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 neglible. 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 commerical 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 commerical 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 prerequisities for mineral exploration and development. LANDSAT multispectral 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:

	Levels of Programme Development		
	£ *Initial (A1)*	£ *Minimal (A2)*	£ *Desirable (A3)*
Projects:			
• Mineral Surveys	60,000	60,000	60,000
• Hydrogeology and Geochemical techniques	400,000	900,000	1,500,000
• *Earth Sciences Newsletter*	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 pojects in this programme:

	Levels of Programme Development		
	£	£	£
	(Priority A1) *Initial*	*(Priority A2)* *Minimal*	*(Priority A3)* *Desirable*
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
Five-year totals: (£)	500,000	1,000,000	1,850,000
Cost per annum; (£)	100,000	200,000	350,000

(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 efficency 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 innoculation, 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:

	Levels of Programme Development		
	£	£	£
	(Priority A1) *Initial*	*(Priority A2)* *Minimal*	*(Priority A3)* *Desirable*
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 consitute 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 rersearch 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, phyiscal 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 aproach 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:

	Levels of Programme Development		
	£ *(Priority A1) Initial*	£ *(Priority A2) Minimal*	£ *(Priority A3) Desirable*
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	14,865,00	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) (km²)	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.