Chapter 1

Science for Technology for Development

(a) Background

The Commonwealth Science Council (CSC) was established in 1975 with the aim of increasing the capabilities of the individual Commonwealth nations to use science and technology for economic, social and environmental development. Over the years its functions have evolved from those of pure liaison to supporting collaborative programmes on specific transfers of technologies that, though they may freely exist, have not been adequately applied to development.

The existence of this present report is a consequence of a further evolution of function. Though, at the meeting of the Commonwealth Science Council in Malaysia, 1982, it was felt that no major change of direction was needed, nevertheless the Council did recommend a change in perspective, emphasis and balance of activities, with more attention being given to science for technology especially in disadvantaged countries. Though the clear intention of the Council was to continue focussing on technology as an instrument for development, a further emphasis was now added: to incorporate that of basic science—and that alone—that underpins those technologies that could be harnessed for a country's development.

(b) Expert Group and its Terms of Reference: Challenges and Constraints

In July 1983, the Council's Executive Committee decided to establish an expert group of scientists to examine ways and means of promoting an expanded programme of scientific co-operation. Their terms of reference were as follows:

(i) To examine and identify key issues for expanding cooperative scientific and technological programmes in the Commonwealth, especially in new emerging areas with major significance for the development efforts of member countries in the next 10-20 years, and giving due consideration:

— to the continuing involvement of networks and regional groups of scientists in project development and implementation,

— to training needs, and to the views of member countries of Council.

(ii) To develop an action plan for enhancing Commonwealth co-operation in specific areas and, having regard to its financial implications, to identify possible sources of funding.

(iii) To submit a report to Council by 1 June 1984.

In expanding and developing these terms of reference various factors—whether underlying intentions, inescapable challenges, or over-riding constraints—came to underly the form and nature of the Group's recommendations. These factors included:

(i) The challenge presented by the very diversity of the Commonwealth constituency, which embraces large nations that are scientifically sophisticated and advanced, and small nations, including island states, with little tradition or expertise in scientific research. For, as envisaged, though primarily directed to the needs of these smaller countries, the new programmes should not be without interest to the larger ones.

(ii) The challenge presented by the new direction requested by the Council—that is, to incorporate more basic science into a programme which in the past has been purely technological or applied. But not just all—or any—basic science would be injected: only that which had both a genuine connection with the real world and which clearly contributed to emerging technological areas crucial for development. For example, while research into the building and launching of satellites would not be appropriate, nor would research into extra-terrestrial life, remote sensing would be highly appropriate—as a clear example of an emerging technology that is highly useful for development and which held greater potential.

(iii) Finances were one obvious constraint. There was never any expectation that a massive subvention could be made available for an expanded programme. Thus the group's ambitions were forced to be realistic rather than grandiose, tailored to a modest increase in existing funds but, equally, capable of being expanded

should present financial constraints diminish. On the other hand, however, since many collaborative mechanisms with their own supporting infrastructures are already in place, cooperative work with other institutions could easily be achieved and thus the need for greatly increased financial resources reduced. Given a good infrastructure, a willingness to collaborate, good scientific leadership and clear perception of problems to be tackled, much can be achieved even with a small amount of money. Multiple effects can result both from small research programmes slotted into existing mechanisms and making use of many of the resources, whether intellectual, structural or financial, that are available.

(iv) Yet another constraint concerns the inescapable need for a multi-disciplinary approach to many of the basic science research questions that underpin technology for development. Yet it is unrealistic to expect such multi-disciplinary work to be carried out alone, in small island states, with limited populations and numerically very few scientists. For example, an effective programme of coastal zone management would require efforts of entomologists, marine biologists, botanists, etc. Thus, once again, one is forced to devise programmes that are not only of use to existing developmental areas, but are of interest to larger sophisticated scientific states. For, to repeat: the aim is not only to help smaller countries but to provide problems of interest to the larger ones. This fact is reinforced by yet another: the larger countries which would inevitably be underwriting most of the research might be more generous if they could appreciate a real direct interest in the programmes.

(v) Finally, one overriding constraint is that the resources presently available are not vast. By comparison with the problems facing many Commonwealth countries, they are, in fact, small. This factor introduces an inescapable and recurring constraint: a proper perspective had to be constantly maintained between two important levels: that of the multifarious problems the countries face and that of the scale of activity that the Commonwealth Science Council might realistically hope to achieve.

(c) Methods and Rationales

The methods and criteria used by the group to determine their recommendations relate back to a number of rationales:

(i) One cannot expect economic or social development unless a country has some technology and innovation;

(ii) There cannot be a healthy programme of applied technological research unless there is some continuing basic research in progress as well.

In this report, these two rationales are clearly linked since no argument is presented for pursuing basic research for its own sake but only for its relevance to the practical developmental problems of the countries concerned. All the areas recommended for action and support had to be seen to make a contribution to the forward development of these countries.

But even given these two rationales, there was a third which relates to the essential requirement to be as pragmatic as possible, recognising that the financial resources available were not, in all likelihood, able to be expanded above 10%, perhaps 20%. This made it absolutely essential for the group to establish priorities. Thus those programme areas that were recommended as top priority were those that one might expect to achieve with a 10% expansion of existing financial resources; medium priority areas are both those one would like to see done and which could be done if more finances were made available; low priority areas were those which, for one reason or another, the group were negative about from the very outset.

The group initially examined some 20–30 subject areas and then did a preliminary elimination. There were essentially two criteria that determined whether or not a programme would be thrown out at this stage: was it obviously out of the question since resources, whether scientific or financial, simply were not available; second, was it being most effectively done by another organisation?

(d) Projects Selected and Criteria for Selection

Finally, a short-list of some 17 subject areas which demanded serious consideration, was drawn up and papers commissioned on each of these from experts (Appendix E). Once this was done then the final selection was made.

We were mindful of two considerations: first to set our recommendations in the broad framework of Commonwealth co-operation and second, to ensure that our programmes fitted into that range of activities which, through its 1982 Review Group, the Commonwealth Secretariat felt it could be involved with. As a result we developed the following criteria for selection of projects:

(i) importance for technology for development as well as a high intrinsic scientific value, that contributed significantly to some branch of knowledge;

(ii) relative usefulness to socio-economic development;

(iii) probability of leading to the required scientific expertise and capability necessary for intermediate and high technology;

(iv) awareness of the need to maintain a balance between meeting immediate needs that required simple to intermediate technology and infrastructure, and relatively long-term needs requiring more sophisticated technology and infrastructure;

(v) relevance to both the less advanced and the more advanced nations, but with special emphasis on the needs of the less advanced nations;

(vi) availability of appropriate infrastructure for project implementation;

(vii) potential relevance to those international development programmes which provide external resources to stimulate, or strengthen, internal resources.

Once the programmes had been selected they were organised into priorities, the criteria now being need, cost, and importance. The final programme of expanded scientific co-operation lists some fourteen areas and the Summary Table (Table 1; Page 6) gives their costing under three further priorities, A1, A2, and A3.

A1, termed initial, assumes the modest increase of 10% of expanded resources; those under A2 reflect the minimal costing that the Group feels essential if the programme area is to have an impact—that is, improve the capacity for science and technology within the smaller countries with an eye to their development; the third priority, A3, is the level of funding that is highly desirable to maintain the programmes not only as viable concerns, but to make long-term impacts. Thus the last two categories, minimal priority A2; desirable priority A3, are more generous programmes whose work will extend over a period of time.

(e) Special Problems of Smaller Countries

Before submitting their papers and making their recommendations the expert advisers on the various subject areas were asked to take particular note of the range of differing needs a nation might require at various stages of development, and to relate research and development both to those needs and to the *stage* of development. For there is great variation here. In the low income sector, for example, less advanced nations are struggling to meet the basic human needs of food, water, shelter and health. In the middle income sector, moderately advanced nations are struggling to reduce inequalities by industrialisation and the processing of natural products. In the high income sector, by contrast, more advanced nations now are generating technology for a more international use and for a wide spectrum of socio-cultural and economic conditions. Yet with the possible exception of the smallest island

Table 1: Summary of the Costing of the Expanded Programme of Scientific Cooperation
(at 1984 £ Sterling prices)

	Financing Levels		
	Initial (Priority A1)	*Minimal* (Priority A2)	*Desirable* (Priority A3)
Programmes:			
Energy Resources	500,000	1,000,000	2,250,000
Mineral and Water Resources	485,000	985,000	1,585,000
Materials Technology	250,000	500,000	750,000
Biological Diversity	500,000	1,000,000	1,850,000
Agriculture Research	650,000	2,100,000	3,390,000
Tropical Forest Ecology	50,000	50,000	50,000
Environmental Planning	200,000	300,000	500,000
Coastal Zone Management	300,000	600,000	800,000
Remote Sensing	310,000	560,000	1,060,000
Biotechnology	300,000	600,000	600,000
Microelectronics	50,000	100,000	100,000
Information Dissemination	10,000	20,000	30,000
R & D Assessment	50,000	100,000	200,000
Scientific Advisory Committee	100,000	100,000	100,000
Administrative Overheads	475,000	475,000	475,000
Five year Total Costs:	4,230,000	8,490,000	13,740,000
(Cost per annum)	(846,000)	(1,698,000)	(2,748,000)

states, most nations have some common interest in all three stages of development. Therefore cooperative programmes which cut across all these stages would both enrich their knowledge and experience and sharpen their own developmental expertise. For the smaller island nations, however, cooperative programmes had also to be aimed at enhancing the scientific capability of their limited personnel in those subject areas most relevant to their needs.

Yet no nation with a population of less than one million can be expected to have a scientific infrastructure of effective broad significance. Twenty out of forty-three Commonwealth countries come into this category.

Indeed, out of the thirty-six nations worldwide, with a population of less than one million, twenty are members of the Commonwealth. Given a recognition that, in the light of these statistics the Commonwealth does have a special responsibility to such smaller nations: the problem facing the Group's recommendations can be stated quite simply: first, how can the recommendations and programmes be comprehended—that is, made sense of—by nations with constraints of small size and populations, and second, how can they stand to benefit from the recommendations. While the Group does not claim to have answered this problem it has appreciated its existence. Its solution may well take the form of structural changes in the organisation of seminars and networks, so as to involve smaller nations more effectively, or it may lie in encouraging the formulation of regional groupings for the purposes of problem assessment and the transfer of technology.

Thus over and above the extended programme of basic science injected into programmes of technology and applied research for development, one further function is implicit: that is, to improve the capacity for science and technology within smaller countries. The group never envisaged that work in these recommended programme areas should be done only by bringing people in from the outside.

Not only did the group want to encourage small countries to have their own programmes wherever possible, and have their own scientists involved, but also wanted to encourage them to initiate their own scientific tradition by training and education. Where personnel were lacking in skills then proper training should be given. For example, the value for a country's development of remote sensing and examination of Landsat photographs is obvious, but training programmes would have to be initiated in the examination and interpretation of these satellite photographs.

Briefly, we recommend that the strategic focus for the expanded programme of scientific co-operation in the Commonwealth, with the intention to focus on basic research as it relates for technology for development, should be towards the setting up of inter-disciplinary research programmes in three main areas: (I) *natural resources;* (II) *new technological aids;* (III) *science management and organisation.* In addition we recommend the setting up of a Scientific Advisory Committee that would both evaluate the programmes on a continuous basis and recommend new programmes as and when becomes appropriate.

The three main areas are now considered in detail below and specific recommendations are given.

(f) Strategic Focus of Programmes

I. Survey and Enhancement of Natural Resources

(i) *Energy Resources*

The following five recommendations are put forward for urgent consideration by the Council in this area:

- Develop specific and appropriate anaerobic microbiological systems to enhance the efficiency of biogas technology with bacteria and indigenous feedstocks appropriate to a given ecological environment;
- Reinforce and extend international efforts leading to the identification and cultivation of fast-growing species of trees, bushes, and other plants, suitable for fuel;
- Survey current wind and solar regimes and assess them for their efficiency as an energy resource and their appropriate use over the short-term; undertake local training both in such assessments and in the use of wind and solar power technology; this programme to start at once;
- Through research, training and the exchange of information, help develop a low-cost, 5 MW solar thermal electric conversion (STEC) modular unit;
- Immediately, develop ways and means of strengthening the information network on energy in the Asia-Pacific region and, over the short-term, establish similar information networks on energy in the Caribbean and African regions;
- Set up a task force of experts who would determine the relative efficiency and priorities of energy resources derived from anaerobic microbiology, solar power, wind and solar regime surveys, and energy information systems projects.

(ii) *Mineral and Water Resources*

We have six recommendations for the Council in this area:

- Undertake research, training and information exchange, in the following aspects of water resources: controlling the nitrate pollution of groundwater provoked by faecal wastes and agrochemicals; the development of remedial measures that could lead to the agricultural, or domestic use of polluted groundwater; developing the simultaneous use of ground and surface waters especially in coastal zones;
- Develop methods that would make the best and most efficient use of rural water supplies and small-scale irrigation techniques; develop technologies leading to the desalination of brackish or

saline waters; develop further methods for the use of limited water resources; study ways of controlling the freshwater-seawater ratios and relationships in small islands. These programmes should be started straight away;

— Develop studies of regional geochemistry through research, training and information exchange; develop also, over the short-term, the application of geophysical techniques, especially deep crustal seismic, reflection profiling;

— Develop, extend and, where present, upgrade, training in remote sensing techniques by using fixed wing aircraft for large countries and for small island states, by using existing, readily available satellite imagery, but supplementing these photographs with ground studies;

— Concentrate, especially in small states, on the training of technicians in geochemical and geophysical techniques;

— Continue with the production and distribution of the *Earth Sciences Newsletter.*

(iii) *Materials Technology*

— Undertake to disseminate information on engineering materials to the less advanced nations;

— Undertake collaborative research in the use of such construction materials as timber, fibre, paper and ceramics, as a means for enhancing both economic productivity and scientific capability.

(iv) *Biological Diversity and Genetic Resources*

— Because of the pressing need to conserve genetic resources and genetic variability for the agricultural and economic use by mankind, undertake studies in biological diversity;

— Concentrate its initiatives in the study of biological diversities, for the short-term, on perennial plants which are (i) poorly known, (ii) not studied by other organisations, and (iii) of potential value for the production of food, fibre, oils and pharmaceuticals;

— Promote, in the medium-term, similar studies in animal species;

— Involve agricultural scientists in these programmes for three reasons: (i) the relevance and importance of their specialised knowledge to food production and primary industry, (ii) their predominant position amongst the scientific community, especially in the less advanced nations, and (iii) to satisfy their need for more stimulating research and an extension of their

present work since this would enhance their professional capability and underpin their work and its significance in their own countries;

— Promote the surveying, and accurate identification of the range of biological species and its diversity, especially in the tropics;

— Train taxonomists, in both the short-term and medium-term, on tropical foods especially, and on those plants which could have an economic and medicinal importance;

— Encourage member nations to set up, or revive, herbaria and museums, gardens and zoos, so that the identification of plant and animal species, either locally used or with potential use, could be consolidated and these plants and animals carefully husbanded and conserved;

— Promote training in the development of those relatively inexpensive, but potentially rewarding, techniques that extend the use of a wider variety of agricultural and industrial plants—such as conventional plant breeding leading to new varieties of crop plants with new characteristics related to yield, harvest index and various other specific qualities; or techniques of micropropagation and meristem cultivation leading towards rapid multiplication by clonal methods; or techniques leading to resistance to viruses, or those applicable to conservation of genes and gene pool, and those techniques that allow for the exchange of clonal stocks amongst nations, or for extending tree crops internationally by clonal methods.

(v) *Agricultural Research*

— Encourage and support member nations, especially in the tropics, to give priority to methods of reducing soil erosion and flood damage, by controlling land use on water sheds; similarly to improve the support given to farmers on good soils, and to methods for extending and expanding agriculture on unsuitable land; to ensure that reasonable profits are available to farmers by maintaining a favourable ratio of prices *for* their crops, to the prices they must *pay* for fertilizers; to deploy more farm technologists to the rural areas, from the urban ones;

— Become involved in agricultural research, but now concentrating on those few areas where a major impact is possible; to provide fresh incentives to good agricultural scientists that will enhance not only their own research but that of the agricultural sector generally, where this includes not only farm agriculture but forestry and fishing too.

— Stimulate, over the short-term, the following projects in agriculture:

A. Local surveys in the tropics for sources of phosphate rocks and the development of simple methods for their processing and subsequent use as fertilisers;

B. Methods for selecting nitrogen-fixing organisms for their use in seed innoculation, particularly, and methods of developing cheaper processes for nitrogen fixation;

C. Extending the study of the relationship of water resources, soil water and agrometeorology, to plant growth and reproduction;

D. Through the techniques of micropropagation, plant breeding, and other selection measures, improve plant genotypes in the tropics so as to enhance the adaptation of these plants to the various physical and socio-cultural conditions;

E. Disseminate information on ova-transplantation techniques that improve animals used in agriculture, especially in the tropics;

F. Study various methods of post-harvest treatment of agricultural commodities especially in relation to climatic conditions, and to the processing and storage of root, tubers and fruit crops in the tropics;

G. Study methods of upgrading animals feed by increasing their protein content using micro-biological treatments.

(vi) *Tropical Forest Ecology*

— Commission a study that will stimulate member nations to make a detailed appraisal of their own local situation on tropical forests and take measures that will either initiate, or strengthen, national policies and programmes so as to arrest the present degradation of tropical forests;

— Take measures to ensure that the Council's scientific programmes in the areas such as energy, mineral and water resources, biological diversity, agricultural research, environmental planning and remote sensing, include the following concerns that are relevant to tropical forest ecology: ecosystem variation, species identification, internal dynamics of ecosystems, suitability of forest lands for other purposes, economic potential of species, identification of conservation areas, protected area systems, and human relationships with forests.

(vii) *Environmental Planning*

— In regional pilot projects extending over a 3-5 year period, develop training in ecological assessment and management, and in the assessment of environmental impacts, that would all lead to improved conservation strategies at local and national levels.

(viii) *Coastal Zone Management*

— Promote research and training in oceanography, especially biological oceanography given its great importance to fisheries; organise on international seminar on the relationships between biological and physical oceanography;

— Urge member nations to collaborate in UNEP Regional Seas Programme and disseminate information on coastal pollution in consultation and collaboration with international organisations such as UNEP, IOC and IMCO;

— Offer advice to member nations on the scientific and technological aspects of the EEZ maritime issues in consultation with national and international organization.

II. New Technological Aids

(i) *Remote Sensing*

— Establish immediately a remote sensing programme; and establish a Task Force that would review present and future Commonwealth activities with the view to (i) assembling those available techniques, capabilities, and infrastructure that would be necessary for obtaining and analysing remotely-sensed data; (ii) formulating a plan of action for an integrated Commonwealth approach for remote sensing, and data transmission and analysis, that would use both aircraft and satellite characters, in a manner which would be beneficial to all Commonwealth nations but particularly the smaller states; (iii) include within this plan of action an examination of the existing arrangement for the training of technicians and scientists in remote sensing, especially on a regional basis and developing new mechanisms for this training; (iv) commission a study on the use of available remote sensing data using papers written by experts, so as to bring the potentials and advantages of remote sensing to the attention of politicians and scientists; (v) establish in the short-term regional networks for the exchange of information on any new developments in remote sensing analysis and applications; (vi) investigate the feasibility of developing aircraft-borne remote sensing capability with palletized equipment for deployment and use by a number of Commonwealth nations.

(ii) *Biotechnology (including Genetic Engineering)*

This area of research is so specialist and moving so rapidly, that it is impossible to lay out a programme that would be valid for five years. Therefore we recommend a regular watch be kept on developments in this field and that the Council:

— Establish a Biotechnology Advisory Committee of expert practising scientists, aiming to achieve the following objectives:

  A. review each year new advances made in potential substrates for microbiological processes, food and animal feed, soil microbes for plant nutrition and health, nitrogen fixation, microbial insecticides, fuel and energy, waste treatment and utilization, cellulose conversion, antibiotics and vaccines, and too, advances in pure culture production techniques;

  B. promote and establish contacts between scientists in the Commonwealth and non-Commonwealth organisations;

  C. screen the practical applications of all aspects of biotechnology given the unpredictable nature of the new advances and their exponential growth;

  D. advise the Council on the need for training in specific and relevant techniques at appropriate regional institutions;

  E. identify important areas for the promotion of collaborative research, as appropriate.

(iii) *Microelectronics*

— Establish in the short-term, a Computer Advisory Committee to advise all member nations, but especially the small states, on the specifications required for a versatile, cheap, portable and standard computer;

— Urge member nations to seek expert advise on micro-computers;

— Establish as a medium priority, special training courses in software development where its adaptation for local uses appears important;

— As a matter of medium priority conduct periodic training courses lasting 1–2 weeks, in computer-aided design, aimed at scientists at the university or similar research levels.

III. Science Management and Organisation

(i) *Information Technology and Dissemination*

— Expand in the short-term the presently existing information networks—the Asia/Pacific energy and the Caribbean science

and technology—to include other areas of science and technology;

— Establish, on a sub-regional basis in Africa and Asia, other information networks, initially in agriculture and energy, utilizing specific areas of science; secure the patronage of the institutions of advanced nations; obtain national commitments to these programmes and to the mobilisation of specialist scientists and librarians, as people who would establish contact at the interface between global and local systems;

— Provide an advisory service in science and technology to member nations, especially the smaller ones.

(ii) *Popularisation of Science*

— Encourage member nations to popularise science both for their administrators and their public, and to produce appropriate local and regional materials that would make science both entertaining and educational while still relating it to pressing economic issues; to commit funds and mobilise the necessary infrastructure for the interpretation of science, especially the Information Ministries, so as to have a continuing basis for the production of significant materials for the establishment and maintenance of an encouraging climate of opinion amongst society.

(iii) *Basic Science Education*

— Encourage immediately, member nations to improve, or stimulate, basic science education in schools and universities by various means—better teacher training, incentives, equipment and curriculum development—so that science cannot only contribute more effectively to technological and economic prosperity, but can be seen to do so.

(iv) *Assessment of Research and Development*

— Promote training in methods of assessment of research and development.

(g) Scientific Advisory Committee

Because of the rapid and predictable growth of science and increased investment in it, advances in science, which are in any case normally unpredictable, are occurring more and more frequently, especially in the more advanced nations. Each advance generates its own, equally unpredictable, stream of technology and the lag time in the technological application of scientific discovery is rapidly decreasing.

Since there is clearly no possibility that the less advanced nations can acquire expertise in all these areas of science and technology, some of which are of enormous potential significance to their own development, it would therefore be invaluable to member nations if, from time to time, these fast-moving areas, especially those significant to development, were monitored, evaluated, and advice on them given. Such reviews would be not only useful to scientists but also to those managers of science in member countries.

Thus it is strongly recommended that the Council should establish a permanent Scientific Advisory Committee, with the following functions: (i) to review advances in science and technology, especially in the new and emerging areas; (ii) to monitor progress in the scientific programme and advise countries on future areas suitable for the development of new programmes and projects. In this respect the Scientific Advisory Committee should complement the work of the Council and its Executive Committee, the Programme Steering Committees and Project Groups in programmes, project development and implementation. Thus the kind of review that this present expert group has undertaken should not be considered as a one-time effort but its work should be sustained and expanded in this way.

The Scientific Advisory Committee should be drawn from a Commonwealth-wide constituency, be composed of eminent scientists in their individual capacities, have its membership rotating on a five-year and staggered basis, and should meet biennially three months before the Council's meeting, so that its recommendations are available for the consideration of the Council. We consider that it would require funding of the level of £100,000 five yearly for its work (Table 1; Page 6). We recommend that the Council gives consideration of a very high priority to the establishment and funding of this committee.