

Science for Technology for Development

An Expanded Programme of Scientific
Co-operation in the Commonwealth

Report of the Expert Group



Commonwealth Science Council

*Science for Technology for Development:
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Cooperation in the Commonwealth*

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Commonwealth Science Council
Commonwealth Secretariat
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‘The research climate in many developing countries is now more hostile than it has ever been. The pressures on governments, particularly in Africa, are so intense and the time periods within which they function are so short, that they are quite unsympathetic to longer-term studies. They need immediate results. All the more reason to encourage researchers to consider, at the outset of their work, the necessary linkage between research and practical application. Developing-country scientists must be encouraged to address the problems around them: their laboratories are their societies.’

Ivan L Head
President
International Development Research Centre
Canada
(1983 Annual Report)

Foreword

Ministry of State Science and Technology	Ministère d'État Sciences et Technologie
Secretary and Chief Science Advisor to Government	Secrétaire et Premier conseiller scientifique du Gouvernement
Ottawa, Canada K1A 1A1	

July 16, 1984

When they met in Kuala Lumpur in August 1982, the Commonwealth Science Council decided that 'there was no need for a major change of direction in Commonwealth Science Council's activities', but recommended, in this perspective, 'a change in emphasis and in the balance of activities through more attention to science for technology, especially in disadvantaged member countries'.

(12 CSC(82) Minutes, item 21, page 32)

Faced with this proposed major shift in programme, the Executive Committee decided at its meeting in July 1983, to establish an Expert Group of scientists 'to examine ways and means of promoting an expanded programme of scientific cooperation in the Commonwealth, to develop an Action Plan and identify possible sources of funding'.

As is customary, members of the Expert Group served in their personal capacities and their views, therefore, do not necessarily represent those of Commonwealth Governments.

We owe a great debt to Sir John Kendrew and the members of the Expert Group for the time and expertise they have devoted to this examination, this look into the future. Their Report is an excellent study of scientific areas where new collaborative programmes between Commonwealth countries could be established to enhance development.

The Group reaffirms the importance of the Council's objective of enhancing indigenous scientific and technological capabilities as a key to improve development particularly through research, training and information exchange on critical topics. The Group also notes the remarkable breadth, richness and diversity of scientific and technological resources in the Commonwealth.

Collectively, these resources provide a powerful tool for progress and development, somewhat unique at the international level, if harnessed cooperatively. The Expert Group has pointed the way ahead for an expanded programme of scientific cooperation. It is a way which provides scope for Commonwealth leadership in an area where there is strong mutual interest between the more advanced and the less advanced nations.

The Report provides an opportunity to the Commonwealth Science Council which must not be allowed to pass. The Commonwealth Heads of Government meeting at New Delhi in November 1983, welcomed the establishment of the Expert Group by the Council and affirmed the priority which they accord to strengthening Commonwealth scientific cooperation.

It is my hope that this Report will provide the platform for achieving this goal of strengthening scientific cooperation in the Commonwealth.

Louis Berlinguet

Letter of Presentation

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1 August 1984

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Commonwealth Secretariat
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Dear Dr Berlinguet

On behalf of the Expert Group on an Expanded Programme of Scientific Cooperation in the Commonwealth, I wish to convey to you our gratitude for your trust and confidence, and that of the Commonwealth Science Council, in appointing us. The Commonwealth grouping is a unique opportunity for cooperation in science and technology, and therefore for assisting in expanding its scope, deepening its substance, enlarging its relevance, improving its quality, updating its content and, generally, shaping it to be a more effective instrument of development.

The task has been full of challenge as well as of opportunity. We have been charged with examining and identifying key issues for this Programme, especially in new emerging areas with major significance for the development efforts of member countries.

The Council's Executive Committee gave the Group the following terms of reference:

- '(a) 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.
- (b) 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.
- (c) To submit a report to Council by 1 June 1984.'

The mandate given to us has been to look not only at the immediate but also the long-term future of science and technology in Commonwealth countries.

We held three meetings in London to discharge the above mandate:

- (a) on 24-25 October 1983, to develop a work plan and to commission submissions by scientific experts;
- (b) on 2-5 April 1984, to review submissions by expert scientists (Appendix B) and to develop a corpus of priorities for the action plan;
- (c) on 28-29 May 1984, to review a draft report.

It is our pleasure to transmit herewith our Report entitled 'Science for Technology for Development', which represents the unanimous conclusions of the Group. We trust that it will be useful to the Council for realising more fully its purpose, and the objectives for achieving it. Since the Commonwealth Heads of Government meeting in New Delhi in November 1983 endorsed the establishment and working of this Group, we trust that this Report will be useful to Heads of Government in the Commonwealth and their senior officials, especially in addressing the application of science for technology for development and rapid social change related to their economies. We hope that it will also be of value to the less advanced countries generally in pursuing scientific and technological development.

In accordance with the terms of our appointment, each member of the Group endorses this Report in our personal capacity, and not as representatives of governments, institutions or countries. We should like to express our appreciation to the support and interest you showed in our work, to the generous contributions we have received from eminent scientists in various subject areas, and to the unfailing assistance we have enjoyed from the Council's secretariat. In finalising the Report I have been assisted by Dr June Goodfield.

Wishing you and the Council every success in your Programme.

Yours sincerely
John Kendrew, FRS
Chairman

Members of the Expert Group

of an Expanded Programme of Scientific Cooperation in the
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NOTE

The main recommendations of the Report are to be found in Chapter 1, and proposals for implementing them are set out in Chapter 5.

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)

	<i>Financing Levels</i>		
	<i>Initial</i> (Priority A1)	<i>Minimal</i> (Priority A2)	<i>Desirable</i> (Priority A3)
<i>Programmes:</i>			
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: (Cost per annum)	4,230,000 (846,000)	8,490,000 (1,698,000)	13,740,000 (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-sea-water 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 micro-propagation 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 inoculation, 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 an 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 advice 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.

Chapter 2

Natural Resources

(a) Energy Resources

The most accurate index of a country's industrial progress is its per capita energy consumption. Over 30 countries within the Commonwealth have an annual per capita income of less than US\$1,000 (Appendix G; Page 93), and an energy consumption of 0.1–0.5 metric tons of coal equivalent (mtce). Compare this energy consumption with 7.0 mtce for Australia, 5.6 mtce for the United Kingdom and 13.5 mtce for Canada. These three countries use two-thirds total energy consumed by the Commonwealth, yet their population is less than 10% of the whole. In the remaining Commonwealth nations, whose population accounts for 85% of the total Commonwealth population, industrial output contributes little to gross national product and the volume of manufacturing industries is negligible. Two general characteristics unite these nations amongst others: they are mostly agricultural based with agro-industries not adequately developed; their indigenous conventional energy resources are either inadequate or non-existent.

Nevertheless, it is generally agreed that if they are to achieve industrialisation and their developmental goals, these nations will have to increase their per capita energy consumption by at least 2 mtce by the year 2000. A case examination of their prevailing pattern of energy consumption shows that the bulk is consumed in the form of hard fuels.

Only about 10–20% is in the more convenient forms like electricity. Yet if a higher level of industrialisation is to be achieved, with an improvement in the quality of life and an enhancement of the gross national product, energy consumption in the form of electricity too, will have to be considerably enhanced. Thus, in most of the countries, by the year 2000, installed electrical capacity would have to increase at a minimum, tenfold.

But irrespective of this, the overall development of any such country will demand a decentralised energy system that will involve a judicious mixture of technologies and a variety of energy resources. For while, on the one hand, large scale centralised systems are essential if sufficient power is to be provided to the industrial sector, small scale decentralised systems, involving low or simple technologies, are the only practical means of improving the quality of life in rural areas. So far as the latter is concerned, we recommend that the Council undertake the development of anaerobic microbiology studies for enhancing biogas systems with indigenous feedstocks. Through research, training and information exchange, this renewable energy resource could be better utilised. Because of its low quality it is not amenable to commercial use but in the vast rural areas it can provide an attractive and effective alternative supply source.

Though simple technologies for the use of biogas exist, little attention has been given to the microbiological aspect of this fuel and studies should be initiated that would examine the effective use of local bacteria, and their particular environments, from one geographical area to the next. Such a research programme is not likely to be expensive and could build on the Council's past programmes in Africa and the Asia/Pacific regions.

In the same area the Council should urge member nations to reinforce existing international efforts that lead to the identification and cultivation of fast-growing species of plants suitable as fuel. Monoculture tree species capable of improved biomass yields, and able to be cultivated under varying conditions, should be introduced and their environmental effects assessed. Improvements in renewable energy technologies, especially from biomass resources, where there is an enormous potential for innovation, whether in devices for conversion or utilisation, would lead to great benefit for the predominantly rural populations. With the help of biotechnology and an understanding of the local microbiology, biomass conversion systems for rural application could be enormously improved.

Similarly, wind- and solar-powered systems could be introduced to meet the decentralised power needs of the rural sector. Efforts directed to improving both the design of such systems and the greater use of local materials, could lead to important cost reductions.

Thus the Council should, as a matter of urgency and present direct action, undertake a survey of wind and solar regimes assessing them for their potential as a source of local energy and the best manner of utilisation. Parallel training in the assessment and use of these resources should also be undertaken. Once again, these activities could reinforce

present programmes in Africa and the Caribbean and once again, these would not be expensive. In addition the Council should undertake, through research, training and information exchange, the development of a modest, low-cost, 5 MW solar thermal electric conversion (STEC) modular unit. This would be a modestly expensive programme and should again reinforce Council's past efforts. Because of advances in the development of low-cost materials and thermo-mechanical systems, economic and efficient solar power systems are not only viable but would be particularly attractive to most of the Commonwealth countries, in spite of the low efficiency presently realised in the direct conversion of solar energy to power.

There are three major and one minor primary technologies to consider so far as meeting commercial needs are concerned: fossil fuel, hydroelectric power, and large-scale terrestrial-based solar power system technologies. Wind power could provide a further alternative in a few selected countries.

Coal is the key fossil fuel here for commercial energy production: there are massive known resources and a considerable potential for new discoveries in Africa and South East Asia in particular. Discoveries of even as low a figure as 20–50 million tons could make a substantial difference to the energy potential of a small country since large research and development efforts are required for the efficient use of low grade coals. A number of methods for coal gasification and liquefaction are now available that produce liquid fuel and at the same time, conserve the gas generated. But these technologies need to be adapted for the less developed nations—in some cases they need to be introduced. The conversion efficiency of low grade coal has potential for even further improvement: utilising the ash content for cement production is one such and this should be studied.

But even more important is the fact that in most of the developing countries thermal stations are run at a very low efficiency level, partly due to the lack of trained manpower and partly due to the use of obsolete systems. Methods that would improve the efficiency of thermal installations and reduce the transmission losses are two vital areas where assistance would be of immense help to developing countries.

The energy information network already established in the Asia/Pacific region should be strengthened; similar networks should be established at once in the Caribbean and African regions. The network in the Asia/Pacific region is under the patronage of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia, and facilitates the linkage of international information that can be disseminated on a regional basis. Such a pattern—an international

information system interfacing with national ones, run under the patronage of the institute of an advanced nation—seems to be very effective in the spread of relevant information on a regional scale.

In the judgement of the Group, the priority areas for the Council's future initiatives are in anaerobic microbiology, solar power systems, wind and solar regime surveys, and energy information systems. The Group has been unable to assign priorities amongst these areas, and suggest, therefore, that the council sets up a task force of experts to determine the relative priorities between these projects. The Group recommends that the Council allocates a sum of £200,000 per year (1.0 million per 5 years) to develop a minimum programme, and £450,000 per year (£2.25 million per 5 years) to develop a desirable programme in this subject area.

(b) Mineral and Water Resources

Besides enhancing our knowledge of the environment, the geosciences form a basis for sustainable industrial and economic development, with water and minerals both contributing. Therefore, nations wishing to continue building their economies need to acquire the indigenous capability to detect, assess, develop and manage these natural resources. Techniques for surveying mineral and water resources depend considerably on local and regional conditions. A variety of subject areas here are amenable to international co-operation: geological mapping, geochemistry, geophysics, remote sensing, hydrogeology, marine geology, hydrocarbon and industrial minerals, are just a few. Certain aspects of mineral and water resources are more amenable than others to industrial co-operation, hydrocarbons for example.

The priority subject areas in a co-operative programme depend on the nature and potential of local mineral and water resources. For instance, a land-bound nation is not likely to derive much benefit from coastal or estuarine studies. We do not recommend that the Council should focus its programme on major geological phenomena since these are of international interest and already well covered by co-operative research and training. Instead, the Council should focus its programme activities on those mineral and water resources of local extent and economic importance.

The Council should consider immediately undertaking research, training and information exchange in the following water resources areas: the control of pollution of groundwater by faecal wastes and agrochemicals; the development of remedial measures leading to the use of polluted groundwater; the development of conjunctive use of ground and surface waters, especially in coastal zones; developing methods for (i) optimising rural water supply and small-scale irrigation, (ii) desalination of brackish

and saline waters, (iii) the use of limited water resources, (iv) the control in small islands of the freshwater-seawater relationships. These projects would build on the Council's past programmes, and with modest additional funds are practical on a network basis.

In view of projected population and industrial demands, water research and development is of a high priority worldwide, especially in Africa and other drought-ridden places. This research would include the assessment, development and exploration of water resources and their quality and quantity control; in some areas such as the South Pacific the study of saline intrusion and surface water relationships would also be important. Assessment of water resources using remote sensing, geophysical and modelling techniques is also of significance but requires considerable funds. The study of environmental hydrochemistry, artesian and phreatic aquifer systems and climatological patterns are of long-term importance.

The Council should urgently consider developing regional geochemistry through research, training and information exchange over the short term. Building on the Council's past programmes, this is practicable with modest additional funds. Geochemical, geophysical and remote sensing techniques are crucial for the detection and analysis of mineral deposits such as hydrocarbons, metals and gems. Satellite imagery is of limited value and geological data needs to be supplemented by aircraft survey and ground truth (or field survey). Rock geochemistry, offshore geochemistry, groundwater geochemistry, hydrocarbon geochemistry and biogeochemistry are important over the long-term, but since they require substantial additional funds for project development, are limited to a few nations. Over the short-term the Council should also consider developing the application of geophysical techniques, especially deep crustal seismic reflection profiling. Though expensive, the cost of such a programme could be minimised by collaboration with commercial organisations. The development and use of interpretive geophysical methods though important is expensive, and in any case, can be pursued by nations on a bilateral basis.

The Council should upgrade training in remote sensing techniques using fixed wing aircraft for large countries, and satellite imagery. This imagery is readily available for use in small island states but must be supplemented with ground truth.

The application of remote sensing for geological mapping and mineral exploration is crucial, for reliable geological maps are essential prerequisites for mineral exploration and development. LANDSAT multi-spectral imagery has been most reliable in the arid and semi-arid regions, while imaging radar is most effective in the tropic-areas with

considerable cloud cover. In certain cases, such as in geophysical survey for minerals, fixed wing aircraft are important, but are inappropriate for small states. Thus Council should consider giving special attention to the training of technicians in geochemical and geophysical techniques, especially in small states. The main limitation at present, for the application of remote sensing techniques, seems to be the absence of the necessary infrastructure.

The Council should continue the *Earth Sciences Newsletter*, which has been a most successful means to disseminate information on geology and mineral resources, in both the advanced and the less advanced nations.

We recommend that the Council allocates funds to the following priority projects in the mineral and water resources programme:

	<i>Levels of Programme Development</i>		
	£	£	£
	<i>Initial</i>	<i>Minimal</i>	<i>Desirable</i>
	<i>(A1)</i>	<i>(A2)</i>	<i>(A3)</i>
Projects:			
● Mineral Surveys	60,000	60,000	60,000
● Hydrogeology and Geochemical techniques	400,000	900,000	1,500,000
● <i>Earth Sciences Newsletter</i>	25,000	25,000	25,000
5-year Totals (£):	485,000	985,000	1,585,000
Per annum (£)	97,000	197,000	317,000

(c) **New Materials Technology**

For our purposes the term ‘material’ means physical matter used to construct things, whether components, devices, machines, habitations or other objects used by man. ‘New Materials’ are those conventional materials which, by improved characteristics or performance, have a high potential for engineering or construction applications. It covers a wide spectrum of material types whose use is dictated by their characteristic properties. Two broad classes of such materials exist:

- (i) Engineering materials, which have a high latent economic gearing factor and permit an engineering structure and machine to fulfill its functions. Examples are metals and alloys characterised by strength and toughness, ceramics and cements with intrinsic high hardness and resistance to temperature and corrosion; plastics and

elastomers characterised by strength, low density and corrosion resistance; composites characterised by high toughness and high strength.

- (ii) Construction materials which include timber, fibre and paper, and whose worth and usefulness lie in their durability and the possibilities for volume production.

Scientific cooperation could focus either on improving the performance and behaviour of conventional materials, or encouraging advances in those general subject areas, that ultimately influence the performance and behaviour of conventional materials.

Improving the performance and behaviour of conventional materials could cover many aspects focussing on the design of suitable ceramic materials, whether for use as substitutes for metallic materials, or applied in high performance situations; improving durability by developing new material protection technologies, or by improvements in wear tolerance; enhancing quality and reliability through the development of new technologies such as non-destructive testing ones; developing lighter, energy-saving materials such as special steels and aluminium, or those special materials required for information technology and microelectronics; increasing the availability of materials of greater perfection such as conductors, through the new techniques for 'doping' Group Three elements with Group Five elements.

An alternative focus would be to advance those common disciplines, or generic subject areas, which would have an impact on new materials as well as the production of raw materials. Examples are: capillary phenomena with possible applications in microporous media containing hydrocarbons; joining technologies with specific efforts on solderability in printed circuit boards; surface engineering with emphasis on ion implantation; electrochemistry of metals; solid/gas reactivity of oxidation and sulphidation of materials at high temperatures and fracture and reliability theory of solids associated with defects.

In our view, the Council should *not* support project activities on engineering materials since these are the subject of extensive R & D in the more advanced nations. However, the Council *should* urgently consider undertaking the dissemination of information on these materials to the less advanced nations.

The Council should, however, urgently consider undertaking collaborative research in the downstream use of construction materials, such as timber, fibre, paper, and ceramics, for enhancing economic productivity and scientific capability. This focus would build on Council's previous experience in rural housing, water hyacinth paper and water hyacinth

fibre-reinforced cement boards. Infrastructure for research and development already exist in the Commonwealth nations on these construction materials and thus they offer considerable opportunities for effective Commonwealth collaboration.

(d) Biological Diversity and Genetic Resources

Because biological diversity constitutes an invaluable source for the discovery of natural resources, its identification and authentication is crucial. The germplasm of this planet contains a repository of genes which, potentially, can be used to enhance the quality of natural products, many of which are uneconomical to synthesize. But through a variety of techniques, like plant breeding or recombinant DNA technology, this potential can be realised. During biogeographical history and evolution this diversity of species came to be concentrated in the tropics. Yet now this genetic resource is in danger of extinction, for a variety of reasons. Living habitats are increasingly manipulated, for limited or short-term purposes; habitats may even be destroyed as space is given over to alternative uses, or by environmental pollution; natural resources may be over-exploited; modern technology can be misused and the environment affected in this way.

Of an estimated 30 million species on earth, a mere 5 million have been identified and authenticated, mainly in the past 200 years. Only 250,000 species of the total stock are plants, so the ratio of plant to animal species is thus 1:119. Wild species are of considerable potential benefit to man, in medicine, agriculture and industry, as a source of natural products for drugs, food, fuels, fibre and industrial base compounds and additives. They also provide agents for a variety of processes—controlling diseases, pests and predators, pollinating flowers, stimulating fruit and seed production, facilitating seed dispersal and thus the establishment of new offspring and enhancing symbiosis.

Biological diversity is crucial both for enhancing genetic resources or for the discovery of new genetic resources. In agriculture, the productivity of major crops cannot be maintained, let alone expanded, without a constant infusion of fresh genetic variability. Much of this genetic material comes from wild relatives of modern crop plants. Agriculturists estimate that some 40 percent of expanded productivity can be attributed to genetic breeding and thus, ultimately to the germplasm and other genetic materials on which plant breeders depend. In a phrase, genetic improvements account for at least one percent of agricultural productivity overall each year.

In addition, wild species offer considerable potential for entirely new foods. Of a global total of some 80,000 edible plants, only about 150 species have ever been cultivated on a large scale, and 90 percent of

the world's food is produced from less than 20 species. Many examples of under-exploited food plants exist, with proven potential for future exploitation; in medicine, wild plants are used for the production of many modern drugs and pharmaceuticals; one in four products sold in modern pharmacies originate from wild plants, resulting in a global commercial value of about \$10 billion a year. In industry, plants are used across a wide spectrum, from the production of paper to thickening for dessert foods, fire hoses, detergents, cosmetics, paints and varnishes, shoes, stamps, golf balls and drilling muds. The chemical industry, in particular, may, in the future, find phytochemicals more cost-effective than petrochemicals. Scientists have only conducted a cursory screening of one plant species in ten, and an intensive screening of one in a hundred. Thus, an analysis of all 250,000 plant species would reveal many new materials of benefit to mankind.

The Council should therefore, urgently consider undertaking the study of biological diversity because of its pressing relevance to genetic resources for mankind. Regrettably, the earth's biological diversity is being reduced at an ever increasing rate. At least one species is being lost each day, and by the year 2000 one million species could have been lost. Many surviving species may well lose 90% of their populations without being threatened to extinction, but in this course they may well have lost half their source of genetic variability. With the support of the scientific community and political leaders, an expanded effort is required to safeguard the biological diversity of this planet and to use it for human welfare.

The Council should concentrate its immediate initiatives in biological diversity on perennial plants which are poorly known, not studied by other organisations, and of potential value for the production of food, fibre, oils and pharmaceuticals. Various international institutions, through the International Boards of Plant Genetic Resources (IBPGR-CGIAR), already collect and use the genetic variability of the major food crops of this planet. In addition, major national institutions within and without the Commonwealth, such as the Rubber Research Institute of Malaysia, the Centre for Sugarcane Research in Barbados and the Banana Research Institute of Jamaica, collect and use the genetic variability of major plantation crops. The genetic variability of export-oriented species is already well collected and used by national and multi-national corporations.

In view of the impending human population and food production crises, especially in the dry zones of this planet, the Council should consider involving agricultural scientists in these programmes for several reasons. Their work is highly relevant to food production and primary industry, in the less advanced nations especially; they hold a dominant

position in the scientific community; they have a need for more stimulating research and an extension of their efforts that would enhance their professional capability.

Though important, the Council should consider promoting the study of animal species in the medium-term.

There are various kinds of activities and techniques available for the better understanding, utilisation and management of biological diversity. The Council should urgently consider promoting the survey and authentication of biological diversity especially in the tropics. Correspondingly, it should consider training taxonomists in the short-term, especially on tropical food, economic and medicinal plants. The cost of these activities are modest, and they build on the Council's past programmes. The Council should encourage member nations to revive herbaria and museums, and gardens and zoos, with the view to enhancing the authentication and husbandry of plant and animal species for local use, respectively.

Advances in cellular and molecular genetics have opened up new avenues for increasing the use of genetic variability. Recombinant DNA technology is of long-term value, but too sophisticated for most less advanced nations. We therefore do not recommend that the Council should support it. The Council should urgently consider promoting training in the development of relatively inexpensive, but potentially rewarding, techniques for upgrading the use of a wider variety of agricultural and industrial tree crop plants. Among such techniques are conventional plant breeding for designing new variations of crop plants with new characteristics related to yield, harvest index and quality specifications; micropropagation and meristem cultivation techniques for rapid clonal multiplication; disease protection; genetic resource conservation; techniques for international transmission of clonal stocks, and for spreading clones of tree crops.

We recommend that the Council allocate funds as follows for projects in this programme:

Levels of Programme Development

	£	£	£
	<i>(Priority A1)</i>	<i>(Priority A2)</i>	<i>(Priority A3)</i>
	<i>Initial</i>	<i>Minimal</i>	<i>Desirable</i>

Projects:

● Potentially valuable plants	-	-	750,000
● Animal species	-	500,000	50,000
● Survey of biological diversity	-	-	750,000
● Training in taxonomy and micropropagation	500,000	500,000	300,000
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Five-year totals: (£)	500,000	1,000,000	1,850,000
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Cost per annum; (£)	100,000	200,000	350,000
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(e) Agricultural Research

Food supply must at least double over the next 30 years in order to match the estimated doubling of the world's population. Agricultural practice (including forestry and fisheries) in the less advanced nations, particularly of the tropics, is not receiving the necessary research support. As a consequence, new and traditional farming communities get very little help from local agricultural scientific efforts, except where it is part of an external aid programme. But at the termination of the aid period this help often collapses. There is considerable need therefore to adapt agricultural techniques and technology through on-site investigations and field testing. The Council should urge member nations, especially in the tropics, to give priority to:

- controlling land use on watersheds to reduce soil erosion and flood damage;
- improving the support they give to farmers on good soils;
- controlling the expansion of agriculture onto unsuitable land;
- ensuring that the ratio of prices for crops to prices for fertilizers provide profits to farmers;
- deploying farm technologists from the urban and suburban areas to the rural areas.

The Council should consider becoming involved in agricultural research, concentrating on a few areas where impact is possible, and providing incentives to good agricultural scientists for enhancing not only their own research but, also that of the agricultural sector, including forestry and fisheries, generally. Agriculture is the dominant economic sector

in most less advanced nations, and hence engages the majority of their scientists. Only a small proportion of agricultural scientists are engaged in real research and development projects. It is difficult to attract the best scientists into agriculture because it is believed to involve routine research. However, more advanced agricultural research is urgently needed in the less advanced nations. Efforts should be made therefore to attract the best scientists, and encourage and train them to use novel techniques, that enhance agricultural production such as micropropagation and meristem culture.

A variety of other subject areas in agriculture are important, such as farming systems analysis, design and management, survey of photosynthetic conversion efficiency of various crops, the responses of crops in relation to nutrients, livestock disease appraisal and monitoring systems. Certain aspects of agricultural research are of long-term importance or too expensive to undertake. These include the development of pest forecasting techniques and of slow-release fertiliser pellets, the enhancement of food supplies by amino acids and vitamin supplement, the preparation of food analogs based on single-cell proteins, regenerated protein foods, carbohydrates and fats derived from simpler chemicals, integrated control of animal diseases, and the genetic improvement of animals using hormones and hormone regulators.

The Council should consider stimulating the following projects in agriculture over the short-term:

- (i) Survey local sources of phosphates rocks in the tropics, and develop simpler methods for their processing and use as fertilisers;
- (ii) Select nitrogen-fixing organisms for use particularly in seed inoculation, and develop cheaper processes for nitrogen fixation including direct oxidation processes, especially in the tropics;
- (iii) Develop the relationships of water resources, soil water and agrometeorology, to plant growth and reproduction, especially in the tropics;
- (iv) Improvement of plant genotype through micropropagation, plant breeding and selection techniques for adaptation to various physical and socio-cultural conditions, especially in the tropics;
- (v) Disseminate information on ova-trasplantation techniques for improving animals, especially in the tropics;
- (vi) Develop in the tropics post-harvest treatment of agricultural commodities especially in relation to climatic conditions, and the processing and storage of roots, tubers and fruits;
- (vii) Upgrade animal feeds in their protein content by microbiological treatment.

These subject areas would reinforce past programmes of Council and, because of their relevance to agricultural production, are unlikely to demand substantial additional funds. Multi-disciplinary studies are needed, especially in the less advanced nations of the tropics and subtropics, to understand the physical, biological and socio-economic factors limiting agricultural yield and production, with the view to enhancing yield to meet the projected demand. Guidelines could facilitate the implementation of activities related to agricultural research.

We recommend that the Council allocates the following sums to projects pertaining to agricultural resources:

	<i>Levels of Programme Development</i>		
	<i>£</i>	<i>£</i>	<i>£</i>
	<i>(Priority A1)</i> <i>Initial</i>	<i>(Priority A2)</i> <i>Minimal</i>	<i>(Priority A3)</i> <i>Desirable</i>
Projects:			
● Nitrogen-fixing	50,000 ⁽¹⁾	500,000	750,000
● Plant-Water Relationships/Plant Genotype Improvements	250,000	500,000	990,000
● Livestock Improvement	50,000 ⁽²⁾	100,000	150,000
● Post Harvest Treatment	50,000	500,000	750,000
● Animal Feed Upgrading	250,000 ⁽²⁾	500,000	750,000
Five-year totals: (£)	650,000	2,100,000	3,390,000
Allocation per annum: (£)	130,000	520,000	674,000

Footnotes:

(1) Information dissemination

(2) Training activities

(f) Tropical Forest Ecology: The deforestation problem

The Council should urgently consider commissioning a study that would both urge member nations to make detailed appraisal of their local situation with regard to tropical forests, and initiate or strengthen national policies and programmes that would arrest the present degradation of tropical forests. These extend over 1.9 billion hectares, cover 12.4 percent of earth's land surface, and 42 percent of the tropics. 1.1 billion hectares of these forests have closed canopies while 0.8 billion hectares have open ones. They constitute a variety of ecosystems and harbour a rich diversity of species still mostly unknown.

Tropical forests are found in three broad regions: South and Central America (42%), Africa (37%) and Asia-Australia-Oceania (21%). Most of the closed canopy forests are in tropical America and the Asia-Pacific region, while most of the open canopy forests are in Africa. Closed forest cover in the tropics is decreasing at the rate of 10–20 million hectares (1–2%) per year, so by the year 2000 they will have declined to about one-half (about 580 million hectares). The principal direct causes of this loss are due to fuelwood gathering, poorly managed industrial logging, and the forest's conversion to use for agriculture. Tropical forests are important for various reasons: locally for timber, food and other economic, environmental and socio-cultural values; globally for balancing atmospheric carbon dioxide. They flourish best under high insolation and precipitation regimes; they harbour invaluable biological diversity and potential genetic resources because of their biogeographical history and evolution. Tropical forest lands are most seriously affected by their transformation for alternative uses, by modern technology and by environmental pollution.

The Council should ensure that its scientific programmes in areas such as energy, mineral and water resources, biological diversity, environmental planning, agricultural research and remote sensing, including the following studies in tropical forest ecology:

- the distribution and the range of variation of ecosystems;
- the identity and taxonomy of plant and animal species;
- changes in the nature, extent and distribution of ecosystem;
- the internal dynamics of a range of tropical forest ecosystems in order to determine how they function without human intervention, and their changes in response to climatic fluctuations;
- the relationship between forest characteristics (e.g. composition, structure, soil) and the suitability of forest lands for other purposes;
- the potential of tropical forest species for economic use and for the development of sustainable farming systems for them (e.g. timber, rattans);
- knowledge on the range of variation, centres of biological diversity, endemism, etc. for the identification of areas best suited for conservation;
- the best distribution of nature reserves and corridors between them, for the preservation of biological diversity and genetic resources;
- anthropological knowledge about people dwelling in, and near, forests for developing better farming systems for their well-being.

Because of the concentration of scientific effort in the temperate zone, comparatively little is known about tropical forests and their ecology.

Although tropical forest ecology is an important and vast scientific area, it is still difficult to generate effective scientific co-operation here, even if it is limited to foci such as nutrient and water cycling, and species diversity in relation to ecosystem resilience, integration, degradation and regeneration. A number of international organisations, such as UNESCO, UNEP, FAO, IUCN and WWF, are already involved in tropical forest research regionally and globally.

The future of tropical forest lands lies in three directions of ecological research related to their degradation:

- (i) Transformation of tropical forests to productive agricultural or forestry systems (e.g. food and cash crops, plantation forestry or agroforestry).
- (ii) Management of tropical forests for the sustained yield of timber and other forest products.
- (iii) Use of tropical forests for the protection of water catchments or as nature reserves.

We believe further research is needed using existing LANDSAT and other available data on tropical forest degradation and tropical forest ecology. We recommend that the Council considers undertaking a study to document the degradation problem, and bring the facts forcefully to the attention of member nations for urgent action. We recommend that the Council allocates £50,000 over 5 years or £10,000 per year for this study.

(g) Environmental Planning

The Council should consider developing training in adaptive ecological assessment and management, environmental impact assessment, and national conservation strategies, particularly as regional pilot projects over a 3–5 year period. The technical activities of such projects would include research training and demonstration; short-term training courses on techniques and methodologies; elaboration of testing manuals and handbooks adapted to the needs and absorptive capacities of the nations concerned; provision of fellowships and grants for reciprocal exchange of scientists amongst Commonwealth institutions; support for existing institutions in the nations concerned, to broaden their scientific and technological capabilities.

Training is the most important activity, especially through long-term fellowships, as it is the key factor for developing and adapting those policies for natural resources management that are consistent with the

socio-cultural environments. Any future programme should take account of existing international efforts, especially those of UNESCO, IITA, IUCN, FAO, IDRC, UNDP, UNEP and the World Bank. Enhanced and sustained use of natural resources on an integrated basis, is the key to national economic development in many less advanced nations, especially in the tropics. Scientific research and co-operation can play a crucial role in helping these nations develop strategies for sustained production, taking into account the variability, complexity and uncertainty of natural resources and the need for local and national action.

The focus of the Council's programme in environmental planning should be on tropical islands and coastal zone areas, particularly in the South Pacific and Caribbean regions. Problems of resource allocation and use are of interest to many of the newly independent, less advanced, nations of the Commonwealth. Coastal zone areas are locations where problems of reconciliation among conflicting land and water uses are particularly acute, and where the scientific community can help planners in clarifying options in alternative resource strategies.

We recommend that the Council allocates the following sums especially to training courses and fellowships in the environmental planning programme:

- £200,000 over five years (£40,000 per annum) to initiate training activities;
- £300,000 over five years (£60,000 per annum) to develop a minimal programme;
- £500,000 over five years (£100,000 per annum) to develop a desirable programme.

(h) Coastal Zone Management

The Council should urgently consider promoting research and training in oceanography, especially biological oceanography, because of its relevance to fisheries; and organising an international seminar on the relationships between biological and physical oceanography.

Such a programme would generate the expertise needed for managing the extended maritime regime, and could be undertaken with little additional funds using co-operative arrangements in consultation with UNESCO, FAO and IOC. Coral reef biology, estuarine biology, ocean tides, currents, and sea level, wave dynamics, marine parks, mangrove biology, and lagoon coastal and shelf-sea front productivity, are some important aspects for study. Most Commonwealth nations have extended coastlines, or are oceanic islands or archipelagoes (Table

2; Pages 34–37). Besides, coastal dynamics, physical oceanography, biological oceanography, coastal pollution and marine geology are all important areas for their economic, social and environmental development.

The Council should consider urgently enhancing the indigenous capability on the dynamics and management of the coastal zone, because of its relevance especially to small island states and to the new maritime regime. This should involve research and training using the pilot-project approach, and should concentrate on training in different disciplines, both on-site in one nation and also regionally.

A network of scientists for follow up activities should be developed, as should a practical handbook on the study, so that the awareness of government officials to the integrated resources management approach could be enhanced. Two pilot-projects, using remote sensing techniques, should be undertaken on two island systems, or states, one in the South Pacific and the other in the Caribbean regions, in collaboration with regional institutions and development banks (e.g. ADB, CDB). Commonwealth nations should use the regional framework for acquiring and developing scientific and technological capability especially where the states are small. Coastal zone management is of growing global importance because a rapidly expanding human population is exerting increasing pressure on the coastal zone, as a source of food, transportation, waste disposal, water for industry and domestic consumption (coastal fresh water in lagoons and estuaries), housing, minerals (e.g. sale) and even as sources of energy (e.g. OTEC, wave/tidal energy). Coastal zones have always been focal points for population centres but until the last two decades or so, the impacts on them have been low. There is a need to learn more about the physics, chemistry and biology of the coastal zones in view of the stresses, such as construction, pollution and over-fishing, both on land and on the adjacent seas. With an understanding of the dynamics of the coastal zone, it is possible to take advantage of its potential without undue deleterious effects.

The Council should urge member nations to collaborate in the UNEP Regional Seas Programme, and should consider disseminating information on coastal pollution in consultation with international organisations such as UNEP, IOC and IMCO. This would have marginal financial implications. Coastal pollution is important especially in marginal seas, where it affects marine productivity, and from land-based sources.

Marine geology is of particular interest to member nations because of the industrial potential of seabed minerals, such as aggregate and

placers. Other aspects of marine geology, such as island arc tectonics and oceanic island geophysics, are expensive and of long-term value.

In view of the UN Law of the Sea Convention, member nations of the Commonwealth with extensive coastlines inherit an enormous burden for managing the extended economic zone (EEZ). The Council should consider offering advice to member nations on the scientific and technological aspects of the EEZ maritime issues, in consultation with national and international organisations such as the International Centre for Ocean Development (ICOD), Halifax, Canada, and the Institute for Marine Affairs, Trinidad and Tobago.

We recommend that the Council allocates the following sums for developing priority projects in the coastal zone management programme:

	<i>Levels of Programme Development</i>		
	<i>£</i>	<i>£</i>	<i>£</i>
	<i>(Priority A1)</i>	<i>(Priority A2)</i>	<i>(Priority A3)</i>
	<i>Initial</i>	<i>Minimal</i>	<i>Desirable</i>
Projects:			
● Biological oceanography	100,000	200,000	300,000
● Pilot-projects on island systems	200,000	400,000	500,000
● Coastal pollution	-	-	-
● Advice on maritime issues	-	-	-
Five-year totals: (£)	300,000	600,000	800,000
Sum per annum: (£)	60,000	120,000	160,000

Table 2: Coastal Parameters and Ratios for Commonwealth Nations and Territories

Name	Location 30N— —30S	Land- Locked	Area (A) (km ²)	Coast Length (L)(km)	Population (P)	$\frac{P}{A}$	$\frac{P}{A}$	$\frac{L}{A}$	Archi- pelago
Antigua & Barbuda	✓		441	153	100,000	226.7	653.9	7.28	
Australia	+ / -		7,686,848	25,760	14,500,000	1.9	562.88	9.29	
Bahamas	✓		13,935	3,542	241,000	14.3	68.04	30.0	✓
Bangladesh	✓		143,998	580	88,513,000	629.8	152,608.62	1.52	
Barbados	✓		430	97	249,000	696.0	2,567.01	4.67	
Belize	✓		22,963	386	145,000	4.3	375.64	2.54	
Botswana	✓		600,372		800,000	1.4			
Britain	✓		244,046	12,429	55,900,000	229.4	4,497.54	25.15	
Canada	✓		9,976,139	90,908	24,343,181	2.4	267.77	28.78	✓
Cyprus	✓		9,251	537	620,000	64.8	1,154.56	5.58	
Dominica	✓		751	148	83,000	133.1	560.81	5.40	
Fiji	✓		18,272	1,129	630,000	32.8	558.01	8.35	
Gambia	✓		11,295	80	603,000	53.1	7,537.50	0.75	
Ghana	✓		238,537	539	11,679,000	49.4	21,667.90	1.10	
Grenada	✓		344	121	110,000	290.1	909.09	6.52	
Guyana	✓		214,969	459	793,600	3.7	1,728.97	0.98	
India	✓		3,287,782	7,003	685,184,692	209.9	97,841.59	3.86	
Jamaica	✓		10,991	1,022	2,188,000	200.1	2,140.90	9.74	
Kenya	✓		582,646	536	14,865,000	29.8	29,598.99	0.70	
Kiribati	✓		886	1,143	59,000	66.5	51.61	38.40	
Lesotho	✓	✓	30,355	-	1,341,000	46.1			
Malawi	✓	✓	118,484	-	5,951,000	52.3			

Name	Location 30N— —30S	Land- Locked	Area (A) (km ²)	Coast Length (L)(km)	Population (P)	$\frac{P}{A}$	$\frac{P}{A}$	$\frac{L}{A}$	Archi- pelago
Malaysia	✓		329,749	4,675	13,900,000	43.0	2,973.26	8.14	
Maldives	✓		298	644	154,000	666.6	239.13	37.31	
Malta	✓		316	140	343,000	1,265.8	2,450	7.87	✓
Mauritius	✓		1,865	177	958,000	482.5	5,412.42	4.09	
Nauru	✓		21	24	7,254	380.9	302.25	5.23	
New Zealand	✓		268,676	15,134	3,300,000	12.2	218.05	20.20	
Nigeria	✓		923,768	853	84,732,000	94.1	99,334.11	0.88	
Papua New Guinea	✓		461,691	5,152	3,007,000	6.7	583.65	7.58	
St Lucia	✓		616	158	124,000	162.3	784.81	6.36	
St Vincent & Grenadines	✓		338	84	107,000	257.7	1,273.80	4.26	
Seychelles	✓		280	491	66,000	357.1	134.41	29.34	✓
Sierra Leone	✓		71,740	402	3,474,000	50.1	8,641.79	1.50	
Singapore	✓		581	193	2,400,000	4,130.8	12,430.00	8.0	
Solomon Is	✓		28,446	5,313	229,000	7.0	43.10	31.50	✓
Sri Lanka	✓		65,610	1,340	14,815,000	228.6	11,055.97	5.23	
Swaziland	✓	✓	17,363	-	557,000	34.5			
Tanzania	✓		945,087	1,424	18,141,000	20.1	12,739.46	1.46	
Tonga	✓		699	419	97,000	1.3	231.50	15.85	
Trinidad & Tobago	✓		5,128	362	1,168,000	234.0	3,266.51	5.05	
Tuvalu	✓		28	24	8,000	285.7	333.33	4.53	
Uganda	✓	✓	236,036	-	13,201,000	55.0			

Name	Location 30N— —30S	Land- Locked	Area (A) (km ²)	Coast Length (L)(km)	Population (P)	$\frac{P}{A}$	$\frac{P}{A}$	$\frac{L}{A}$	Archi- pelago
Vanuatu	✓		14,763	-	117,000	6.7			
Western Samoa	✓		2,842	403	157,000	70.3	309.00	7.55	
Zambia	✓	✓	752,614	-	5,766,000	7.7			
Zimbabwe	✓	✓	390,580		7,600,000	18.4			
Anguilla	✓		90.6		6,500	71.74			
Bermuda	✓		53	103	59,000	1,113.20	572.81	14.14	
British Virgin Islands	✓		153		12,500	81.69			✓
Brunei**	✓		5,765	161	220,000	38.16	1,366.45	2.12	
Cayman Is	✓		259		17,340	66.94			
Christmas Is	✓		135		3,184	23.58			
Cocos Islands	✓		14		487	34.78			
Cook Islands	✓		234	120	18,200	77.77	151.66	7.84	
Falkland Is	✓		12,173	1,288	1,890	0.15	1.46	11.67	
Gibraltar	✓		6.5	12	29,600	4,553.84	2,466.66	4.72	
Hong Kong	✓		1,060.18	733	5,147,000	4,854.83	7,021.82	22.51	
Monserrat	✓		102.3		12,074	118.02			
Niue	✓		259		3,600	13.89			
Norfolk Is	✓		34.5		2,180	63.18			
Pitcairn Is	✓		70						
St Helena	✓		121.73		5,216	42.84			

Name	Location 30N— —30S	Land- Locked	Area (A) (km ²)	Coast Length (L)(km)	Population (P)	$\frac{P}{A}$	$\frac{P}{A}$	$\frac{L}{A}$	Archi- pelago
St Kitts/ Nevis*	✓		261.6	193	50,000	191.13	259.06	11.93	
Tokelu	✓		10		1,600	160			
Turks & Caicos	✓		499		7,400	14.82			✓

Footnotes:

* As of 19 September 1983, St Kitts/Nevis became 48th Commonwealth member.

**As of 31 December 1983, Brunei became 49th Commonwealth member.

Chapter 3

New Technological Aids

(a) Remote Sensing

Remote sensing is a technique for acquiring information about objects, areas of phenomena by means of sensors mounted on space craft or aircraft. Although of great value to weather forecasting and other meteorological tasks, especially in the tropics, one aspect, that of meteorological phenomena, is not considered here. For it is a specialised field undertaken mainly by national meteorological services in co-ordination with the World Meteorological Organisation (WMO). Remote sensing by aeroplanes and satellites differ only in practicalities, not in principle. Aircraft imagery is available at specified times with excellent resolution for specific coverages; while satellite imagery is bound by the track of the spacecraft, both in terms of timing and coverage. Aircraft imagery has been available for many purposes (e.g. mapping), while satellite imagery is still in the experimental stages. Geophysical data can also be obtained from low flying aircraft. Remote sensing may be applied to various aspects of this expanded programme:

- (i) Agriculture/Forestry: Classification of crops
Areal extent of crops
Crop Disease
Stress due to lack of water
- (ii) Land Use: Identification of land uses
Changes in land use
- (iii) Cartography: Hill shading
Aeronautical charts
- (iv) Geology: Geological mapping
mineral exploration

- (v) Water: Soil moisture
 Sea and lake levels
 Snow cover
 Coastal turbidity
 Sediment flow
 Fish finding
 Thermal pollution

Remote sensing provides considerable opportunities for scientific co-operation in the Commonwealth because of:

- (i) the wide disparity in its development in the different nations of the Commonwealth;
- (ii) the modular nature of the technique, allowing nations to adopt the technology at grades suitable to their financial and developmental levels; and
- (iii) its benefits to countries with either large land areas and/or highly dispersed populations such as Australia, India, New Zealand and Canada. These countries have developed remote sensing techniques over the last 10 years and used them extensively. However it is important to distinguish between data required in quasi-real time (e.g. crop monitoring), which are very expensive, with the existing systems in LANDSAT 5, and data which are not time-dependant (e.g. geological), which exist in archives on previous satellites. Simple equipment and images, at near reproduction costs, are all that is required to make a start on historical information. Remote sensing by satellites is still experimental, and there is therefore considerable opportunity for scientific development without the need for expensive installations.

Indeed, with its wide coverage of tropical areas, Commonwealth nations could contribute in a number of special ways: using existing facilities in member countries towards training at any required level; conducting in-depth workshops (4–6 weeks duration) on particular topics such as the use of microwaves and conventional aerial surveys; developing end-to-end experiments involving the identification of a specific application goal and its attainment by the collection and analysis of data; through Commonwealth co-operation, acquiring hardware for obtaining and analysing data from the newer satellites, and, because of high costs, in hiring aeroplanes for specific surveys.

In the short term remote sensing activities could include:

- training and education (e.g. basic matter and energy relationships; remote sensing capabilities in various parts of the electromagnetic spectrum; multi-stage sampling techniques; photo-interpretation; digital data processing);

- workshops (e.g. photo-interpretation techniques, digital processing of data, data use and application);
- end-to-end experiments (e.g. thematic map for use by planners/decision makers);
- establishment of small national or subregional centres; and
- solving of particular tasks.

Based on these short-term activities, discussions on larger co-operative ventures could take place with a view to their establishment in the medium-term. Such activities may include airborne surveys and ship-borne earth stations. Long-term activities could include the establishment of regional centres and earth stations. Remote sensing is an economical way to provide the smaller nations with information for national planning and economic advancement.

For the larger nations, positive co-operative efforts in remote sensing should keep them in the technological race, and provide a wider source of data for the improvement of their own science. Some equipment is needed, such as interpretative devices (e.g. densitometer, additive colour viewer, microfiche camera system, aerial film drier, mobile photo-processing), radiometers and chlorophyllscanners, and in ground-truth data collection. The equipment needed is relatively cheap however.

The identification of national, regional or Commonwealth needs in remote sensing is a major task:

- (i) LANDSAT 4 & 5: Twenty Commonwealth nations besides others are not totally visible from the new LANDSAT satellites (Table 3; Page 45), and they are mainly located in the Caribbean, West African, East and Central Africa, and the South Pacific regions.
- (ii) National laboratories for photo-interpretation: About 35 Commonwealth nations appear to have no permanent national interpretation facilities, although some do have facilities which have been provided for specific projects, or users.
- (iii) Training: About 10 Commonwealth nations appear to have national facilities for training, and these have considerable scope for co-operative use.

In the past, major donor agencies have contributed to the development of remote sensing in the less advanced nations. Moreover the technologically innovative countries are particularly willing to fund such projects; for example, the USA in connection with its space programmes and through USAID; the European Economic Community in connection with European Space Agency (ESA) through European Development

Fund (EDF); Canada through the Canadian International Development Agency (CIDA). The possibility for co-operation in remote sensing exists between New Zealand and the Pacific Islands. Remote sensing is particularly appropriate for Commonwealth co-operation and mutually beneficial to nations, regardless of their size and state of technological development.

The Council should consider supporting a remote sensing programme for the short-term, and establishing a Task Force to review present and future Commonwealth activities in remote sensing. The objectives of this Task Force should be:

- (i) to review available techniques, capabilities and infrastructures of Commonwealth nations to obtain and analyse remotely-sensed data;
- (ii) to formulate a plan of action for an integrated Commonwealth approach, beneficial to all nations but particularly the small states for remote sensing and data transmission and analysis, using both aircraft and satellite carriers;
- (iii) to examine within this plan of action, existing arrangements and new mechanisms for the training of technicians and scientists in remote sensing, especially on a regional basis;
- (iv) to commission a study in the short-term on the use of available remote sensing data, and based on the expert papers submitted, make politicians and scientists more aware of the potentials and advantages of this programme;
- (v) to establish in the short-term regional networks for information exchange on new developments in remote sensing analysis and application; and
- (vi) to investigate the feasibility of developing aircraft-borne remote sensing capability, with palletised equipment, for deployment and use by a number of Commonwealth nations.

This initiative would diversify remote sensing capability on a global basis, and enhance the scope of basic sciences in each participating nation. It would reinforce the Council's previous interest in land use, coastal management and environmental planning, and should not involve substantial additional funds if undertaken on a network and cooperative basis.

We recommend that the Council allocates the following sums for developing projects in the remote sensing programme:

	<i>Levels of Programme Development</i>		
	<i>£ (Priority A1) Initial</i>	<i>£ (Priority A2) Minimal</i>	<i>£ (Priority A3) Desirable</i>
Projects:			
● Task force	60,000	60,000	60,000
● Commissioned study and Project Groups/ Networks	250,000	500,000	1,000,000
● Aircraft Remote Sensing Capability	-	-	-
Five-year total: (£)	310,000	560,000	1,060,000
Sum per annum: (£)	62,000	112,000	212,000

Table 3: Landsat Coverage for Commonwealth Countries

<i>Country</i>	<i>Receiving station and Average Detail</i>	<i>Location of Receiving Station</i>	<i>Receiving station in Commonwealth Country or Not</i>
Antigua and Barbuda	Partly visible to Greenbelt, Maryland for Landsat 1, 2 & 3. Not visible for Landsat D & D.	Maryland, USA	No
Australia	Totally visible from Alice Springs, Australia	In Australia	Yes
Bahamas	Totally visible from Greenbelt, Maryland	In US	No
Bangladesh	Totally visible from Hyderabad, India	In India	Yes
Barbados	Not visible	—	—
Belize	Visible from Greenbelt for Landsat 1, 2 and 3 and not visible for Landsat D & D.	In US	No
Botswana	Totally visible from Johannesburg	In South Africa	No

<i>Country</i>	<i>Receiving station and Average Detail</i>	<i>Location of Receiving Station</i>	<i>Receiving station in Commonwealth Country or Not</i>
Great Britain	Totally visible from Kiruna and from Pucino	Kiruna in Sweden Fucino in Italy	No
Canada	Visible from Prince Albert, Fairbanks, Goldstone, Shoe Cove, Greenbelt	In US and Canada	Prince Albert and Shoe Cove Canada—Yes
Cyprus	Fucino (Totally visible)	Italy	No
Dominica	Not visible	—	—
Fiji	Not visible	—	—
The Gambia	Not visible	—	—
Ghana	Not visible	—	—
Grenada	Not visible	—	—
Guyana	Visible to Cuiaba	In Brazil	No
India	Totally visible from Hyderabad, India	In India	Yes
Jamaica	Visible to Greenbelt	Maryland, USA	No
Kenya	Partly visible to Johannesburg	In South Africa	No
Kiribati	Not visible	—	—
Lesotho	Totally visible to Johannesburg	In South Africa	No
Malawi	Totally visible to Johannesburg	In South Africa	No
Malaysia	Visible to Djarkarta, Bangkok, Hyderabad (Partially)	Indonesia, Thailand and India	No No Yes
Maldives	Visible to Hyderabad	India	Yes
Malta	Totally visible to Fucino	In Italy	No

<i>Country</i>	<i>Receiving station and Average Detail</i>	<i>Location of Receiving Station</i>	<i>Receiving station in Commonwealth Country or Not</i>
Mauritius	Not visible	—	—
Nauru	—	—	—
New Zealand	Not visible	—	—
Nigeria	Partly visible to Fucino	In Italy	No
Papua New Guinea	Visible to Alice Springs	In Australia	Yes
St. Lucia	Not visible	—	—
St. Vincent	Not visible	—	—
Seychelles	Not visible	—	—
Sierra Leone	Not visible	—	—
Singapore	Visible to Djarkata, Bangkok	Indonesia and Thailand	No
Solomon Is	Not visible	—	—
Sri Lanka	Visible to Hyderabad	In India	Yes
Swaziland	Visible to Johannesburg	In South Africa	No
Tanzania	Partly visible to Johannesburg	In South Africa	No
Tonga	Not visible	—	—
Trinidad and Tobago	Not visible	—	—
Tuvalu	Not visible	—	—
Uganda	Not visible	—	—
Western Samoa	Not visible	—	—
Zambia	Visible to Johannesburg	In South Africa	No
Zimbabwe	Visible to Johannesburg	In South Africa	No

(b) Biotechnology (including Genetic Engineering)

Biotechnology has been defined by the European Federation of Biotechnology (in 1981), as 'the integrated use of biochemistry, microbiology and chemical engineering in order to achieve the technological application of the capacities of microbes and culture cells'. A recent offshoot of biotechnology is genetic engineering which, by gene splicing and recombinant DNA cloning, directly manipulates the genetic material itself. Biotechnology is a rapidly advancing area and, because of its significance to human welfare, is of considerable public and political interest. Some technological breakthroughs have already occurred: the development of new nitrogen-fixing plants; single-cell edible proteins; new crops resistant to pests; bacteria for use in waste recycling and pollution control; petrochemical substitutes; gene therapy to correct monogenic diseases such as sickle-cell anaemia; genetic screening for the isolation of genes responsible for birth defects; basic knowledge of immunological and molecular processes, including cancer.

The greatest beneficiaries of a Commonwealth programme in biotechnology will be agriculture, health and industry; and the major foci for research for the less advanced nations could be:

- (i) Medicine
 - vaccines to eliminate tropical diseases such as malaria, trypanosomiasis, and hepatitis (long-term);
 - epidemiology and diagnostic medicine (short- and medium-term);
- (ii) Agriculture
 - biochemistry and genetics of plants (medium-term);
 - plant breeding for increased grain yield, protein content, disease resistance and climatic or soil tolerance (long-term);
 - micropropagation (short-term).
- (iii) Animal Husbandry
 - vaccines to eliminate animal disease (long-term);
 - production of animal growth hormones for increased meat yield (long-term);
 - ova-transplantation (short-term).
- (iv) Industry
 - production of bulk chemicals from sugar cane and lignocellulosic wastes (cane bagasse and rice straw) (short-term);

- lignin degradation to produce chemicals (long-term);
- microbial transformation of bulk chemicals into high value (long-term).

Biotechnology is advancing very rapidly and research is not very expensive. It is appealing to governments, so much so that UNIDO is establishing international centres in India and Italy, with collaborating centres in several other nations. Recombinant DNA technology has excellent long-term prospects, and the Council should encourage individual scientists from the less advanced nations to learn new techniques in existing institutions.

The Council should urgently consider establishing a Biotechnology Advisory Committee comprising expert practising scientists with the following objectives:

- (i) to review annually the advances made in potential substrates for microbiological processes, food and animal feeds, soil microbes for plant nutrition and health, nitrogen fixation, microbial insecticides, fuel and energy, waste treatment and utilisation, cellulose conversion, antibiotics and vaccines, and pure culture production techniques;
- (ii) to promote and establish contact between scientists in Commonwealth and non-Commonwealth organisations;
- (iii) to screen the application of all aspects of biotechnology in view of the very rapid and unpredictable nature of new advances;
- (iv) to advise the Council on the need for training in specific techniques at appropriate regional institutions; and
- (v) to identify important areas for the promotion of collaborative research, as appropriate.

In a rapidly advancing area such as biotechnology, the less advanced nations require a periodic review of advances. Such reviews will alert them of those new technological impacts that stimulate science and the education of young scientists; help them reach a balance between scientific research and science education; promote the training of scientists in the new techniques, either by visiting scientists from advanced laboratories or by exchange fellowships, so that scientists from the less advanced nations can visit more advanced laboratories or nations.

We recommend that the Council allocates funds to develop the following projects in the biotechnology area:

	<i>Levels of Programme Development</i>		
	<i>£</i> <i>(Priority A1)</i> <i>Initial</i>	<i>£</i> <i>(Priority A2)</i> <i>Minimal</i>	<i>£</i> <i>(Priority A3)</i> <i>Desirable</i>
Projects:			
● Biotechnology Advisory Committee	50,000	100,000	100,000
● Implementation of recommendations	250,000	500,000	500,000
Five-year Totals: (£)	300,000	600,000	600,000
Sum per annum: (£)	60,000	120,000	120,000

(c) **Microelectronics**

The microelectronics revolution has been characterised by three major developments: miniaturisation of electronic circuitry or chips; the very large scale integration (VLSI) of extremely complex circuitry on a single chip; microprocessors, which are VLSI systems performing specific functions. It is a rapidly advancing field dominated by multinational corporations, particularly in the area of hardware. However not all research and development is occurring in the large-scale areas, and many more modest areas of development are being tackled by small groups. Commonwealth programmes could be developed in three areas:

- (i) the fabrication of very large scale integrated (VLSI) circuits involving silicon systems and devices ('chips'), with emphasis on bulk production of 'uncommitted logic arrays' (ULA) which can be adapted for different applications;
- (ii) the application of software engineering to develop expert systems (innovated or adapted), or intelligent knowledge-based systems (IKBS), for application in areas deficient in human expertise (e.g. medicine, agriculture, environmental studies); and
- (iii) robotics, involving design or construction of software for remote control, special tools for computer architecture and hardware for sensing devices.

The proposed programme could establish links with industry to provide initial customer participation in design processes, and a research programme aimed at developing expert systems for use in areas of local interest to member nations (e.g. medicine, agricultural, etc).

The Council should consider establishing a Computer Advisory Committee to advise member nations, especially the small states, in the short-term, on specifications for a versatile, cheap, portable and standard Computer. The Council should urge member nations to seek expert advice on microcomputers. The development of a Commonwealth microcomputer is attractive, but it is difficult to improve on existing machines particularly since several nations have already specified educational microcomputers (e.g. United Kingdom, India, New Zealand). There is, nevertheless, a need for a cheap, versatile and portable school microcomputer. There is also considerable potential for adapting microcomputer hardware for specific purposes (e.g. medical diagnosis, agricultural economics and word processing).

The Council should consider establishing, on a medium priority basis, special training courses in software development where its adaptation for local use appears important. The availability of cheap microcomputers facilitates the development of cheap software. Software development is a major technological challenge, particularly for various local needs, and is suitable even for small and disadvantaged states.

Microcomputers are important for schools and colleges in respect of both hardware and software development, and teaching aids. It is therefore important for young people to become familiar with microcomputers through mass education and literacy programmes in the Commonwealth.

Computer-aided Design (CAD) is the use of computers in systems design with interactive graphic capabilities, by its ability:

- (i) to transform design data to basic binary blocks, which are the fundamentals of electronic systems;
- (ii) to draw design graphics, which are the pictorial representation of the designs of products, etc; and
- (iii) to give the designer capability to man-machine iterative interactivity in 'real time' with the model under design.

The Council should consider giving medium priority to the conduct of periodic training courses of 1-2 weeks duration in computer-aided design, for scientists at the university and research levels. Computer-aided design could be used as a draughting tool for the design of domestic equipment, agricultural implements, leather products, textile products, wood products and food products in Commonwealth member nations. It is a rapidly changing technology characterised by expensive hardware and highly developed software. Hardware development is the domain of multinational corporations and we do not recommend that

Council should give it support. In view of its rapid advances, scientists in Commonwealth nations should be kept abreast of new technological developments in, and applications of, computer-aided design, especially at the university and research levels.

We recommend that the Council allocates funds for the establishment of the Computer Advisory Committee in this programme as follows:

- £50,000 over five years (£10,000 per annum) to initiate this project.
- £100,000 over five years (£20,000 per annum) to develop a minimal and desirable project.

(d) Epidemiology and Public Health

Recent progress in molecular biology is leading to new vaccines needing field trials and more specific diagnostic methods of great epidemiological value in the control of communicable diseases, while important new pathogens are being discovered. The communicable diseases are immensely important, being the principal cause of death and disability in the tropics. In the less advanced Commonwealth nations, the epidemiology of communicable diseases needs strengthening, and is perhaps the most cost-effective mechanism for improving human health and contributing to socio-economic development.

Communicable disease epidemiology provides an almost unique opportunity for scientific cooperation relevant to development that is mutually beneficial to both the less advanced and the more advanced nations. Expertise in the biological and molecular sciences is in the more advanced nations while opportunities for field studies and experience are in the less advanced nations. Communicable disease epidemiology comprises of four components:

- (i) Determining the best methods for controlling endemic diseases (e.g. malaria);
- (ii) Investigating outbreaks (e.g. typhoid, cholera);
- (iii) Evaluating immunisation programmes and other control measures; and
- (iv) Designing and operating surveillance systems.

In view of the World Health Organisation's specialist groups and regional networks on immunisation, tropical diseases research and diarrhoeal disease control, we recommend that the Council should not consider involvement in the epidemiology of communicable diseases.

Socio-economic development and industrialisation has led to an increasing prevalence of many non-communicable diseases in the less advanced nations, hitherto associated only with the more advanced nations. There has to be a greater understanding of the genesis of these diseases in the less advanced nations, and this requires the availability and integration of skills in epidemiology with those in biochemistry, food chemistry, surface chemistry and many other sciences. Epidemiological research could be beneficial to the planning and management of health services on emerging non-communicable diseases (e.g. cardiovascular diseases, new patterns of cancers, and other 'diseases of development'), occupational health, and of large-scale field testing of interventions against tropical diseases (e.g. schistosomal drugs, leprosy and malarial vaccines). However, in view of World Health Organisation's specialist groups and regional networks, the Council should not consider becoming involved in these areas of non-communicable diseases.

Chapter 4

Science Management and Organisation

(a) Information Technology and Dissemination

Information technology fundamentally represents the integration of microelectronics and communications technologies for data acquisition, storage and dissemination. Systems already exist for the exchange of scientific and technological information, such as that for agriculture by CAB. The hardware for information technology systems is commercially available. There are two gaps in existing information systems that need to be filled : one is the dissemination of information of local interest to complement highly developed systems for information of international interest like CAB; the second relates to information transfer *between* the less advanced nations, rather than—as at present—between the more advanced and the less advanced nations. Interlinkages between international information systems and local or national information interest, and between the more advanced and the less advanced nations, have been successful when patronised by institutions from the more advanced nations such as the CSIRO, Australia, for CRRERIS on energy, and the IDRC, Canada, for ECLA on science and technology.

The Council should consider (i) expanding the Asia-Pacific energy and the Caribbean science and technology information networks to include other areas of science and technology, in the short-term; (ii) establishing information networks on a subregional basis in Africa and Asia, using specific areas of science; (iii) securing the patronage of advanced national institutions; (iv) obtaining national commitment and mobilisation of specialist scientists and librarians as contact points for interfacing between global and local systems; (v) emphasising initially on agriculture and energy. Such information networks on science and technology would complement those socio-economic networks already well developed for national and international financing systems.

The Council should further consider developing a capacity to provide an advisory service in science and technology to member nations, especially the smaller nations, similar to the Technical Advisory Group (TAG) of CFTC. There is a need to develop a clearly-perceived capability for giving unbiased advice in specific areas of science and technology, in the short-term. The pre-consultancy services of Secretariat staff should be used as well as the consultancy services of experts with regional expertise, who can be contacted through national and international organisations. To provide such a service the Council would need to have access to data banks.

We recommend that the Council allocates for access to data banks for information dissemination and advice:

- £10,000 over five years (£2,000 per annum) initially;
- £20,000 over five years (£4,000 per annum) for a minimal capacity;
- £30,000 over five years (£6,000 per annum) for a desirable capacity.

(b) Popularisation of Science

Science and Technology have pervasive effects on the lives of all, and the extent of their impact depends on individual scientific education and awareness. The diffusion of science in society is generally concomitant with the process of technological acculturation but this has been marred by three factors: the lack of awareness among scientists of the impact of science on society and of the scientific components of social problems; the lack of an enhanced public understanding in the application of science to decision-making; and by a socio-cultural deprivation whereby the need for an understanding of objective scientific analysis, evidence and scientific methodology, is not appreciated.

Popularisation of science facilitates the evolution of a knowledge-based society. Science may be popularised through various techniques, media and education systems. Society is being stratified, especially in the less advanced nations, on a scientific and technological basis. Thus popularisation of science is necessary not only to enhance national allocations for science, but also to harness the talent of young people excited and motivated by science.

The Council should urge member nations to popularise science for the administrators and the public; to produce appropriate local and regional materials for making science both entertaining and educational while relating it to pressing economic issues; to commit funds and mobilise

their infrastructure, especially the Information Ministries, on a continuing basis for producing materials and generating an appropriate climate. Efforts are needed in the less advanced nations to complement the high level of science popularisation in the more advanced nations.

(c) Basic Science Education

Basic education in science has been marred especially in the less advanced nations by traditional socio-cultural pressures, the nature of training science teachers, and by the poor availability of equipment for experimental science. As a consequence, most nations have not been able to utilise the results of educational research over the past two decades in science curriculum development, in revision and innovation, or in teaching methods at all school levels, in attitude development, or skills development, or cognitive development. Attempts in curriculum development, to treat science as an empirical experience in investigation and discovery, have been marred by a variety of factors.

The Council should urge member nations to stimulate basic science education in schools and universities through better teacher training, incentives, equipment and curriculum development, so that science may contribute more effectively to technological and economic prosperity, in the short-term. There is a need to consult the HRDG Education Programme of the Commonwealth Secretariat, UNESCO, ICSU-CTS and CASTME when undertaking future activities in this area. Basic science education is important for enhancing indigenous scientific and technological capability. A re-orientation of science education systems particularly in the less advanced nations demands reformation of curricula at all education levels.

(d) Assessment of Research and Development

Nations wishing to develop and extend their own scientific and technological capability clearly need to select the most relevant R & D areas for their socio-economic and environmental needs. Successful management of scientific research and technological development (R & D) is a pre-requisite for sustainable social, economic and environmental development. The integration of R & D assessment into the processes of decision-making and management is important if assessment is to be useful. In many less advanced nations there is a gap in the application of R & D assessment to management. Selectivity in R & D is becoming essential for all nations, whether large or small, more advanced or less advanced, because of limited human and financial resources, and of the unpredictable nature of scientific and technological advances and their impacts. R & D assessment varies according to the science and technology priorities of the member nations, the kinds of activity being evaluated along the innovation spectrum, the emphasis

being placed on the quality of research, the effectiveness of programme management and organisation, the potential impact of specific research results, and to future orientations and strategies. Assessment methods must therefore reconcile with differing needs and perspectives, and must be flexible, pragmatic and relevant to objectives.

The Council should consider promoting training in R & D assessment methods. There are four approaches to R & D evaluation:

- (i) evaluation of scientific and technological priorities at a high level of generality, and dependent on national mechanisms for coordinating research funding;
- (ii) ex-ante evaluation of specific programmes and projects to specify design of objectives or indicators for measuring the realisation of objectives;
- (iii) monitoring to provide information on projects within programmes; and
- (iv) ex-post evaluation.

External assessment of R & D personnel, institutions and programmes is invaluable at 4–5 yearly intervals, provided assessors are expert in the areas to be evaluated. Council could assist member nations in locating assessors, where necessary.

Chapter 5

Implementation and Action Plan

(a) Implementation

We have been advised on the various ways in which these programmes and projects could be implemented, whether through regional programmes, projects, special networks, special coordinators or steering committees. We have both noted the variety of research, training and activities to disseminate information that these projects involve and also the steps in implementation of special programmes (See Volume on 'Background Papers' CSC(84)EG-2). Though it will be necessary to ensure the involvement of good, committed scientists from the various research and development sectors, if the Council's purpose in this expanded programme of science for technology for development is to be achieved, we do not see any necessity for drastic changes in the *implementation* of future programmes.

(b) Action Plan

Costing

The recommendation for programme activities in the various subject areas have been classified into high, medium or low priority. Programmes of low priority have not been costed, nor have those of medium priority for, though we did consider them to be worthy, we did not feel costing at this stage was justified. So, only recommendations of high priority have been costed. Moreover, since it is rarely possible to predict with any degree of accuracy what technical developments are likely to follow from research findings, it is impossible to make precise costings of all these scientific activities. This uncertainty is increased in those scientific activities which have a multilateral base, where the

vagaries of fluctuating exchange rates or the unknown, unpredictable responses of government authorities make themselves felt. Yet a third factor influenced our inability to make precise costings at this stage: there are wide divergences of opinion about what facilities or manpower will be needed in order to reach an objective.

The 'standard' network that we have used as our basis for programme costing assumes adequate but not luxurious funding. There are 9 categories of activity, or staff, within each network and these are defined and costed immediately following this section. The lifespan of each network is assumed to run for five years and in ten countries and little or no equipment will be required. Where any project is specific to a region three networks on the same topic have been assumed. Where a project, for example, information dissemination, calls for activities somewhat less than those demanded by a full network, the costs are based on the costs of those activities within a network.

	<i>Cost (£)</i>	<i>Secretariat Manpower (Man Months)</i>
(a) Initial Survey (Consultant)	10,000	1
(b) Meeting of Scientists/Workshop/Planning Meeting	20,000	2
(c) Information Dissemination (at £2,000 pa)	10,000	5
(d) Fellowships (2 per country)	100,000	2
(e) Consultancies (2 @ £5,000)	10,000	2
(f) Mid-term Meeting	20,000	2
(g) Final Meeting	20,000	2
(h) Publication of Handbooks/ Reports/Results	10,000	3
Sub-total	200,000	19
(i) Secretariat Staff: time for reference work	68,000	
Total	£268,000	24
say	£250,000	24

Note: The Secretariat cost to maintain one project officer is £2,830 per month. All costs are at 1984 prices.

For example: A network of information only might consist of items (a), (b), (c), and (h) of the above list, giving a cost of £50,000.

Using the standard cost estimates given above and calculated on 1984 prices, all the high priority actions recommended have been costed. But taking into account the global economic situation presently prevailing, the high priority recommendations have been categorised even further. In Table 4 (Page 65) each scientific programme area has been costed into three separate categories:

- (A1) Activities such as training activities and meetings which could be easily initiated but which would not sustain a research programme;
- (A2) Activities which would contribute to a minimal programme (for example, research and training), but which, without critical supplementary funds, could not achieve the Council's overall objective of enhancing indigenous capability for development; and
- (A3) Activities which would contribute to a desirable programme of research and training and which would both achieve the Council's overall purpose and also attract significant external funds for further work.

The total cost of the expanded programme of scientific cooperation is:

- £4,230,000 over five years (£846,000 per annum) for an initial programme level;
- £8,490,000 over five years (£1,698,000 per annum) for a minimum programme level; and
- £13,740,000 over five years (£2,748,000 per annum) for a desirable programme level.

These costs include overhead administrative costs which are in the council's Regular Budget. However, they do not include external and national funds allocated to projects and programmes which are not managed by the Council, although we assume that they would inevitably attract these.

These estimates for implementing the expanded programme of scientific contribution are composed of the following components (Table 5, Page 76):

- (i) a CFTC contribution of £1,115,000 over five years (£223,000 per year), which is not expected to increase significantly;
- (ii) external funds of £195,000 over 5 years (£39,000 per year) in the present economic climate, is difficult to assure and is therefore kept static;

- (iii) the Council's Regular Budget of £1,745,000 over five years (£349,000 per year). This represents a 10.8% increase over the 1983/84 Budget, sufficient, that is, to accommodate an increase of one project staff member over the present six, to cover the diversity of subject areas considered in the expanded programme;
- (iv) the Council's Project Budget of:
- £1,175,000 over 5 years (£235,000 per annum) for an initial programme level;
 - £5,435,000 over 5 years (£1,087,000 per annum) for a minimum programme level;
 - £10,685,000 over 5 years (£2,137,000 per annum) for a desirable programme level.

(c) Programme Finance

(i) *Existing*

The Regular Budget of the Council is made up of contributions from the 31 member nations on an agreed scale. Five countries, Australia, Britain, Canada, India and New Zealand contribute 82.4% of the budget, while the other 26 countries contribute the remaining 17.6%. Over the last 5 years this budget has been a modest one (£193,000–£315,000) with very little increase from year to year, and specifically designed to meet the administrative costs of the Council's Secretariat in London. Extra funds for programmes are provided by the Commonwealth Fund for Technical Cooperation (CFTC) and other agencies. In addition, it has been possible to allocate a small proportion (5.1%, £16,000) to commission studies on a project basis only. But normally programme finance is not included in the Council's regular budget. So far as funding of the recommended project areas is concerned, the administrative costs associated with programme development and management, with project coordination and those activities of network development such as pre-project commissioned studies, network meetings, programme advisory meetings, and regional meetings of Council members, could be reflected and borne by the Council's regular budget.

The Project Fund consists of unexpended balances from the Council's small Regular Budget, which are held in a separate account established under the provisions for programme finance. It is an unpredictable quantum, and its growth up to 1981–82 has been somewhat erratic because of some unpaid contributions from member nations. In June 1982, the Fund amounted to a total of £157,258 with an outstanding contribution of £80,645. Thus the net sum available was £76,613. Even this sum cannot be utilised fully because of the need for a threshold

cash flow position. Although the Council has no funds for programme activities, this Project Fund has contributed modestly to programme development, fellowships, equipment purchase, and to complement regular and other forms of programme finance.

The Commonwealth Fund for Technical Cooperation (CFTC) has been the regular and major source of programme funds (60%), and its allocations to the Council's programme activities have been increasing annually, comparable to other functional Division of the Commonwealth Secretariat. These funds are restricted to multilateral training needs (e.g. courses, seminars and workshops) of member nations. They were once available for programme development and project management meetings but this is no longer the case. They are not available for research cooperation unless this has a training element (e.g. internship, supervision), nor for the purchase of scientific equipment. It would be reasonable to expect a slight increase in CFTC's contributions to the training components of Council's programmes, with the accommodation of those training elements involved in research cooperation.

(ii) *Future*

Provisions exist in the Memorandum of Understanding on the Council for a Project Budget, based on voluntary and external donations and miscellaneous income. However, we were surprised to learn that the Council has no funds for its programmes, nor provision for contributions by member nations towards programme finance. This is unusual for an intergovernmental organization involved in programmes, and generates undue stresses and frustrations when undertaking programme development and collaborative activities. The Council should therefore regularise its Project Budget for financing programme activities, such that this budget is of suitable and effective size; say,

- £5.5 million over 5 years (£1.1 million per annum) for a minimum programme level, and
- £10.7 million over 5 years (£2.2 million per annum) for a desirable programme level (Table 5).

Contributions towards the Council's Project Budget for financing programmes should be on a voluntary, pledged basis. In view of the prevailing economic conditions, the Council should aim for a Project Budget initially of £5.5 million over 5 years (£1.1 million per annum) to develop a minimum level of programme activities. When global economic conditions improve, the Council should aim for a Project Budget initially of £10.7 million over 5 years (£2.2 million per annum) to develop a desirable level of programme activities.

These sums are not substantial in view of the fact that mechanisms are already in place for scientific cooperation. They would ensure the involvement of the Council in areas of science of developmental significance, including new emerging areas, and raise the level of Commonwealth cooperation. A core programme finance on a continuing basis, commensurate with the scope of the Council's programme activities, would ensure both a more secure basis for programme and project planning and development, and the attraction of external and national funds, either on a regular or special project basis.

(iii) *External Sources*

Two major external sources, the Overseas Development Administration (ODA) of Britain and United Nations Environment Programme (UNEP), have provided funds to specific projects during 1979-84. Some minor grants have also been received from the Commonwealth Foundation, United Nations Centre for Human Settlements (UNCHS), and United Nations Educational Scientific and Cultural Organisation (UNESCO), but these amount to less than 40% of total funds for the Council's programmes, and are unlikely to increase on a regular basis. In addition, member nations have contributed to programmes in the form of local costs for meetings, workshops, training courses and research. However, since the extent of support varies for each nation it cannot be fully quantified. In any case, whatever increase in funds may be made available by the CSC, as a result of this Group's recommendations, these programmes will still depend on other sources of external support and funding.

In the past the Council's most successful projects were those with adequate external funds for research, training and information dissemination. Examples are the Water Hyacinth Project supported with UNEP funds, the Asia/Pacific Metrology Programme with ADAB funds, the Rural Energy Survey with CFTC funds, the African Energy Projects with ODA funds, and the various training and information dissemination activities with CFTC funds. International funds for scientific research, in the less advanced nations especially, are generally scarce. Universities and scientific institutions in these nations are usually entirely dependent on government grants which barely cover their administrative and management costs and leave little or no funds for research activities. In some cases, a national science infrastructure exists, so that research grants occasionally become available through National Science Councils, University Grants Committee and similar bodies. Again, these funds originate from the national treasury and are inadequate for sustained research in science. Furthermore, other factors affecting the situation: industrial or private foundations are not well established in these nations; the chronic shortage of foreign currency

experienced by many of these nations hinders overseas training, information acquisition, and procurement of equipment and consumable materials. Research in developing countries is therefore unable to generate the necessary momentum for enhancing indigenous scientific and technological capabilities, to the extent that technological dependence can be reduced. Funds are therefore necessary for catalysing scientific research, training and information dissemination in these nations.

International funds abound for large scale research and implementation programmes and projects (Table 6; Page 72). While effective in developing an administrative infrastructure, especially in governmental systems, they are less effective in generating relevant research especially around good individual scientists. The Council has not sought these funds in the past, and, since these funds are usually given to governments, would be unable to do so in the future.

By contrast a variety of funds also exist for small-scale research projects. These are effective enough in stimulating research but often ineffective in developing infrastructure. The Council has had some experience in obtaining these grants and should continue to do so.

Only a few international agencies finance individual research efforts. While effective in reaching good individual scientists and generating interesting research, these have not been effective in developing infrastructure, and the Council has not utilised this avenue of research financing. It would appear necessary therefore for the Council to diversify its sources of external funds for research to keep good individual scientists in place.

A variety of intergovernmental, national and multilateral, non-governmental and private organisations provide funds for scientific and technological research, training and information dissemination (Table 7; Page 74). Intergovernmental organisations that finance science and technology activities insist that requests for funds are sent through appropriate government channels. This makes them virtually unavailable for the Council's scientific and technological programmes. Nevertheless, the Council needs to develop a closer liaison with national central agencies which are the contact points with these funds. The Council should continue seeking direct funds on behalf of participating member nations for specific projects with organisations like UNEP and UNDP.

Several national and multilateral organisations (Table 8; Page 74) such as Australian Development Assistance Bureau (ADAB), UK's Overseas Development Administration (ODA) and the International Development

Research Centre (IDRC) of Canada, have supported the Council's activities. Once again, these agencies require requests to be submitted by member nations for bilateral or multilateral financing. The Council should continue to seek funds from these organisations, since their potential in the Council's expanded programme of scientific cooperation is promising.

Among non-governmental organisations (Table 9; Page 75), only the Commonwealth Foundation has hitherto supported the Council's training activities through fellowships, participation in meetings and financial resource for personal professional development. These organisations should be further explored as a source for fellowship, exchange visits and research. Hitherto, no serious attempts have been made to seek funds from private organisations (Table 10; Page 81). Although these organisations may prefer not to extend support to an intergovernmental body like the Council, they may consider as appropriate specific project requests that fit their objectives, from scientists participating in the Council's programmes. The Council needs to spend much effort in matching these organisations with suitable scientists. The Council should explore a variety of approaches for seeking funds from external agencies for research, training and information dissemination. In particular, it should develop a special relationship with the various financing institutions within the Commonwealth family, like the Commonwealth Fund for Technical Cooperation (CFTC), the Commonwealth Foundation, the aid agencies in Commonwealth countries such as the Canadian International Development Agency (CIDA), the Overseas Development Administration (ODA), UK, and with non-governmental and private organisations in Commonwealth countries, such as the International Development Research Centre (IDRC) and the Royal Society.

(d) Secretariat Organisation

An expanded programme of scientific cooperation in the Commonwealth implies a shift in the functions of the Council's Secretariat. From being predominantly a source of liaison and support it will become a source of advice, on the promotion of research and development, and on diversification of science and technology. Council must therefore give special attention not only to the staffing and organisation of the Secretariat but particularly the level of specialised professional staff with expertise that can meet the new challenge of its expanded programme of scientific cooperation. The staff strength of the Council's Secretariat is presently very modest. We are convinced that the staffing of the Secretariat must be expanded, if only to some small extent, because of the scope of the expanded programme and the substantial work required.

Because of the current economic climate, at this stage we recommend only that the Council budget for one more project officer to help initiate this expanded programme, over and above the six project officers presently supported. In view of the balance of this expanded programme, and the scientific specialisations of existing professional staff in the Secretariat, this professional staff member should be a biologist. The Council and its Secretary should deploy the existing professional staff to initiate this expanded programme, and when economic conditions permit, should aim for a further growth in the Secretariat, corresponding to the size and nature of the expanded programme.

Table 4: Summary of High Priority and Action Plan for an Expanded Programme of Scientific Cooperation in the Commonwealth

(All values for programme costs at 1984 prices: £)

STRATEGIC FOCUS: AN INTERDISCIPLINARY APPROACH TO THE USE OF SCIENCE FOR TECHNOLOGY FOR DEVELOPMENT INVOLVING NATURAL RESOURCES, TECHNOLOGICAL AIDS & SCIENCE MANAGEMENT
(e.g. INTEGRATED RESOURCES MANAGEMENT)

<i>Levels of Programme Development: Scientific Area/Goals and Objectives</i>	<i>Initial (Priority A1)</i>	<i>Minimal (Priority A2)</i>	<i>Desirable (Priority A3)</i>
Scientific Advisory Committee			
1. Establish a Scientific Advisory Committee to review advances and programmes, and advise on emerging areas	100,000	100,000	100,000
Five-year sub-totals: (Sum per annum)	100,000 (20,000)	100,000 (20,000)	100,000 (20,000)

Natural Resources:

(a) *Energy Resources*

2. Develop anaerobic microbiology for enhancing biogas systems with indigenous feedstock; research training and information dissemination
3. Assess and use energy resources in wind and solar regimes; survey and training
4. Develop a modest, low-cost, 5 MW solar thermal electric conversion (STEC) modular unit; research, training and information dissemination
5. Strengthen the energy information network in the Asia-Pacific region

Table 4—continued

<i>Levels of Programme Development: Scientific Area/Goals and Objectives</i>	<i>Initial (Priority A1)</i>	<i>Minimal (Priority A2)</i>	<i>Desirable (Priority A3)</i>
Natural Resources—continued			
<i>(a) Energy Resources—continued</i>			
6. Establish energy information networks in the Caribbean and African regions			
7. Establish task force of experts to determine relative priorities	500,000	1,000,000	2,250,000
Five-year sub-totals: (Sum per annum)	500,000 (100,000)	1,000,000 (200,000)	2,250,000 (450,000)
<i>(b) Mineral and Water Resources</i>			
8. Control pollution of ground-water by faecal wastes and agrochemicals; research, training, information dissemination			
9. Develop remedial measures for using polluted groundwater; research, training, information dissemination			
10. Develop conjunctive use of ground and surface waters especially in the coastal zone; research, training, information dissemination	400,000	900,000	1,500,000
11. Develop methods for optimising rural water supply and small-scale irrigation; research, training, information dissemination			
12. Develop desalination of brackish and saline waters; research, training, information dissemination			
13. Develop methods for the use of limited water resources; research, training, information dissemination			
14. Control and use freshwater-seawater relationships in small islands; research, training, information dissemination			
15. Develop regional geochemistry; research, training, information dissemination			
16. Develop the application of geophysical techniques especially deep crustal seismic reflection profiling; research, training, information dissemination			
17. Train technicians in geochemical and geophysical techniques especially in small states; training, information dissemination			

Table 4—continued

<i>Levels of Programme Development: Scientific Area/Goals and Objectives</i>	<i>Initial (Priority A1)</i>	<i>Minimal (Priority A2)</i>	<i>Desirable (Priority A3)</i>
Natural Resources—continued			
<i>(b) Mineral and Water Resources—continued</i>			
18. Continue the production and distribution of the <i>Earth Sciences Newsletter</i> ; information dissemination	25,000	25,000	25,000
19. Economic minerals: phosphate rock (Agricultural Research)	60,000	97,000	60,000
Five-year sub-totals (Sum per annum)	485,000 (97,000)	985,000 (197,000)	1,585,000 (317,000)
<i>(c) Materials Technology</i>			
20. Disseminate information on engineering materials in the short-term especially to less advanced nations; information dissemination			
21. Promote downstream uses of construction materials including timber, fibre, paper and ceramics in the short-term; research, training, information dissemination	250,000	500,000	750,000
Five-year sub-totals (Sum per annum)	250,000 (50,000)	500,000 (100,000)	750,000 (150,000)
<i>(d) Biological Diversity and Genetic Resources</i>			
22. Survey and authenticate biological diversity of perennial plants, especially in the tropics, and of potential value for the production of food, fibre, oils and pharmaceuticals; surveys, training, information dissemination			
23. Study of animal species; surveys, training, information dissemination	500,000	1,000,000	1,850,000
24. Promote involvement of agricultural scientists to enhance food production and primary industry; training, information dissemination			
25. Train taxonomists especially on tropical food, economic and medicinal plants; training, information dissemination			

Table 4—continued

<i>Levels of Programme Development: Scientific Area/Goals and Objectives</i>	<i>Initial (Priority A1)</i>	<i>Minimal (Priority A2)</i>	<i>Desirable (Priority A3)</i>
Natural Resources—continued			
<i>(d) Biological Diversity and Genetic Resources—continued</i>			
26. Promote development of inexpensive techniques for upgrading agricultural and industrial plants, such as conventional plant breeding, and microproagation and meristem cultivation techniques			
Five-year sub-total (Sum per annum)	500,000 (100,000)	100,000 (20,000)	1,850,000 (350,000)
<i>(e) Agricultural Resources</i>			
27. Survey local sources of phosphate rocks in the tropics, and develop simple methods for their processing and use as fertilisers; survey, research, training, information dissemination	60,000	60,000	60,000
28. Selection of nitrogen-fixing organisms, their use particularly in seed inoculation, and the development of cheaper processes for nitrogen fixation including direct oxidation processes, especially in the tropics; research training, information dissemination	501,000	500,000	750,000
29. Development of the relationships of water resources, soil water and agrometeorology to plant growth and reproduction especially in the tropics, research, training, information dissemination	250,000	500,000	990,000
30. Improvement of plant genotype through microproagation, plant breeding and selection techniques for adaption to various physical and socio-cultural conditions, especially in the tropics; research, training, information dissemination			
31. Disseminate information on ova-transplantation techniques for improving animals husbanded especially in the tropics, information dissemination	50,000	100,000	150,000
32. Develop post-harvest treatment of agricultural commodities especially in relation to climatic conditions, and to the processing and storage of roots, tubers and fruits in the tropics; research, training, information dissemination	50,000	500,000	750,000

Table 4—continued

<i>Levels of Programme Development: Scientific Area/Goals and Objectives</i>	<i>Initial (Priority A1)</i>	<i>Minimal (Priority A2)</i>	<i>Desirable (Priority A3)</i>
Natural Resources—continued			
<i>(e) Agricultural Resources—continued</i>			
33. Upgrade animal feeds in their protein content by microbiological treatment; research, training, information dissemination	250,000	500,000	750,000
Five-year sub-totals (Sum per annum)	650,000 (130,000)	2,100,000 (420,000)	3,390,000 (678,000)
<i>(f) Tropical Forest Ecology</i>			
34. Commission study on tropical forest degradation	50,000	50,000	50,000
35. Include concerns in tropical forest ecology and other programmes			
Five-year sub-totals (Sum per annum)	50,000 (10,000)	50,000 (10,000)	50,000 (10,000)
<i>(g) Environmental Planning</i>			
36. Develop adaptive environmental assessment and management, environmental impact assessment, and national conservation strategies; research, training, information dissemination	200,000	300,000	500,000
Five-year sub-totals (Sum per annum)	200,000 (40,000)	300,000 (60,000)	500,000 (100,000)
<i>(h) Coastal Zone Management</i>			
37. Develop oceanography, especially biological oceanography, because of its relevance to fisheries	100,000	200,000	300,000
38. Develop indigenous capability on the dynamics and management of the coastal zone on a pilot-project basis, and on two island systems or states, one in the South Pacific and the other in the Caribbean regions; research, training information dissemination	200,000	400,000	500,000
39. Disseminate information on coastal pollution in consultation with international organisations such as UNEP, IOC and IMCO; information dissemination			

Table 4—continued

<i>Levels of Programme Development: Scientific Area/Goals and Objectives</i>	<i>Initial (Priority A1)</i>	<i>Minimal (Priority A2)</i>	<i>Desirable (Priority A3)</i>
Natural Resources—continued			
<i>(h) Coastal Zone Management—continued</i>			
40. Offer advice to member nations on EEZ maritime issues in conjunction with international organisations such as ICOD; Advisory Committee, information dissemination.			
Five-year sub-totals (Sum per annum)	300,000 (60,000)	600,000 (100,000)	800,000 (160,000)
New Technological Aids			
<i>(a) Remote Sensing</i>			
41. Establish a Task Force to review present and future Commonwealth activities with the view to:	60,000	60,000	60,000
(a) available techniques, capabilities and infrastructure for obtaining and analysing remotely-sensed data;			
(b) formulating a plan of action for an integrated Commonwealth approach beneficial to all nations particularly the small states, for remote sensing and data transmission and analysis, using both aircraft and satellite carriers; and			
(c) examining within the plan of action existing arrangements and new mechanisms for the training of technicians and scientists in remote sensing, especially on a regional basis.			
42. Commission a study in the short-term on the use of available remote sensing data, potentially based on the expert papers submitted, for sensitising politicians and scientists on its potentials and advantages; study, information dissemination			
43. Establish in the short- and long-term regional networks for information dissemination on new developments in remote sensing analysis and applications; information dissemination	250,000	500,000	1,000,000

Table 4—continued

<i>Levels of Programme Development: Scientific Area/Goals and Objectives</i>	<i>Initial (Priority A1)</i>	<i>Minimal (Priority A2)</i>	<i>Desirable (Priority A3)</i>
New Technological Aids—continued			
(a) Remote Sensing—continued			
44. Promote development of aircraft-borne remote sensing capability, with palletised equipment, for development and use by Commonwealth nations; research, training, information dissemination			
Five-year sub-totals (Sum per annum)	310,000 (62,000)	560,000 (112,000)	1,060,000 (212,000)
(b) Biotechnology (including Genetic Engineering)			
45. Establish a Biotechnology Advisory Committee comprising expert practising scientists:	50,000	100,000	100,000
(a) to review annually advances made in potential substrates for microbiological processes, food and animal feeds, soil microbes for plant nutrition and health, nitrogen fixation, microbial insecticides, fuel and energy, waste treatment and utilisation, cellulose conversion, antibiotics and vaccines, and in pure culture production techniques; survey, information dissemination			
(b) to promote and establish contact between scientists in Commonwealth and non-Commonwealth organisations; information dissemination			
(c) to screen the application of all aspects of biotechnology in view of the exponential and unpredictable nature of new advances; survey, information dissemination			
(d) to advise Council on the need for training in specific techniques at appropriate regional institutions; training			
(e) to identify important areas for the promotion of collaborative research, as appropriate; research, training, information dissemination			

Table 4—continued

<i>Levels of Programme Development: Scientific Area/Goals and Objectives</i>	<i>Initial (Priority A1)</i>	<i>Minimal (Priority A2)</i>	<i>Desirable (Priority A3)</i>
New Technological Aids—continued			
<i>(b) Biotechnology (including Genetic Engineering)—continued</i>			
46. Implementation of recommendations	250,000	500,000	500,000
Five-year sub-totals (Sum per annum)	300,000 (60,000)	600,000 (120,000)	600,000 (120,000)
<i>(c) Microelectronics</i>			
47. Establish a Computer Advisory Committee to advise member nations especially the small states, in the short-term, on specifications for a versatile, cheap, portable and standard computer; Advisory Committee, survey, information dissemination	50,000	100,000	100,000
48. Establish special training courses in software development where its application for local uses appears important			
49. Conduct periodic or occasional training courses of 1-2 weeks duration in computer-aided design, for scientists at the university and research levels; training, information dissemination			
Five-year sub-totals (Sum per annum)	50,000 (10,000)	100,000 (20,000)	100,000 (20,000)
Science Management and Organisation			
<i>(a) Information Technology and Dissemination</i>			
50. Expand the Asia-Pacific energy and the Caribbean science and technology information networks to include other areas of science and technology			
51. Establish information networks on a subregional basis in Africa and Asia, using specific areas of science, securing the patronage of advanced nation institutions, obtaining national commitment and mobilisation of specialist scientists and librarians as contact points, and emphasising initially on agriculture and energy			

Table 4—continued

<i>Levels of Programme Development: Scientific Area/Goals and Objectives</i>	<i>Initial (Priority A1)</i>	<i>Minimal (Priority A2)</i>	<i>Desirable (Priority A3)</i>
Science Management and Organisation—continued			
(a) Information Technology and Dissemination—continued			
52. Develop an advisory capacity; access to data banks	10,000	20,000	30,000
Five-year sub-totals (Sum per annum)	10,000 (2,000)	20,000 (4,000)	30,000 (6,000)
(b) Popularisation of Science			
(c) Basic Science Education			
(d) Assessment of Research and Development			
53. Promote training in R & D assessment methods for managing science; survey, training, information dissemination	50,000	100,000	200,000
Five-year sub-totals (Sum per annum)	50,000 (10,000)	100,000 (20,000)	200,000 (40,000)
Total Programme Costs (5 year basis)	3,755,000	7,965,000	13,115,000
Overhead costs (5 year basis)	475,000	475,000	475,000
TOTAL (Sum per annum)	4,230,000 (846,000)	8,490,000 (1,698,000)	13,740,000 (2,748,000)

Table 5: Composition of the Costing of the Expanded Programme of Scientific Cooperation

(£ at 1984 prices)

<i>Financing Levels:</i>	<i>Initial</i>	<i>Minimal</i>	<i>Desirable</i>
Five year Total Costs: (Cost per annum)	4,230,000 (846,000)	8,490,000 (1,698,000)	13,740,000 (2,748,000)
Components:			
1. Existing:			
(a) CFTC contribution:			
Five year totals: (Allocation per annum)	1,115,000 (223,000)	1,115,000 (223,000)	1,115,000 (223,000)
(b) CSC Regular Budget:			
Five year totals (Sum per annum)	1,745,000 (349,000)	1,745,000 (349,000)	1,745,000 (349,000)
2. Additional:			
(d) CSC Project Budget: (including modest contribution from external sources)			
Five year totals (Sum per annum)	1,370,000 (274,000)	5,650,000 (1,126,000)	10,880,000 (2,175,000)

Table 6: International Funds Supporting Various Types of Scientific and Technological Activities

<i>Types of Activities</i>	<i>Requirements and Characteristics</i>	<i>Range of Funding (US\$ per year)</i>	<i>Funding Agencies Providing Support</i>
Individual Research Efforts	<ul style="list-style-type: none"> — Scientific capability and creativity — Interaction with peers — Access to literature and (possibly) travel — Access to scientific equipment and materials in a limited scale — One scientist with (possibly) technical assistants — Minimum of managerial skills — 1-4 years of support 	Less than \$10,000	I F S
Research Projects	<ul style="list-style-type: none"> — Scientific and technical capability and creativity — Interaction with peers and with users of research results — Access to literature and travel — Access to specialised scientific equipment and materials in a continuous fashion — Multidisciplinary teams (e.g. 3-5 Researchers plus assistants) — Access to (possibly) pilot plants and small scale field trials — Intermediate level of managerial skills — 2-5 years of support 	\$10,000-\$150,000	Private Foundations (Ford, Rockefeller, etc) <ul style="list-style-type: none"> — SAREC — BOSTID (AID/NAS) — UNESCO — UN Agencies — UNDP — NUFFIC — IDRC — CIDA

Table 6:—continued

<i>Types of Activities</i>	<i>Requirements and Characteristics</i>	<i>Range of Funding (US\$ per year)</i>	<i>Funding Agencies Providing Support</i>
Large-scale Research and Implementation Programmes and Projects (possibly including extension work, industrial implementation and training)	<ul style="list-style-type: none"> — Technical and scientific capability — Interaction with other research groups, farmers, industry, government agencies, international agencies etc — Access to specialised laboratories and materials exclusively for the programme or project — Large multidisciplinary teams (e.g. 5-20 researchers plus assistants) — Access to pilot plants and industrial facilities, large scale field trials — High level of managerial skills and control — 4 or more years of support 	More than \$150,000 reaching in some cases several million dollars	<ul style="list-style-type: none"> — AID — ORSTOM — SIDA — GTZ — Other bilateral agencies (Dutch, British, Belgian, etc) — WHO (tropical diseases) — CGIAR — World Bank — IFAD — ADB — IDB

SOURCES: F. Sagasti, G. Oldham, P. Vorauri and P. Thiongane 1984
 Evaluation of the International Foundation for Science (1974-1981)
 Final Report. IFS, Stockholm.

Table 7: Intergovernmental Sources of External Funds for Research

European Economic Community (EEC) Science and Technology for Development Programme 1983–1986

Islamic Foundation for Science Technology and Development (IFSTD)

Colombo Plan Bureau

United Nations Development Programme (UNDP)

UN Financing System for Science and Technology (UNFSST)

United Nations Educational, Scientific and Cultural Organisation (UNESCO)

United Nations University (UNU)

Commonwealth Fund for Technical Cooperation (CFTC)

North Atlantic Treaty Organisation (NATO)—Scientific Affairs Division

Table 8: National and Multilateral Sources of External Funds for Research

The Swedish Agency for Research Cooperation with Developing Countries (SAREC)

Overseas Development Administration (ODA)

Swedish Commission for Technical Cooperation (SCTC)

Swedish Fund for Industrial Cooperation with Developing Countries (Swedfund)

Austrian Foundation for Development Research

Netherlands Organisatie Voor Internationale Ontwikkelingss Arrenweking (NOVIB)

Australian Development Bureau (ADAB)

Canadian International Development Agency (CIDA)

International Development Research Centre (IDRC)

Swedish International Development Authority (SIDA)

Table 9: Non-governmental Sources of External Funds for Research

International Foundation for Science (IFS)

Royal Society of London

Commonwealth Foundation

International Council of Scientific Unions (ICSU) including its member Unions, its Committee on Science and Technology in Developing Countries (COSTED) and the International Biosciences Networks (IBN)

Table 10: Private Sources of External Funds for Research

Volkswagen Foundation

1% for Development

Leverhulme Trust

Battelle Memorial Institute

Ford Foundation

Rockefeller Foundation

Carnegie Corporation

Toyota Foundation

Alexander Von Humboldt-Stiftung

Appendix A:

History of the Commonwealth Science Council

1. The Commonwealth Science Council (CSC), established in 1975 by the Commonwealth Heads of Government meeting in Kingston, Jamaica, is an autonomous intergovernmental body collaborating closely with the Commonwealth Secretariat through a Memorandum of Understanding. Its purpose is to increase the capabilities of individual nations to use science and technology for their economic, social and environmental development. The council achieves this purpose through a variety of objectives, notably through scientific and technical collaboration on a network basis among member nations, through the most effective use of the scientific and technological resources of member nations, through developing a monitoring, evaluation and advisory capability responsive to the needs of individual member nations, through the promotion of scientific research and technological development, and through the promotion of a diversification of science and technology in member nations. The history of Council dates back to 1946, when a Standing Committee was established for the British Commonwealth Scientific Officials Conference, with a secretariat in London. This Committee has undergone a number of mutations since:

1946: Standing Committee, British Commonwealth Scientific Officials Conference

1958: British Commonwealth Scientific Committee

1964: Commonwealth Scientific Committee

1975: Commonwealth Science Council

2. Prior to 1975, the Council (or then Committee) performed a liaison function. Since 1975, however, the Council has embarked on a cooperative and supportive programme limited to the transfer of technology freely available but not adequately applied to development. This change in Council's functions has resulted in some successful programmes on technology such as that on Rural Technology, Energy, Standardisation and Metrology, and Geology and Mineral Resources; and in the establishment of networks of collaborating scientists on specific projects. The Council established a Working Group in 1981, to review its programmes. On the basis of this Group's report, the Council noted in 1982, the measure of success its limited programme had achieved and the non-linear advances in technology, and decided to shift its programme emphasis from technology transfer to the use of science for technology for development.

Appendix B:

Scientists who Contributed their Expert Opinions to the Expert Group

<i>Scientist</i>	<i>Area of Science</i>
1. Dr. C. E. Astley-Boden, Mineral Physics CSIRO, Sydney, AUSTRALIA	Remote Sensing—The Australian Perspective
2. Professor C. H. R. Atkinson, Director, Microbial Technology Laboratory, PHLS Centre for Applied Micro- biology and Research, Salisbury, Wiltshire SP4 0JG, ENGLAND, UK	Microbiological Aspects of Genetic Engineering and Biotechnology
3. Dr. I. E. L. Baumgart, 27 Onehuka Road, Lower Hutt, NEW ZEALAND	Coastal and Maritime Zone Management
4. Professor D. Bradley, Division of Communicable and Tropical Diseases, London School of Hygiene and Tropical Medicine, Keppel Street, (Gower Street), London WC1E 7HT, ENGLAND, UK	Epidemiology of Communicable Diseases

Appendix B—continued

<i>Scientist</i>	<i>Area of Science</i>
5. Dr. J. Brown, GEC, University & Schools Liaison, Wembley, Middlesex HA9 7PP, ENGLAND, UK	Microelectronics
6. Professor G. M. Brown, FRS, Director, Institute of Geological Sciences, Keyworth, Nottingham, ENGLAND, UK	Geosciences
7. Dr. R. Chandra, Computing Department, Imperial College of Science and Technology, Exhibition Road, London SW7 2AZ, ENGLAND, UK	Information Technology
8. Dr. D. S. Cronan, Applied Geochemistry Research Group, Department of Geology, Royal School of Mines, Imperial College of Science and Technology, London SW7, ENGLAND, UK	Coastal and Maritime Zone Management
9. Professor B. O. Drasar, Division of Communicable and Tropical Diseases, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London WC1E 7HT, ENGLAND, UK	Epidemiology of Communicable Diseases
10. Dr. Peter Ellis, Physics and Engineering Laboratory, DSIR, Lower Hutt, NEW ZEALAND	Remote Sensing

Appendix B—continued

- | <i>Scientist</i> | <i>Area of Science</i> |
|--|---|
| 11. Dr. N. C. Fleming,
Institute of Oceanographic
Sciences,
Brook Road,
Wormley, Godalming,
Surrey, GU8 5UB,
ENGLAND, UK | Coastal and Maritime Zone
Management |
| 12. Professor H. M. Gilles,
Department of Tropical
Medicine,
Liverpool School of Tropical
Medicine,
Liverpool,
ENGLAND, UK | Epidemiology of Diseases
Caused by Protozoa and
Helminths |
| 13. Dr. M. Hadley,
Division of Ecological Sciences,
UNESCO,
Paris,
FRANCE | Integrated Resources
Management |
| 14. Professor B. S. Hartley,
Centre for Biotechnology,
Imperial College of Science and
Technology,
London SW7,
ENGLAND, UK | Genetic Engineering/
Biotechnology— |
| 15. Dr. E. D. Hondros,
National Physical Laboratory,
Teddington,
Middlesex, ENGLAND, UK | New Materials |
| 16. Dr. K. McCracken,
CSIRO,
Mineral Physics,
Sydney,
AUSTRALIA | Remote Sensing |
| 17. Dr. D. J. McLaren,
Geological Survey of Canada,
601 Booth Street,
Ottawa,
Ontario K1A OE8,
CANADA | Geosciences |

Appendix B—continued

- | <i>Scientist</i> | <i>Area of Science</i> |
|---|---|
| 18. Dr. J. R. Metcalfe,
Director,
CAB Information Service,
Farnham House, Farnham
Royal,
Slough SL2 3BN,
ENGLAND, UK | Information Technology |
| 19. Dr. N. Myers,
Consultant in Environment and
Development,
Upper Meadow,
Old Road,
Headington,
Oxford OX3 8SZ,
ENGLAND, UK | Genetic Resources—Under
Exploited Plants |
| 20. Sir Charles Pereira, FRS,
Peartrees,
Teston,
Maidstone, Kent ME18 5AD,
ENGLAND, UK | Agriculture |
| 21. Dr. M. E. D. Poore,
Commonwealth Forestry
Institute,
Oxford University,
Oxford,
ENGLAND, UK | Tropical Forest Ecology |
| 22. Professor R. W. Radley,
Silsoe College,
Department of Agricultural
Engineering,
Silsoe, Bedford MK45 4DT,
ENGLAND, UK | Agriculture |
| 23. Professor U. R. Rao,
Director,
Indian Space Research
Organisation,
Satellite Centre,
A1-6 Peenya Industrial Estate,
Peenya, Bangalore 560 058,
INDIA | Remote Sensing |

Appendix B—continued

- | <i>Scientist</i> | <i>Area of Science</i> |
|--|---|
| 24. Professor G. Rose,
Department of Medical Statistics
and Epidemiology,
London School of Hygiene and
Tropical Medicine,
Keppel Street,
London W1,
ENGLAND, UK | Epidemiology of Non-
Communicable Diseases |
| 25. Dr. P. Ryder,
Assistant Director,
Meteorological Office,
London Road,
Bracknell, Berkshire RG12 2SZ
ENGLAND, UK | Information Technology |
| 26. Dr. N. W. Simmonds,
The Edinburgh School of
Agriculture,
West Mains Road,
Edinburgh EH9 3JG,
SCOTLAND, UK | Genetic Resources—Crop
Plants |
| 27. Professor R. O. Slatyer, FRS,
Research School of Biological
Science,
Australian National University,
P.O. Box 4,
Canberra, ACT 2600
AUSTRALIA | Ecological and Environmental
Sciences |
| 28. Professor J. Spence,
Department of Biological
Sciences,
University of the West Indies,
St. Augustine,
TRINIDAD & TOBAGO | Agriculture |
| 29. Dr. P. Treleaven,
The University of Reading,
Department of Computer
Science,
Whiteknights Park
Reading RG6 2AX,
ENGLAND, UK | Information Technology |

Appendix B—continued

	<i>Scientist</i>	<i>Area of Science</i>
30.	Dr. E. P. Wright, Institute of Geological Sciences, Wallingford, ENGLAND, UK	Geosciences

Appendix C

Statement of Commonwealth Scientific Cooperation by the Commonwealth Heads of Government, Meeting in New Delhi on 23–29 November 1983

Commonwealth Scientific Co-operation

- '8. Heads of Government expressed their appreciation of the work of the Commonwealth Science Council which was charged with fostering co-operative activities designed to enhance the scientific and technological capabilities of member countries. They welcomed the establishment of an Expert Group to examine ways and means of promoting an expanded programme of Commonwealth scientific co-operation, which would encourage work in new areas of developmental significance, including high technology, and affirmed the priority which they accord to strengthening Commonwealth scientific cooperation.'

Appendix D

Programme Areas and Thrusts of the Commonwealth Science Council

(a) Energy Programme

1. The Council's Energy Programme concerns appropriate energy supplies (conventional, alternative, or renewable) and upgrading conventional energy technologies (such as through transfer of viable renewable energy technology). Activities in this programme have been implemented through three regional programmes, namely the Caribbean Alternative Energy Programme (CAEP), the African Energy Programme (AEP) and the Asia-Pacific Rural Technology Programme (APRTP). Their aim has been to develop renewable energy technologies and to evaluate rural needs and resources. These activities have enhanced the awareness of participants to the vital importance of energy for sustainable social, economic or industrial development. R & D projects are being pursued in solar crop drying, charcoal production, and biogas production, in the African Region. Substantial data in meteorology (wind systems, local solar insolation factors, etc) is being collected, and a significant use of energy accounting (energy assessment, auditing) is being carried out, in the Caribbean region.

2. The Programme's thrust is on the ability of member nations to initiate, develop and apply coherent energy policies and plans in the context of overall socio-economic needs; on the feasibility of each of a number of projects in the African region, such as solar heating and cooling, wind energy for water pumping, wind electricity, and meteorological data collection; and on the development of networks for information gathering and dissemination within the Caribbean region.

(b) Mineral Resources Programme

3. The Council's Mineral Resources Programme concerns the mapping, exploration, extraction, analysis, management and utilisation of mineral resources. This Programme is advised by the Commonwealth Committee on Mineral Resources and Geology (CCMRG). Its thrust is on geological mapping using remote sensing or photographic imagery techniques; mineral exploration (terrestrial, marine, estuarine or off-shore) using geochemical and geophysical methods; the authentication of mineral resources of economic value and on hydrological and hydrogeological survey for the assessment and management of underground and surface water resources.

4. This Programme also publishes and distributes a bi-monthly *Earth Sciences Newsletter* to disseminate current information on geology and mineral resources, especially to geologists with poor access to literature. This Newsletter has been particularly successful.

(c) Renewable Natural Resources Programme

5. The Council's Renewable Natural Resources Programme concerns survey, identification, collection, authentication, culture, conservation and management techniques and methodologies for natural resources (viz: plant, animal and microbial) with potentially viable socio-economic benefits (protein-nutritional, medicine-pharmaceutical, or economic-commercial). Activities in this programme have comprised mainly training workshops, field surveys and commissioned studies, implemented under the auspices of three regional programmes, namely the Caribbean Natural Products Programme (CNP), the African Natural Products Programme (ANP) and the Asia-Pacific Rural Technology Programme (APRTP). The Council's past activities on Renewable Natural Resources have been fairly successful in initiating national programmes on evaluation of specific natural resources especially marine algae and seaweeds in the Caribbean and Africa regions, and medicinal plants in the Asia-Pacific and the Caribbean, and in identifying a number of projects for collaborative inter-country or inter-regional effort particularly the Water Hyacinth Project in the Asia-Pacific region.

6. It is envisaged to enlarge the scope of this programme to include conservation and management of genetic resources for sustainable human use; and the development and preparation of new commercial products such as pharmaceuticals, using genetic engineering and fermentation technology methods. In the Caribbean Natural Products Programme (CNP), activity centres around ethnobotany and botanical taxonomy, authentication of medicinal plants in order to isolate those plant resources with medicinal-pharmaceutic values, and isolation of various non-food marine natural products from seaweeds, various

invertebrates, and trash fish. In the African Natural Products Programme (ANP), activities have focussed on medicinal plants, agro-industrial wastes, culture of micro-organisms, and agro-forestry systems for enriching the soil. In the Asia-Pacific Rural Technology Programme (APRTP), the viable management of the water hyacinth through biological control using safe and environmentally acceptable agents for suppression, the utilisation of the water hyacinth as feedstock for biogas digesters and also as resource for paper, have been successful. Activities are being focused on marine algae, medicinal plants, and plants for agro-industrial uses.

(d) Environmental Planning Programme

7. The Council's Environmental Planning Programme concerns the integrated assessment, management and planning of natural resources in relation to the environment. This programme focuses on ecological management, environmental assessment, and ecosystem evaluation with the view to developing ecological indicators.

(e) Industrial Support Programme

8. The Council's Industrial Support Programme concerns scientific and technical services supportive to industrial development. The Programme has been implemented through three regional programmes, namely the Asia-Pacific Metrology Programme (APMP), the African Programme on Standardisation and Quality Control (APSQC) and the Caribbean Metrology Programme (CMP), to build up an infrastructure knowledge in scientific measurement (for exactitude and credibility), standardisation (for national, regional, or international recognisability), and quality control (for national, regional or international acceptability). Future activities of the programme are envisaged to include microcomputers (microprocessor applications, etc), new materials (alloys, plastics, composites, ceramics or biological materials), and new techniques (e.g. genetic engineering). A Memorandum of Understanding has been signed between the Council and the African Regional Organisation for Standardisation (ARSO) incorporating all the activities of APSQC with effect from January 1984.

(f) Science Policy and Organisation Programme

9. The Council's Science Policy and Organisation Programme concerns the formulation of a policy for science and a scientifically-based policy (including the establishment of infrastructure) to enable the management of science and scientists for development. This programme comprises research management and evaluation, organisational infrastructure, and information dissemination for technological aculturation. Future activities will focus on methodologies for evaluating national R & D efforts, on the role of indigenous professional scientific bodies,

on national mechanisms for coordinating research and development funding, on the application of computer-based information for decision-making, on disseminating information on advances in science and technology pertaining to development, and on the development of reliable statistical indicators of local scientific and technological innovations for measuring productivity, growth and development, instead of input-output economic indicators.

(g) Fellowship Scheme

10. The Council's Fellowship Scheme aims to develop local expertise through opportunities for skill enhancement and professional training for scientists involved in the Council's programmes.

Appendix E

Subject Areas for a Cooperative Programme Referred to Member Nations

1. Genetic Resources
2. Integrated Resource Management
3. Remote Sensing
4. Coastal Zone Management
5. Tropical Forest Ecology
6. Soil Erosion
7. Floods and Droughts
8. Natural Hazards Forecasting
9. Energy
10. Environmental Quality
11. Atmospheric Science
12. Metrology and Standards
13. Design Engineering
14. Genetic Engineering
15. Biotechnology
16. Microelectronics
17. Maritime Management
18. Sea-bed Mining
19. High Energy
20. Laser Technology
21. Computer-Aided Design
22. Space Science

Appendix F:

Steps in the Implementation of the Commonwealth Science Council's Programme

- (1) Establishing advisory committees, expert panels or task forces to elaborate a programme area into potential projects;
- (2) Establishing networks of active scientists as project groups or working groups to exchange information on each potential project, and to elaborate the scientific issues, technical activities and modes of cooperation for the project;
- (3) Seeking the advice of professional experts, referees or consultants on project activities and modalities, and on priorities between projects;
- (4) Securing the endorsement of Council for financial, governmental and institutional support;
- (5) Implementing the technical activities specified for each project, with adjustments made by the project group;
- (6) Establishing advisory committees, expert panels or task forces to evaluate the projects and programmes from time to time, and to advise on the future of projects and programmes.

Science for Technology for Development

Rationales used by the Expert Group:

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

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

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