 times larger dose of virus. Here there is clearly a genetic difference in susceptibility within a given species. Another factor is age – in most virus infections e.g. influenza, it is the extremes of age that are most affected. But between populations the age incidence may vary, for instance it is the younger age groups that suffer paralysis due to the Polio virus in Sri Lanka, while in other more developed countries where Polio still exists it is the older age groups (15–25 years) that are mainly affected. A similar shift in the age incidence of small pox is seen between an immune and non-immune population in India. It is also noticed that there

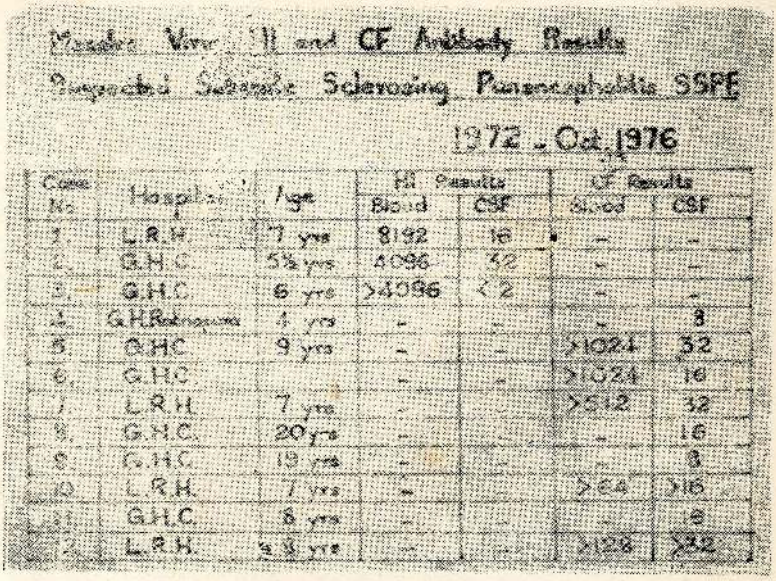
can be a sex difference, specially with an increase in smallpox during pregnancy In fact most virus diseases tend to be more severe in pregnancy probably associated with hormonal changes and stress. A further example is the much commoner occurence of joint involvement (or arthritis) in adult females infected with Rubella (or German measles). Another major factor influencing the outcome of a virus infection is the state of nutrition, the malnourished having less resistance. There are several other factors too that influence the outcome of a virus infection so that it is not always easy to predict the outcome.

The variability in host response is also due to the variety of defence mechanisms that the body possesses. From mechanical and chemical barriers at the portals of entry of a virus, these extend to non-specific biochemical substances in body fluids and a variety of cells that police the body. Having evaded all these some of the viruses that enter the body have to find cells with suitable receptors that they can attach on to. If these are lacking viruses connot invade a cell. Once infected, the cells do not give up the battle they react by producing a substance called interferon which diffuses to other cells preventing the multiplication of virus there. This is one of the principal ways in which a virus infection is contained and in passing I must say that it is regrettable that there are some clinicians who help to depress the interferon response by the use of steroids too early in virus infections. But of even greater importance in restricting a virus infection and in preventing reinfection is the immune response which is specifically directed against that particular invading virus. This immune response is of two types - antibody (immunoglobulins) and cells (lymphocytes) but they are very complex processes that cannot be gone into here.

The object in outlining the body defences, even so sketchily, is to give some idea of the multiplicity of factors that go into the reaction of the body to invasion by a virus. And each of these is in turn influenced by many other factors, some like age and nutrition that have been mentioned and, several others like alcoholism that have not.



7. Variety of outcomes of Virus infections.



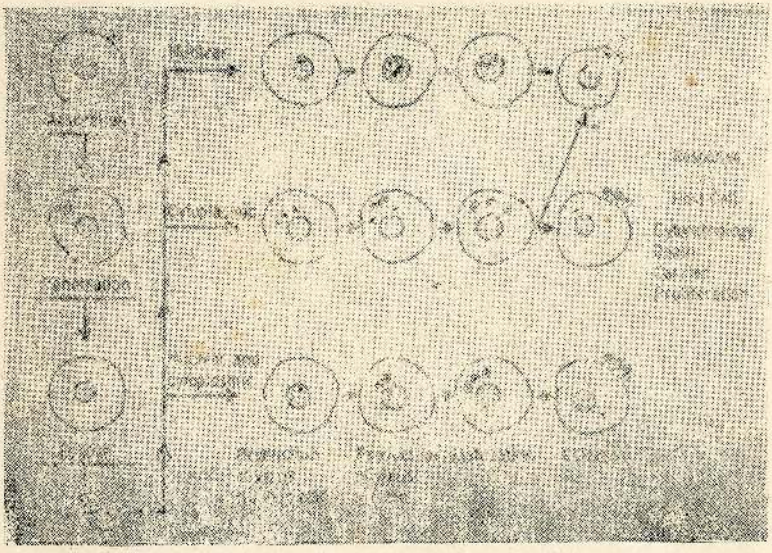
Measles Virus HI and CF Antibody Results
Progressive Subacute Sclerosing Panencephalitis SSPE
1972 - Oct. 1976

Case No.	Hospital	Age	HI Results		CF Results	
			Blood	CSF	Blood	CSF
1	L.R.H.	7 yrs	8192	16	–	–
2	G.H.C.	5½ yrs	4096	32	–	–
3	G.H.C.	6 yrs	>4096	< 2	–	–
4	G.H.Kalutara	4 yrs	–	–	–	8
5	G.H.C.	9 yrs	–	–	>1024	32
6	G.H.C.		–	–	>1024	16
7	L.R.H.	7 yrs	–	–	>512	32
8	G.H.C.	20 yrs	–	–	–	16
9	G.H.C.	19 yrs	–	–	–	8
10	L.R.H.	7 yrs	–	–	>64	>16
11	G.H.C.	8 yrs	–	–	–	8
12	L.R.H.	4½ yrs	–	–	>128	>32

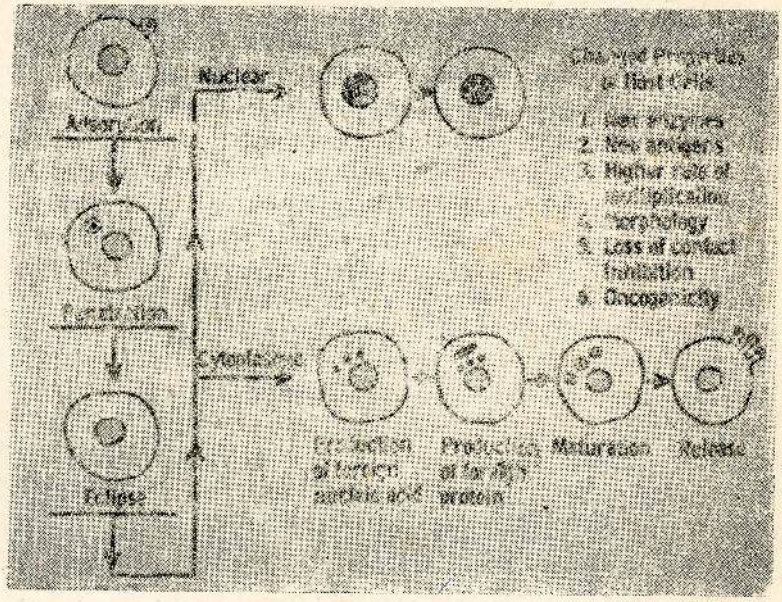
8. Cases of subacute sclerosing panencephalitis in Sri Lanka.

9. Chickenpox (Varicella-Zoster). Virus infection in a child.

10. Herpes Zoster in an adult. (Chickenpox virus flaring up years after a childhood infection).



11. Multiplication (replication) of a virus in a human cell may occur in different ways.



12. Cancer cells resulting from virus infection. Where the virus has multiplied in the cell nucleus ("Nuclear") there is intimate linkage of the genetic material.

In the midst of such a dynamic process it is very difficult to give the type of clearcut "either-or" answer that Formal Logic demands. A hundred viruses may cause disease in a given context while ten thousand may fail in another. It is not a simple equation of virus + human = disease but it is a multiplicity of equations with a multiplicity of variables

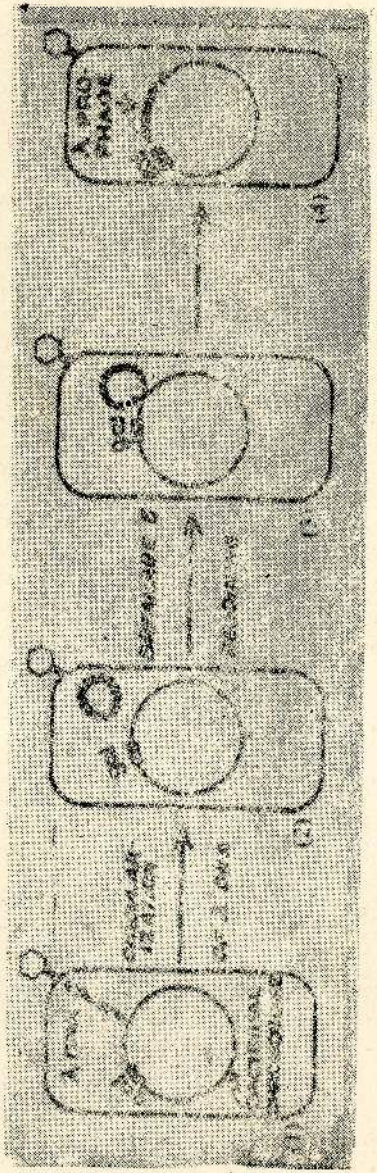
Some idea of the variety of courses that a virus infection may take is given in *Figure 7.* For instance it has been found that following a relatively common and usually trivial measles infection there is quite frequently brain involvement (EEG changes) and occassionally frank encephalitis. But in a few unfortunate children measles virus remains latent in the brain cells, usually not as complete virus particles, and sometimes even years later leads to a chronic degenerative disease (subacute sclerosing panencephalitis, SSPE) which invariably ends fatally. In Sri Lanka for instance 12 such cases have been virologically confirmed by us *(Figure 8)* In fact viruses may remain quiescent in a harmonious equilibrium for decades e.g. following childhood chickenpox *(Figure 9)* the virus may remain in nerve ganglia till old age when some slight trauma shifts the balance so that vesicles erupt in the neighbouring skin producing Herpes Zoster or shingles — *(Figure 10).*

Within a cell too the outcome of virus infection may vary. There may be active replication ending in rupture or lysis of the cell or there may be a gradual budding off of virus particles. The different stages may occur in the nucleus and/or the cytoplasm *(Figure 11).* Viruses have been definitely implicated in the causation of animal cancers; while in the case of human cancers there exists a strong suspicion though it has not been condusively established as yet, a much more difficult task. In most DNA virus infected cancer cells *(Figure 12)* it is found that the virus genetic material is intimately linked with the cell genome (nuclear material) and apart from some new antigen proteins (the T antigens) there is no visible virus. This cell divides and the virus material too divides with it. In other words the host cell has changed its properties by incorporating the virus and the virus itself is no more.

A similar negation of Formal logic can also be illustrated by viruses (bacteriophages or phages) that invade bacteria. Besides the usual lytic infections, phage too can remain latent in the bacterium with its genetic material linked to that of the host, this is called Lysogeny — (*see Figure 13).* It is such a lysogenic phage or virus that makes the diphtheria bacillus produce toxin and become harmful to man.

A final point to illustrate the complexities of the virus host relationship is that under certain circumstances the body defences are themselves responsible for injury to the host. For example the rash in measles, as well as encephalitis when it occurs, are a result of damage by the immune (T) cells of the host. In several virus infections kidney damage can result from the deposition of complexes containing antibody and antigen in these organs e.g. viral hepatitis, mumps. In fact, the whole large field of Auto-immune diseases is a consequence of the Immune System, that was designed by nature to protect the host, damaging his own tissues. No further exposure of the limitation of Formal Logic are needed than these examples of how a thing has turned into its opposite (see Appendix 2 — point 12) in complete agreement with the Laws of Dialectics.

These few examples should demonstrate the complexities of the relationships between viruses and their hosts. It is impossible to make them fit into the simplified concepts of Formal Logic. But rather must the virus and the human host each be viewed separately and together as changing dynamic processes. Thus at any moment in the human there is a contradiction between the building up process and the breaking down process which as you know, affects even the bones that look so solid (of first 4 points of Dialectics, Appendix 2). There is a relation and interconnection between the two processes (point 6) and this is that of two opposites, the virus and the humam host, (point 8) and there is a fundamental unity of those opposites (point 9). As we have seen this unity of opposites is conditional, temporary and relative but their struggle goes on and is absolute (point 10). This, taken with point 5, which states that quantitative change generally leads to qualitative change explains how with the replication of the virus a stage will come where a qualitative change



13. Lysogeny of bacteriophage.

and its spread in epidemic waves, was for long explained on the basis of a hypersensitivity (allergic) reaction to a second Dengue infection. There was resistance to the idea that a new virulent strain of the virus had appeared by authorities like Halstead and many others But the occurrence of HF/SS where only one type of Dengue virus exists (some Pacific islands) seems to favour the emergence of a new mutant virus, a dialectical process.

(3) There is a clinical impression that the complications of measles, as well as deaths from it are on the increase in Sri Lanka. Is this not to be expected, going by the African experience, when the state of nutrition of the poorer sections of a community deteriorate. More paediatricians should join us in trying to establish this point in order to decide whether it is advisable to immunise the vulnerable groups.

(4) We are not sufficiently alert or equipped to tackle new virological problems in Sri Lanka. Besides genetic change, there is a possibility of the introduction of arboviruses by the large populations of migratory birds that come to the island. The opening of forests may permit human infection by new arboviruses as occurred in Mysore with Kyasanur Forest Disease. We must ask ourselves whether every case of jungle fever is really malaria!

(5) Hospital statistics show that about 1000 cases of encephalitis occur in Sri Lanka each year with a mortality of over 30%. With the limited facilities available to us we have not been successful so far in determining whether the Japanese encephalitis virus is a sufficiently important cause to merit immunizing against it. A short-coming on our part! Further, are there other viruses responsible for encephalitis in Sri Lanka besides those we have found so far?

(6) How much longer are we going to send scarce antibiotics literally down the drain in treating sore throats that are more often than not due to viruses? When are we virologists going to prove this fact ?

(7) Why has polio immunization had such limited success in Sri Lanka - is it purely operational or due to interfering viruses, or is a new immunization schedule called for?

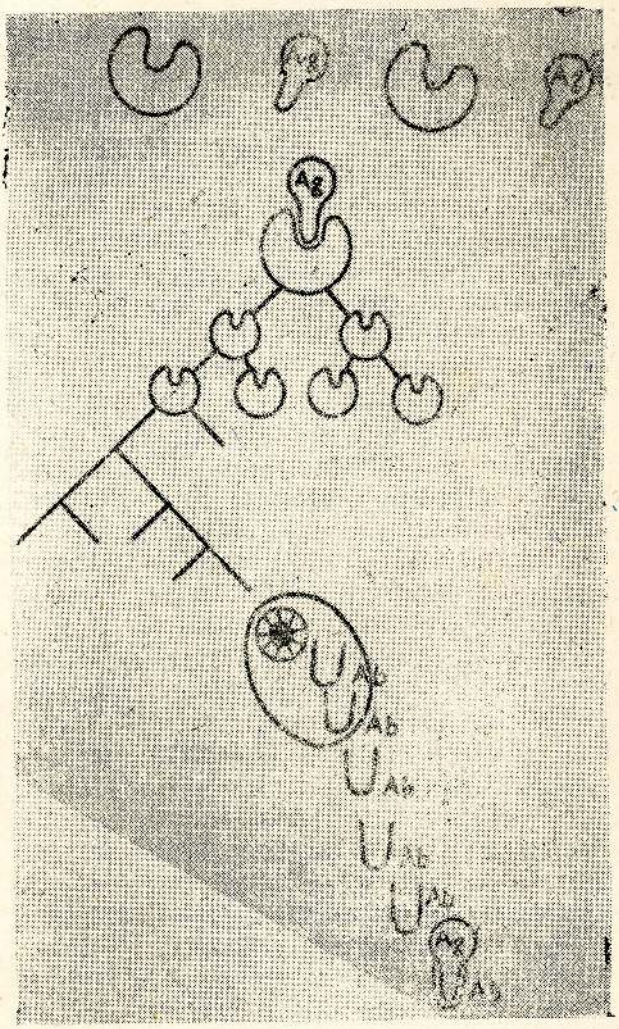
illness, results and if it progresses still further another qualitative change, death. Short of this there is infection but no illness. When the body defences eventually overcome the infection, there is not just a return to the old state of health but a qualitatively new immune individual. When another virus infects the human being a new process with a new dialectic is set going (point 11) and this new process has to be studied afresh and understood not on the basis of preconceived ideas but according to the concrete reality (point 7). And it is not sufficient to think of just one human being but of the entire community and of not one stage in the process but its entire historical evolution. It is such a total dialectical approach that would enable us to fully understand the complexities of nature.

Some dialectical reflections

I should like to conclude with some observations pertaining to health, especially in Sri Lanka, that suggest themselves when one views problems dialectically. They may not be original but in presenting them here I hope the scientific community will pay some attention and help to promote appropriate action:

(1) Mac Farlane Burnet's Theory of Clonal Selection is generally accepted to be the explanation of the mechanism of the vital Immune Response (*Figure 14*). While it solves most of the problems that other theories like the Instructional Theory failed to clear it has a serious limitation in that *it does not provide for any new antigen that may arise*, and these are bound to arise. It assumes that each one of us has a complete set of immunologically completent cells at birth, each cell having the potentiality to react against a particular antigen so that every possible antigen that we may be exposed to throughout life is covered. It is difficult to visualise such a large number of genetically different cells being present at birth or shortly after. Jerne's modification that starts with 30 or 40 such cells, which by point mutation and recombination reach the requisite number, seems a more likely explanation.

(2) The sudden appearance of the Haemorrhagic Fever Shock Syndrome (HF/SS) as a complication of Dengue in 1953, (many years after dengue virus infections have been known to occur)



14. Burnets' Theory of clonal selection – Each Antigen selects out the appropriate lymphocyte which then multiplies to produce daughter plasma cells which in turn produce the corresponding antibody.

(8) Can the rabies eradication programme which is about to be launched ever succeed in Sri Lanka without overcoming the Buddhists reluctance to kill stray dogs? Is our health education adequate?

(9) Our investigations suggest Sri Lanka may be heading for another Dengue epidemic with the risk of haemorrhagic fever. Do we prevent it by mobilising the people to eliminate household mosquito breeding sites such as tins and tyres or do we wait to resort to heroic resuscitation measures once our children bleed and collapse?

(10) The above observations are largely directed towards the prevenion of illness in the community as a whole. It is sad that many doctors still fail to see the problem of the individual patient as part of the problem of the community. Their focus on curing the individual in the context of Sri Lanka's limited resources, benefits a few, mainly a privileged few. A shift of emphasis to prevention would benefit a far larger section of the community.

(11) In trying to prevent illness e.g, malnutrition, it is important to recognise all the contributory factors but they should not be given equal weight. Instead, attention should be focused on the principal ones e.g. poverty. It would be a crime for us to ignore or hide these primary causes just because they are embarrassing.

(12) The realisation finally that the solution of Sri Lanka's major health problems (infectious disease, malnutrition and anaemia principally) lie outside the hands of the medical profession. The provision of proper nutrition, housing, water supply and sanitation need socio-economic and political solutions.

Conclusions

In this short period an attempt was made to understand the complexities of the relationship between viruses and humans by applying the Dialectical method of logic. I hope that in the process the limitations of Formal Logic were adequately exposed. But certainly, one can exist quite happily without a knowledge

of Dialectics in the way that people did for a long time believing that the world was flat. Just as the fear of falling over the edge may have inhibited exploration at that time, I feel that as scientists if we are to explore the frontiers of science for a better understanding of and a mastery of nature then a grasp of the dialectical character of nature itself is vital. It is a credit to scientists that quite a few of them do think dialectically specially in tackling their particular problems without a knowledge of dialectics. In fact, even the early Greek Philosophers did use dialectics at times. But in the overall approach formal logic still dominates

Life is full of contradictions and there is a constant struggle to resolve these contradictions. Without them life would cease. And there will be a struggle too before Dialectics gains general acceptance and displaces Formal logic as the dominant system of logic. We may not be here when that day dawns because a suitable milieu for it can be created only by a radical socio-economic transformation. But I have no doubt that this day will dawn.

Appendix 1

The Basic Laws of Formal Logic

1 *LAW OF IDENTITY.* This states that "a thing is always equal or identical with itself". (In algebraic terms A=A.)

2 *THE LAW OF CONTRADICTION.* This states that one thing is not another. (A is not non-A or A is not B).

3 *THE LAW OF THE EXCLUDED MIDDLE.* This states that "everything is and must be one or other of two mutually exclusive things". (A is either B or it is not B, it cannot be both B and not B).

Mechanistic Materialism

This has been the philosophical basis of the progress of science and is itself based on formal logic. Some of its basic premises are;

1 It sees the world as composed of "indivisible, indestructible, material particles which in their interaction manifest such properties as position, mass, velocity. In other words permanent and stable things with definite, fixed properties".

2 It concludes that no change can ever happen except by the action of some external cause, so that it tends to separate motion from matter.

3 Further, it sees each thing as existing in separation from other things, as an independent unit, so that the relations between things are merely external and make no difference to the intrinsic nature of these things themselves.

Appendix 2

Some aspects of Dialectics

1 Considers the universe not as static, not as unchanging, but as in a continual process of change and development, a *dynamic equilibrium.*

2 *All things are processes*, going through an uninterrupted change of coming into being and passing away.

3 *Matter is always in motion*, that motion is the mode of the existence of matter, so that there can no more be matter without motion than motion without matter. Matter and motion are intimately linked in the form of energy.

4 Change and motion of any thing or process is inherent within it, as a result of the struggle of opposite tendencies or contradictions within it and does not have to be impressed by some outside force.

5 Quantitative changes do not continue indefinitely but generally lead to *qualitative changes*. These may occur abruptly and take the form of a leap from one state to another. (Caterpillar ⟶ butterfly).

6 In the manifold processes taking place in the universe things come into being, change and pass out of being, not as separate individual units, but in essential *relation and inter-connection* so that they connot be understood each separately and by itself but only in their total relations and inter-connections.

7 *Truth is always concrete*, never abstract i.e. things / processes must be studied as they really are, in their real Interconnection and movement. We cannot apply any preconceived scheme and try to make everything fit into this.

8 It is found that the properties of things or processes, their relationship, their mode of action and interaction all divide into fundamental opposites (eg. positive and negative electricity, + and − in mathematics, north and south poles in magnetism, matter and anti-matter, electron and positron).

9 There is a *unity of these opposites*. They cannot be understood in separation one from the other. There cannot be a Magnetic north pole without a south. Thus it is not a question of a *number* of different things or different properties or different relations but of *pairs of opposites*. Therefore, when one thinks of electric charges these are not just a number of different charges but they divide into positive and negative.

10 "The unity of opposites is conditional, temporary, transitory, relative. The *struggle of opposites is absolute*" (Lenin). Qualitative change is a result of this unity of opposites.

11 *Each kind of process has its own dialectic*, which can be grasped only by the detailed study of that particular process. The dialectic of living organisms differs from that of inorganic matter or of society. That of one living organism differs from that of another.

12 *Each phenomenon can be transformed into its opposite.* All boundaries in nature are conventional and mobile, so that there is not a single phenomenon which cannot under *certain conditions* be transformed into its opposite.

13 Every process has more than one contradiction. Among these various contradictions there will be a principal contradiction and secondary contradictions. It is not possible to solve the secondary contradictions without solving the principal contradiction.

Therefore, in summary one may say that "common sense" or "formal logic" (Metaphysics) thinks in terms of fixed unchanging things whose properties and potentialities it seeks to fix and determine once and for all. It considers each thing by itself, in isolation from every other, in terms of irreconcilable anti-thesis– "either-or". It contrasts one thing to another, one property to another not considering things in their real movement and interconnection and not considering that every subject/matter represents a unity of opposites, opposed but inseparably connected together.

Contrary to Metaphysics, Dialectics refuses to think of things each by itself as having a fixed nature and fixed properties –"either-or" - but it recognises that things come into being, exist and cease to be in a process of unending change and development, in a process of complicated and ever-changing interrelationships in which each thing exists only in its connection

with other things and goes through a series of transformations, and in which is always manifested the unity, inseparable interconnection and struggle of the opposite properties, aspects, and tendencies characteristic of every phenomenon in nature and society.

Contrary to Metaphysics the aim of Dialectics is to trace the real changes and inter-connections in the world and to think of things always in their motion and interconnection.

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SECTION B—AGRICULTURE AND FORESTRY

PRESIDENTIAL ADDRESS

Towards Meeting the Food Requirements of Tomorrow

by

MERVYN PULLE

On behalf of the Agriculture and Forestry Section, permit me in the first instance to congratulate you Sir, our General President for very ably steering the activities of the Sri-Lanka Association for the Advancement of Science during the current year, which marked an important milestone in the history of the association. The International seminar on scientific and technical cooperation among Non-Aligned nations, the minisessions, the National Academy of Sciences and completion of the Headquarters project are some of the notable achievements realized during your tenure. Our section too, in accordance with the accelerated pace of the association, embarked on several ventures and we were able to successfully initiate and co-sponser a number of symposia, seminars and talks on vital topics, which were of timely interest in national development. I which to acknowledge with sincere appreciation the fullest co-operation of the Section B committee, particularly the indefatigable Secretary and other members, who most willingly volunteered their services for the successful implementation of our sectional programmes. It is indeed a privilege to record the many contributions made by our sectional members for the 1976 Annual Sessions, which amply demonstrates that the forum of the SLAAS is considered most appropriate for formal presentation of a substantial quantum of research in agriculture and forestry conducted in Sri Lanka.

Having prefaced my presidential address with the relevant acknowledgements, I wish to proceed "Towards meeting the food requirements of tomorrow".

It was with a great degree of hesitation and consternation that I decided to devote my presidential address on "Towards meeting the food requirements of tomorrow". The obvious reason is that the food problem has been discussed at length by individual governments, foundations and international organizations and even with grandiose plans the problem appears insurmountable today, with lesser expectations for the morrow; a situation inspite of all the spectacular advances in Science and technology and progress in international cooperation, that have opened up incalculable vistas for human betterment. However, considering the stark reality of the situation, I would be failing in my duty and my chosen discipline, if I do not avail myself of this opportunity to emphasize possible approaches that could effectively eliminate or reduce the magnitude of the problem. Acceptable solutions can be found by recognizing our difficulties, locating and defining them, crystallising a number of tentative ideas concerning solutions, reviewing experiments and observations that are available and making conclusions.

The subject of food does not necessitate much amplification. The mass of humanity is pre-occupied with food at least thrice daily and this pre-occupation in the present day context has reached unparalleled heights consequent to dwindling food supplies and price increases. The poignant fact, that food contributes to nation building is evident since in the developmental sphere, fulfillment of mankind's basic need is deemed indispensable to direct energies and efforts to the economic and cultural advancement of society and country.

My task today is to approach meeting tomorrow's food requirements from the standpoint of food science and nutrition. Basically, the solution resolves itself into providing enough of the right foods to feed everyone. In a technical interpretation, this denotes furnishing vital nutrients to provide the physiological requirements and adequate quantities of acceptable comestibles for psychological satisfaction. This indeed is a formidable task. How are the multitudes going to be fed? What will be the source of this modern-day miracle? The

question is quite clear and any attempt at a solution would be as a modest aim to provide 2,200 calories and 45g. protein daily to each person whatever his economic standing, ecological situation, education or religion. This aim is unattainable so long as a minority in developed countries consumes 3600 calories per day at the expense of it's health

The current level of per capita food consumption must be established, and their inadequacy in terms of physiological requirements evaluated prior to a discussion of the future demand for food. It is not my intention to elaborate on this aspect which was deliberated adequately at the recent Annual Sessions of the Nutrition Society of Sri Lanka. However, certain salient points must be drawn to attention. The FAO / WHO experts, modified nutritional allowances to suit physiological needs of our population in 1973, indicate that 2,200 calories and 48g. protein on a per caput basis would constitute an adequate diet. The available evidence indicates that food supplies have been sufficient on the average to meet nutritional requirements, with the highest ever recorded during the past two decades being 1970 when 2,359 calories and 50g. protein were available per head per day. Yet, we are christened a protein-calorie deficient nation. How do we overcome this apparent contradiction? Firstly, available food supplies do not necessarily imply an index of food consumption. Also, the lack of reliable data to accurately determine levels of food consumption has been stressed and the compromise followed to build up reliable information is to compare data from food balance sheets, consumption surveys and nutritional studies which when used together provide the necessary cross-checks and corroborative evidence. Both food balance sheets and consumption data indicate an average supply of about 2,200 calories and 45g. protein per head per day. The food supply is characterized by an overwhelming dependence on starchy staples and vegetable fats, which including sugar, supplies three-fourth's of the calories in the diet. Over 60 per cent of the protein supply is derived from cereals with fish and pulses contributing 14.5 and 10.2 per cent respectively.

The overall adequacy of the diet suggested by approximating requirements is further misleading since a normal distribution is assumed. The nutritional allowances could be more realistically arrived at through the various rural dietary surveys and findings of the Socio-Economic Survey, which clearly depicts the relation of income to diet. When all these issues are viewed in its proper perspective the existance of a protein - calorie deficiency and additional inadequacy with regard to calcium, iron and riboflavin were confirmed in the lowest income group, constituting 36 per cent of the population and appeared to be only marginal in a further 40 per cent. As these findings were obtained in 1969/70, the effects of the recent food crisis, spiralling price increases and reduced purchasing power could safely lead one to conclude that these deficiencies are prevalent in a considerable majority of the indigenous population.

Food Crisis

The world food crisis, originating from a combination of longer term problems and temporary set-backs such as shortfalls in production in many countries, shrinking grain stock-piles, unfavourable weather, increased fuel prices and inflation suddenly emerged in a pronounced form in 1972. In that year, the world food output declined for the first time in more than twenty years, and considering the import-oriented nature of our food economy the crisis also had its impact in Sri Lanka. Recalling just one aspect of the impact to refresh our minds on the gravity of the food crisis, I refer to the bread queues that figured prominently in this country consequent to wheat flour being made a rationed commodity. Although with tolerable short-term remedial measures the food crisis has eased out to a considerable extent, yet the problem is ever present, primarily due to the increasing food demands of a rapidly growing population.

Food-oriented Organizations

The fact that the food crisis was anticipated and its' wake despite the concerted effort of several organizations is a matter of discernation. On tha global scene, one is aware that world consensus was drawn on the food problem, and rightly so, since Hunger is everybody's business. The magnitude of the problem

merited the unreserved attention not only of individual governments but placed on an international footing it realized the dawn of various humanitarian organization. The objectives of the Freedom-from-Hunger campaign, FAC, CARE, UNICEF and others are indeed laudable, but even with due recognition of their intensive and extensive efforts, are we getting any closer to provide adequate food to people everywhere. It is not my intention to belittle the unstinted activities of these concerned bodies, but it seems to me, that either the problem keeps escalating at such a pace to reduce their efforts, or organizational limitations whether it be political, economic cultural or otherwise somehow appear to dampen their activities.

Much has been said, written and rather than be designated a sceptic may I add done on the food front. Perhaps the order of the day is to inaugurate a seminar or conference to formally pose the problem and at the end of the deliberations the answers will certainly crystallize. This observation is by no means restricted to activities concerned with food. In most instances the follow-up action of the discussions embarked on, leaves much to be desired. With much admiration regards integrity, I wish to cite a remarkable conclusion of a committee report as far back as 1967, which has particular relevance to my observation and also the magnitude of the food problem. In a 3 - volume report on "The world food problem" the panel on World Food Supply of the President's Science Advisory Committee of the United States stated, and I quote "We have been unable to devise any new or original statement of the world food problem. The subject has been treated so thoroughly in orations and editorials during the past two decades that both its size and significance tend to be obscured by rhetorical overskill." The report however continues "The scale, severity and duration of the world food problem is so great that a massive, long-range innovative effort unprecedented in human history will be required to master it". In the fervent hope that my submission today will not be thus fashioned, the guidelines presented therein would serve as a vital parameter in discussing food requirements.

It would be pertinent to note that this report was forwarded in 1967, long before the food crisis became a reality. During the ensuing years numerous ventures have been surfaced such as

the World Food Conferences, while already established organizations intensified activities on the food front. At the conclusion of each such venture, the solution appears certain as on every occasion, sure set proposals are offered to finally solve the food problem. Let me draw your attention to the concluding address on the proceedings of a symposium convened by the Rockerfeller Foundation, "Strategy for the conquest of hunger", which not only focussed finality but created a golden path in these words, and I quote "This is an imporrtant occasion, for there has now emerged a clear basis of hope for a world beset by a food crisis. There is a promise of a new surge of economic development for nations willing to modernize agriculture. For much of rural mankind long by passed through modern science, there may now be alternatives, balanced diets not hunger, education not the darkness of illiteracy, reasonable health rather than the handicap of disease, opportunity not despair and the like."

POSSIBLE APPROACHES

Increased acreage and yield

Let me now focus your attention to possible approaches to the food problem. To take off on an agricultural premise, it has been strongly advocated that increased output will be a deciding factor. For meeting the requirements of tomorrow, this aspect is inadequate and I propose that serious consideration be given to the concept of increased nutrients per acre.

In an attempt to comprehend the distinction between these two parameters and justify my contention it is necessary to examine these aspects. Increased output could be achieved either through increased acreage or increased yield. What are the realities of these two criteria? In regard to addition of arable land for increased output, what are the prospects? The world picture reveals that 70 per cent of the total land area is barren and infertile for several reasons for crop production or to supplement animal production. Furthermore as at 1975, it is estimated that 80 per cent of the usable land has already been cropped. Land is a valuable resource and, apart from other considerations the characteristic of inelastic perimeters alone, would influence

the limit to which new land could be alienated even at tremendous cost for cultivation purposes. In the local context this criterion has particular significance, and proper exploitation of the land is indispensable to harness it's potential not only for the immediate future but for posterity. On the initiative and auspices of the highest authorities in the government, Sri Lanka embarked on a production effort with the desired objective of optimum utilization of the land. Perhaps one of the premier notable developmental activities in our country's modern history in the food production sector, the Mahaweli Diversion Scheme, would usher in the much desired goal of self-sufficiency in food by contributing to the use of additional land being under the plough.

Increased acreage should ideally be intimately linked with increased yield if production targets are to be attained. Ironically the achievement of higher yields, as we are all aware depends on a number of factors and in the main, centres around the financial commitment which in the context of Sri Lanka is a major constraint. Although it is beyond the scope of this present-action to detail the deciding factors, it is relevant to indicate that the World Food Conference held in 1974 on "Proposals for International and National Action", these were summarized into four broad categories to include (a) agricultural inputs (b) Research (c) overall rural development and (d) investment. May be, I would not digress too far, if I comment on the research aspect which is the prerogative of most of us in the SLAAS. Often, particularly with scarce facilities and resources the current thinking is to transfer direct technology amply documented in the literature to our conditions. It is imperative, that one critically dissociates from this fad and evolve the specific methodologies to suit Sri Lanka. The term appropriate technology, seldom fully understood, is generously quoted but re-thinking and re-orientation of research consciousness to gear our particular needs, financial or otherwise, should be the worthy index of investigations. Another facet of research which come to my mind is information. On one hand is the information available to the scientist through the various journals and publications, and on the other dissemination of knowledge to be meaningfully passed on to the farmer. For a number of reasons

both aspects to say the least are extremely limiting. We have just mooted and take pride in the National Academy of Sciences, but how could we merit this status, when our journals are years overdue. Are we in the mainstream of developments in our respective disciplines, or as the general rule in Sri Lanka are we lagging far behind without the faintest hope of being at par, or even just short of the latest developments? At least in the area of dress and fasion, we strive very hard to cope with so called 'mod' trenps, but whatever happend to priorities? With regard to dissemination of knowledge, the communications media apper to make an effort but would catchy slogans alone suffice to achieve desired results.

The aspect of increased yield has its own own limitations even with all the deciding factors effectively handled. Norman Borlang that renowned Noble Prize scientist, was quizzed in 1973 as follows "People have been told that high yielding varieties will solve all problems and suddenly the food shortage has emerged. How do we reconcile this contradiction? With the aid of an illustration, Norman Borlang shed valuable light on this query. Taking the example of India he showed that because of high yielding varieties wheat production increased from 12 to 26.5 million metric tons over a period of seven years, but simultaneously raised the issue of population rise during the same time.

Increased nutrients / acre

Considering the limitations of both land and yield parameters, the current and future situation should be best approached from a quantitative and qualitative standpoint by increased nutrients per acre. Let me illustrate this criterion which in a reality today, and should be granted the proper impetus tomorrow. Given an acre of land, realize how many cattle could be raised? Consider the same acre devoted to soybeans and the apparent disparity is readily noticeable. To make the argument more valid let us consider the conversion factors of grain to meat which are estimated as 10, 5-6 and 3 lbs of grain to produce 1 lb. each of beef, pork and poultry respectively. When these aspects are critically looked into, the need for increased nutrients per acre is such more pronounced.

Quantitatively a yield of 2000-3000 lbs. of soybeans could be obtained depending on management and cultural practices as opposed to the raising of 1-2 head of cattle. Consider the nutrients in the poundage. Soybean has been a conventional dietary item in the oriental diet for centuries and in the recent past made a noteworthy impact on the agricultural sector of many devloped and developing nations This renaissance of soybean must be duly heralded, particularly with reference to its nutritional attributes which leads itself to be utilized in a variety of ways as flours, sauces, beverages and enrichment of established foods.

In the event that I may be misinterpreted that the preceding remarks advocated a strong plea for a vegetarian diet, may I clarify that this was not the issue. The crux of the matter is that with far-reaching land reform, including parcelization, the individual allotments keep shrinking. Thus for optimum utilization of the land, crop and animal husbandry should complement each other in a more or less symbiotic fashion. The small land allotments makes this target easily attainable and combined with intensive home gardening in the final analysis not only increased yield and acreage but increased nutrients per acre would be conveniently realized.

Increased Food Supplies;

Another approach towards meeting the food requirements of tomorrow would be to increase food supplies by encouraging the consumption of food substitutes and improvement of fisheries. Decline in traditional food supplies and economic considerations warrant food substitutes to become increasingly important in the dietary patterns of Sri Lanka. An array of comestibles could effectively substitute in varying amounts for conventional dietary items, wherein the ideal premise would be to use agricultural commodities that could be produced within the country. This contention merits further consideration in view of the quantum of food imports and consequent constraints in valuable foreign exchange in the endeavour to feed the indigenous population. During the height of the food crisis the remedial measures adopted by the government were reiterated by the Prime Minister in her Inaugural Address to the Annual Sessions of the

Nutrition Society of Sri Lanka 1976, and I quote, "I personally launched the food war to use every home garden and every available bit of land to grow short-term food crops such as manioc and sweet potatoes."

The concept of food substitutes recognized and implemented in the country was the proper approach. However, since food consumption for civilized man is governed not only to satisfy hunger but for psychological reasons as well, the acceptance of non-traditional items at that stage was frowned upon and influenced solely as a result of shortage of conventional foods. Food substitutes to be meaningfully introduced to the diet should not be done overnight, since consumer resistance would prevail if a long term goal is to be arrived at Gradual and incremental introductions, by far would be ideal. Recall the enhanced price and world sugar shortage which lead to consumption of substitutes, chiefly jaggery accepted intially with reserve, on compulsion. It is heartening to note that at the present time the use of jaggery has increased tremendously and often supercedes that of sugar. Many such items could be drawn to your attention whether they be carbohydrate or protein food substituents.

Looking back to the recent past, it is with concern that I submit as to whether all these worthwhile attempts to encourage food substitutes produced locally were futile and negated, particularly with the influx of wheat flour through courtesy of PL 480 funds, the re-entry of mysore dhal via the CRA or any other source legal or illegal, at almost the transition when the palate of the majority of the people was being oriented to a changing food pattern. The re-emergence of traditional food supplies was to put it bluntly a terrific blow to the food situation. Dietary patterns of a nation, like its culture are rather stable and individualistic. During the early stages of the production war, a single meal or part of a rice meal was gradually replaced by manioc and other substituents, but now with the availability of wheat flour at a reasonable price, the people have reverted back to bread and other wheat flour based preparations.

As an added impetus to accept carbohydrate substituents, food and nutrition education should be imparted to the masses through the communications media. The consumer should be

made aware of the actual nutrient status of rice as reported in the literature, which conclusively reveals that among the cereals, millets and adlay are of the highest nutritive value and constitute better balanced foods. Maize and kurakkan are superior to rice, especially polished rice, which could be regarded as the poorest of all cereals in protein, fat and mineral elements. Thus, apart from supplying calories, rice can hardly be called a nutritious food. Whatever happened to the whole grain meals prepared with mixed cereals—I am here refering to those menus that were prepared by the Extension Division of the Department of Agriculture and exhibited island—wide? Also, refering back to the concept of increased yield could we draw a parallel from the 7-15 ton yield of manioc as opposed to say, 100 bushels of paddy.

On the assumption that substitute whole grain cereals present some difficulty, a feasible approach could certainly be made in bread and other breakfast preparations. This proceeds in the realm of flours wherein composite flours i.e. wheat, non-wheat mixtures could be used for various leavened and unleavened baked goods. The non-wheat component must be a local counterpart and most starchy foods such as sorghum, maize and kurakkan among the cereals, with even manioc and ash plantain flours. Utilization of single substituent flours or different blends have shown that a 30 per cent level of substitution can be realized by modification of ingredient composition and bakery technology. It is opportune to report that these findings would be implemented by the Ministry of Planning and Economic Affairs where a compromise level of 5-10 per cent suggested to the Mixed Flour Bread Project would be implemented in the near future. Taste panel surveys of these items rate satisfactorily with regard to consumer acceptance. One could visualize the saving in foreign exchange in wheat imports, as a result of partial substitution along with the incentives for local production of substituents.

In the area of pulses, plentiful substitutes are available and from a nutritional aspect too, their use is strongly advocated. Soybeans, winged beans and other pulses conveniently grown in this country should rightly form a large portion of the diet.

World Food Agencies have involved themselves in specific soybean projects and Sri Lanka is no exception in this connection. Current culinary practices use soybeans directly in the preparation of various breakfast items and snacks in the local diet and to achieve nutritional benefits, enrichment or fortification of prepared food should receive highest priority. A note regarding soymilk, clearly representative of a commodity wherein acceptance is a deciding factor in it's incorporation in the diet. The adult palate is sophisticated being able to perceive customary flavours mainly through usage, and soymilk for adults in my opinion is rather disconcerting. To meaningfully use soymilk, the infant or young baby would offer no resistance since anything to satisfy hunger would be consumed. A start should be made in early life so that the change in dietary habits would evolve almost naturally.

Fisheries

The two major food supply sources for humanity on earth are agriculture and fisheries, and within the realm of increased food suppliers the latter area needs further exploitation. The oceans cover approximately seven-tenths of the earth's surface and in addition oceans are the great reservoirs from which are fresh water supplies originated. Improvement and furtherance of the catch from ocean and fresh water sources should be an immediate concern. Today, fish accounts for 14 per cent of the total world consumption of animal protein. When we consider that 120g. of fish would adequately provide for one-half of a persons daily requirements, the potential for tomorrow remain's enormous and is rarely tapped. At the turn of the century, the catch registered 5 million tons and the most recent figure, 70 million tons, was recorded in 1973. It is estimated that the maximum sustenable yield is 120-130 million tons, beyond which the reproductive stock would deplete to a point of continuously diminishing returns.

In Sri Lanka our land perimeters are enveloped by the ocean and the landscape is generously dotted with ponds, estuaries, lakes, lagoons and other water reserves which could be employed for systematic breeding and enhanced fish production. Needless to mention, that fish can multiply without encroaching upon the

arable land of the country. Successful attempts have been made in India to culture fish is some paddy fields. This type of paddy-cum- fish culture is advantageous because of the manurial effects of fresh water and destruction by fish of the weeds and insects injurious to paddy. It would be appropriate also to promote aquaculture to be associated with home gardening which would contribute even to a small extent to the animal protein component. It may be of interest to point out that the ancient Chinese, Egyptians and Romans had resorted to successful aquaculture.

Although large-scale fisheries in Sri Lanka have made much headway again, influenced by the human palate, consider the extremely few types of fish that are consumed. In every instance, the catch is immediately scrutinized, and in a more cursory glance hosts of so called inedible types are thrown back into the ocean. This rejection is more pronounced in specialized catches such as prawns, lobsters which are high-priced foreign exchange earners. The unconventional fish types must be studied and brought to the table sooner than later, particularly in view of the fact that the FAC estimates that by 1985, we would numerically exhaust conventional fish types. Food Scientists have been able to add at least two varieties, the Krill and Lantern fish which are now eaten in the USSR and other countries. Further valuable fish protein concentrates have been isolated from less consumed fish types.

Post-harvest technology

Of immediate concern is the vital area of post-harvest technology where existing food supplies could be better sugmented through the reduction of wastage and development of agricultural processing industries.

Although post-harvest losses are inevitable, yet that wasted in this country are phenomenal, no doubt precipitated by the tropical climatic conditions and lack of proper management, storage and marketing facilities. It is reported that among the cereals, percentage losses could reach 20 and in vegetables 30-40 per cent losses are realized. The ultimate effect of losses is not only quantitative but also qualitative, wherein available nutrients are considerably reduced. In the case of cereals and legumes,

insects and rodents consume as well as contaminate the produce. The important part of the grain is attacked and in addition to nutrient losses, damaged seeds succumb to invasion by harmful microorganisms, resulting in textural changes often producing a powdery grain. One parameter to demonstrate losses would be the Protein Efficiency Ratio (PER) which falls from 1.8 to 1.4 in cereals, and, 2.2 to 1.7 in legumes within a one-month period.

Ceres the FAO bi-monthly review on Development, has published a startling revelation which makes interesting reading in its issue of Jan-Feb, 1973 titled "Of rats and men". Basically this reference estimates the world rat population, the extent of damage in food and consequent financial losses. On the basis of 1 rat for every two inhabitants in the temperate areas, and 3 rats per inhabitant in tropical zones, the world rat population was calculated at 4,250 thousand million. The article of course points out what the ratio of rat to people in the tropical zone is an underestimate. A single rat would consume or contaminate 10 kg of food, which would present a terrifying total of 42.5 million tons of food annually, or at the average us $ 400 per ton rate for cereals, $ 17 thousand million is dispensed as a result of rodent attack. This money equivalent represents the Gross National Product of twenty five of the poorest nations in the world. On this premise, I have calculated the figures for Sri Lanka which is summarized as 40 million rats and a loss of Rs. 1.6 thousand million annually. The gravity of the situation needs serious reflection.

In the case of fruits and vegetables the problem in even of a greater magnitude, since they are more degradable. We cannot afford luxurious refrigeration equipment associated with storage of horticultural produce, but methodologies should be developed to reduce post-harvest losses. Food Scientists are now taking a closer look at the old traditional preservation techniques used in Sri Lanka, which could be modified within the reach of the farmer and consumer, so that these processes could be made less cumbersome. It is pertinent to draw attention to the very large losses that results from the current culinary practices employed in Sri Lanka. From the manner of rice preparation alone a loss of 30% thiamine and other water-soluble accessories are brought about by the use of excess quantities of water introduced

initially and discarded at the termination of cooking. In a similar manner, valuable nutrients in vegetables are lost in the gravy which is often not fully consumed. Vegetables produced, particularly the tender types, could be readily eaten raw to obtain maximum nutriture but exhaustive cooking in open utensils results in valuable components not reaching the table. Food education should include the housewives also, to imbibe correct culinary practices for maximum retention of important constituents.

Agricultural processing industries

Agricultural processing industries can be associated with post-harvest technology and could be intimately linked on a locale or situation basis, finding its way into the various DDC Projects Within the strategy of agricultural development, these agro-based industries may be geared to several advantages such as (1) extension of the range of commodities produced by the farmer (2) transfer surplus of perishables which otherwise contributes to wastage (3) additional employment (4) diversify the range of products available to the consumer and (5) when exported would realize valuable foreign exchange for Sri Lanka. Many items come to my mind in this connection such as waste from the fruit processing industry, coconut water, utilization of horticultural products with techniques of fermentation, dehydration, smoking, salting and the like.

New food sources

The discussion on new food sources could be conveniently classified into semi-conventional foods and unconventional foods. The former category has immediate application, while the latter will certainly make its appearance before the close of the Century.

The semi conventional types include vegetable protein flours, defatted oil-seed flours and fish protein concentrates. In all these commodities it is endeavourd to utilise more fully, known and unknown food types. Much work has been done in the area of vegetable protein flours, predominantly soybeans.

Consequent to oil extraction, the material obtained is an extremely rich component of protein, carbohydrate and other non-lipid materials processed as flours, isolates or concentrates depending on the protein percentage.

Incorporation of these products to established foods would result in much needed enrichment or fortification, particularly in an attempt to alleviate protein deficiencies. If bread is cited as an example, incorporation of 5% soy flour, along with the non-wheat component would enhance not only the nutritive value but, also taste and flavour considerations. Thriposha, Sri Lanka fortified food programme of the Ministry of Health in cooperation with CARE employs a wheat-soy blend with a constituent make up of 73.1% pre-cooked wheat flour, 4% stabillzed salad oil and 2.9% vitamin and mineral premix. Inaugurated in 1973, this integrated nutritional intervention project within the Family Health Programme, has rapidly expanded its reach for the vulnerable sectors of the population, the pregnant and lactating mothers, infants, pre-school and primary school children. The objective of combatting malnutrition through the project is not only significant but laudable.

Moving into the area of defatted oil seed residues, I note with interest the paper on "Rubber seeds for human food" to be read at this annual session. In addition, once the undesirable gossypol is removed from the cotten seed, a flour containing 20% protein is obtained. Many other oil seeds provide the required feasibility as food sources. Production of Fish Protein Concentrates follows the same principle, after removal of the bones and other inedible portions and oil extraction. Since legume and fish protein concentrates are essentially bland and this characteristic can be made beneficial by the addition of desired flavours to suit the discriminating human palate. The same could be said to gluten concentrates, water extracted by continuous kneading and emersion of the wheat dough in water, for a prescribed period.

Unconventional foods

The development of unconventional foods by Food Technologists could be regarded as the answer to the challenge of

dwindling conventional food supplies, wherein the alternative would be to explore all possible sources for conversion to human food. Two phenomena are employed, namely chemical synthesis or mass culture of microorganisms, and investigations have been successfully conducted using leaves, petroleum, distillery residues and reclamation and re-cycling techniques. The luxuriant foliage around us although inedible today, because of the high cellulose content may furnish the required food tomorrow, and this is not fantasy or make-believe.

A realistic start has been made and is in restricted operation with the use of certain grasses and clovers. Mechanical separation of the fibrous material leaves behind a valuable protein as nutritious as fish or animal protein. Even morphologically, a single leaf resembles a metabolically active animal organ such as the liver, rather than simple organs like bones and seeds, and the amino acid complement is versatile and more completely balanced. Dietary studies are currently pursued in India and Nigeria to feed school children with 10g. leaf protein concentrate daily and it is reported that Kwashiorkor and Marasmus were cured in these experimental groups of children. Cost figures in India reveal, that although capital expenditure is high, the concentrate itself is priced much lower than fish and animal protein. Another aspect where technology is adopted for small-scale use, is the texturizing of vegetable protein, and with addition of specific flavours it is made possible to partake leaf protein "meats" indistinguishable from that of pork, chicken and the like.

It is difficult to imagine for the barest moment the consumption of petroleum, but the fact that certain micro-organisms such as Chlorella could use petroleum as a food source has prompted oil producing nations to expedite the available technology. A factory installed in Al-Jubail, Saudi Arabia is equipped to produce 100,000 tons of microbial protein which is fed to animals and poultry. Sri Lanka could consider this approach when we are able to tap the much sought after oil.

Feasibility studies on reclamation of waste products has held the attention of scientists of various disciplines. The work on sewage water which serves as the food source for known algae

such as Scenedesmus opened man's ingenuity in being able to process the alga into an edible form for human consumption. Noodles served in West Germany with processed algae, has been well accepted by the people. In Belize, citrus fruit rind becomes the raw material in the formulation of a nutritious protein which is supplied to the synthetic meat industry. The same criterion could be applied to plantain, potato and sweet potato wastes. Investigations in the reclamation of waste products have been widened to include methanol, mollases and even inert material like cellulose and wood pulp. Of particular local significance are distillery residues and fruit processing wastes which are currently been explored for possible advantages on a low-cost basis.

Re-cycling techniques

The ultimate in the sphere of reclamation would be the use of sewage water and animal and human wastes. With due recognition of the seriousness of the food problem, various re-cycling techniques are studied so that the distant tomorrow may be furnished with a possible solution. Fermentation and dehydration processes, not only produce a high protein residue but the by product methane serves as a valuable fuel source.

The developed status of U. S. A. does not provide a barrier for the use of dehydrated poultry dung containing 30–40 percent protein on a 20% replacement in formulating pellets for poultry feeding. Conclusive studies have also shown the ability of a strain of thermophilic bacterium to digest cellulese and lignin in cow dung, while in the Phillipines re-cycled waste is fed back to swine. Human waste, through appropriate treatment of sewage could be successfully re-cycled with algae, and rough and edible fish culture, to give additional by products like methane, fish meal and high quality irrigation water.

Population

Time nor the required expertise does not permit me to elaborate on other contributing factors such as inequality in food distribution between affluent and non-affluent nations, lack

of proper transport facilities, and social, religious and ethnic influences on food consumption and population Although population is listed last, it may be the most important, because, even though we implement all possible approaches, the problem will remain and perhaps worsen unless our numbers are held in check.

The rapid rise in population coupled with the growing impact of food has attributed the attention of a large number of individuals, at home and abroad, and the problem began to be viewed in the Malthusian setting, as a race between population and food production. Presumably. as we are all aware of the population explotion, without further ado I wish to only quote some significant statistics which are self-explanatory in assessing the more or less terrifying situation-Regards the doubling rate; the estimated quarter billion figure in O. A. D. doubled progressively in 1,650,180,100 and 45 years and the next doubling is predicted within 35 years. Sri Lanka's population which stood at 5.5 million in 1935, reached 14.1 million last year, and is projected to record 21.9 million in the year 2000. It must be borne in mind that population increase is not a mere addition of babies but proportionately increases the reproductive capacity of a nation. Every unit of 10,000 people may be reckoned as equivalent to 7,310 feed consumption units.

CONCLUSION

Ladies and Gentlemen, in concluding my presidential address, I wish to reiterate that meeting tomorrow's food requirements is indeed a formidable task, as the challenge is of immense proportions. The opportunity for great service rests on individual governments, foundations, the food industries, scientists of various disciplines and those involved with knowledge and organizational talents, to evolve the complex and interwinding programmes for a lequate solution.

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SECTION C

ENGINEERING, ARCHITECTURE AND SURVEYING

PRESIDENTIAL ADDRESS

Engineering Education (?) in Sri Lanka Today

by

H. SRIYANANDA

At the very outset, I must apologise for the title of this address. It is the result of an attempt to select a topic which is of interest to all members of the SLAAS, and yet comes within the scope of Section C, and on which I believe I have something of importance to communicate. The reason for the apology is that it is not possible to restrict oneself to the narrow field described by the title. This applies to all the restrictive adjectivs in it, viz: "engineering", "in Sri Lanka" and "today". It will be necessary, at least in broad outline, to go beyond the restrictions of discipline, geography and time.[1] The mark of interrogation in the title is, as is obvious, an indication of the questionability of the existence of any worthwhile engineering education in Sri Lanka today.

Engineering education is the classic example of "technical" education. Technical education, as conceived by the Munasinghe Commission[2] is "that specialised training and education imparted to students or persons, to prepare and fit them for occupation in the various fields of service and production". In other places, the commission has recommended that 'liberal education" should form part of the curriculum of all "technical" students. For example, on the training of architects, it says "with oriental studies, archaeology and modern science forming part of his educational environment, the young architect will be better equipped to bring about a synthesis of the aesthetic values of oriental culture and modern functional requirements".

Thirteen years after the presentation of the report of the above Commission, it is sad to note its following comments still true: "It is disconcerting to observe that the system of engineering education which (sic) obtains in the country, has not made it possible for the country to be less and less dependant on expert engineers recruited from abroad." It would of course be naive to expect to find a single reason for this situation. Perhaps it would be more fruitful to attempt to investigate what we hope to achieve by the provision of engineering education, at a more fundamental level.

The lack of achievement—I am almost tempted to call it the negative achievements—of the contemporary engineering community in Sri Lanka is sharp contrast to what had been achieved by the engineers of this country over a period of over two thousand years, starting from the time of the early settlers in the "dry zone". Even today, it is said that irrigation engineers from Sri Lanka enjoy a wide reputation throughout the world on the strength of the achievements of the old "tank builders". Brohier, commenting on the construction of the Parakrama Samudra in the 12 Century, has stated: "This achievement, we might say, crystallized the genius of Ceylon's people as irrigation engineers, raising the science to a standard which no history of any other country has brought to light.....However, one fact alone stands out from the saga of labour which created a unique civilization for Ceylon back in the mists of time, is that of all the works to which it was turned, those raised for the purpose of irrigation, call to mind the finest concepts of engineering skill, and not just merely the undertaking or of patient craftsmanship, as the other monuments do".

Very little is known about the type of education that produced engineers capable of these achievements in ancient times Perhaps the distinction lies in what Brohier calls the "width of vision". After all, the technical competance of present day Sri Lankan engineers is on a par with that of those in any other modern society, and we may safely assume, is of a much higher level when compared with that of the ancients.

"Vision" as opposed to "technique" is attributed to a "liberal" education, whereas our recent attempts at producing engineers have concentrated on imparting a "high level of technical knowledge." Whitehead has this to say on the distinction between technical and liberal education[4]: "The antithesis between technical and liberal education is fallacious. There can be no adequate technical education which is not liberal, and no liberal education which is not technical! that is, no education which does not impart both technique and intellectual vision. In simpler language, *education should turn out the pupil with something he knows well and something he can do well.*"

Even within the field of technical education in the narrow sense, our educational system is geared to the production of the 'operation and maintenance" type of engineer. This is an inheritance from our colonial past. The education and training of the engineers for Research and Development work as opposed to that for the maintenance of existing facilities is mainly a matter of the development of attitudes. It is here that the lack of a liberal education has been most telling. Engineering graduates from the University of Sri Lanka who have had the opportunity of working abroad have found the academic level of their education to be at least on par with that obtainable in any other country. As long as they are abroad, they generally outshine their peers in all branches of activity, including R & D. However, if and when they return to their country, they relapse into inactivity (and redundancy).

The reasons generally attributed for this are

1. lack of facilities
2. lack of appreciation of their work
3. administrative and political interference
4. overburdening with unproductive and unrewarding work

and 5. lack of atmosphere (group activity etc.).

Even though all the above reasons are true, there is a more fundamental and intrisic reason which affects the productivity of scientists and engineers in this country which arise directly from their training.

I would call this the lack of commitment

Modern science (and technology) has never attempted to serve mankind. It has always aligned itself with power and authority and served the interests of those in authority. Brecht, in his preface to the Life of Galileo, states[5]: "The fact is that Galileo enriched astronomy and physics by simultaneously robbing those sciences of a great part of their social importance..., these sciences stood for a while, at the barricades on behalf of all progress. It is true that a swing-back took place in the following centuries, and these sciences were involved in it, but it was in fact a swing instead of a revolution; the scandal, so to speak, degenerated into a dispute between experts. .....As far as these particular sciences are concerned, they never regained their high position in society, neither did they ever again come into such close contact with the people.

"Galileo's crime can be regarded as the 'original sin' of modern natural sciences. From the new astronomy which deeply interested a new class—the bourgeoisis=since it gave an impetus to the revolutionary social current of the time, he made a sharply defined special science, which—admittedly through its very 'purity', i e. its indifference to modes of production—was able to develop comparatively undisturbed. *The atom bomb is, both as a technical and a social phenomenon, the classical end product of his contribution to science and his failure to society.*"

In the developed countries, there are enough facilities and opportunities to work in the service of the establishment. However, in countries like Sri Lanka, the establishment itself is so weak and dependant on a foreign centre that it cannot provide sufficient opportunities for an indigenous scientific community in R & D work. The only type of work it can provide would be in the operation and maintenance of services and in a very vulnerable, foreign dependant (on technology, raw materials, markets, finances and management) consumer goods industy.

Any genuine R & D work on the part of the scientific community in a country like Sri Lanka can only stem from a change of attitude on the part of that community. *We owe it to ourselves, to humanity and to science and technology to break away from the traditions of over three hundred years, and to develop a new science and technology committed to the service of man.*

This of course is not a problem that concerns the poor countries alone. It is a global problem, and interest on some aspects of this problem have been shown by a number of researchers in the developed countries[6]. The following table comparing different facets of 'hard' and 'soft' technology is from Robin Clarke[7].

Society with hard technology	Society with soft technology
1. ecologically dangerous	ecologically adapted
2. high energy consumption	low energy consumption
3. heavy pollution	light or no pollution
4. one way use of materials & energy	recycling of materials & energy
5. narrow time scale	wide time scale
6. mass production	emphasis on artisanship
7. high specialisation	little specialisation
8. 'nuclear' familes	extended families
9. predominantly urban	predominantly rural or small town community
10. estrangement from nature	integration with nature
11. authoritarian politics	democratic politics
12. technological boundaries are of economic nature	technological boundaries are natural
13. world trade	local trade
14. destuction of local culture	preservation of local culture
15. abuse of technological opportunities	laws against abuse of technology
16. destruction of other life forms	partial dependance on the presence of other life forms
17. innovation motivated by profit	innovation motivated by needs
18. growth economy	zero growth
19. capital intensive	labour intensive
20. creates generation gap	brings young and old together
21. centralised	decentralised
22. productivity increases with size	advantages of small-scale production

Society with hard technology	Society with soft technology
23. processes too complicated	processes generally comprehensible
24. technological accidents frequent and serious	technological accidents infrequent and insignificant
25. totalilitarian solutions of technological and social problems	diverse solutions of technological and social problems
26. monoculture in agriculture	diversity in agriculture
27. quantity receives priority	quality receives priority
28. nutrition by specialised industry	food industry involves everyone
29. income as incentive for work	satisfction as incentive for work
30. complete interdependance of all productive units	self-sufficient small units
31. science and technology estranged from culture	science and technology forms a part of culture
32. science and technology of specialist elites	science and technology practiced by all
33. contrast between work & leisure	little or no difference between work and leisure
34. high unemployment	concept of work non-existent
35. technological goals for a part of the planet for a limited time	technological aims valid for all at all times

However, I believe that not enough attention has been paid to the effect of technology on social organisation and to the distinction between work and leisure. Even the critics of the left have, in general, neglected to draw any conclusions from the fact that technology often dictates the organisation of production. It, in its present form, also condemns man— at least those men who can find employment—to eight hours of unrewarding work everyday of his working life[8].

Most of us have been so conditioned by the overwhelming presence of modern technology that we tend to assume that both the hierachical organisation of production and the boredom of work are necessary evils of any production process-rather than being attributes of the current technology. I have earlier attempted to study the process of "work" using systems analysis techniques by analogy with an electrical system, and this led to a demonstration of the possibility of a non-hierachical' or a 'horizontal' form of organisation. When the subject of self-rewarding work was introduced at a recent discussion[10], one of

the participants remarked that it might resemble Aldous Huxley's Brave New World where men are genetically selected and bred to like their particular jobs. This is another example of our pre-occupation with the present-day technology and the consequent self-imposed limitation of vision. What was intended is closer to the situation in Huxley's other novel, 'Island', where the technology is made to fit the needs of man, and not the other way round.

Let us now come back to the question of education A common criticism of the engineering curriculum in Sri Lanka is that it is too theoretically oriented.

Whitehead[11] has this to say of science: "Science is a river with two sources, the practical source and the theoretical source. The practical source is the desire to direct our actions to achieve predetermined ends The theoretical source is the desire to understand. Now I am going to emphasise the importance of theory in science. But to avoid misconception, I must emphatically state that I do not consider one source is in any sense nobler than the other, or intrinsically more interesting", *If we re-examine the contents of our undergraduate programmes in the light of the above I would contend that there is insuffic'ent theoretical development. The fact is that our courses turn out graduates with neither theoretical nor practical capabilities.* The solution is not to attempt to make them more practical oriented by introducing the teaching of particular skills, but to reorganise the courses in such a way as to impart basic theoretical knowledge, and more important, to develop the attitudes of inquiry and research. Practical skills can be developed by the individual to suit his particular needs when the occasion arises, provided that there is a genuine commitment to what ever goal that is set. If we try to teach all the practical skills that would be required during the working life of an engineer, we may need to extend the duration of a University course to 20 years or more What we should eliminate is not the theoretical bias (which, I contend, is not there to begin with) but the

tendency towards book learning—be it "theory" "or practice"—there can be, and there is, "book learning" even in such "practical" subjects as workshop technology.

Apart from the more obvious reasons such as the insufficiency of resources, muddled thinking, right from the very highest "academic" levels, has been one of the major causes of this situation. Attempts are made to "maintain standards" -- meaning the ability of students to answer examination questions -- without serious consideration of the intent of the whole exercise. Earlier, Whitehead was quoted as saying "education should turn out the pupil with something he knows well and something he can do well". We have been, and are, turning out students who can answer examination questions well, and what is worse, we are, by the nature of the education that is given them, aelienating them from society so that they find themselves both incompetent and unwanted.

Let us now re-examine the main theses of this address.

1. Education should be directed towards the attainment of both personal and social objectives.

2. There should be no contradiction between the above objectives.

3. Long term social objectives must be evaluated for the greater satisfaction of all men and women, and should take account of natural limitations on resources etc.,

4. We should have sufficient "width of vision" to envisage a totally different social and productive system from what exists today, and concieve of a new science and technology to make it possible.

5. Education should help augment the commitment of the student to such a goal.

6. It should be "reseach" oriented rather than "maintenance" oriented in other words, should be "pro-revolutionary" rather than "pro-establishment."

The above are global goals, not restricted to the poor or "underdeveloped" countries. In this country, this has sometimes led to the response that they are Utopian, or that they can only be implemented in a developed country with sufficient resources. Even the most radical of the thinkers in developed societies contend that reorganisation of the world structure can only originate from their societies. This neglects the fact that the most important resource necessary for such a reorganisation is human – it is the commitment of men and women to a just, stable and equitable society. Such a commitment can and need to be created in our part of the world. In this context, one may point out to the very successful methodology of teaching literacy to adults developed by Freive[12].

I would like to end this address with a plea for a closer look at engineering education as imparted in this country so as to :

1. create a commitment to humanity and justice.

and 2. to develop an inquiring attitude of mind and an aptitude for creativity based on sound fundamental principles, rather than an ability to solve stock problems with "conventional wisdom and knowledge".

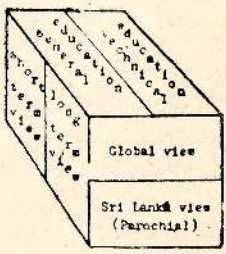
Notes

1 Some of these aspects were discussed at the 3rd Workshop on the Role of the Technologist in Society—The Education of the Technologist—conducted by Section C of the SLAAS in association with Section F and the Institution of Engineers. A handout distributed at this workshop is reproduced below.

THIRD WORKSHOP ON THE ROLE OF THE TECHNOLOGIST IN SOCIETY—
THE EDUCATION OF THE TECHNOLOGIST
1600—2000 hrs on 1976—05—03.

Which view should we take?
(In the extremes—a global, long term, general view: or a local, short term, 'technical' view?)

The questions posed below are from some such view points.



There is a very high drop out rate among school children in Sri Lanka. Should not the removal of its causes (mainly social) have priority over most other reforms? Could this be accomplished by curriculum revision? In particular, does pre-vocational training help?

What should be the medium of instruction at University Level? Cannot the disadvantages of using a foreign language, alienation, etc..) be removed by providing a balanced general education without losing its advantages (cohesion among different communities, etc.)?

How should we train our future engineers and technicians? Is it necessary to have two such classes? (or for that matter, classes 'lower down', such as those of artisans)? Given the proper environment, would not most people be capable of achieving at least a 'graduate' intellectual level? Can we not reorganise society and production in such a way as to use such people for most jobs?

Do we need to think of 'technical education' as a distinct discipline? Would not a more broad based general education be preferable?

In our present state of development, are we justified in undertaking pure and abstract research of no immediate utility? On the other hand, can we afford not to undertake pure research, leaving us in a subordinate and dependant position on foreign know how for all time?

Can we not exploit our human resources (not in the manner traditionally advocated viz: labour, intensive industry, but) by developing an 'intelligence intensive industry? If we do succeed in such an endeavour, can we not present this as a model for a better world?

There are two apparently contradictory views expressed on the balance between theory and practice. One is that we in Sri Lanka have a very theoretical outlook which neglects the development of practical skills. The other is that we have neglected serious theoretical analysis. Cannot both these be true, in that we have concentrated on 'book learning' without developing an independent creative ability?

What is 'appropriate technology'? Is it second rate (and out of date) technology as is commonly understood, or is it not something that needs a very high level of original and creative thinking to develop, something more than, and above, 'non-traditional' technology?

Should there be two distinct types of activity – 'learning' and 'working? Should they not be integrated (possibly, after an initial period of intensive learning)?

2 The Munasinghe Commission Report, published as Ceylon Sessional Paper X—1963.

3 A description of the building techniques and skills employed in the ancient irrigation works in Ceylon is given in Appendix B of R. L. Brohier's "Food and the People", Colombo, Lake House Investments, 1975. The book traces the history of food production in Ceylon from the earliest times to the present day, including the interplay between cultural, legal and technical aspects. About the engineers who built these works, he says: "They were men possessed of high technical ability, with wide vision and a highly developed 'water' and topographical sense".

4 Whitehead, A. N. "Technical Education and its Relation to Science and Literature", Presidential Address to the Mathematical Association of England, 1917.

5 Brecht, Bertolt. "Laben Des Galilei", Verlag, Berlin. 1955 (Translation – Versey, D. I. "The Life of Galileo", Methuen, London, 1963).

6 For example, see the special issue (No. 23, June–July 1972) of the Spokesman on "Socialism and the Environment" (publishers The Betrand Russel Peace Foundation Ltd.) The following extracts are from Robert Jungk's paper on "Politics and Technology" in this issue.

(i) "The first doubts about the positive evaluation of science and technology naturally appeared in connection with their military purposes. These were–and are–allayed by argument that the available knowledge was

simply incorrectly applied and that politics is responsible for this abuse. But with some justification the question is now being asked whether scientific and technological research as currently practiced do not intrinsically contain the seeds of their destructive application."

(ii) "This critical unrest, first felt among the younger generation, will demand a 'new science' and a 'new technology', which will not militate against nature, against man and his participation in the formation of 'policy', but which will be subject to humane and participatory principles. The already visible, and steadily increasing, failure of technocracy should of course not merely be viewed impassively, but should serve as a spur for the development of lifesaving and life-ensuring democratic concepts."

Also, see "Blueprint for Survival", republished by Penguim from the Ecologist. Also "The unviablity of Capitalism" by Colin Stoneman in the Spokesman (No. 23, June-July 1972). Stoneman says : "I want to start by stating two facts - (1) The 'developing countries' are not developing, and cannot do so in the present world system; (2) The 'developed countries' are on a suicide course that at least will destroy their way of life, and quite probably the whole of civilization, in the course of the next few decades.

"Few socialist will dispute the first fact. Many will, I am afraid, be inclined to dismiss the second as another mainfestation of the current 'fashion' for ecology, The concern with pollution is often seen as no more than a middle-class attempt to divert attention from the central need for redistribution (in all aspects); and the poor countries, understandably tend to view the pressure that is being put on them to control their pupulation growth as another aspect of imperialism."

7 Robin Clark's table comparing hard and soft technology given in the text is reproduced from the paper by Jungk referred to under note 6.

8 On work and leisure, Humboldt (in Wilhelm von Humboldt: "The limits of State Action" Editor J. W. Burrow, CUP, Cambridge 1969) says : "...all peasants and craftsmen might be elevated into artists: that is men who love their labour for its own sake, improve it by their own plastic genius and inventive skill, and thereby cultivate their intellect, enoble their character, and exalt and refine their pleasures And And so humanity would be enobled by the very things which now, though beautiful in themselves, so often serve to degrade it."

See also Noam Chomsky: "Problems of Knowledge and Freedom–The Russel Lectures", London, Fontana/Collins, 1972. The following extracts are from the lecture "On Changing the World".

(i) "Such ideas are in sharp contrast to a widespread view that 'All social democratic ideals' fundamentally relate to how we distribute our wealth and allocate our resources: that is what socialism is about...' For Russel, what socialism is about is the liberation of the creative impulse and the reconstruction of society to this end. Wealth might be distributed equitably in a prison and resources allocated rationally by a dictatorship or corporate oligarchy. Social democratic ideals are concerned with freedom..."

(ii) "The convergence of the great industrial systems to some form of state capitalism or state socialism—a particular form of autocratic control of production—has proceeded somewhat along the lines that Russel foresaw. Half a century later, one can see still more clearly the 'extreme similarity between the Bolshevik commissary and the American Trust magnate.....both.....imbued with the importance of mechanism for its own sake, and of their own position as holders of the key to the clockwork."

9 Sriyananda, H. "Systems Analysis—An Introductory Overview", Department of Electrical Engineering, Katubedda Campus, Publication No. 2, September 1967.

10 "Commitment to Justice"—Seminar organised by the Social and Economic Development Centre (SEDEC) at the Lewella Retreat, Kandy; 17—20 September 1976.

11 Whitehead, A N. "The Organisation of Thought", Presidential address to Section A at the Newcastle meeting of the British Association for the Advancement of Science, 1916.

12 See "Cultural Action for Freedom" and "Pedagogy of the Oppressed" by Paulo Freive. Both are available in Penguins.

SECTION E — PHYSICAL SCIENCES

Presidential Address

"LOOKING INTO METALS"

by

P. P. G. L. SIRIWARDENE

I think I should speak for a short time about what metals are, before we can describe what their internal structures look like and before we look at a seriese of slides to illustrate what I have said.

As you all know, metals have been used by man for at least the past five thousand years or so, and we are aware of the extent to which we depend on metals in our everyday lives. We are aware of our dependence on metals for our material needs. Civilization, as we know it, is not possible without the use of metals. When we think of the earliest use of metals evidence is available of nomadic tribes who used crude metal mainly for making implements useful in hunting. In the next stage, the gradual settling down of humans led to their increased dependence on growing their own food and this led to the development of an agricultural society. Due to this there arose an increased use for metals with the need for more use of implements and tools for farming purposes

Evidence is also available to show that iron in a crude form had been extracted since early times and that it had been even converted into small rods of steel. Precious metals such as gold too had been used in those times, of course, in very small quantity. Metal extraction had begun in the Middle East region and these methods had spread into parts of Europe and also into Northern India. Later, this influence progressed down to the South and also reached Sri Lanka where too evidence has been recorded of the production of iron and its "purification" into steel. Slag heaps are yet seen in parts of the countty.

Steel produced in India and probably in Sri Lanka as well, had even found their way to make the famous Damascus swords. It is fascinating to read these early accounts and also the accounts by persons such as Ananda Coomaraswamy. The first alloys to be prepared were the bronzes and this was also in the Middle East. There is evidence of early bronze statues and other articles of bronze such as the ancient bronze coins. Metals that were available in early times were those which could be obtained relatively easily, for instance gold was found even in a native form and iron was easily obtained by the reduction of iron ore in small furnaces using charcoal as the reducing agent.

Copper, tin, lead, silver and zinc too have early histories of extraction. Strangely enough, it took a very long time before the widely used metal, aluminium, could be extracted. It was only in the 1880's that the electrolytic method came into use to prepare aluminium from naturally occurring bauxite. Reduction methods, however, for extracting metals such as iron, were much more straightforward. This century has seen the rapid development of new materials especially during the last three or four decades. Among these have been numerous special alloys of metals used for a wide variety of specific purposes depending on whether they require to be heat resisting, corrosion resisting, fatigue resisting and so on. There is such a variety of materials today. In fact, as J. D. Bernal put it ' Available materials set a limit to the techniques of any age" — and how dependent therefore are we today on this large variety of materials.

Metallurgy has been both an art and a science. It is the art and science of obtaining and adapting metals to serve our different needs. Metalturgy has several branches. There is extraction metallurgy which deals with the extraction of metals from naturally occurring sources called *ores*. Sometimes we may even call this branch *chemical metallurgy* to also include refining or purification processes.

Another main branch is *physical metallurgy* which deals with the behaviour of metals. In fact this branch has broad scope and includes the study of metal structure and the correlation between structure and properties. Another aspect of physical

metallurgy is the testing of metals. The study of metal structure is called *metallography*. My talk today, namely, '*Looking into Metals*' is with a view to using some examples of metals and alloys and to look at their macrostructures or microstructures and explain their behaviour and properties. Metals are unique in this respect in that the same metal can be made to undergo change to give different structures, and thereby the same metal can be made to acquire different properties and hence different uses. This is a very great advantage in the use of metals. Before we look into some slides it is necessary to very briefly become aware of some basic facts in the study of metals.

Metals are crystal structures. The atoms which compose a metal form a system of positively charged ions held together by an 'electron gas' which is negatively charged. This is a very simple way of describing the 'metallic bond'. As the total positive charge is equal to the total negative charge, a metal is electrically neutral. Ions in a metal are in a regular arrangement and this is what is called a crystal arrangement. Metals are built up of crystal units or unit cells and these are repeated in three dimensions to give the total metal structure.

Several crystal systems and unit cells are known but metals generally fall into three types of unit cells One type is the face-centred cubic, examples being copper and aluminium; another is the body-centred type such as ferrite; and the third is a close-packed hexagonal type, zinc and magnesium being such examples.

Another feature we might mention is that pure metals are generally soft and hence do not find much application, anyway not on a large or industrial scale. Crystals in a pure metal are too regular, the structure has little or no distortion. Distortion in a structure is often beneficial; it increases the hardness of a metal and therefore alters and often improves the mechanical properties. One can distort a structure in several ways. By beating a metal with a hammer we can distort the structure and the area which became distorted would have a greater hardness than the rest of the metal.

A useful and more practical way of creating irregularities in the structure and hereby alter the properties is by producing alloys. Steel is an alloy of iron and carbon; alloy steels would have other elements in addition. Brass is an alloy of copper and zinc; bronze is an alloy of copper and tin and there are of course very many other alloys. Alloys are products of two or more metals. Chemical elements such as carbon, silicon or phosphorus can also function as alloying elements. Such elements which are neither metals or non-metals are referred to as *metalloids*.

There are two types of alloys, *substitutional alloys* and *interstitial alloys*. An example of the former is brass where atoms of zinc replace some of the atoms of copper, that is, some atoms are substituted by other atoms. An example of the interstitial type is steel where carbon atoms being very small fit into the interstices or spaces in between the atoms of iron.

With these preliminary remarks let us now look into some metal structures. The structure of metals began to be observed around the beginning of the last century when Widmanstatten polished the surface of a piece from a meteorite and on etching this, observed a beautiful geometric pattern. This type of pattern is now called a Widmanstatten structure.

Since the meteorite was a iron-nickel alloy it was soon deduced that metals and alloys are crystalline materials.

Other metallographers followed, for instance Martens after whom the martensitic structure is named, and Austen who is remembered by the austenite structure. Around the middle of the last century the microscope found use in studying metal structures and the metallurgical microscope began to be developed particularly with the work of Sorby in about 1890 in England.

Let me briefly indicate how a metal is prepared for examination under a metallurgical light microscope. A small specimen of about half to one inch in diameter is cut from the metal to be examined taking care that no undue heating occurs during the cutting, because if this happens, the structure could change. A mirror-like polish is obtained on the surface to be viewed by

polishing on successively fine grades of emery paper and finally on a mechanically rotated polishing wheel where an abrasive such as a suspension of alumina in water is used. The polished surface is next etched by dipping for a short time in a suitable chemical such as nital which is nitric acid in alcohol. Nital is commonly used for etching steels whereas for brasses a ferric chloride solution is suitable. There are different etching reagents or mixtures of reagents depending on the metal or alloy to be etched The etchant attacks different parts of the metal surface differently and brings out the structure.

We referred earlier to the crystal structure of a metal but studies or information right down to the arrangement of atoms or ions is not always necessary for the practical purposes of a metallurgist or an engineer. The larger structure known as the grain structure is often sufficient. A metal consists of a system of grains (which are crystals) separated from each other by grain boundaries. A metal solidifies from the molten state by the formation of solid nuclei which grow and this process of nucleation followed by growth produces the grains.

At grain boundaries the regular arrangement of atoms is disturbed and they are therefore weaker than within the grains. The etchant therefore attacks the grain boundaries more than the grains themselves and hence the grain boundaries show clearly. The etched specimen is viewed in the metallurgical microscope by reflected light and the microstructure is observed. It is sometimes possible to see a structure even without the use of a microscope as for example, the crystalline structure of a sectioned iron or steel ingot or the grain structure on the surface of a galvanized iron sheet. These are the larger structures or marco-structures. The grain size is often related to the hardness of a metal and hence to its mechanical properties.

A large grain size indicates a softer metal and the hardness increases as the grain size becomes smaller. Grain size alters if a metal is heated sufficiently and allowed to cool. A faster cooling rate results in a smaller grain size and increased hardness. A slow cooling rate produces a larger grain size and a softer material as happens in the heat-treatment process known as annealing.

It is interesting that the hardness of a metal can be altered by varying both the heating temperature and the heating time. Therefore, the same hardness can be obtained by holding the same metal either at a higher temperature for a shorter time or at a lower temperature for a longer time. When the microstructures of each of these cases is observed the similarity is remarkable, the grain sizes in the two cases being identical. The use of the light microscope has its limitations of both magnification and resolution. The maximum magnifications obtainable may be a little over x1000. Using oil-immersion lenses however magnifications of x1500 may be possible. The resolution may at higher magnifications be insufficient. In any case when magnifications of over about x2000 are needed the electron microscope comes into use. The electron microscope is now used extensively for the study of metal structure. It was not until the 1930's that the optical possibilities of the electron were realised. The earliest was the electron photograph of an oxide cathode, the photograph resulting from its own thermally emitted electrons. The magnification was very poor and Bruche and Johannson of Germany who did this work also in the same year published their first paper on a transmission type of electron microscope. German workers continued to take electron micrographs but at small magnifications. By 1941 good photographs of aluminium alloys appeared using the oxide replica technique. In fact this replica technique began as a natural replica when Mahl in Germany found that the oxide layer on aluminium could be stripped off by scratching the surface with a needle and attacking the metal through the scratch with mercuric chloride. The oxide layer stripped off is thin enough to be examined by transmission in the electron microscope. The oxide replica technique became quite developed particularly for aluminium, magnesium and their alloys. The surface after electrolytic polishing, was electrolytically oxidized. Iron or steel cannot be examined in this way and the use of plastic replicas developed for such uses. The polished surface is etched and then given a thin layer of a plastic material such as polyvinylaldehyde known by the trade name Formvar. The layer is stripped off and examined as a replica by transmission in the electron microscope. These replicas proved to be quite reliable and reproducible. Another development in replica techniques was the carbon replica where a thin layer of carbon

is made to form on the etched surface through vapourisation. This layer is removed by dipping in a suitable medium and then examined by transmission in the electron microscope. This technique was developed in the mid 1950's.

Replicas were used at that time as it was not possible to prepare thin enough metal specimens for examination by electron transmission. However, thin foil preparation has advanced very much and today the examination of thin foils of metals and alloys is widely carried out. By 1963 itself thin foil specimen preparation techniques were established and many studies became possible due to very fine structures becoming observable with high resolution. In this way investigations ranging from phase change studies to those where dislocation morphology of the crystal structure was involved became possible.

Outstanding developments took place in the improvement of electron microscopy and innovations in instrumentation particularly in high voltage transmission electron microscopy and scanning electron microscopy. Many studies and also discussions and arguments arose in structure – property developments and there was a tremendous increase in research involving the use of the electron microscope in metallurgy. For example, in Acta Metallurgica alone such research papers which were about 10 percent of the research papers published in 1960 rose to about 40 per cent by 1970.

The development of electron metallography saw the introduction of the double-condenser lens system giving high illumination intensities. Resolving powers of about 3Å were virtually guaranteed. The electron microscope itself became useful for electron diffraction measurements. Electron microscops of the million volt tpye are also available today. Significant investigations have been possible on age-hardening, a term used for changes that take place in certain alloys such as aluminium alloys when left over periods of time. The term precipitation hardening is also used as age-hardening changes are associated with precipitation of phases. The electron microscope by study of precipitation at interfaces has enabled very significant investigations to be carried out which have long term implications on the development of steels and the control of properties by heat

treatment. Precipitation of intermetallic phases within ferritic and austenitic matrices have received study. The effects of hydrostatic pressures on the transformation products or iron-carbon alloys have been investigated.

Work hardening in metals and alloys have been examined by electron microscopy after work hardening at very high strains even up to 99.9 per cent. Work hardening, as the term implies, refers to hardening due to the metal being worked, that is by rolling, drawing, forging or by other means. The study of deformation in crystal structures, dislocations in the crystal structure caused by such deformation, dislocations at grain boundaries, precipitation at grain boundaries, recrystallisation of metals after heating, are all problems, for the solution of which, the electron microscope is playing a leading role.

The electron microscope has enabled detailed study of fatigue mechanisms. There are studies on fatigue processes in multiphase materials particularly aluminium alloys. There are studies on fatigue crack initiation. The scanning electron microscope finds extensive use for examining initiation and propagation of fatigue dracks which are problems of much practical importance. The development of supersonic aircraft has led to an increased need for studying problems of fatigue at high temperature, involving both fatigue and creep. Creep is the change in dimension of a structure under its own load over periods of time. Of course this change in dimension is enhanced by increased temperature and unless materials have good creep resisting properties failure is possible of structures constructed with such materials. Electron microscopy has been widely used to study creep deformation processes particularly in high temperature ranges. The term 'fatigue' that I mentioned earlier is, I am sure, known to you. A metal if it is subjected to alternating stresses will undergo fatigue and might develop cracks and fail completely just as you could break a piece of wire if you go on bending it backwards and forwards for some time. Metals used for structures which are influenced by such alternating stresses must be so selected that they have good fatigue resisting properties. For instance, this is very important in aircraft manufacture.

I can continue to give many examples of studies being made using electron microscopy but the essential feature is that the microscope enables one to make investigations using high magnifications and high resolutions. It is not often useful to have an image highly magnified if its component parts cannot be seen clearly. The resolving power of the microsecope has therefore to be good. That is, the ability to see clearly two or more objects close to each other as separate.

Let me, in any case, refer to just one more area where electron microscopy is playing a vital role. This is in the study of superplasticity - the study of the mechanism by which superplastic deformation occurs. You would, no doubt, know what plasticity means. Metals undergo plastic deformation. Unlike an elastic deformation where the metal would return to its original dimensions once a load or weight that has been applied to it is removed, beyond such an elastic range, metals enter the plastic range where removal of an applied load yet retains an increase in the metal's dimensions.

The microstructural characteristics of metallic materials that exhibit what is called superplasticity are being recognised and it appears that ultrafine-grained structures are required. Subsequent deformation can then occur by a number of mechanisms which have been studied by both replica and thin foil techniques. Rapid advances in metallography have been due to the use of electron micrography and an argument for high voltage electron microscopy is that thicker metal foils can be examined by transmission and this also makes the preparation of the foil easier. It also helps the belief that the structure seen in a thicker foil may be more truly representative of the material studied. There are also other advantages because with increasing valtage there is a decrease in the wavelength of the electron beam and hance a reduction in any chromatic and spherical aberrations in the lens. A disadvantage of high voltage electron microscopy is of course its cost and the installation itself would be more cumbersome.

It may also be mentioned that an outstanding development in electron microscopy has been the scanning electron microscope where the beam of electrons is made to scan the specimen surface

and either the back-scattered electrons or the secondary electrons are used for image forming. Topographical contrast has led to wide application of this type of microscope because a large specimen can be used and, with the large depth of focus, fracture surfaces can easily be examind such as fatigue fracture, ductile fracture, crack propagation and so on.

In the limited time left, let us rapidly go through the slides. The *first slide* shows the metallurgical microscope. There is a source of light, the light enters a collimator which has an adjustment to control the intensity of light, the light strikes a glass slip which is at an angle and gets reflected down through the objective lens on to the specimen surface on a stage. After striking the surface it gets reflected back through the glass slip and enters the viewer's eye through the eye piece. By using suitable eyepiece and objective lenses the magnifications can be altered.

Slide 2: Shows a model of a crystal structure. You will notice the regular arrangement of ions represented by small spheres. Perfect crystals are rare, crystals usually have imperfections. This slide shows some of these imperfections. We see impurity atoms, some impurity atoms are interstitial i.e. are placed in the spaces between the normal atoms. We also see atoms (or ions) missing. These spaces are called vacancies.

You will remember that I mentioned that metals normally fall into three types of crystal structure namely face-centred cubic, body-centred cubic and close-packed hexagonal. The face-centred cubic unit cell is as the name implies cubic in shape with ions at the eight corners of the cube and one at the centre of each of the six faces of the cube. The body-centred cubic structure has eight ions at the eight corners and one at the geometrical centre of the cube. In the close packed hexagonal there are two hexagonal faces with ions at each of the six corners in each face and sandwiched between these two faces is a triangular shaped set of three ions, one at each corner of the triangular arrangement. The sandwiching by these three ions makes the normal hexagonal structure more closely packed and hence the term.

Slide 3: Is an electron micrograph of a magnification of X 150,000 showing a dislocation in a crystal. You will notice that the perfect array of atoms as seen elsewhere is disturbed in one area where the arrangement is "out of step" as a line. This is a 'line dislocation.'

Slide 4: This shows the two different types of solid solution phases. Note in the substitutional type some atoms are different to the others but they are of about the same size and have merely substituted one for the other. For instance the dark circles can be considered to be zinc atoms and the lighter ones as copper atoms as would be in the case of brass. In the other illustration small atoms are placed at the interstices or at the spaces in between the parent atoms. This is an example of an interstitial solid solution, the small atoms may be carbon and the large ones iron as in the case of steel.

Slide 5: Is a typical ingot structure; in fact it is a macrostructure visible with the naked eye. The cross section shows fine grains at the outside where the cooling rate has been high and these grow inwards like columns, called columnar grains and in the centre where the cooling rate is relatively much lower the grains are more or less polygonal and equiaxed. We see this in the major part of the structure but towards the top we see the impurities which have been forced up and these form a small section at the top. This section if large is usually cut off as it contains impurities and only the cleaner section is used for practical purposes.

Slide 6: Shows microstructures of three types of cast iron. Cast irons contain a higher proportion of carbon than steels, usually around 3 or 3.5 percent. The first figure is a grey cast iron where you see flakes of graphite. This type of cast iron is easy to machine due to these flakes which also have a lubricating action. The second one is also a grey cast iron but there is also more pearlite in the background. Pearlite is a system of alternate plates of iron carbide and iron (as ferrite). Iron carbide itself is called cementite in these structures. The third figure shows nodules of carbon in a matrix of iron. It is a malleable form of cast iron produced by heating to high temperatures whilst

packed in some inert material like silica. The carbon collects into nodules like rosettes and are no longer in flakes and imparts malleability and makes the material susceptible to easy shaping for instance.

Slide 7: Shows diagrams illustrating the analogy between the light microscope and the electron microscope. The diagrams are side by side, in one there is a lamp as the sourse, the other has a cathode as the source of electrons. These are collimating lenses, glass in the light microscope and magnetic lenses in the electron microscope. The electron beam strikes the specimen which may be a replica or a thin foil and then passes through the objective which is also a magnetic field and then a projector lens projects the image on a fluorescent screen at the bottom. Focussing devices are available and also devices for taking micrographs, the photographic plates below the fluorescent screen can be exposed by raising this screen and lowering it after the required exposure time.

Slide 8: is a typical stress-strain curve showing how the dimension of a specimen changes with increasing load. Up to a point there is an elastic range where the specimen will return to its original length once the load is removed but after that is the plastic range where a permanent deformation will remain even when the load is removed. Then with increasing load there is finally the fracture point where the specimen will break into two.

Slide 9: Grains are seen in both these pictures. In addition there are fractures that have taken place. In the top picture the fracture path is along grain boundaries. This is called intercrystalline fracture. In the other case the path is across grains and this is transgranular fracture.

Slide 10: Is a cup and cone fracture cause in a tensile test. One section is hollow and the other portion has retained what is missing and fits into the hollow. This type of fracture is called a cup and cone fracture.

Slide 11: Is an example of corrosion inside a copper pipe used to handle drinking water. The corrosion is non-uniform and is initiated by inhomogeneities in the metal. The picture shows deep isolated holes close to each other and this is referred to as 'putting'.

Slide 12: shows corrosion at a weld due to a corrosive environment attacking the surface and the corrosion proceeding along the weak grain boundaries.

Slide 13: Are two other examples of corrosion. One shows more or less uniform corrosion inside a brass water pipe. This is due to dezincification, loss of the zinc component in brass by corrosion attack. The other shows corrosion at the elbow or corner in a steam pipe. This is due to erosion at the bend due to impingement attack by the liquid steam condensate.

Slide 14: shows microstructures of a steel after various stages of isothermal transformation. At the high temperature, for example about 1000 degrees centigrade, the structure would be austenite; then on quenching to say 500 degrees and holding at this temperature for various times (these are called isothermal transformations) the structure changes to pearlite and depending on the temperature and time of isothermal transformation the type of pearlite also changes.

Slide 15: shows a typical temperature time transformation diagram showing the transformations which would give for instance, coarse pearlite or fine pearlite, or a feathery type of pearlite called bainite. These are all examples of microstructures.

Slide 16: shows three structures. The top one is of a transverse section of a cast cylindrical zinc ingot. The etching reagent is 5% hydrochloric acid. Small equiaxed grains are at the periphery due to the rapid chilling by the cold casting mould wall. Then beyond this small crystal formed towards the centre of the ingot.

The centre figure is a section of nickel pellet produced by decomposing nickel carbonyl vapour. You will notice a very fine grain and the successive layers of metal formed due to the decomposition shown as concentric circles.

The bottom picture shows chromium deposited electrolytically and a network of cracks is seen due to the internal stresses generated during electrodeposition.

Slide 17: illustrates the influence of purity and rate of casting on continuously casting aluminium ingots and these determine the nature of equiaxed and columnar grains that are produced. In the last picture you will notice that with greater impurity content and increased casting rate the columnar crystals are no longer formed.

Slide 18: shows the size and nature of grains formed when impurities are present and **Slide 19** shows microstructures of copper and of aluminium alloys. The first shows crystals growing in a fern like pattern; these are called dendrites; it is a dendrite structure, the second, also a copper alloy with nickel and aluminium shows polygonal or equiaxed grains and also shows in some places crystals like "parallel sets", like images of one another. These crystals are called 'twins' and the phenomenon is called "twinning".

Slide 20: Shows electron micrographs of Armco iron by using thin foils in the microscope. The four micrographs show how the shape of the grains have been altered with different degrees of deformation of the metal. You can see the dislocations created and the shearing of the metal in the direction of slip directions of the crystal planes.

Slide 21: Here are three micrographs. One is of a Copper-30% zinc brass, cold worked and annealed. The etchant is ferric chloride solution. Equiaxed grains of alpha brass are seen. There are also "twins" like before. These are the grains that like narrow parallel lines. You will notice that some grains are darker than others. This is because of the orientation of grains being different due to their growth in different directions. The etchant attacks these differently oriented grains differently and hence the difference in shades. The middle micrograph is a copper - 40% zinc brass, You see light alpha grains and dark beta brass grains as a new beta phase has now developed with increasing zinc content. The third picture is of brass similar to the middle picture but this has been annealed and the grains are rounder.

Slide 22: Shows a tin-antimony-copper alloy called white metal etched with ferric chloride. There are needle like CuSn

precipitates, forming star-shaped dendrites and also cube shaped precipitates of SnSb. The background or matrix is tin with a little antimony and copper dissolved in it.

Slide 23: Shows a grain system of a nickel-chromium-carbon alloy showing precipitation at the grain boundaries. The precipitates include carbide formation at the grain boundary

Slide 24: Shows a carbon steel shawing areas of ferrite grains and pearlite areas which appear dark. The pearlite areas are actually alternate ferrite and iron carbide plates. The etchant is nital, that is nitric acid in alcohol.

Slide 25: Is also a plain carbon steel heated to about 900 degrees centigrade, quenched at 600 degrees and maintained at this temperature for different times. These are isothermal transformations and you see that the original austenite gradually gets converted to more and more pearlite.

Slide 26: Give electron micrographs of a quenched carbon steel tempered at varying temperatures for varying times. These are micrographs of Formvar replicas. The fine needle like martensite structure of a quenched specimen changes to areas of ferrite and iron carbide particles form at the grain boundaries. These particles grow in size and also the ferrite grains grow in size with increasing tempering temperature and tempering time. Tempering is merely reheating.

Slide 27: Also a grey cast iron with graphite flakes in a matrix of pearlite and

Slide 28: Shows black heart malleable cast iron with graphite in the form of nodules or rosettes as we had seen earlier. The background show clear ferrite grains. The picture at the bottom is of white heart cast iron where the black carbon is not seen at the edges due to decarburization but is seen as nodules only towards the centre. White heart cast iron is prepared by heating grey cast iron surrounded by iron oxide and the latter removes the carbon as carbon monoxide and causes decarburization. In the case of black heart the heating was done where the grey cast iron was packed in silica which was inert and hence no decarburization occurred.

Slide 29: Shows micrographs of some welds. The top is a micrograph of a brazed T-joint in copper, the bottom one is a butt weld in a mild steel plate.

Slide 30: Shows surface hardening of steel. The first is due to nitriding where the outer surface has a thin layer of iron nitride which causes hardness. The lower picture shows an outer hard carbide layer due to carburizing, that is heating the metal packed with a carbonaceous material in boxes. Liquid carburizing is also possible by enclosing in sodium cyanide or gas carburizing can also be done by a heating in a hydrocarbon or even a town's gas atmosphere The carbon penetrates the surface and more easily along the weak grain boundaries towards the interior of the metal.

Slide 31: Pure iron oxidized very lightly. This is an electron micrograph of a carbon replica showing crystals of oxide on the surface in a definite orientation relationship with the underlying metal. It is like a beautiful flooring design for those interested in looking at that way.

Slide 32: Shows pure iron with crystals in the form of 'whiskers'. It is an electron micrograph. You will notice the unusual and beautiful pictures you can get with metals.

Slide 33: Show oxide scale due to corrosion. These micrographs show corrosion layers in iron which has undergone different degrees of corrosion.

Slide 34: Is the last one. The micrograph on the left is of a mild steel specimen taken from a boiler ofter 20 years of service. You will notice how graphitization has taken place during service, that is the iron carbide in the steel has decomposed and carbon nodules have begun to form which will cause disintegration of the metal in those areas. On the right is a mild steel specimen taken from wall of a pipe, etched with nital.

There are inclusions due to impurities and when this pipe was welded the contraction stresses have opened up the region with inclusions giving major cracks.

I have taken more than the time allotted for this talk and I appreciate your patience to listen to a topic which certainly is not easy to be made totally clear in a limited time. However, I do hope that I have done justice to this topic which enables us to find out and explain the behaviour of that important class of materials namely, metals, so vital to our lives.

INFRASTRUCTURE,

RURAL DEVELOPMENT AND PHYSICAL PLANNING

by

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Introduction

'Physical Planning and National Development', the theme of this thirty-second Annual Session of the Sri Lanka Association for the Advancement of Science, is a subject which has been my principal concern during my professional life.

I wish therefore during this Session, to which members of the public have been invited, to keep to this theme, but to concentrate on the needs of rural communities which form the majority of the people of Sri Lanka and of all countries of the developing world.

I also wish to discuss the role of infrastructure on which both rural communities and rural development depend, as well as the contribution which physical planning is able to make in the provision of infrastructure, in the promotion of rural development and in helping to meet the essential needs of rural communities.

The problem of defining INFRASTRUCTURE arose during HABITAT, the United Nations Conference on Human Settlements held in Vancouver in June 1976, when it was described as 'the network designed to deliver or remove people, goods energy or information, including transport and communications', and was distinguished from 'services' such as education, health, culture, welfare, recreation and nutrition.

I suggest the definition should be broader than this, and that 'infrastructure' should refer to the whole *physical* framework within which all activity, including agriculture and other forms of development, takes place; ie housing and buildings of all kinds, roads and other forms of transportation, communications, water and energy supplies, all forms of water and refuse disposal, and measures to prevent flooding, erosion and all forms of environmental pollution.

This paper is concerned with the ROLE of infrastructure and will attempt to deal with principles, policies and planning, rather than with details of the design and implementation of various form of infrastructure. Also, although there may well be similarities between the rural problems in the developed and developing world, it will give emphasis to developing countries where the majority of the world's poor and under-privileged are to be found.

Developing Nations

Conditions in developing nations vary enormously in character and intensity, from country and from continent to continent. Africa has a very low polulation density, relatively little pressure on land, and comparatively few urban settlements of any size south of the Sahara. South America also has relatively low population denisities but, in general, a large proportion of the urban population is concentrated in comparatively few centres. For example, in Argentina roughly one-third of the total population is found in the capital city, Buenos Aires.

In Asia however population densities are very much higher, there is considerable pressure on both urban and rural land in many places, and problems often appear insoluble. India, for example, roughly equal in area to the toe of Africa, has a population twice that of the whole African continent, and greater that Africa and South America combined. In contrast there are the special problems of the small island nations, mainly to be found in the Caribbean and the Pacific, often with populations smaller than the annual increase in some cities.

Yet whatever their differences, most developing countries share a number of features in common. The great majority of people still live in the rural areas where service, facilities and opportunities are normally few, and there appears to be little hope of economic or social advancement; there are large-scale and unplanned movements of people from rural areas into the larger urban centres where they add further to already existing problems of overcrowding, disease, unemployment and social unrest; and developed resources of all kinds are totally inadequate in relation to overall needs.* Also, in spite of the wide difference in their scale, the basic problems concerning rural development and approaches to their solution remain the same.

Urban Development

Although this paper is concerned with rural development, the subject cannot be considered realistically and effectively without taking into account urban problems also. The basic human needs of both rural and urban communities are the same, and have to be met. Also, although rural and urban problems may appear to differ in many ways, they have a great deal in common, and neither can be solved in isolation from the other. It is also necessary, in view of past emphasis on urban needs and projects, to state the case in favour of greater attention being paid to rural development.

HABITAT, the largest and most sophisticated of UN conferences, called to consider problems brought about by urbanisation, was of special importance to developing countries whose rapidly increasing populations, combined with large-scale and unplanned urban growth, present problems of major proportions unknown in the developed world.

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*note : mention should be made of a special category of nations within the developing world, countries such as Venezuela in South America, Nigeria in Africa, Indonesia in Asia, and those in the Middle East which are both oil producing and exporting. The vastly increased revenues from oil resulting from recent massive price increases have either helped greatly or solved the financial needs of such countries.

There is no doubt that urbanisation has a major and positive role to play in national development but, fortunately, the former view that nothing should be done to hinder the growth of cities and the movement of rural people into the larger urban centres, where they can form the basis for industrialisation and economic growth, is no longer accepted. This outdated concept, which was valid in the United Kingdom during the last century, when cities grew as a result of an agricultural revolution and in response to the growth of industry, gives little consideration to the human and social problems which arise under today's circumstances.

The problem today in the urban areas of developing countries is not the need to increase the size of the labour force, but the difficulty of providing work, shelter, community services and an adequate way of life for those already there. In most cases new city migrants merely add to and aggravate existing severe urban problems.

It is sometimes argued that rural areas are unable to support existing and growing populations, but flight to the larger towns and cities is no adequate solution to this problem. Opportunities for increased employment rarely need to be confined to existing large urban centres, and much can be gained by guiding movements of population and co-ordinating them with the development of natural resources and the creation of new jobs in smaller urban settlements and rural areas.

If attempts to alleviate present urban conditions and solve urban problems are to have any chance of success, it is necessary in the first place to prevent the existing situation from worsening. Unfortunately this is beyond the ability of any city for, apart from the limited resources available for the purpose, part at least of the cause of urban problems, as well as the possibility of their amelioration or solution, are to be found well beyond the boundaries of the city and the authority of its administration.

Although urban areas will continue to grow whatever action is taken, at least a reduction in the magnitude of future urban problems and the rate of their growth might be possible if greater attention is paid to the needs and potential of the RURAL areas.

This is necessary in any case. The rural areas contain the great majority of populations and, in spite of large-scale rural-urban migration and a growing proportion of people living in towns and cities, rural populations continue to increase. The present figure of under 2000 millions is expected to reach almost 3000 millions by the end of this century.

Urban - Rural Interdependence

Co-operation between urban and rural sectors is essential, for it is clear that neither alone has the answer to the economic and social problems facing developing nations. Both sectors must make their contribution in co-operation, not competition. Also, urban problems can only be solved within a planning and development context embracing both urban and rural sectors. The larger towns and cities urgently require some respite from the masses of migrants constantly flooding into them if they are to be able to make an effective start on the solution of their many problems, whereas the rural areas cannot go on indefinitely losing to the cities many of their most promising member, particularly the young, on whom the future development and life of the community should depend.

The task facing the developing world is a formidable one for it has been estimated that the net increase in its potential working population during the Second Development Decade (1971 - 1980) is likely to reach 226 millions, compared with only 55 millions in the developed world. The report of a Working Group on Rural Development published by the British Ministry of Overseas Development as long ago as July 1969 summed up the situation clearly when it said that :

> "at the heart of the problems of development in the poorer countries lies the question of how the economy of the towns and the rural sector can grow in harmony".

Rural development and employment in agriculture must not be considered second-rate alternatives to industrial employment. No one will deny the importance of and the need for industry, but this does not have to be at the expense of agriculture. Any programme of industrialisation should be developed gradually, and will only be successful in most cases if it is based upon a

healthy, prosperous agricultural sector, providing the food needed by growing urban populations as supplying many of the raw materials for industry. A thriving rural community is also an essential part of the consumer market for the products of an expanding industry, as well as being a source of financing for further economic development.

Even though the majority of people are to be found in rural areas it is understandable that so much attention in the past has been given to the larger towns and cities, for it is there that, due to the sheer physical concentration of people and human activity, human needs and problems are most clearly seen, and demands for their alleviation or solution are loudest. It is also in the cities that the leaders of government, industry and commerce, and other affluent and affluential members of society are to be found.

However, it is increasingly being recognised and accepted that urban dwellers have no divine right to the priority and attention they have received in the past, to a large extent at the expense of those living in the rural areas. There is also a growing appreciation by many countries of the value of their greatest single natural resource, the LAND, and of the importance of its development in agricultural and related terms. Some countries, for example, have for some years placed tremendous importance on rural development, and others in current national development plans stress the new role which agriculture must play, and the increased contribution it is now expected to make to the economic development of the country.

In many countries of the developed world agriculture has tended to lag behind industry, in terms of the technical level of equipment, the rate of development, and the productivity of labour. Rural workers remain less well off than their urban counterparts, and the national objective often appears to be the freeing of agricultural labour for work in other economic sectors. In the countries of the developing world where, in most cases, priority has also been given to industry to the neglect of agriculture, a completely different approach is needed to the solution of rural problems.

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note: the word 'agriculture' in this paper includes all forms of farming activity, as well as estate crops, forestry and fisheries.

Attempts to ensure a more even distribution of national benefits must be based on the greatest possible creation of employment opportunities in both urban and rural sectors. In terms of agriculture, priority needs to be given to the opening up of new land where this is possible, the improved productivity of soils rather than that of labour, the improvement of traditional techniques, and the employment of equipment, techniques and methods of a labour intensive, rather than a capital-intensive nature.

Rural Development

Rural development may be considered the sum total of measures of an economic and social nature, implemented physically in spatial terms, involving the use and development of natural and human resources, in relatively sparsely populated areas, the objectives being an improvement in levels of living for all members of the rural community.

The basis of successful rural development must be increased agricultural production of all kinds, but agriculture, which is often seasonal, must be supplemented by other forms of economic activity. This will often be connected with the recovery or development of other natural resources, including minerals, and the processing of agricultural products. There are however other considerations. The term 'integrated rural development' has become very popular of late, particularly in relation to technical co-operation programme, usually applied to agricultural projects incorporating more than one aspect of development. However, it is rare that such projects of a mainly economic nature form part of truly comprehensive programmes of rural development in which provision is made for other community needs.

The creation of employment opportunities and increased productivity, essential though they are, are just one form of action which must be taken if rural populations are to be stabilised and rural communities enabled to become alive and productive. Other community needs must also be met if the sense of neglect, deprivation and isolation experienced by rural populations, which has led such large numbers, particularly the young, to migrate and seek a more promising and satisfying way of life in

urban centres, is to be eliminated. However, the past neglect of agriculture itself, has been due at least in part to their scattered nature, making it difficult if not impossible, with the limited resources available, to provide services and infrastructure on a shared, communal basis.

Provision of Infrastructure

If there is to be any real improvement in the lot of the rural poor and deprived in countries of the developing world, the aim must be, not only increased employment and production, but the complete 'urbanising' of rural populations. This does **NOT** mean 'urbanisation' either as normally understood by the term, or in the statistical sence adopted by the United Nations, is settlements of 20,000 of more people. It means bringing urban-type opportunities and services within reach of all people, and providing rural communities, and the development and services on which they depend, with the INFRASTRUCTURE needed. to bring levels of living up to an acceptable standard:—

— buildings, not only for shelter and obvious social purposes such as education, health and recreation, but for commercial activities and economic purposes such as the storage and processing of agricultural products;

— roads, culverts. bridges etc. linking rural communities with each other and with regional towns and cities, serving development areas and providing access to urban markets; plus other necessary transport facilities;

— reservoirs, channels etc. for the supply of water and energy, for human, agricultural and industrial purposes;

— pits, drains, plant and works for the disposal of surface and waste water, and all forms of human and other refuse;

— check dams, earthworks and other measures to prevent flooding, soil erosion, and all forms of environmental pollution.

Planned Settlements

The development of agriculture, particularly that of a labour–intensive nature, requires the widespread dispersal of workers over the land. However, if the general provision of services and infrastructure, so often absent in the past, is to become feasible, it must be done on a shared, communal basis with homes, readily accessible to work areas, yet concentrated as far as possible within or very close to planned settlements.

The size, number and distribution of such settlements will depend on various factors such as the numbers of people involved, forms of economic activity, employment needs, levels of technology, the areas and distances involved and the type of facilities and services provided. In all cases a network of settlements will need to be established, on a hierarchical basis, varying in size from the smallest village with the most basic services, to regional centres with marketing facilities and higher educational and health facilities etc. each settlement interdependent and readily accessible, bringing within reach of all the basic opportunities and necessities of life, making possible acceptable levels of living for the whole rural population.

Such a pattern of development will not come about by chance, or without official intervention. It must be the reponsibility of government both to ensure that rural areas receive a fair allocation of national resources, and to determine the settlement pattern, thus providing a planned framework for rural investment and development within which it is possible for individual communities and families to decide their own courses of action and accept responsibility for meeting their own needs.

Comprehensive Planning

The kind of policies and programmes which will help bring about the co-operation needed between urban and rural sectors, and lead to more effective rural development, cannot be introduced on a purely local, informal or voluntary basis. A thriving rural community will not come into being solely through its own efforts any more than the problems of the city can be solved within its own boundaries. Policies and programmes, established at national and regional levels, should plan for and co-ordinate

action between and within both urban and rural sectors, providing a framework for national development within which government, individual communities and families can co-operate and contribute.

Unfortunately, even when national plans emphasise the need to encourage rural development and to reduce the disparity between urban and rural communities, all too often the kind of measures necessary to help bring this about such as policies for the development and distribution of industry, the selection and development of new growth poles, and investment in urban-type services and infrastructure in rural areas, are absent from such plans.

There needs to be a complete end to the 'laissez faire' approach to development usual in the past, with its sole emphasis on economic returns, and the resultant over-concentration of industry and other forms of investment in the region of the capital city and other major urban centres. National development plans must no longer be thought of in terms of separate, unrelated, unco-ordinated, and frequently competing sectors of development such as industry, agriculture, transport, education, housing and so on. All sectors should form part of one comprehensive, co-ordinated plan of development and human settlement policies for the effective employment of people and resources, and a more equitable distribution of development and urban-type opportunities, facilities and services throughout the nation.

In the past it was quite usual to judge the relative success of development programmes by the extent of the increase in the Gross National Product. Such programmes, based largely on economic and industrial growth, and judged successful in GNP terms, have tended to benefit a small, already privileged minority of the urban community, leaving many of the urban poor as well as a majority of the rural population no better or even worse off than formerly.

Today there is a welcome tendency in development programmes, not only to consider economic and industrial performance, both of which are important, but to pay greater

attention to the realisation of social objectives, with declared attempts to reduce the disparity between urban and rural communities and to ensure a more equitable distribution of the economic and social benefits resulting from development.

This adds a new and more realistic dimension to national development planning, calling for greater attention to be paid to physical considerations, ie the relationship between population and resources, and the spatial distribution of development. This also implies much more emphasis on RURAL development for it is the rural areas which have suffered the greatest neglect and where the poorest, most deprived majority of populations is to be found.

Development Planning

Planning describes a process, flexible and subject to change, which attempts in advance to arrange for the effective deployment of resources in relation to human need It is a term loosely applied to activities in the fields of finance and economics, social affairs, and physical development, by far the greatest attention by national governments being given to financial considerations. National economic development plans have been a common feature of most developiug nations for more than two decades, usually prepared by economic planning units, and concerned with various aspects of national economic growth. However, it is questionable just how successful these plans have been.*

It is now being realised that development planning requires more than just 'economic' inputs. There is a need also for the experience and advice of physical (land-use) planning services at both national and regional levels, not merely at the local, urban level to which they have so often been confined in the past. The three essential and complementary aspects of planning, the economic, social and physical, co-ordinated, must form part of and contribute to the development planning process from the very beginning.

*note : the one attempt at a national economic development plan by Britain ended in failure

Physical (Land-Use) Planning

Unfortunately, the role of physical planning and its contribution to the development planning process are still not widely enough known nor accepted. Physical planning is concerned with the design, growth and management of the physical environment, in accordance with predetermined and agreed policies, whereby balanced social and economic objectives may be achieved. This is effected by making provision for and co-ordinating all forms of development activity, at national regional and local levels, making the fullest use of available human and natural resources.

One of the basic essentials of any development policy is the examination and evaluation of the many, often conflicting, demands for the use of land in urban and rural areas by both public and private sectors, in order to ensure that such land is used and developed in the best interests not just of the individual owner, but of the local community and the nation.

This safeguarding of land against its wrongful, wasteful or premature use or development is one of the most important continuing functions of physical planning, a function which, in order to be effective, must cover all aspects of the development process from participation in the formulation of national development and urbanization policies, to the detailed application of such policies through the medium of physical development plans at all scales from the regional down to the local level.

Stated briefly, the contribution of physical planning to the development process within a nation should be to :

a. provide a planned framework of development for the physical environment, within which a balanced, ecologically sound programme can be carried out;

b. provide the legislation necessary for the planning, control, encouragement and implementation of the development process;

c. ensure the establishment of a centralised, consultative framework with overall responsibility for the planning, evaluation, co-ordination, administration and implementation of a comprehensive development programme.

At the national level the 'economic planning unit' has come to be accepted as an important agency of government in most developing nations, usually responsible for advising on the economic aspects of development, the financial evaluation and co-ordination of the development proposals of various ministries and agencies, and for determining the timing of proposals for economic, and sometimes social growth.

A complementary 'physical planning unit' is needed at the national level, to advise on the ecological and physical implications of development policies and proposals, and to help establish a realistic and balanced spatial distribution of development for the whole country and its people. In order to operate effectively, it must consider and take into account aspects of human need and development such as the following, each inter-related, each having its effect on the total physical environment within which all economic and social development must take place:

population	patterns, growth, movements, rural–urban migration, social services.
land	availability, ownership, reform, costs, social capabilities, erosion, planning, control, use.
employment	urban and rural, needs, manpower, industry, industrial location, labour intensive measures, appropriate technology, formal and informal.
urban development	problems, growth rates, growth patterns, management, administration, legislation, slums, squatters, informal settlements, renewal, transport, public utilities.
rural development	natural resources, processing, community development, communications, marketing.
housing	needs, financing, societies, co-operatives, self-help, site-and-service, location, services.
environment	human ecology, conservation, protection, pollution, utilisation or disposal of wastes.

Levels of National Planning

The need for a physical planning service, and its contribution to the development planning process, occurs separately at national, regional and local levels; yet each level of service is interdependent, forming a complementary part of the whole. Constant consultation, evaluation, co-ordination and integration are obviously necessary, and provision must be made for these within the machinery of government.

Although the importance of physical planning advice and assistance at the national, policy-making level cannot be stressed strongly enough, it is at the intermediate, regional level that physical planning makes its greatest contribution, for it is at this level that national development policies are translated into physical form and, through the preparation of regional plans, provide the detailed framework for development. It is also at this level that, through a constant two-way exchange of information, national development policies and local human needs and aspirations may best be reconciled.

At the *national level* physical planning policies and programmes, which must include provision for the planned spatial distribution of development and human settlements, must conform to national economic and financial constraints and social objectives, must be based on regional analyses and evaluations, and must be implemented at the local level, aiming to utilise natural resources and meet local human needs and aspirations.

At the *regional (state) level* development plans must conform and give physical expression to national economic and social objectives, through a hierarchical network of interrelated settlements, must be based on regional surveys of local conditions and needs. and must provide a blueprint for the implementation of development at the local level.

At the *sub-regional (local) level* development plans, considered in much greater detail, and principally urbran in character, must make provision not only for the implementation of official development programmes and projects, but for all forms of human need and activity, much of it of an informal, self-help nature, initiated planned and carried out by the community itself.

Priorities of Planning

As already stated, the need for land-use planning occurs separately at national, regional and local levels, but each forming part of one comprehensive physical planning service. Although there is a growing if slow improvement in the developing world where the development planning process is concerned, physical planning at the national level still remains the exception, rarely having any major effect on the formulation of national development and urbanisation policies.

Regional and local physical planning services are found much more frequently, their establishment often depending on the separate initiatives of regional and local administrations which, in the absence of any broader physical planning framework, compete with each other in attempts to attract as large a share as possible of limited development opportunities.

Ideally, the preparation of regional development plans should take place within the regions concerned, the responsible planning departments being either regional offices of the national physical planning service, or part of the state or provincial government machinery. However, when professional planning resources are limited, as is the case in most developing countries, it is important that they should not be dissipated, serving regional and local initiatives and interests.

They should be concentrated at the national level where they can make the most effective contribution, working alongside the economic and social planning services, advising on and providing an overall spatial framework for development. In addition they can assist with the preparation of essential regional and local development plans, until such time as increasing numbers of professional staff make possible the setting up of regional and municipal planning offices, responsible for the preparation of their own physical development plans within the national framework.

Organisation of Planning*

Although a variety of approaches has been adopted by different countries, no ideal form of development planning

* See chart at end of paper

organisation has yet been devised. This seems unlikely to occur as conditions in individual countries vary enormously in terms of location, land area, population, resources, etc. in levels of development and in systems of government. In spite of this, it is possible to indicate broad guidelines which could have general application. (See appendix).

National planning should be the responsibility of president, prime minister or cabinet, for only at this level can decisions be taken regarding development priorities and the distribution of resources. The 'economic planning unit', normally responsible in developing nations for advising on and preparing national – usually economic – development plans, is found in either the prime minister's department or the ministry of finance and economic development or its equivalent, the ultimate responsibility for planning and development resting with either the prime minister or the minister responsible for economic development.

The 'physical planning unit' should be introduced at this level, working in close and constant co-operation with the economic planning unit and, preferably, a social planning unit, within the ministry or department responsible for national development planning.

However, the formulation of national development policies and the preparation of national development plans depend on access to up-to-date and as complete information as possible regarding the nation's resources. In most countries this information and the responsibility for its collection are scattered among various ministries and development agencies and boards, making its assembly and evaluation by the economic, social and physical planning services extremely difficult.

There is a great deal to be said for the centralisation and co-ordination of services such as statistics, lands, surveys and mapping, geology, soils and minerals, forest resources and water resources within this same department responsible for national development planning. From there such information, on which a great deal of sectoral development relies, can be made available to other ministries and agencies.

Central Planning Board

The composition and extent of development proposals in individual fields or sectors, and the success or otherwise of their implementation often depend on the personality and influence of responsible ministers, who are frequently reluctant to relinquish any of their powers to a separate authority. Yet the need for the co-ordination of all planning and development activities is paramount.

This co-ordination might be made the collective responsibility of a special committee or board set up for this purpose. Initially this body could be established on a relatively simple ad hoc basis, consisting of senior representatives of various development ministries and agencies, acting under a chairman appointed by the 'planning authority' ie the minister responsible for planning.

The eventual aim should be to establish a permanent 'central planning board' or its equivalent, with direct responsibility for co-ordinating, integrating, and ensuring the implementation of development programmes. This board would answer to the planning authority, perhaps under his chairmanship, and would deal with basic principles and policy matters; with the detailed consideration of development proposals and plan preparation made the responsibility of subordinate committees appointed for this purpose, working with the economic, social and physical planning units.

Board members might consist of ministers or other senior government executives representing sectors of development, science councils, etc, together with senior advisers on the economic, social and physical aspects of development, the physical planning adviser possibly acting as secretary to the board

The subordinate committees, working individually or jointly would consider special fields of study such as population, employment, industrial development, rural affairs, communications, take whatever action is required of them, and make recommendations back to the board. The economic, social and physical planning units should be represented on and service each of these committees.

All development policies, plans and programmes, after consideration by the central planning board and with the agreement of the planning authority, would be submitted to the 'approving authority,' possibly the president or prime minister, who would be the final arbiter in the event of disputes arising.

Community Involvement

This paper has concentrated mainly on the responsibilities and activities of government. It would be wrong to end without stressing also the rights, responsibilities and involvement of communities families and individuals.

At HABITAT considerable criticism was voiced against governments by those attending the FORUM, the informal, non-governmental part of the conferenee. This criticism, some of it no doubt justified, was directed against government policies and actions which not merely ignored or failed to meet the essential needs of the poor, but at times intervened and even legislated against measures which, in the absence of effective government direction, help or encouragement, the poor and disadvantaged were forced to take on their own behalf.

Whatever the shortcomings of governments may be, communities and individuals must recognise that governments, both national and regional (state or provincial) have a responsibility towards their total populations which cannot be met by any other agency, that of ensuring the fair distribution of national resources and development opportunities.

On the other hand governments should not only accept such responsibility but should recognise that, in situations where resources, financial and otherwise, are not only limited but totally inadequate, development policies must place much greater emphasis on harnessing the initiatives, skills, time and energy of the people themselves.

Such policies should create an overall framework for national development within which each member of the community, in both urban and rural areas, may have a say in local community, decisions, may have an active part however small in the development of his community, may share in the economic and social

benefits which result from such development, and may, to as great an extent as possible, accept responsibility for meeting his own needs and those of his family.

The Contribution of Science

The opportunity has been taken in this paper, not only to stress the importance of INFRASTRUCTURE to effective rural settlement and development, but also to emphasise the importance of the planning process within government in the provision of INFRASTRUCTURE and the implementation of rural development programmes.

What part does science have to play in this, and what action needs to be initiated? In my opinion there is a great deal needing to be done.

Where the development of settlements is concerned, and the provision of services and INFRASTRUCTURE within them, the governments of developing nations cannot, with any hope of success, continue to adopt the high-coat technological solutions of the developed world, and the traditional forms of planning, administration, legislation, financing, management, education and so on, handed on by former colonial administrations.

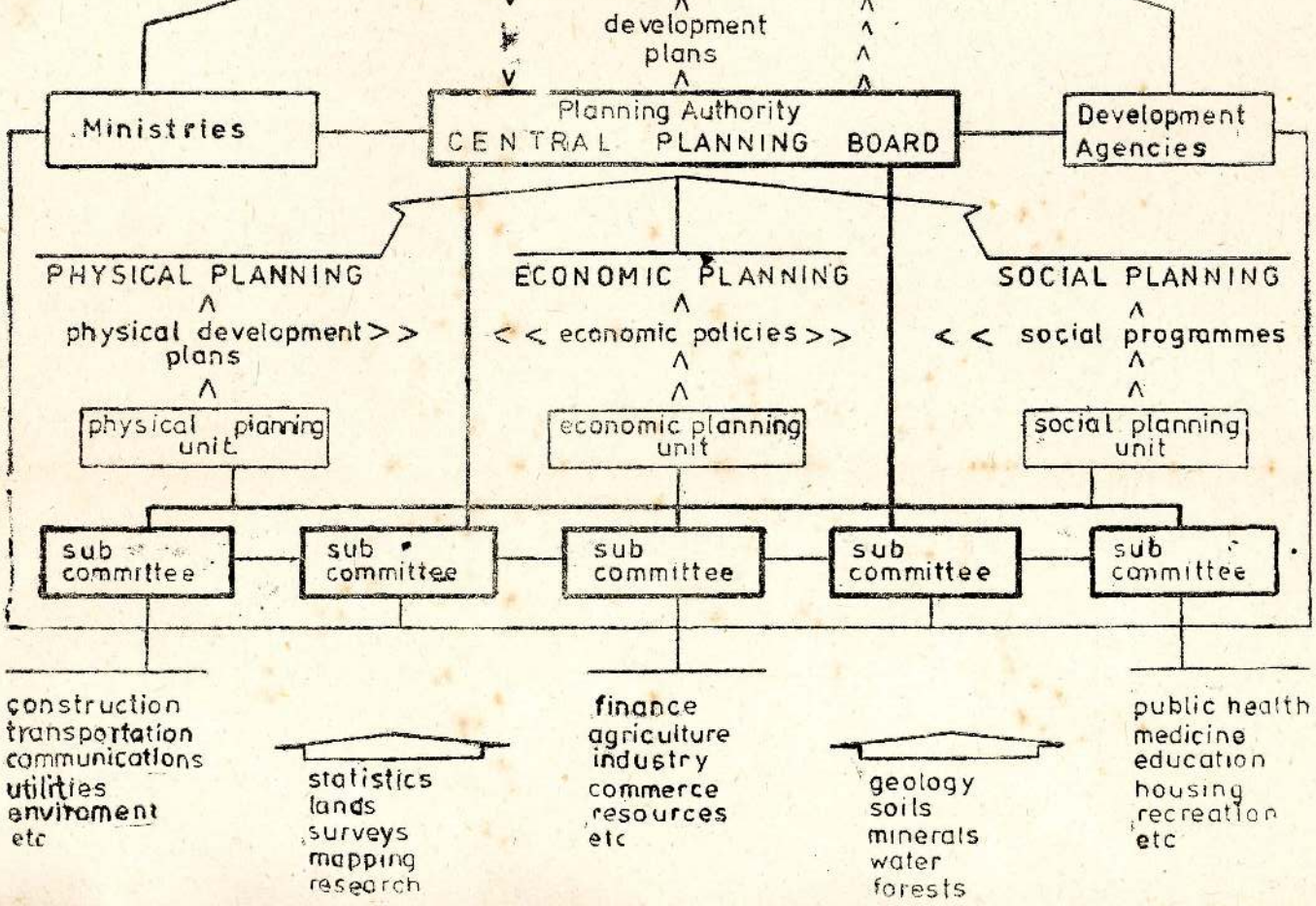
New and more appropriate solutions concerning all aspects of living, capable of dealing effectively with the needs of total communities, must be developed and adopted. Such solutions must recognise the limited, inadequate nature of most of the resources available, and must be based to a very great extent on the adoption of informal, self-help-type methods, harnessing the initiatives, time, energies and ambitions of the people themselves. This is particularly the case where the provision of infrastructure is concerned.

A great deal of relevant work has already been carried out, much of it unknown outside the countries concerned. For example, investigations have been carried out into the disposal possible utilisation of solid human wastes, without resorting to the large-scale and wasteful use of often-limited water supplies, and a start has been made in various countries on the urgent problem of developing alternative sources of energy for rural

communities. Such work must continue, together with research into building and construction standards and techniques, and into many other aspects of infrastructure such as, for example, the collection, storage and distribution of water supplies.

There is a need for the investigation, enumeration and evaluation of research of relevance to the developing world already carried out in the fields of infrastructure, not only within the Commonwealth but elsewhere, and for the results of such research and its practical application to be made known to countries facing similar problems. Research also needs to be initiated into aspects of infrastructure and its provision which have so far been neglected. In addition, governments need to be encouraged to establish effective development planning procedures, making it possible for economic social and physical planning services, working in close and constant co-operation, to make their rightful contribution to the formulation, planning and implementation of national urban and rural development and human settlement policies and programmes.

Such action, if carried out, would contribute to the alleviation of immense human problems, make possible more acceptable levels of living for many of the poor and underprivileged in both urban and rural areas, and lead to a more just society.



A POSSIBLE STRATEGY FOR ACCELERATED FOOD PRODUCTION IN DEVELOPING COUNTRIES

by

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Introduction

All the literature of food production/consumption in relation to population growth in the developing world show an imbalance, with population growth outstripping food production. Many scientists have predicted food shortage in these countries, though many others do not agree. They content that food shortage, if it exists is in terms of food quality and not quantity. Be that as it may, there is evidence that concerted efforts need to be made to improve food production in the developing countries of the world.

Brief historical perspectives

The attempt here is only to highlight what, briefly was the agricultural heritage passed on during the post-independence period in most developing countries. During the colonial era, most of agricultural endeavours and policies were directed towards an export economy. Therefore, based on geographical locations, West Africa produced cocoa, rubber and oil palm; from my brief experience since yesterday, Sri-Lanka has been geared towards producing tea, rubber and coconut all for the export market.

It would be easily seen that such policies were detrimental to food production; for which in over 50 - 100 years no streamlined policies were made. Rather, comprehensive programmes for food importation were operated. Rice, sugar, tomato puree, canned beans and other such items were imported from already well developed economy.

In the next chapters, an attempt will be made to briefly survey our heritage of food crops production as at now. In most developing countries, between 70 - 90 percent of the inhabitants is involved in agriculture, compared with less than 7 percent in Europe and the USA. This implies that farm inputs are low and mechanization is very rudimentary. Seeds are low yielding and susceptible to many debilitating diseases. Fertilizers are not used and neither is erosion controlled. Resultantly farming is an unattractive back breaking venture as returns on labour and other inputs are very low.

The prevalent farming system is such that it is unammenable to mechanization and utilization of improved management. This has often been blamed on the land tenure system. What prevails therefore, are small farm holdings on which a multiple of different crop species are planted for as long as there is space to do so. Most, if not all the labour input is that of the farmer and his family. Occasionally, however, other farmers in the neighbourhood gather to help each other in times of bounteous harvests.

The big question is therefore, that with this type of agricultural back-ground, what are the prospects of increased production.

Ingredients for improved food production

1. **Expansion of farm land:** This supposes that new, previously unused or unarable land should be opened for farm use. What is happening is that farm labour is decreasing as well as farm holdings.

2. **Better use of opened land:** development of improved farm technology like erosion control, planting dates, plant populations, seeding rates etc.

3. **Improved high yielding, disease resistant seeds:** This is probably one of the greatest factors in improved food production. It allows for crops to be extended to places where they had not been grown either through endemic diseases or other reasons.

4. **Improved farm inputs** - in terms of farm management, fertilizer use, pest control and eradication.

5. **Capital (loans)** - to ensure the purchase and use of high cost inputs like tractors, sprayers and possibly pay for labour.

6. **Development of improved storage and market structures:** More often than not, most of the farm produce is lost because of poor drying, storage and marketing facilities. This happens right from the farm-gate to urban markets where the produce is sold.

A cursory survey of what is currently available shows that in many developing countries, it would appear that the infrastructure needed to solve the above listed ingredients are available. They exist as isolated programmes which need to be integrated and extended to the peasant farmer level before any appreciable result can be obtained.

National Food Crop Research Programmes

Various national, single or multi-commodity research organizations have been established for the development of major food crops. The main problem had been that research efforts had not been concerted and research programme had been unco-ordinated. The multi-disciplinary approach to research is now widely being adopted and in many countries, more high yielding and adaptable crop varieties are being developed. Similarly, the know-how for maximising the yield of these crops under the existing conditions are being collected.

National, Agricultural Extension/Research Liaison

The purpose, at least in theory had been to extend the results obtained by these various research bodies to the present farming population. The farmers should know that new seeds and the technique of growing them exist. The results that we know today suggest that these farmers are not being reached, therefore, all research efforts and the results obtained have not changed their habits. Because of this ineffectiveness, Extension/Research Liaison organizations have not been able to transmit the needs of the farmers back to the laboratories for solution.

It might therefore, occur that at the end, research findings may be unrelated to the problems confronting the largest body of farmers in the country. Yet as we all know, agricultural research is a very costly venture. It is useless if it is producing results which do not reach the farmer, because it has no way of knowing, that it is not solving farmers problems.

It would be necessary to look at a very typical example. The bulk of farmers in developing countries is involved with multiple cropping on small holdings, yet very little effort, except in recent times, has been devoted to solving farming problems under this agro-system. Research has, more often than not, be devoted to developing crops and the attendant technology for monocropping. Yet it is known that mono-cropping is beneficial under large scale farming involving much land, mechanization and other inputs. All these are not within the reach of the peasant farmers.

National Seed Production Programmes.

The main objective of such programmes is to develop projects aimed at multiplying improved seeds developed locally or imported and making such seeds available to farmers at the pertinent seasons. Such projects in many developing countries are not necessarily geared towards actual needs, and many therefore again, not be serving the useful purpose for which they were established.

Suggestions for accelerated food production

From the account above, it would appear that the main institutional structures for enhanced food production exist in many countries, developed or developing. What is required is an arrangement which will co-ordinate and direct these efforts to solving national needs.

Firstly, it is necessary to re-examine the present farmers and their ways. Can their problems in terms of mixed cropping be solved without too much adverse effects on sociological bearing, for example – land tenure system, crop insurance and labour? What is the best solution, should the answer be yes or no. It

becomes obvious that the solution does not lie in these uncoordinated independent small holdings. It would involve, I believe, an integrated approach that would involve the dissemination of known technology, provision of capital, marketing etc. Therefore, the first approach is to organise farmers into co-operatives in which they pool their land and labour to be able to benefit from economics of scale.

Secondly, the farmer must know the available inputs (seeds, fertilizers, etc.) through demonstration, whereby they can choose their own inputs. This can be done by an "out-reach" programme by the extension services, with good back-stop from research. In Nigeria presently, a similar project is being done through the National Accelerated Food Production Project (NAFPP).

In this programme, a few varieties (2 or 3) of improved seeds, fertilizer versus no fertilizer, weeding versus no weeding and similar other inputs are put in a MINI - KIT and demonstrated on the farmers fields. The choice is completely left to the farmers to make. The farmers choice of inputs are then expanded in a PRODUCTION - KIT for larger scale production. The advantage of this system is that the farmer, the extension workers and researchers are involved all the way. The researcher sees at first hand the problems of the farmers and then establish programmes to solve those problems.

In some of the projects like the Badeku, Ilora village projects, the researchers go on to the extent of helping the farmers to negotiate loans, store and market the increased farm produce, mostly maize. It is easy to see that the various projects would grind to a halt if the increased produce are not taken off the farmers hands before they rot away at the farm gates. The value of over 200% increase in farmer's participation in this out-reach programme implies that it is getting popular.

A few problems have started to appear

1. The question of farming systems involving mixed cropping has not been solved. In the next phase of the programme therefore, efforts will be made again to demonstrate appropriate crop species and varieties which can be combined to

give the best yields as well as give a guarantee against crop failure typical of mono-crops in a particularly bad year.

2. The problems of other agro-allied inputs like credit loans, fertililizer and mechanization become more acute, as they must be provided on time. Credit co-operations are being expanded and Agricultural Service Stations are being established at strategic locations. These will provide facilities for tractor hiring, supply of fertilizers, herbicides and pesticides at highly subsidised rates.

3. Minimum price guarantee - So that farmers may not be discouraged, minimum price guarantee for the major food items produced on farms have been provided. Of course, this brings with it the problem that middle–men may insist on purchasing at these minimum prices, store the produce and release them at very much increased prices later on. To obviate this possibility, consumer co-operatives using grant-aids from government are being encouraged to take over this function.

4. The question of land availability — Short of a Land Reform Law, this will continue to present difficulties in the future. The short term solution, in its absence would be to endeavour to utilize more purposefully, the land that has already been opened up. This can be achieved by producing a more stable form of land use to replace shifting cultivation.

Conclusion

In summary, it is my belief that the fears that many developing countries may not be able to feed themselves may not be fully justified. It is patently obvious that facilities and other institutional activities for increased food production have not been exploited. Many programmes to do so are just beginning.

However, the prevalent system of un-co-ordinated programmes, small holdings and low farm inputs have to be rejected. In its place should be established an agro-system that is well suited to the eco-systems and at the same time boldly utilizes easy credits, labour intensive larger holdings under co-operative management. As a technical service to this system, the research bodies, extension workers and farmers have to be involved in an out-reach endeavour with feed-back mechanism.

ENERGETICS AND STRATEGIES FOR AGRICULTURAL DEVELOPMENT

by

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Agricultural development is no longer just a matter of producing more food with any technique that will increase yields. Two major problems have forced planners to consider the costs as well as the yield of new technologies. The first problem of cost to appear was the biological costs of the use of insecticides. There are some ways in which insecticides can be used to increase yields but they are not often used because of the biological consequences. The second problem came with the pricing policies of oil producing nations which greatly increased the costs of energy used in agriculture. Problems of costs such as these, are most crucial for the developing countries that must significantly increase production to feed their population. For this reason it is essential to find ways to define the costs and benefits of any new technology and base political decisions on sound scientific analysis.

New technologies for agriculture have a fixed cost paid by the farmer, such as money put out for fertilizer, chemicals, fuel and tools, but there may also be a future cost. For example, insects evolve resistance to insecticides and the built in resistance of crops to pathogens is often breached by new mutants among the pathogens. This biotic evolution of pests requires that certain technologies be accompanied by a plan for developing alternative forms of crop resistance faster than organic evolution can overcome biotic control measures. In addition to the need for anticipating biological changes, there is the need to anticipate economic problems. Mechanical equipment and fuel costs are

determined by the price of energy, which has a strong inflationary component and dependence on technologies requiring large inputs of outside energy leaves the agriculture of a country vulnerable to fluctuations of energy cost in the international market.

It is matters such as these that will, in time, force every nation to exercise some measure of control over the resources that go into the agricultural sector so as to achieve the desired output at an acceptable cost. Although agriculture is regulated by political decisions in all countries at this time, the tools for the analysis of farming are a totally inadequate basis for making political decisions. The technical advice on agriculture fails because the sets of agricultural data on which decisions are made do not allow one visualize, let alone evaluate, the range of consequences of policy alternatives with any reasonable degree of certainty.

Political decisions in agriculture should be based on information that describes as accurately as possible what alternative decisions may be possible and define the consequences of each alternative. The decisions must be political, but the base on which these decisions are made is the responsibility of science and should not be allowed to persist as adversary arguments from research units and University departments. The scientists must use their resources and seek the support they need to develop really effective models for the operation of agricultural ecosystems. These models should do two things - i) They should unambiguously define the relations between the inputs and outputs of an agricultural system, ii) They should show the functional relation-ships of all the components of agricultural systems in a way that will allow one to predict the consequences of manipulating the elements within the system. The literature contains two fundamentally different ways of approaching this problem. One is by deduction, which is most commonly in the form of some kind of statistical analysis. The other approach is inductive. Processes are defined and falsifiable hypotheses developed in a form that will test the assumptions of a cause-effect relation and well specify the form of that relationship.

Deduction

Complex statistical analyses of large sets of data are the basis for much deduction and such analyses can now be handled with great ease. Indeed, it is not even necessary to think. The computor programmer can define the form that data must take and even if some data are absent they may be generated in some cases. A calculator can be programmed to be set the results in type so that all an author has to do is write the table headings and explain the results. But such approaches are fraught with danger. The analysis cannot deal with new combinations of conditions. For example, birth rates can be predicted only if external variables have no differential effect on birth rates in the future and this is almost never true. The possibility of a correlation being due to a cause effect relationship can be tested only by using data and logic that is completely independent and unrelated to the statistical process.

Consider an example of crop production in which three sets of data are analysed: i) data on the yield per hectare ii) the work done to harvest and thresh (this can be either the work of humans or machines or both), iii) the rainfall for the first three-quarters of the growing season. These three things are closely correlated. If one looks at the analysis as a pure exercise in mathematics it tells you that if more work is put into threshing, then the yield might go up, or it may be interpreted as evidence that running threshing machines produces rain.

Threshing machines do not produce rain, but the statistical analysis *per se* cannot distinguish spurious correlations from a valid correlation that defines a real function like the correlation of yield with rainfall. In setting up experiments or in analysis, we select for tests only relations we already feel to be significant and never, or at least rarely, test associations we feel must be meaningless.

The real danger of statistical analysis lies in the selection of things to test. A subjective a *priori or a posteriori* rejection of some results as spurious and accepting other correlations as true almost always tends to verify familiar and comfortable notions. In the case of analyses of data where no selective biases exist that analysis does not determine which correlations are meaningful.

The decision makers need something more reliable than the subjective arguments of scientists about what correlations are intuitively satisfying or worth testing and which ones are counter-intuitive. I believe science can provide logically sound analyses that are much more free of internal subjective interpretations. The analysis of energetics by biologists, agriculturists and economists is gaining effectiveness as a descriptive and predictive device. It seems likely that energy models can be developed to the point of their serving as suitable devices for decision making and that is the main topic I wish to consider here.

The General Structure of Energy Flow Models.

Biologists, agricultural scientists, economists and anthropologists have used energetics to define cause and effect relations. If this can be done in a reasonably comprehensive way for agricultural systems, then scientists may be able to predict the consequences of various political decisions.

The first energy flow model was that of Transeau (1926) for a cornfield in Ohio. He defined the dynamics of energy flow within a corn field. 2.04×10^9 Kcal of light energy are received per hectare, $.33 \times 10^6$ Kcal are fixed of which 6.2×10^6 Kcal go into the grain which is harvested. Forty years later Pimentel and associates (1973) did a complete analysis of an average hectare of U. S. farm land planted to maize and found the annual inputs to be:

Biotic	Human labor	1.2×10^4
	Seeds	1.7×10^5
External	Machinery	1.0×10^6
	Gasoline	2.0×10^6
	Fertilizer	2.6×10^6
	Chemicals	5.4×10^4
	Irrigation	8.4×10^4
	Drying	3.0×10^5
	Transport	1.7×10^5
	Electricity	7.5×10^5
		7.14×10^6

These inputs drove a system that produced a crop of maize with a caloric value of 2.02×10^7 Kcal. For each Kcal of fossil fuel put into the system 2.90 Kcal of food were obtained.

A large quantity of energy from fossil fuels is used to run agriculture in a developed country but the flow of energy is rather simple. An input of fossil fuel equal to three or more times the yield is common for both the United Kingdom (Spedding and Walsingham, 1976) and the United States.

There are only two biotic inputs, seeds, and human labor. Both represent biotic energy stored from the season before and used to produce the current season's crop. Labor is troublesome to measure and Pimentel et al. (1973) give only the Kcal hrs. of work. It takes only 9 hours of work per hectare but the family unit to which the farmer belongs must be supported all year if the farm is to function. A more complete estimate of the biotic cost of the labor is to consider the total needs of the rural population per hectare of cultivated land. There are about 9.4×10^6 farm residents that cultivate 0.44×10^8 ha of crop land which is 0.21 persons per hectare. Each person consumes around 1.13×10^6 Kcal yr^{-1} and so the biotic cost of labor is 2.41×10^5 Kcal which raises the total energy budget by 2.29×10^5 Kcal, an increase of only 3 per cent. Labor is never a major factor in western agriculture.

The United States can be visualized as a system in which very large inputs generate a mass of food that is then transferred to urban areas, used there and virtually no residues ever return to the land. It is a simple linear flow of materials and energy with little use of by-products and no recycling of significance.

In India, which can be used to illustrate the major differences between the West and South Asia, biotic inputs are maximal and there is much more recycling. The work going into Indian agriculture is animal labor from a rural population of 4.39×10^8 people and a bullock population of 7.4×10^7. The annual per capita input of food is known, hence, the biotic labor for India will be:

	10^7 Individuals	Per capita consumption (10^5 Kcal)	Total Annual Consumption (10^{14} Kcal)
Human	43.9	9.5	4.17×10^{14}
Bullock	7.4	79.2	5.86×10^{14}

The crop lands total 1.48×10^8 ha and the per hectare figures for the above biotic inputs, census data for the energy inputs in the form of fertilizer and irrigation and seed input (assumed to be the same as the United States) are as follows:

Biotic	Human labor	2.82×10^6
	Bullock	3.96×10^6
	Seeds	1.70×10^5
External	Irrigation	1.66×10^5
	Fertilizer	2.41×10^5
	Chemicals	3.35×10^1
		7.36×10^6

The average yield of crops per hectare, 3.12×10^6 Kcal falls far below even the biotic demands of 6.95×10^6 Kcal ha^{-1}. The reason for this is that the output of hay and straw is not included as harvested crop. Those by-products represent 1.0 to 2.0 times the Kcal of the crop and so if by-products for cattle food is taken to be $1.5 \times (3.12 \times 10^6) = 4.68 \times 10^6$, then the total harvested output for human and bullock food will be of the order of 7.8×10^6 Kcal ha^{-1} yr^{-1}.

Very little of the straw and hay is transported out of the local agricultural system. It would appear from the above analysis that 0.9 of the harvested crop is eaten and recycled locally. These are crude estimates but the general pattern is quite clear. Agriculture in India is driven by inputs that are mostly (94 per cent) biotic and result in a significant recycling of nutrients.

Discussion

This sort of an analysis shows how the subjectively obvious differences between South Asian and United States agriculture can be quantified. This quantification can be a purely academic exercise or it may be expanded to deal with analyses of agricultural policies. Agricultural policies are, at the moment, usually determined on the basis of compartmentalized advice from information such as: the production of paddy in isolated plots, the damage by insects in one area or another, the fear of epidemics of plant pathogens or the promise of some protein rich

strain. If the specialists could be drawn together and asked to produce the best possible model for the flow of energy and coupled the energy flow data with the mass transfers of carbon, nitrogen, phosphorus and potassium, then a country would have a model giving the dimensions of agricultural processes. The importance of each claim for funds could be estimated on a common scale.

The model should include information on responses. How much will the yields be expected to increase for each increment of fertilizer? What is the potential stock of green manure? How much of the plant production is available for fuel, construction, cattle food and fiber? What are the costs of crop specialization among farmers in terms of the energy needed for transport, storage and distribution?

The scientists have a major responsbility in developing national, local and single crop energy budgets because these appear to be the best devices for describing how complete agricultural systems actually work. Once this is done, then, the politicians can demand that scientific advice be accompanied by reasonable estimates of the consequences of some proposed new practice or line of research and be forced to show how it fits into the overall structure of a national agricultural pattern.

There is no reason for ecologists and biologists failing to produce precise analytical models for the functioning of agriculture in a country. Once developed, these models can provide an objective frame work that relates the inputs to the outputs. Agricultural policies manipulate inputs and abstract models should be able to show how the results of changing some input will affect the overall agricultural system of a country.

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NOTE: The details of a complete energy budget for Indian Agriculture are given in a course syllabus available from the author.

VOTE OF THANKS

by

W. R. N. NATHANAEL

President - elect

Mr. President, Hon. Minister, Professor Koenigsberger, Your Excellencies, Distinguished guests, Ladies & Gentlemen.

It is with some trepidation that I have come up to perform an important function. Proposing a vote of Thanks I consider a delicate task and I am rather unaccustomed to it. Nevertheless, I admit that I have been deputed a most pleasant duty, and I am mindful of the honour and responsibility that have devolved upon me.

Looking back a little, 1976 may be described as an active and eventful for our Association, implying perhaps our indebtedness and gratitude to more and more people for more and more things. The most important event that occured during the year was the Special International Session on "Scientific and Technological Cooperation among the Non-aligned Countries," at which 34 delegates from 18 non-aligned countries participated. To ensure the consolidation of the gains made at this International Seminar, the Association is now engaged in important post session work. Then, we commenced on 2nd March this year the Building Project for the construction of our Headquarters. This was made possible *only* because of the tangible assistance received from Government, and brought to fruition through indefatigable hard work and indomitable perseverance against heavy odds, of our affable President and all others in the vanguard charged with the responsibility for this work. As you must be aware this Building is due to be opened this afternoon. To mention another major undertaking – the formation of the National Academy of Sciences in Sri Lanka under the sponsorship of this Association. This has just been inaugurated, explaining why for the first time in history of our Association two Ministers of State were to have been associated with the inaugural part of our Annual proceedings.

First of all to the Minister of Housing and construction – we feel extremely grateful to you Sir, for your kind presence with us this morning to open our 32nd Annual Sesson, in spite of the many pre-occupations which your high office demands of you. Our thanks should really be doubled when we are reminded of your ready responce to our previous invitation to open our 26th Annual Session in 1970. We take these courtesies on your part as a token of your continued interest in our Association for which we are truly grateful.

Next, our own Minister of Industries and Scientific Affairs – who unfortunately is unable to be present with us for unavoidable reasons. However, in his absence I must not fail to make reference to the unflagging interest he has evinced in us and his conscientious attitude towards our problems and difficulties. We are also deeply appreciative of his magnanimous gestures in giving us material support to the full. We have had occasion to thank him all along the way of our achievements and today it is my privilege to thank once again the Minister of Housing and Construction who has so kindly agreed to take his place in inaugurating the National Academy of Sciences of Sri Lanka, which is a source of inspiration for the future, for which we are truly grateful.

From the inception of our Association, distinguished personages from the Diplomatic and Overseas Missions and International Organizations have encouraged us by their presence at our Annual Sessions. I reckon this is a signal honour that boosts our prestige. International aid, cooperation and partnership in many of our rational projects are in existence now and we scientists in Sri Lanka are not unmindful of our deep sense of gratitude to a number of countries who have helped and are still helping us so generously – especially in the field of Research and Development. Your Excellencies and estimable gentlemen from Foreign Missions, it is my very pleasant privilege to thank you for gracing this occasion by your presence. We feel so greatly honoured that you are with us this morning.

In the words of our own Minister – "Science must necessarily be international in character. It can only rise to the fullest stature in a world that recognises the equality of nations." I

think we should congratulate ourselves, that we have with us today Foreign Delegates from the countries and sister-Associations - who are scientists; I am sure that their interest and participation in the Session during the next few days will encourage us to pursue with increasing vigour what we have set out to do. Apart from forging personal contacts which prove to be the beginning of pleasant friendships for many of us, our Annual Sessions are also great occasions for scientific fraternisation, exchaning thoughts and views that are mutually beneficial. Some of our guests have travelled quite a long way to be with us, and I can only assure you that your presence with us is a source of much affectionate enthusiasm.

We have a distinguished contemporary scientist as our Chief Guest today - Professor Koenigsberger, with your attainments and stature Sir someone has to make a long speech to thank you for everything that your visit to our midst means to us. You are due to deliver your first address to us a little later this morning and I feel that the mantle appropriately falls on our President to perform this pleasant task and I will as an act of propriety not attempt to forestall him in any way.

On going through the Reports, and records of activities of the Council, the six sections of the Association, the General Research Committee, the Committee for the Popularization of Science and the Science and Technology Committee I have to reiterate my earlier statement that the Association has been active during the current year. Accordingly, I will be failing in my duty if I do not express a word of thanks to the respective Chairmen, and office-bearers when there is so much evidence of assiduous hard work during the course of this year climaxing in the arrangements for the Main session with a full programme of research papers. Special thanks are also due to our effective Hony. General Secretaries who have had to put in arduous work, sacrificing much of their leisure to make this Session an all-round success. Treasurers are notoriously unpopular; they are loved by nobody - not even their own colleagues. Our Hony. Treasurer appears to be an exception. Someone has said that a sound Treasury is more important than a pretentious metropolis. Perhaps he has worked on this principle to have successfully continued in office for the ensuing year.

Lastly, if I have failed to make reference to or thank anyone, I ought to have, do forgive me.

I am glad that my duty today does not involve me in making a long speech and certainly there should be limited loquacity especially when the pendulum is poised to strike the auspicious hour for tea.

I am convinced, Ladies & Gentlemen, that all the members of our Association share the sentiments I have expressed, and I could ask you to support with hearty applause this Vote of Thanks which I have great pleasure in moving. Thank you,

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