OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

(ii), 55p. tables diagrams maps

RESTRICTED

21713

DP/ID/SER.A/1775
21 November 1996
ORIGINAL: ENGLISH

HIGH-LEVEL ADVICE ON THE DEVELOPMENT OF A HERBAL-BASED R&D PROGRAMME FOR INDUSTRY

SI/SRL/96/802/11-52

SRI LANKA

Technical report *

Prepared for the Government of Sri Lanka
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of P J Hylands, Consultant in plant drug development

Project Manager: T. De Silva, Chemical Industries Branch

United Nations Industrial Development Organization
Vienna

---

* This document has not been edited

V.96-87859

CONTENTS

Contents contd....

Abbreviations

ANMAP	-	Asian Network on Medicinal and Aromatic Plants
BMARI	-	Bandaranaike Memorial Ayurvedic Research Institute, Ministry of Indigenous Medicine
CARP	-	Council for Agricultural and Research Policy
CISIR	-	Ceylon Institute of Industrial and Scientific Research
IUCN	-	The World Conservation Union
NARESA	-	Natural Resources, Energy and Science Authority of Sri Lanka
WHO		World Health Organization

Abstract

Project number SI/SRL/96/802

Title **High-level advice on the development of a herbal-based R&D programme for industry**

The mission was undertaken after a briefing in Vienna from 20 August to 13 September 1996 and the work was accomplished according to the Job description as in Annex 1. The mission was required to provide advice to the Government of Sri Lanka on the provision of an appropriate strategy for the development of its phytopharmaceutical industry. By virtue of its geography and topography, Sri Lanka is rich in natural resources, particularly higher plants. The country has in addition a long history of the use of plants in medicine, particularly through the Ayurvedic system. Furthermore, the country already has a dedicated institution for research and development and the transfer of technologies to industry - the Ceylon Institute of Scientific and Industrial Research. CISIR has a long history of work in the area of natural products but the consultants found that the current activities do not live up to their expectations nor to the reputation of CISIR itself. Significant changes are required in the attitude of management and in the Centre's policies if it is to regain its position as a significant player on the world stage in natural products.

The consultant together with two other consultants, namely, agronomist and pilot plant technologist, evaluated the state of development of technology at the Institute and gathered data on its transfer to industry as well as the use and cultivation of medicinal plants by the various institutions and industry. The report was complied by the consultant with appropriate inputs from the agronomist and the pilot plant technologist. They visited a number of industrial units and studied their processing methods and collection of medicinal plant raw material. Little cultivation is currently undertaken and the consultants see a significant opportunity to increase this area, so having an impact on import substitution and stimulation of the internal economy. Equally industry uses outdated and inefficient technologies and the consultant team saw that important cost savings and improvements in quality could be readily achieved by improving the transfer of up-to-date production methods used in the phytopharmaceutical industry.

Special emphasis should be applied to improving the mechanisms by which such modifications in the areas of agronomy, analysis, standardization, quality control and process technology are transferred from CISIR to industry. Eventually, the level of product quality could be brought up to international standard so that Sri Lanka could enter the sector on the world level.

The consultants have presented a coherent strategy for the implementation of such changes at CISIR which involves first a more detailed evaluation by an international consultant to provide a working schedule for the action plan. Certain elements of such a plan are already apparent: strengthening of the technical base by the provision of more qualified staff and some equipment consolidated by a programme of appropriately orientated training in the phytopharmaceutical industry abroad. A multidisciplinary research effort centered on CISIR based on the creation of a new multidisciplinary Natural Products Group, apart from its existing Division, but also involving inputs from other research establishments, should be initiated. All these activities would also benefit by the close attention of experienced international consultants.

Further, the consultants feel strongly that the creation of a commercial arm within CISIR would greatly facilitate the upgrading of the phytopharmaceutical industry in Sri Lanka. UNDP could offer significant assistance in this sector. Also, the base level of capability at CISIR is sufficiently high to allow the introduction of new processing methods, to enable Sri Lanka to enter the world market with high quality, innovative niche products such as spice extracts and perfume raw materials but significant internal reorganization is required to achieve these aims. The consultants are nonetheless optimistic about the future of the Sri Lankan plant medicine arena provided these inputs can be provided.

1. INTRODUCTION

SRI LANKA

Sri Lanka is an island situated in the Indian Ocean off the southern tip of India, separated from it by the Palk Strait. The island is approximately 430 km. long by 225 km. wide at its maximal extremities with an area of about 65000 sq. km. It extends between approximately 5-10° North and 79-82° East. A distinctive topographical feature is a series of peaks (ranging from about 900-2500m in height) in the centre of the southern part of the island which form the Central Highlands (the Hill-Country) (see sketch map, Annex 2).

By virtue of its location and topography, a variety of climates exist, largely dependent on the monsoons and elevation. The climatic regions comprise (a) the Wet Zone (the southwest sector of the country, comprising part of the Hill-Country) with an average annual rainfall of 2540 mm and an average annual temperature of 26° (Colombo), (b) the Dry Zone of the north and east which experiences heavy rain in the northeast monsoon (November-January) (total annual rainfall less than 1875 mm) and has an average temperature between 29-35°, and (c) the Hill-Country which experiences rainfall between 1400-2500 mm annually and average daytime temperatures of 21° (Kandy) and 14° (Nuwara Eliya). This variation in climates suits a wide variety of crops: paddy predominates in the wet zone below 700 m, while rubber is cultivated at intermediate elevations, and tea (and some coffee) is produced in the Hill-Country. Coconut palm grows profusely along the coast and in some inland regions. As a result of these exceptionally varied and favourable growing conditions, the economy of Sri Lanka has been essentially agriculture-based, though only 2.9 million hectares (approximately) of the country's 6.6 million hectares (approximately) are under cultivation.

CISIR

The Ceylon Institute of Scientific and Industrial Research was created in 1955 as a result of a recommendation by a World Bank Mission in 1952. It was originally part of the Ministry of Industries but is now under the Ministry of Science, Technology and Human Resources Development, a change viewed positively by the present management since they take it as a recognition by government of the importance of the Institute's role. It is located in central Colombo, a purpose-built complex of buildings with laboratories, workshops and offices. It employs over 100 scientific and technical personnel. At the end of 1995, these included 15 at PhD level, 20 with Master's degrees and 10 graduates, which represents a gradual decline over the last 5 years. The activities in CISIR are carried out by five divisions and two units: Agro and Food Technology Division, Chemical and Environmental Technology Division, Materials Technology Division, Process and Plant Engineering Division and a Corporate Services Division, and Calibration and Measurement Unit and Electro Technology Unit. A major function of the Corporate Services Division is the operation of a comprehensive Information Services Centre of the CISIR which offers a wide range of services, government organizations, academia and industry. The library attached to the centre was set up in 1955 and is one of the largest technical libraries in Sri Lanka. It has more than 35000 monograph publications and subscribes to over 500 periodicals. Computerization is gradually being introduced as well the provision of a number of databases on CD-ROM. The Division publishes a regular newsletter promoting its services.

CISIR has as its current role the promotion of technological and industrial growth through demand-driven research and development. It supports industry by:

- undertaking contract testing and research for improving product quality and technical processing,
- providing technical services and consultancy,
- developing new technologies and
- undertaking technology transfers.

It also undertakes research to facilitate and accelerate new technology development and undertakes training. In addition, it has a role in monitoring environmental pollution.

Agro and Food Technology Division

The Division comprises a Product and Process Development Group, a Post Harvest group and a Services group. A Natural Products Development Group has recently been reconstituted within the Division. The Product and Process Development Group provides industry with technological knowhow for agro-based food processes (mainly cereal-, coconut-, fruit and vegetable- and other plant-based), having considerable experience, since the inauguration of the Institute, in spices and essential oils. The Post Harvest group undertakes demonstrations and testing of methods aimed at the improvement of quality and storage characteristics of fresh fruits, vegetables and foliage plants. The Services group provides analytical (physical, chemical and microbiological [the latter through collaboration with the adjacent Microbiology unit]) services for quality certification of raw materials and finished products in this area.

Process and Plant Engineering Division

The main unit of this Division is the Pilot Plant, the objective of which is to scale up manufacturing processes either developed at a laboratory scale by the Institute itself or suggesting modifications to processes originating from industry. The scale up process involves prefeasibility studies, identifying process equipment, and the design, development, fabrication, installation and commissioning of appropriate equipment.

Chemical and Environmental Technology Division

The Chemical and Environmental Technology Division comprises three sections: environmental technology, chemical technology and laboratory services, each with a manager. The activities of the Laboratory Services section are in turn divided into three, each overseen by a senior technical officer: waste water and air analysis; agrochemical, pesticide and solvent residue analysis; and potable and process water, industrial chemical and paint analysis.

The management of CISIR has recognized that the facilities and approach of the Institute need new input to meet the challenges presented by Sri Lanka's desire to expand its plant-based industries to the important value-added sector, particularly in the areas of quality control, agrotechnology and process technology. To this end, it has thus requested UNIDO to assist by advising on the initiation of an appropriate goal-orientated research and development programme for the phytopharmaceutical industry (see job descriptions SI/SRL/96/802/11-52/0730AO, and SI/SRL/96/802/11-53/0730AO attached as Annex 1).

Almost all of the original objectives of the mission were achieved by detailed discussions with staff of a number of government and private institutions, observation of the facilities of these institutions and their operation as well as field visits to state and private factories and field stations. The consultants have formed a clear understanding of the operation of CISIR both internally and in its interaction with outside bodies but lack of time did not permit demonstration of improved methods in any field.

2. PRELIMINARY ACTIVITIES

On arrival in Sri Lanka, the consultants had meetings with the counterpart staff, principally scientific, technical and administrative personnel of CISIR, with the Director-General of NARESA and with the Export Development Board. Meetings were also held with Mr. Tilak Gunawardana, Assistant UNDP Resident Representative, UNDP.

Considerable time was spent in individual discussion with counterpart personnel at CISIR in order to become acquainted with the operation of the Institute and its industrial interactions. The facilities of the Agro and Food Technology and Process and Plant Engineering Divisions were evaluated. It was not possible to visit the laboratories of the Chemical and Environmental Technology Division. It immediately became apparent that significant problems existed in technology transfer from CISIR to industry and much time was spent in discussion with senior staff of CISIR as well as with industrial users. It appears that CISIR, the only institution with capabilities to carry out R & D work for the generation of viable technologies in various fields including essential oils, oleoresins and phytopharmaceuticals through process development, process optimization and scale up and technology transfer to user industries, had recently been experiencing internal and external constraints which hampered its activities.

Two field trips were undertaken: the first was to the Hill Country to visit the Botanic Garden at Peradeniya, the Research Station of the Department of Export Agriculture at Matale, the field station of CISIR (part of the Mahaweli Development Programme) at Girandurukotte, the Ayurvedic Herbal Gardens at Haldumulla and the pine oleoresin production facility of Conifer Products Processing (Pvt) Ltd., at Nugathalawa. The second visit was 'down south' to visit the small scale field production facilities (e.g. at Moratuwa) of companies producing a number of essential oils, principally from cinnamon bark and leaf.

It was not possible to visit any of the universities concerned with work on natural products. Lists of people met and institutions visited are provided in Annexes 3 and 4.

3. FINDINGS

A. Food and Agro Technology Division, CISIR

This Division comprises six research officers supported by four technical staff; the research staff include three PhD level scientists and two at Master's level. There is an appropriate strong chemistry bias to the staff, five of whom are chemists. Only one PhD has qualifications in an agriculture-related discipline. A Natural Products Development Group has recently been reconstituted within the Division. The current activities of the group involve some research into essential oils and medicinal plants but much of the chemists' time is taken up by providing analytical services to the essential oil and herbal products industries. These services (for example, evaluation of raw material and finished products for some of the Ayurvedic medicine manufacturers, aflatoxin analysis, etc.) are provided at a commercial rate and currently contribute about 30% of the Group's total operating costs. CISIR competes for these services with private consultancies and the Bureau of Standards. The latter is in the process of producing the first series of Sri Lankan standard specifications.

In addition, the group undertakes specific research projects - a typical current example is the problem of adulteration of oil of *Citronella* with kerosene which is difficult to detect but severely reduces the marketability of this important Sri Lankan product. Attempts are being made to devise a robust field test to detect this adulteration but this work is hampered because some samples of Sri Lankan unadulterated oil contain high hydrocarbon levels.

The group also attempts some phytochemical and pharmacological studies, sometimes in collaboration with universities in Sri Lanka and abroad (such as clinical studies on Ayurvedic treatments for rheumatoid arthritis and atopic dermatitis in association with BMARI and the University of Uppsala, Sweden), and offers assistance to BMARI in its efforts to standardize the Ayurvedic medicinal preparations used in their clinical evaluations (see below). All of these activities are on an *ad hoc* basis and would benefit from the initiation of a coherent plan. A further activity is in product development, examples being the formulation of a toothpaste from an old tooth powder formula, a herbal shampoo and the taste

improvement of certain Ayurvedic oral preparations, projects undertaken on behalf of, for example, Hettigoda Industries (Pvt) Ltd. It is significant however that neither a trained analyst nor trained pharmacist with experience in product development is currently on the staff of the section. This lack of experience seriously hampers the section's development activities.

The group forms part of the Asian Network on Medicinal and Aromatic Plants.

The equipment of the Natural Product group is adequate for simple analysis but not for modern efficient methods of separation. For example, the lack of capillary gas/liquid chromatography hampers the ease with which routine analysis can be undertaken (and the reliability of the results). In any case, it is felt that more emphasis should be placed on method validation and calibration, for example, by analyzing positive control samples on a daily basis. Also, a system of sample logging should be introduced to remove analytical bias by 'blinding' samples, *ie.*, the analyst should not know the origin of the sample under analysis. Improvements in equipment are obviously required: a modern gas/liquid chromatograph with computerized data capture and control is essential for meaningful analysis but as important is the need to generate a working culture in which the reliability of the result is paramount. The reason for this is that no trained analyst is on the staff of the group but the situation could immediately be improved by closer collaboration with the Analytical Unit. Natural product chemistry (isolation studies in particular) is not carried out to up-to-date standards: phytochemical work is especially impeded by the lack of preparative and/or semi-preparative high performance liquid chromatography. A list of equipment currently available in the Food and Agro Technology Division is shown in Annex 5 and a list of staff of the Natural Products Development Group in Annex 6. A list of personnel in the Pilot Plant and Process Engineering Division is provided in Annex 7. The equipment available in this unit is shown in Annex 8.

CISIR has, in the Chemical and Environmental Technology Division, an analytical laboratory which should act as a central analytical unit with slightly more modern equipment than that in the Natural Products Group, staffed by trained experienced analysts but little, if any, cooperation between the Natural Products Group and this analytical unit was observed. The Food Science section provides apparently effective development services to industry. Some of the services required by the herbal-based industry (for example, microbiological studies on raw materials and finished products) are provided by sections of the Division other than the Natural Products Group. There is no management line to such activities from within the Natural Products Group, an omission which obviously hampers control and efficiency. A list of the personnel in the Laboratory Services unit of the Chemical and Environmental Technology Division is given in Annex 9 and the available equipment is shown in Annex 10.

The agronomical work at CISIR has consisted of preliminary attempts to explore the possibilities of cultivation of a few selected medicinal crops (*Cassia angustifolia* [introduced from India], *Piper longum*, *Solanum xanthocarpum*, *Withania somnifera*, *Aloe vera*, *Gloriosa superba* and *Catharanthus roseus*). These studies have been difficult to achieve because at present there is no trained agronomist to take up the appropriate field trials. As already mentioned, CISIR has only one Senior Research Officer concerned with the agriculture-related aspects of the work. He is well qualified in plant biochemistry and biotechnology but has no trained support staff and, in addition, he is engaged in many other activities of the Institute involving liaison with other organizations.

No crop improvement programme (except the selection of superior crop varieties) has been undertaken through either conventional breeding or modern biotechnological approaches on medicinal and aromatic crops in general and spice crops in particular.

CISIR has no research farm near Colombo to take up research and development work leading to agrotechnological development on medicinal and aromatic plants. The farm which has been allocated to CISIR for agricultural work by the Mahaweli Development Authority at Girandurukotte is about 150 km from CISIR. This is attended on a day-to-day basis by only one skilled labourer, the CISIR officer only being

able to visit about once a month. Further, there are no infrastructure facilities (farm implements, net house, farm sheds, etc.) on site. Under such conditions, no programme on the development of agrotechnology for medicinal and aromatic crops can be undertaken or monitored effectively.

The process and plant engineering division of CISIR houses a pilot plant, design engineering section and a workshop responsible for process optimization and scale up, design of chemical plants and their fabrication and development of technologies on turn key basis. The pilot plant is equipped with various equipment and machinery to carry out different unit operations and unit processes. These were inspected by the consultants. Lists of machinery available in the workshop and of its staff are given in Annexes 11 and 12.

Operational expenses of CISIR are provided by the Ministry of Science, Technology and Human Resources, CARP, NARESA (the latter, for example, providing support for the publication of literature disseminating information on essential oils) but also from its own direct activities such as the provision of analytical and contract (e.g. development) services. The consultants were informed that there is increasing pressure on the group to provide such analytical services in order to increase its revenue. However, the consultants feel that the services provided are inadequate because of lack of suitably trained personnel and equipment. This has contributed to the dissatisfaction with the services provided by CISIR perceived by the consultants on the part of industrial users. In addition, this internal emphasis naturally has deleterious consequences on its ability to carry out research.

This very wide range of activities carried out by the whole group causes the staff to be spread very thinly and this, coupled with the inadequate human resources, seriously hampers the work of the group.

B. Bandaranaike Memorial Ayurvedic Research Institute

This institute, under the direction of the Ministry of Indigenous Medicine, was established in 1962. It undertakes research into the ancient Sri Lankan literature (and has a fine collection of original manuscripts) as well as some clinical research (in the following disease areas: rheumatoid arthritis, asthma, diabetes, psoriasis, muscle wasting, chronic headache, prostate hypertrophy, anal fistula and hemorrhoids, leucoderma, worm infestation, heroin dependence, malaria, epilepsy, hepatitis and renal calculi). The latter has been partially supported in the past by WHO by the provision of training and equipment. It also attempts studies on the preparation of Ayurvedic medicines but is seriously hampered by lack of personnel and equipment. Only one chemically-trained research officer is presently on the staff and he attempts to carry out standardization of raw materials and finished products as well as investigating the original plant materials. In the past, some chromatographic (thin-layer) evaluations have been carried out but no modern (e.g. gas/liquid, high performance liquid or hp/thin-layer) chromatographic studies are possible. BMARI has a small (17 acres) garden near the Institute in which the major plants used by the Ayurvedic system of medicine are grown. The Ministry of Indigenous Medicine (Department of Ayurveda) has four herbal gardens at different locations in the country, namely, Haldumulla (a large farm), Pattipola, Girandurukotte and Pallikelle. Some plants have been introduced from abroad (mainly from India) and others have been domesticated from natural habitats in Sri Lanka. However, effective scientific efforts have not been made to develop agrotechnology for crop improvement, even of the plants which are used in large quantity in Sri Lanka for Ayurvedic medicine preparation. Moreover, the facilities on the farms are inadequate for their proper maintenance.

C. Industries

Visits were made to two companies producing Ayurvedic medicinal products: Hettigoda Industries and Link Natural Products (Pvt) Ltd., to three companies producing essential oil products: Bio Extracts (Private) Ltd., Conifer Products Processing (Pvt) Ltd. and Essential Oils and Spices, and to the government-owned Ayurvedic Herbal Products Factory.

Ayurvedic Medicinal Products

All of the production facilities visited took great pains to use, as far as possible, traditional methods of preparation. This produces a disorganized and inefficient industry using primitive and outdated process technologies. Dried plant materials (sometimes in mixtures of 70 species) were boiled with water in open galvanized vessels (with much concomitant heat loss and inefficiency) until the volume was reduced to 25%. After straining, the liquor is inoculated with *Woodfordia fruticosa* flowers and allowed to ferment in wooden casks. After about 30 days, the supernatant is decanted and bottled as 'herbal wine'. Simple decoctions and pastes were also produced by traditional methods.

The consultants detected a general reluctance to improve on these methods, little attention being paid to savings on fuel efficiency, for example, because of the desire to produce end products as close as possible to the traditional. Consequently, the industries lack R&D facilities either to update their technologies to improve the quality of their products (and hence their efficiency and profitability) nor expedite the absorption of new technologies.

There is however a new, market-driven desire to improve on the quality of the products in terms of taste, ease of preparation and superior presentation, such as to produce instant Ayurvedic teas. CISIR scientists are involved to some limited extent in these studies but attempts at technology transfer have had limited success because of the factors enumerated above.

Manufacturers did not control well their starting plant materials: adequate monographs were either not available or not applied comprehensively. Many of the plant materials used were imported through companies such D. Peiris and Co., Ltd. This import business, although operating on a relatively large scale, handled dried plants often in open bales with no efforts being made to limit or even control contamination or spoilage during processing and distribution. Consequently, the consultants felt that, for example, the microbiological load would be unacceptable on a world wide basis. Peiris is beginning to manufacture its own products including 'healthy drinks'.

Essential oil distillation and oleoresin manufacture

Distillation of essential oil-bearing plant materials is also carried out using direct heat from burning rubber wood. In general, methods of preparation are directly from the original cottage industries, are on a small scale, disorganized and inefficient. The distillation stills used are of primitive design and coil type condensers dipped in water tanks are most inefficient, resulting in low recovery and inferior quality of oil. The oil separators to trap the oil are also defective, resulting in loss of oil. Methods are labour intensive, all these factors contributing to the high cost of finished products.

The pine oleoresin plant recently set up at Upali Organization Pvt. Ltd., Uwathanna, Kalupahana (Conifer Products Processing (Pvt) Ltd.) is a classical example of primitive design and outdated technology. The melting of the resin and its distillation to produce rosin and turpentine oil is carried out by using direct heat from burning wood which causes decomposition and results in a poor quality rosin. The condenser of the unit is under capacity which produces a very hot condensate leading to loss of turpentine oil. No proper conditions and controls are observed with consequent inadequate control on the quality of the product.

There is a desire to diversify to produce fractionated oil and other value-added products but no technology is currently available to achieve this.

Consultants were surprised to learn that, at present, no pilot scale production is currently being carried out on Process development and scale up in the field of herbal drugs and essential oils in CISIR. In the past, good quality work was accomplished in the essential oil field but no proven technology has been generated recently by CISIR which could have been transferred to the industry. Discussions were held with the pilot plant and workshop group to discover the constraints and problems faced by the pilot plant for the pilot scale, production, design of chemical equipment and its fabrication in the field of herbal drugs and essential oils and thus understand why technologies in this field were not developed for the user industry.

Another major problem observed, however concerned the plant material. Hettigoda, which claims to supply 70% of Sri Lanka's requirement for Ayurvedic medicines, produces a total of 129 items, of which 59 are for government use in hospitals and clinics. It employs 325 staff, almost all untrained. It turns over 72 million Sri Lankan rupees/year. It handles some 750 different plant materials, 60% of which are Sri Lankan grown. The rest are imported mainly from Asian countries yet all could be grown in Sri Lanka. This is probably due to lack of research and development efforts in bringing these plants into cultivation. The result is a permanent shortage of plant raw material in all Ayurvedic manufacturing units. Significantly, all the Sri Lankan materials are collected from the wild (see IUCN, below).

Much imported material is of poor quality, there being no adequate standards against which the material can be evaluated. Quality control of starting plant material is entirely organoleptic, no trained pharmacognosist being employed in any company visited, nor in CISIR. A typical quality control sheet from a producer of Ayurvedic medicines is attached as Annex 13. Quality control of all fresh and dried plant materials is a problem, especially in Ayurvedic preparations in which the constituents of many plants are unknown and are, in any case, probably significantly transformed by the robust methods of processing. Most industries rely on significant CISIR input for analyses and general assistance. However, no systematic attempt is made at CISIR to play a leading role in the development of standards for the plant materials used - a function which it could readily fulfill. The consultants feel that much benefit would be generated by the integration of analytical services into one unit at CISIR.

Pharmaceutical products

Aid from the Government of Japan was provided in 1987 in order to establish the Sri Lanka Pharmaceutical Corporation with a pharmaceutical production unit. It currently employs about 100 staff and makes 42 tablet and capsule products, principally the staple drugs such as simple antibiotics, analgesics, antiparasitics, etc. The unit appears to function efficiently (though not to GMP or GLP) and operates a number of high speed tabletting and capsule filling machines producing 700 million units and, in 1994, claims a profit of 20 million rupees. Quality control appears to be adequate, with good in-process controls and checks and comprehensively documented standard operating procedures. It is served by an adequate analytical laboratory with facilities for microbiology (it conducts microbial challenge testing for preservative evaluation) and stability evaluation. Record keeping appeared to be satisfactory. Management prides itself on its internal training programmes: staff are recruited only at the junior level and given in-house training - the company feels that this is preferable to retraining experienced staff who may have been exposed to less stringent working practices in their previous employment. It has no contact with the manufacturers of Ayurvedic medicines and has no plans to extend its product range to the plant-based area.

A number of multinational companies have packing plants in Sri Lanka, e.g. Glaxo-Wellcome, Warner Lambert, Reckitt and Colman, etc.

D. Sri Lanka Export Development Board

The Sri Lanka Export Development Board promotes and develops products and services for export from Sri Lanka. It motivates exporters by providing incentives and removing disincentives. Among ten Divisions is the Export Agriculture Division which, among others, operates field programmes in the following sectors: spices (cinnamon, pepper, cardamom, nutmeg and mace), essential oils and herbal products (including therapeutic wines). It encourages producers to enter the value-added sector such as the preparation and packaging of ready-mixed spices and in the production of organically-grown herbs which attract a significant premium. It provides incentives to prospective exporters in the form of low interest loans for the purchase of equipment and as working capital. Recent spice export figures are shown in Annex 14. The department operates its own Field Research Station at Matale.

Export Agriculture Field Research Station, Matale

The station is housed in a fine 3-year old building with good simple facilities but is critically short of staff. Originally, the research emphasis was on beverage crops (tea, coffee and cocoa) but is currently trying to work on spices (cinnamon, clove, black pepper, cardamom, nutmeg and mace) with minor programmes on vanilla and local lemon grass. A major problem highlighted by staff was the high price of Sri Lankan-produced materials. This was related to the relatively high cost of labour (compared with India, for example) but no attempts had been made to reduce costs by improving efficiency of production by processing or agrotechnological improvements. Studies had been undertaken on intercropping; for example, cardamom under rubber and a number of crops (cocoa, betel and cinnamon) with coconut. Currently, however, almost no scientific work was being undertaken because of lack of suitably trained staff.

E. Government institutions

NARESA and CARP

NARESA (the successor body to the National Science Council) administers all the sciences in Sri Lanka. It gives regional and subject awards and grants for individual projects (some of the work of the Food and Agro Technology Division of CISIR is supported by NARESA, e.g. essential oil adulteration, the feasibility of production of mosquito-repellent coils, genetic improvement of black pepper cultivars) and it has a science library and information service. NARESA also supports publications in the technical area (e.g. some essential oil monographs of CISIR have been disseminated through NARESA funding). CARP also funds certain projects of CISIR, such as studies of intercropping coconut with certain medicinal plants and the development of topical preparations of *Aloe vera* for use in the treatment of burns and hence the promotion of the aloe cultivation.

Ministry of Environment

The Ministry of the Environment is currently engaged in preparing a strategy for biodiversity action, with technical backup provided by IUCN, with financial support from the World Bank. There are plans for a special programme for the conservation of medicinal plants but the problem is complex because, in Sri Lanka, there are more than seventy organizations concerned in some way with biodiversity issues.

Biodiversity in Sri Lanka

Sri Lanka has more than 3350 species of higher plants, some 25% of which are endemic. More than 90% of the endemic species are concentrated in the small fragmented rain forests of the southwest area of the country. Deforestation is proceeding at a high rate, approximately 42000 hectares being lost each year. Because of its biodiversity, level of endemicity and the rate of loss of habitats, Sri Lanka has been designated one of the world's 'hot spots' for special attention in global efforts to prevent loss of genotypes. Lists of aromatic plants in Sri Lanka are shown in Annexes 15, 16 and 17.

A point often overlooked in considerations of biodiversity is the number of micro-organisms associated with plant species. It is estimated that each species of higher plant may have at least 20 species of uniquely associated micro-organism, often present as endophytes. Loss of the plant therefore implies consequent loss of many more genetic resources. This has incalculable costs; for example, the western pharmaceutical industry has produced many novel drugs from microbes: recent important examples include mevinolin (a cholesterol-lowering agent) and cyclosporin (an immunosuppressive agent, without which transplant surgery could not take place). With such a special flora of higher plants, this issue is of particular relevance to Sri Lanka and special efforts should be made to preserve this unique resource.

It is significant, and of especial concern, that, of the medicinal plants used in Sri Lanka in the industry producing Ayurvedic medicines, at least 60% are grown in Sri Lanka but almost all of these are collected from the wild. There is no doubt that this practice, coupled with land clearance schemes for hydroelectric power and irrigation projects, is having a strongly deleterious effect on Sri Lanka's foremost natural resource - its biodiversity.

The remaining 40% of Ayurvedic medicinal plants are imported (mainly from Asian countries) at a cost of at least 60 million rupees. These imports represent more than 70 species of which half are indigenous to Sri Lanka (and so could be cultivated); the other 35 species could possibly be substituted by local plants, not only saving the imports but promoting local industry.

4. CONCLUSIONS

1. General

1.1 Sri Lanka is in an enviable position by virtue of its biodiversity and ranges of habitat and climate of being able to produce a wide variety of plant-based products in the medicinal, aromatic and spice sectors. With appropriate inputs, it will be able to exploit its natural resources to the full by the development of a significant, global phytopharmaceutical industry.

1.2 It has a widespread Ayurvedic medicine industry but significant technological input is required for this not only to become a player on the world stage but to improve its products for internal consumption.

1.3 There is considerable scope for the development of other (non-Ayurvedic) value-added herbal products to significantly contribute to the economy.

1.4 Sri Lanka's natural resources are a major factor in its potential success. However, if urgent steps are not taken to improve the management and conservation of its flora (currently ravaged by collection from the wild), Sri Lanka's enviable resources will be a memory only and no development in the currently important area of indigenous phytopharmaceuticals will be possible.

1.5 CISIR is well placed to lead these initiatives but current constraints and operating difficulties need to be urgently addressed if it is to fulfill its potential. The consultants propose internal changes on two levels to address this issue.

1.5.1 The most urgently required modification is a change in administrative structure at CISIR to promote truly multidisciplinary scientific activities. This will require a reorganization in which appropriate expertise and facilities are made available on a project basis, probably through a matrix management system. This will not be easy to introduce; historical Divisional barriers are high but the consultants are convinced that in order to restore CISIR to its prior pre-eminent position in the area of natural products, such a management change is a prerequisite. A diagram outlining these changes is provided in Annex 18.

1.5.2 The second modification addresses the role of CISIR vis-a-vis industry. Its interface position between industry and research and development is unique and should be significantly strengthened. One way in which this may be achieved is through the creation of a commercial arm, as has been successfully implemented by some scientific institutions in the United States, Europe and Far East. The presence of such a body would greatly facilitate technology transfer. In addition, the body could concern itself with vital issues such as the protection of intellectual property and commercial arrangements, so leaving the

existing scientific and technical staff to concentrate on their scientific work. One way of achieving this could be through a consortium of interested industrial groups who could 'buy in' to the concept with a relatively modest investment for which they would obtain early access to CISIR-generated technology. An alternative would be individual or collective joint ventures. A diagram showing one proposed structure is given in Annex 19.

1.6 Increased emphasis should be placed on the undertaking of suitably-directed research projects at CISIR. The consultants feel that much of this could be market-led and financed. They feel strongly that research should play an important role in the activities of the stepped-up Institute envisaged by the rest of the recommendations. The provision of simple services should continue but should be provided by the appropriately-trained personnel at CISIR, utilizing the best analytical tools available. This will lead to more reliable analytical data which the industrial users will appreciate and value. This in turn will address an issue that was frequently reported to the consultants, namely the need to increase industrial confidence and belief in CISIR. The full potential of CISIR cannot be achieved without significant research effort. However, this will only be possible if much closer collaboration between CISIR and industry is implemented, as in 1.5, above.

1.7 A shortcoming is that the entire Food and Agro Technology Division and particularly the Natural Products Group at CISIR is understaffed and underresourced, particularly with highly qualified younger staff, and, as a consequence, it lacks direction and focus.

1.8 The consultants were informed that Sri Lankan-produced plant products such as extracts and oils were perceived to be of low quality which could in any case not find markets on the world scene because of high price. The latter was attributed principally to the relatively high labour costs compared with competitors such as Indian products. The consultants felt that though this was true, not enough emphasis had been placed by the industry on reducing production inefficiencies and improving product quality, both of which would improve the marketability of Sri Lankan products. A good example is to be found in the pine resin production facility visited. Although the raw material was abundant and of good quality (of a fine, pale colour and largely free from debris), the application of (too high) direct heat during distillation produced a discoloured rosin of low value. Equally the distillation process used very inefficient condensation with consequent significant loss of turpentine oil. Further, no facilities were available to allow the production of value-added products such as distilled oil. The use of steam heating and improved condensation would prevent these problems. Furthermore, CISIR has the capability to transfer suitably-modified technology to industry but the consultants perceived two issues which hampered the effectiveness of CISIR in this regard. The first was the lack of a suitable demonstration facility with which to prove to the factory owners and managers the value of the suggested modifications (and hence the value of their investment) and the second was the lack of personnel to carry out the endeavours. There is a significant need for the personnel additions on the lines suggested below in order that CISIR be able to carry out this part of its mission effectively.

1.9 The consultants were informed by industrial users that the charges for analysis and other services by CISIR were excessive. For example, industry objected to being charged 1500 Sri Lankan rupees for a gas/liquid chromatographic analysis of an essential oil sample. In the opinion of the consultants this price is probably not too high but the perception is difficult to dispel. The provision of improved service through the use of better analytical equipment and improved control methods (and consequently a more reliable service) may be one way to improve the profile, hence 'perceived value' of CISIR by industry, but more significant would perhaps be a radical change in pricing strategy to become more success orientated. This would need a major shift by management. For example, if industry desires advice on entering a more value-added sector such as the manufacture of a refined oil product, instead of paying an up-front fee, CISIR should consider a staged payment system whereby a modest proportion (say, 5%) of the total payment could be paid as a deposit, the balance being payable on successful implementation of the improved or new technology.

More radical, but highly appropriate with the increase in private enterprises in Sri Lanka, could be payment or partial payment to CISIR in royalties on the value-added product or even stock in the company concerned.

Both of these approaches would, the consultants believe, be welcomed by industry as a measure of CISIR's increased belief in itself and the provision of its services. Further, the latter would be greatly facilitated by the proposal in 1.5.2 (the creation of the commercial entity).

2. Phytopharmaceutical industry

2.1 The herbal based industry in Sri Lanka uses methods of preparation and quality control inadequate for Sri Lanka and certainly not appropriate to allow it enter the world market.

2.2 Quality control must be improved. CISIR should play the leading role in this activity both for Ayurvedic preparations and other plant-based products but this requires the internal changes outlined above.

2.3 CISIR should lead the scientific effort to establish standards for medicinal plant products by means, for example, of an Ayurvedic pharmacopoeia with detailed monographs on each plant drug. This could be carried out in association with BMARI.

2.4 CISIR should play a leading role in an interdisciplinary effort to undertake a critical evaluation of the efficacy and safety of Sri Lanka's Ayurvedic medicines.

In addition to the identity and quality issues outlined in 2.3 above, it could serve as a centre for high quality, controlled clinical studies to be undertaken in association with physicians using the hospital at BMARI. Traditional medicines are being evaluated as part of the health care provision in a number of countries throughout the world but often in a disorganized and *ad hoc* manner. Some of the staff at CISIR are already involved in preliminary *ad hoc* studies but in collaboration with BMARI and appropriate industry, CISIR could become a leader in the phytopharmaceutical arena worldwide.

2.5 Fundamentally, the capability of CISIR is appropriate for this type of work but facilities should be improved in a few key areas. The services section of the Agro Food Technology Division of the CISIR has adequate base facilities to support agronomical and process development work.

2.6 Non-Ayurvedic plant products could be developed such as value-added herbal extracts and fractions, and processed oils and components.

2.7 Advances in world technologies could be introduced to CISIR to enable it to develop unique, niche products. This however requires the changes outlined above.

2.8 Currently, lack of resources and appropriate experienced management has not allowed the degree of focus required if CISIR can realize its full potential and make its optimal contribution.

3. Agronomic aspects

3.1 Sri Lanka has a vast potential for exploitation of medicinal and aromatic plants through the home garden cultivation system as well as larger scale cultivation systems.

3.2 At present there is almost no commercial cultivation of medicinal and aromatic plants in the country except the cultivation of a few medicinal plants (*Aloe vera*, *Solanum xanthocarpum*, *Piper longum*) in home gardens and the cultivation of *Cymbopogon nardus* on a large scale in the southern provinces of the country.

3.3 The cultivation of *Cymbopogon nardus* is not economic to the farmers because of the fact that no R&D work has been done to reduce the cost of production through development of agrotechnology, particularly crop improvement.

3.4 At present, mainly only three Institutions, namely CISIR, the Department of Export Agriculture through its Export Agriculture Research Station and Department of Ayurveda through the BMARI research station, Nawinna, Maharagama, are engaged on work on medicinal and aromatic plants. All three organizations are most inadequately staffed to take up agronomical studies of indigenous crops such as domestication of valuable indigenous crops, introduction of exotic crops, development of agrotechnology, seed biology, nursery and planting management, scheduling irrigation, fertilizer management, weed management, harvest management, medicinal and aromatic plant-based cropping systems (for land use efficiency), plant protection, crop improvement through conventional and modern approaches of plant biotechnology.

3.5 Some agrotechnological work has been undertaken and continues to be carried out by individual research stations specializing in food and other crops throughout the country such as those devoted to coconut, tea, coffee and rubber. These activities function in isolation, of necessity in a disjointed manner, with much duplication of effort, apart from CISIR in the main, and without overall direction. This does not allow them or CISIR to benefit from the economies of scale a more coherent effort would allow. It is therefore advocated that appropriate inputs be taken from these external institutions and transferred to the newly created Natural Products Group.

4. Process plant and workshop

4.1 Some equipment and machinery in the Pilot Plant is non functional and requires to be either modified or repaired to make these operational. Modifications required are shown in Annex 8.

4.2 Further updating of the pilot plant facilities is needed by additional inputs to the plant.

4.3 No facility is available in the pilot plant to develop distillation technology on materials of a leafy or grassy nature.

4.4 Although a glass fractionating column of 10 litre capacity is available, it is not in working condition and also the capacity of this unit is too small to allow pilot scale technology to be developed in the field of essential oil fractionation.

4.5 There is a lack of methodology to be adopted in process scale up and quality parameters.

4.6 There are too few competent and trained staff to carry out pilot scale production in the field of essential oils and herbal drugs.

4.7 There are no processes at present in hand which could be transferred for scale up.

4.8 No mechanism exists to seek out appropriate current projects from industry.

4.9 There is poor coordination between the pilot plant staff and the management.

4.10 There is no link and liaison between the user industry and CISIR in general and the pilot plant staff in particular.

4.11 There is a lack of leadership and coordination within the discipline.

4.12 There is a financial crunch to carry out process development work.

4.13 The workshop facilities are very good and the staff is quite adequate. However additional training to welders in the art of stainless steel welding is needed. The list of machines available and the staff working in workshop is given in Annex 15.

5. RECOMMENDATIONS

1. General

1.1 CISIR should be designated the leading institution for R&D work needed for the development of a phytopharmaceutical industry in Sri Lanka. Such an industry is highly appropriate for Sri Lanka with both its natural resources and history. With appropriate inputs, CISIR has the real potential to become a world-class institution. As well as upgrading the existing technology used by industry, CISIR is well placed to lead the introduction of new technology.

The important potential of natural products in Sri Lanka warrants the creation of a significantly enhanced Natural Products Group within CISIR, operating across existing divisional barriers.

The activities of this upgraded Natural Products Group should be made more multidisciplinary within CISIR as a whole. This requires the overcoming of historical Divisional barriers but the consultants feel that it is the only way forward in the natural products group can regain its place as a leading research and development institution.

In addition to its traditional role for the development and transfer of technology, it should have the additional function of leading research in Sri Lanka on the validation of Ayurvedic medicine.

1.2 The staff of the enhanced Natural Products Group should be increased at two levels. Firstly, the recruitment of an industrially-experienced scientific manager to drive and focus the activities of the upgraded group is essential. This is a key position and a job description is provided in Annex 20. He should be assisted by the further provision of appropriate international consultants.

Secondly, experienced recently qualified postdoctoral staff should be recruited in all areas of expertise together with appropriate support staff. Details of these appointments follow in the appropriate sections. It is important to decrease the average age of scientific and technical personnel in all disciplines. Younger scientists will have experienced training in the use of modern technology - an important requirement for the upgraded group.

1.3 Limited laboratory and pilot equipment should be provided. Details of these acquisitions follow in the appropriate sections.

1.4 Training of selected scientists should take place in appropriate institutional or industrial laboratories in more developed countries, well experienced in quality control, standardization and research on medicinal and aromatic plants and for the pilot plant staff in process development and process scale up methodology. Details are provided below in the appropriate sections.

1.5 An outline action plan is provided in Annex 21. The first stage in the implementation of the plan should be the appointment of an experienced international consultant (Job Description in Annex 22). He should spend at least one month in Sri Lanka in close liaison with CISIR, Government and industry to prepare a detailed strategy for the execution of the later stages of the plan.

2. Phytopharmaceutical

2.1 A well-qualified Research Officer at postdoctoral level should be employed to direct the serious efforts envisaged in the standardization of medicinal plants. A job description is attached as Annex 23. This is another key position; this area should be developed as a vital service to the important Ayurvedic and other plant industries and would benefit from collaboration with BMARI. It is important that this position be staffed by an individual with pharmaceutical training and experience as opposed to the discipline of pure chemistry because his breadth of knowledge is required for interface with pharmaceutical, development, technical and regulatory personnel. The anticipated output would be a series of definitive monographs on the important medicinal plants of Sri Lanka.

2.2 Modest additions to the equipment of the Institute should be provided (Annex 24) to raise the level of the service provided by CISIR and so to encourage industry to use the full potential of CISIR. The equipment is also required for the effective carrying out of medicinal plant research in CISIR.

2.3 Further support staff should be provided (job descriptions attached as Annex 25) to assist in routine work and so release more-qualified staff for research.

2.4 A serious initiative should be mounted to transfer improved technology to the essential oil and oleoresin processors. Key elements of this initiative are described in the appropriate sections on agronomy and process technology, below.

3. Agronomic aspects

3.1 In order to introduce new crops (indigenous and exotic) in Sri Lanka and develop agrotechnology on various agronomical parameters including micropropagation and crop improvement, CISIR should take up a crash programme on these aspects for which the following action plan is required.

A1 Selection and identification of plant species.

A2 Domestication of selected crops (based on national priority bearing in mind use and resource constraints) available from natural habitats in Sri Lanka.

B Development of agrotechnology of potential crops for which preliminary work has already been done for technology transfer.

C Continuous crop improvement programmes through conventional and biotechnological methods should be adopted on the crops which are already under cultivation to improve and maintain economic return.

D Introduction of crops/high yielding varieties of new and exotic medicinal and aromatic plant species from different countries and their agrotechnological development for their propagation and large scale cultivation.

E Development of crop rotation and intercropping systems for medicinal and aromatic plants with plantation and other agricultural crops for increased efficiency of land use.

F Utilization of waste lands in general lowlands/salt affected soils, in particular through cultivation of suitable medicinal and aromatic crops. (Details are given in Annex 26).

3.2 For the proper and effective implementation of the proposed action plan, it is necessary that either a very senior level agronomist (Qualifications and Job Description given in Annex 27A) should be employed

or a consultant in the field of agronomy should be deputed by UNIDO under a split mission of six months in a phased manner. The consultant should be in Sri Lanka for two months in the beginning of the programme for introduction of new crops and layout of field trials on the crops on which preliminary work has already been done including planting of field trials and post planting care and monitoring. The consultant should visit Sri Lanka 3-4 times in a year at gaps of 3-4 months for a period of one month each time to record observations, analysis and processing of data and also to assess the progress of crop development. The appointment of a senior level consultant in the field of agronomy is essential since CISIR lacks leadership at a senior level who can manage to carry out such type of work in the well organized scientific manner.

3.3 In addition to the above, for effective implementation of the programme, CISIR should recruit a minimum of 2 scientists in agronomy, 2 scientists in genetics and plant breeding, one scientist in plant entomology and one scientist in plant pathology. These personnel can be recruited at junior level who will be trained by the consultant/senior agronomist employed for the programme. The Job Description of the junior level scientists is given in Annex 27B.

3.4 CISIR should take immediate steps to procure a small farm land of about 5 hectares in the initial stage, close to Colombo, for conducting initial field trials on different aspects of agrotechnology development.

3.5 At present, indiscriminate felling of trees with medicinal value and other flora is being continued which is disrupting the ecological balance and biodiversity of the country. In order to save the unique environments due to this deforestation, it is of the utmost necessity to discourage the above practice and also to take up a programme on afforestation by way of cultivating plants of medicinal value.

3.6 Efforts should be made to procure germplasm of those medicinal and aromatic plants which are not available in Sri Lanka but which can be propagated and cultivated in the conditions of this country.

3.7 Although some training has been imparted to the counterpart at CISIR on methods of R&D pertaining to breeding and cultivation of some medicinal and aromatic plants, it is necessary that the staff working in this field should be given aggressive training in order to have wide exposure in the field of cultivation and crop improvement and post harvest technology of these crops. For this, the UNIDO, Indo-Sri Lanka programme other international agencies could be contacted to seek their assistance.

4. Pilot plant

4.1 Necessary steps should be taken to update the pilot plant facilities by way of modifying/rectifying some of the existing equipment. The necessary recommendations for modifying and rectifying some of the existing equipment are given in Annex 8.

4.2 Steps should be taken to procure some additional equipment and machinery needed for updating the pilot plant facilities. (Details of additional input of plant machinery are given in Annex 28).

4.3 Identification of some market-led projects in the field of herbal drugs, essential oils and oleoresins and development of technologies on a pilot scale is needed.

4.4 Recruitment of a qualified chemical engineer (chief coordinator) at senior level who can guide and organize pilot plant process development work and design of chemical equipment. (Job description given in Annex 29).

4.5 Recruitment of 2 qualified chemical engineers at junior level to carry out pilot production and process scale up. (Job description also given in Annex 29).

4.6 Training to be imparted to existing staff in process development and process scale up methodology.

4.7 Link and liaison to be created between CISIR and user industry to know their problems and update their technologies. For this a liaison cell has to be setup within CISIR to create contacts and gain confidence of the user industry who are at currently apprehensive about the competence of CISIR.

4.8 On the spot demonstrations to be carried out by pilot plant staff to convince user industry about the proven technologies developed by CISIR in the field of herbal drugs and essential oils.

4.9 Steps should be taken to seek financial assistance from the Government of Sri Lanka through some international agencies or funding organizations to meet the financial inputs for updating of pilot plant equipment and machinery.

4.10 The consultants are of the firm opinion that if the plant equipment and machinery required for the process development of herbal drugs and essential oils is not updated and the qualified staff is not recruited, neither new technologies can be developed nor existing technologies with the user industry can be improvised by CISIR with the result, that this very important export-orientated industry in the field of herbal drugs and essential oil may face a crisis in the near future to compete in the international market which would be a great loss to this country in general and the related industries in particular. This action-orientated programme for the pilot plant is outlined in Annex 30.

Annex 1

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION
SI/SRL/96/802/11-52/0730AO

Post title Consultant in Plant drug development

Duration 1.0 m/m

Date required ASAP

Duty station Colombo, Sri Lanka

Purpose of project To assist in setting up of a goal oriented research and development programme to promote the phytopharmaceutical industry in Sri Lanka by developing expertise in quality control, agrotechnology and process technology for the production of value added herbal preparations.

Duties

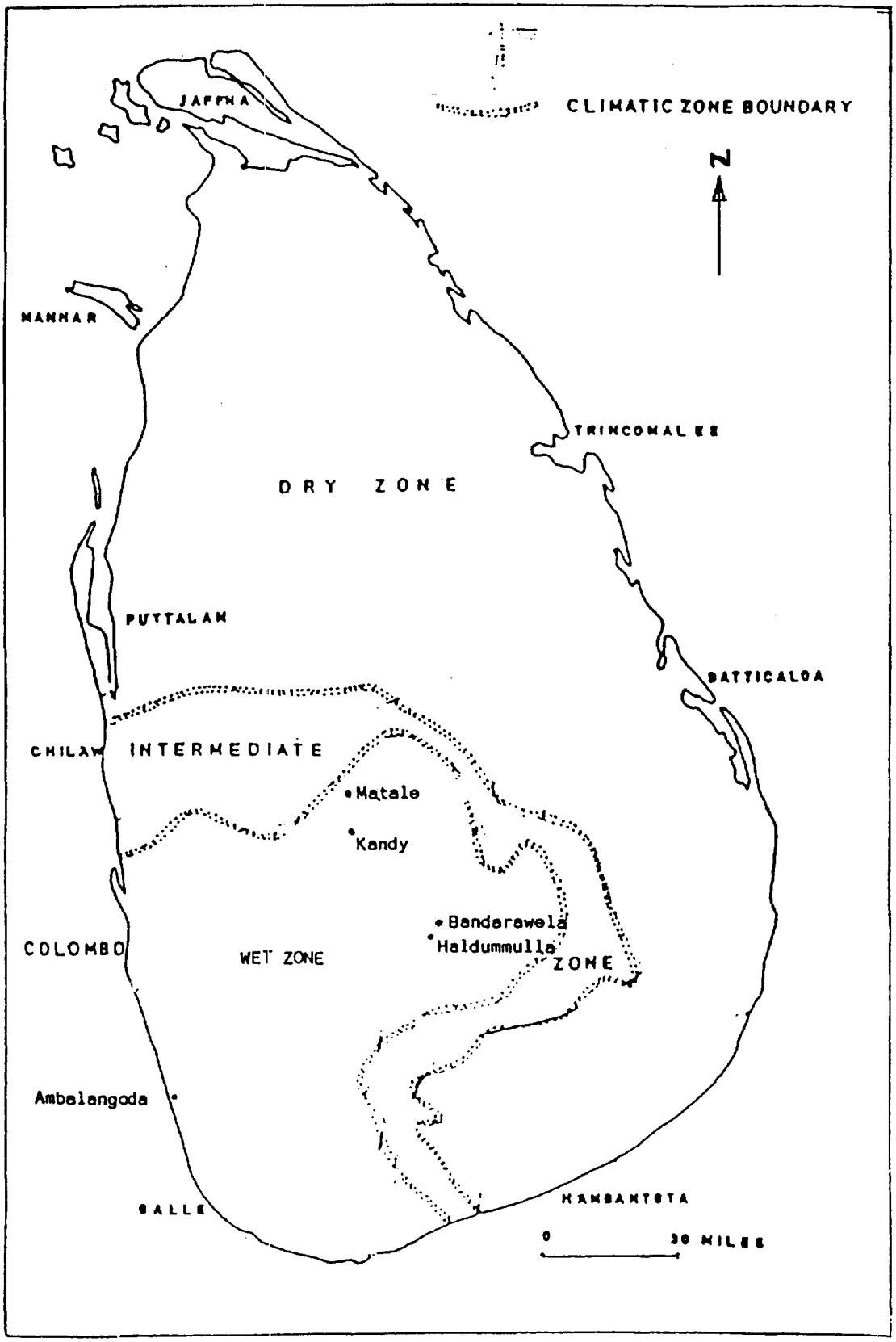
- Assess the R & D work in drug development presently carried out at the Ceylon Institute for Scientific and Industrial Research (CISIR) and other institutions.
- Discuss the problems and constraints faced by CISIR with the Chairman and the Director and other staff at the CISIR and propose remedial action.
- Advise the counterpart staff on methods to be used for plant based drug development.
- Assist counterpart staff in solving problems they have encountered during drug development and formulation into dosage forms.
- Demonstrate methods that should be incorporated into a drug development programme.
- Prepare an action oriented plan for R & D work needed for the development of the phytopharmaceutical industry in Sri Lanka.
- Adviseon how to improve the R & D and industrial application work on plant drug development presently being carried out in Sri Lanka.
- Submit a comprehensive report (in a hard copy and on a diskette using Word Perfect 5.1/5.2) on his findings and recommendations for a goal oriented R and D programme to promote and service the phytopharmaceutical industry in Sri Lanka.

Qualifications: A pharmacist/chemist with postgraduate qualification and over 10 years experience in plat drug development.

Language: English

Annnex 2

SKETCH. MAP OF SRI LANKA



Annex 3

List of people met

N T Amarasinghe	Manager, Pilot Plant, Process and Plant Engineering Division, CISIR, PO Box 787, Bauddaloka Mawatha, Colombo 7
L S R Arambewela	Senior Research Officer, CISIR, P O Box 787, 363, Bauddhaloka Mawatha, Colombo 7
R Bahardeen	General Manager, Bio Extracts (Pvt) Ltd., Orugodawatte and 10 Mile Post Road, Colombo 3
K R Dayananda	Senior Research Officer, Natural Products Development Group/AFTD, CISIR, 363, Bauddhaloka Mawatha, Colombo 7
M A T De Silva	IUCN Sri Lanka Country Office, 7, Vajira Lane, Colombo 5
N D Ediriweera	Head, Agro and Food Technology Division, CISIR, PO Box 787, 363, Bauddhaloka Road, Colombo 7
H P M Gunasena	Chairman, Faculty of Agriculture, University of Peradeniya
T Gunawardana	Assistant Resident Representative, Sustainable human development, UNDP, 202-204, Bauddhaloka Mawatha, Colombo 7
S Jayakody	Factory Manager, Link Natural Products (Private) Ltd., Malinda, Kapugoda
P Jayanetti	Senior Scientist, Department of Ayurveda, Bandaranaike Memorial Ayurvedic Research Institute, Navinna, Maharagama
S Jayasinghe	Manager, Services, Agro and Food Technology Division, CISIR, PO Box 787, 363 Baudhaloka Mawatha, Colombo 7
P M Jayatissa	Director, CISIR, 363 Bauddhaloka Mawatha, Colombo 7
W Jayawardena	Chairman, Link Natural Products (Pvt) Ltd., 97A, Galle Road, Colombo 3
G Karunapala	General Manager, State Pharmaceuticals Manufacturing Corporation of Sri Lanka, 11, Sir John Kotalawala Mw., Kandawala Estate, Ratmalana
N Karunatilake	Chief Quality Controller, Bio Extracts (Pvt) Ltd., 10, Mile Post Avenue, Colombo 3
P M Kavikara	Managing Director, D Peiris & Co Ltd., 31, St John's Road, Colombo 11
D Nugawela	Managing Director, Link Natural Products (Private) Ltd., 97A, Galle Road, Colombo 3
W Pathirana	Production Manager, State Pharmaceuticals Manufacturing Corporation of Sri Lanka, 11, Sri John Kotalawala Mw., Kandawala Estate, Ratmalana
D A Perera	Managing Partner, Eoas International, 34/3, Lumbini Avenue, Ratmalana

J Ranatunga	Senior Research Officer, Agro Food Technology Division, CISIR, 363, Bauddhaloka Mawatha, Colombo 7
C K Samaraweera	Managing Director, Conifer Products Processing (Pvt) Ltd., Green Gables, Nugathalawa
L Senaratne	Acting Assistant Director, Bandaranaike Memorial Ayurvedic Research Institute, Nawinna, Maharagama
P E Soysa	Director-General, Natural Resources, Energy and Science Authority of Sri Lanka, 47/5, Maitland Place, Colombo 7
J Weerasinghe	Superintendent, Ayurveda Drugs, Hettigoda Industries (Pvt) Ltd., 33/3, Sri Dharamarama Road, Ratmalana
P J Wickremansinghe	Deputy Director, Research Field Station, Ministry of Export Agriculture, Matale
P N S Wijeratne	Assistant Director, Sri Lanka Export Development Board, Trans Asia Building, 115, Sir Chittampalam A Gardiner Mawatha, P O Box 1872, Colombo 2
L M Wijesundra	Chief Pharmaceutist, Sri Lanka Ayurvedic Herbal Products Company, PO Box 20, Navinna, Maharagama
R O B Wijesekera	Chairman, CISIR, 363, Bauddhaloka Mawatha, Colombo 7

Annex 4

List of Institutions and Organizations Visited

Bandaranaike Memorial Ayurvedic Research Institute, Navinna, Maharagama

Bio Extracts (Pvt) Ltd., 10 Mile Post Road, Colombo 3

Botanic Garden, University of Peradeniya

CISIR

Conifer Products Processing (Pvt) Ltd., Green Gables, Nugathalawa

Department of Export Agriculture, Research Station, Matale

EOAS International, 34/3 Lumbini Avenue, Ratmalana

Hettigoda Industries (Pvt) Ltd., 33/3 Sri Dharamarama Road, Ratmalana

IUCN Sri Lanka Country Office, 7 Vajira Lane, Colombo 7

Link Natural Products (Private) Ltd., Malinda, Kapugoda

Ministry of Indigenous Medicine, Herbal and Medicinal Plant Garden, Haldummulla

Natural Resources, Energy and Science Authority of Sri Lanka, 47/5 Maitland Place, Colombo 7

Sri Lanka Ayurvedic Herbal Products Corporation, Ministry of Indigenous Medicine, 94 Old Kottawa Road, Narwinna, Maharagama

Sri Lanka Export Development Board, 115 Sir Chittampalam A Gardiner Mawatha, Colombo 2

State Pharmaceuticals Manufacturing Corporation of Sri Lanka, 11, Sir John Kotalawala Mawatha, Kandalwala Estate, Ratmalana

Annex 5

Equipment currently available in the Food and Agro Technology Division, CISIR

Chromatographic

Gas/liquid chromatograph, Varian	1
Gas/liquid chromatograph, Shimadzu	2
High performance liquid chromatograph, Waters	1
Variable wavelength uv detector, Kanuer	1
Fluorescence detector, Shimadzu	1
Thin-layer chromatograph plate spreader, Camag	1
Uv observation cabinet	1
Fraction collector, Gilson	1
Fraction collector, LKB	1

Other

Laboratory rotavopor, Buchi	3
Centrifuge, Hereaus	1
Analytical balance, Bosch	1
Analytical balance, Sartorius	1
Top-loading balance, Sartorius	1
Micro balance, Sartorius	1
Water analyser, Sartorius	1
Distillation apparatus, Kottermann	1
Flavour trap, Fryka	1
Computer 486, JRL	2
Computer 286, Unisys	2

Annex 6

Natural Products Development Group, Food and Agro Technology Division, CISIR

List of Staff

Dr U M Senanayake	Senior Research Officer, (Special Grade) B.Sc (NZ), M.Sc (NZ), Ph.D (UNSW) M I Chem C, C Chem
Dr (Mrs) L S R Arambewela	Senior Research Officer, (Special Grade) Manager - Natural Products Development Group B.Sc (Hons), Ph.D (SL), F I Chem C, C Chem F.I.A.M.
Dr J Ranatunga	Senior Research Officer, B.Sc (Spec.) Agriculture (Peradeniya) Post Graduate Diploma (UNSW), Ph.D (UNSW) Australia
K R Dayananda	Senior Research Officer, M.Phil, Grad. I Chem, M I Chem C, C Chem
M S B Mohottalage	Research Officer, B.Sc (Hons), M.Phil, M I Chem C. C Chem
C S Basnayake	Research Officer, B.Sc (Spec.) Chemistry (Peradeniya)
Ms V S Bandara	Technical Assistant Grade I, Chem,C, LTCC
Ms P I P K Fernando	Technical Assistant, LTCC
Saman Weeraratne	Technical Assistant Grade I, Chem C, LTCC
Ms Manel Weerasekera	Technical Assistant, N.D.T
Ms W S K Fernando	Clerk/Typist
M V M Faizal	Lab. Attendant

Annex 7

Staff of the Plant and Process Engineering Group, CISIR

1.	Mr. P. Gunawardena C.Eng.,MI Mech.Eng.(London) F.I.E.(S.L.), H.N.D.(Mech.)	-	Head. Process & Plant Engineering Division
2.	Ms. N.T. Amarasinghe Dip.,M.Sc.(Chem.Eng.) Bradford C.Eng., M.I.Chem.Eng., F.I.E.D.	-	Manager, Pilot Plant
3.	Mr. N.A.T.D. Gunasekera B.Sc. (Chem.Eng.)	-	Research Officer (on contract basis)
4.	Ms. P.L.C. Dias N.D.T. (Chem.Eng.) M.I.E.D.	-	Senior Technical Officer
5.	Mr. P. Jeyachandran N.D.T. (Mech.Eng.)	-	Senior Technical Officer
6.	Mr. M.S.N. Perera N.D.T. (Chem.Eng.)	-	Technical Assistant
7.	Mr. J.A.P.V. Jayasinghe N.D.T. (Chem. Eng.)	-	Technical Assistant
8.	Mr. A.A.V. Amarasinghe N.D.T. (Chem.Eng.)	-	Technical Assistant
9.	Mr. M.S. Mannapperuma	-	Technical Assistant
10.	Ms. Y. Athukorala	-	Draughtsman
11.	Ms. K.P.R.T. Perera	-	Clerk/Typist
12.	Mr. G. Sirisena	-	Glass Blower
13.	Mr. D.M. Weerawardena	-	Boiler Operator
14.	Mr. M. Dayananda	-	Electrician
15.	Mr. B.W. Prematileka	-	Laboratory Attendant

Annex 8

List of equipment currently available in the Process and Plant Engineering Division, CISIR

	Equipment	Features	Remarks
1.	Vacuum still	Capacity: 45L/batch maximum.	working order
2.	High speed centrifuge	Capacity: liquid feed rate of 30-40 l per hr	working order
3.	Tray drier (oil fired)	Capacity: 100 - 200 kg per batch 30^0C - 100^0C	working order
4.	Oil Expeller	Capacity: feed rate 20 - 50 kg/hr	working order
5.	Ribbon mixer	Capacity: 50 kg of material/batch	working order
6.	Universal Grinder	Capacity: Feed rate 40 - 60 kg/hr of cereals and grains	working order
7.	Vibratory screen	Capacity: Feed rate 10 - 20 kg/hr	working order
8.	Plate Heat Exchanger	Capacity: 25 kcal/hr	working order
9.	Toothed colloid Mill (wet grinder)	Capacity: 20 kg/hr	working order
10.	Colloid Mill	Capacity: 20 l/hr	working order
11.	Plate and Frame Filter Press	Capacity: 2-4 l/min	working order
12.	Cross Beater Mill	Capacity: 5-10 kg/hr	working order
13.	Hammer mill	Capacity: 1-2 kg/hr	working order
14.	Jaw Crusher	Capacity: 1 kg/hr	working order
15.	Disc Grinder	Capacity: 2-3 kg/hr	working order
16.	Roll Mill	Capacity: 2-3 kg/hr	working order

	(Adjustable)		
17.	End Runner Mill	Capacity: 1 kg/hr	working order
18.	Twin blade Universal Mixer	Capacity: 25 litres	working order
19.	Multi Purpose Extraction unit	Capacity: 15 kg/batch	working order *

* This multipurpose unit needs following modifications to make it properly functional. The unit is being used without any insulation. Proper insulation to extractor body, vapour line, reboiler and its vapour line is to be provided with glass wool. Provision to be made to provide cohabition system by connecting the drain of the separator to the bottom of the still with a S.S. pipe through a U tube seal. The condenser of the reboiler should be followed by a chiller to avoid solvent losses during solvent recovery under vacuum. This chiller should be fixed between the condenser and the receiver and to be connected with existing chilling plant for brine circulation. The chiller could be made out of a S.S. 304 coil having 1 sqmt. cooling surface housed in closed M.S. cylindrical vessel with provision to circulate brine solution outside the coil.

20.	Fruit Pulper	5 - 10 kg/hr	working order
21.	Snow Maker	3 kg/large cylinder	working order
22.	Mincer	10-20 kg/hr	working order
23.	Liquid/Liquid Extractor		working order
24.	Wiped Film Evaporator	Capacity: for tea extract 10l/hr	product pump and distillate pump need replacement.
25.	Continuous Extractor	Capacity: Raw material feed rate: 8-10kg/hr	Hot water circulation system of trough, feed water heating element and trough inclination system need replacement.
26.	Twin screw extruder	Capacity: feed rate 10 -25 kg/hr	Needs replacement of armature of the dc drive motor.
24.	Belt Drier	Capacity: 3-5 kg/hr	Not in use
25.	Fractionating column		Needs replacement of high vacuum pump.

26.	Spray Drier	Capacity: Product rate 3-5 kg/hr	Pre-setting and controlling of temperature of hot air is not possible due to non availability of the controlling system. Non availability of nozzle type atomiser. **

** This should be provided by procuring a thermostatic control range 0-200^{0}C with a sensor and fitted to the unit. A nozzle type atomiser or a nozzle of an oil burner to be incorporated in the system so that this unit can be put into operation.

Annex 9

Staff of the Laboratory Services unit in the Chemical and Environmental Technology Division, CISIR

A M Mubarak BSc, PhD, CChem, FIChemC	Manager, Chemical Technology Group
Ms Suneetha de Costa, BSc, MPhil, CChem, MIChemC	Quality Manager
Ms Sharmini Wikremaratne, BSc, MSc	Deputy Quality Manager
W R K Fonseka, BSc (Eng)	Research Officer
G V Mallika, BSc, MPhil	Research Officer
	Manager, Laboratory Services
	Acting Technical Manager
	Head of Division
	Deputy Technical Manager
	Manager, Environmental Technology

A number of positions are vacant and some duplication of responsibility is currently operated.

Annex 10

List of equipment in the Laboratory Services Unit, Chemical and Environmental Technology Division, CISIR

1 Turbo blending Karl Fischer volumetric apparatus
2 Shimadzu gas/liquid chromatograph
3 Low/medium pressure high performance liquid chromatograph
4 Ommi mixer and microhomogenizer
5 Refrigerated centrifuge
6 Gas/liquid chromatograph with electron capture detector
7 Brookfield viscometer
8 Flame photometer
9 Karl Fischer moisture analyser
10 Heavy duty mixer
11 Gas analyser
12 Cooled incubator
13 Varian atomic absorption apparatus
14 Mercury analyser with capability for low level detection

In addition, some older equipment is available:

1 Shimadzu gas/liquid chromatograph
2 Ion liquid chromatograph
3 MEF2 Universal Cameron microscope
4 Shimadzu QP1000A gcms
5 Amino acid analyser
6 Model 552 double-beam UV/VIS spectrophotometer
7 Fluorescence spectrometer

Annex 11

List of machinery available in the workshop, CISIR

Center lathes (mid size)	3
Universal milling machine	1
Shaping machine	1
Surface grinder	1
Upright drilling machines	3
Manual guillotine shear	1
Light duty plate rolling machine	1
Welding machine	1
Plasma cutter	1
Tig welding machine	1
Power hammer	1
Bending machine	1
Fly press	1
Spray painting machine	1
Multi Purpose wood working machine	1
Cross cutting machine	1
Band saw	1
Power hacksaw	1
Gas welding/cutter set.	1

Annex 12

List of staff in the workshop, CISIR and their respective skills

1.	G.V.D. Ranjithsena	Lathe Machinist
2.	L.N.P. Fernando	Lathe Machinist
3.	W.P. Weerawardena	Machinist (contract)
4.	V.D. Ganegoda	Fitter
5.	C.G. Fonseka	Welder/Fitter
6.	M.K. Piyalal	Welder
7.	W. Rozairo	Carpenter
8.	S. Solaman	Carpenter
9.	W. Coonghe	Carpenter
10.	M.U. Nimalsiri	Carpenter
11.	N.L. Perera	Carpenter
12.	G. Sarath Kumara	Carpenter
13.	N. Weerasinghe	Electrician
14.	D. Wijeratne	Electrician
15.	J. Sujeewa	Electrician
16.	U. Amarajeeewa	Motor Mechanic
17.	B. Jayawardena	Motor Mechanic
18.	S. R. Rodrigo	Labourer
19.	U.A. Kannangara	Labourer
20.	C. Witharana	Labourer
21.	E. Premadasa	Fitter
22.	H.K. Somasiri	Painter
23.	D.L. Amarasinghe	Painter
24.	L.D. Thilakeratne	Tool Issuer
25.	S.P. Dharmaratne	Clerk/Typist
26.	R. Chandana	Casual

CHARGE HANDS:

1.	W.T. Fernando	(Garage)
2.	D.W. Wijesuriya	(Carpentry)
3.	D. Dantanarayana	(Electrical)
4.	P.A. Robinson	(Fitting & Welding)

Annex 13

QUALITY TEST REPORT

QUALITY COMPARISION

A. Organoleptic characteristics		Present Sample	Standard/Previous Sample
1. Colour & Texture	:		
2. Odour	:		
3. Taste	:		

PHYSICAL CHARACTERISTICS :

1. Brix	:		
2. Viscosity	:		
3. Specific Gravity	:		
4 Alcohol & water free solids in 10 ml	:		
5. pH value	:		

C. Comments:- .....

.....

.....

.....

Proceed with production/suspend production for further investigations.

.....

Quality control officer

Date.....

Annex 14

Export Statistics for the Last 3 years

	1993		1994		1995	
	Volume (MT)	Value (Rs.Mn)	Volume (MT)	Value (Rs.Mn)	Volume (MT)	Value (Rs.Mn)
Cinnamon	8,728	1645.16	9,016	1626.12	9,852	1721.31
Pepper	7,847	401.24	3,407	316.99	2,768	357.97
Cloves	1,650	71.87	971	41.3	1,116	65.36
Nutmeg	760	33.9	656	35.4	741	49.80
Mace	24	1.7	22	3.7	14	3.28
Cardamom	14	7.5	26	10.8	19	7.97
Coffee	1,087	47.06	4,371	375.4	1,281	127.40
Cocoa	53	2.7	15	0.91	10.5	.08

Source: Sri Lanka Customs

PNSW/ana/19/3/96

Product	Country	1993 Quantity (MT)	1993 Value (Rs Mn)	1994 Quantity (MT)	1994 Value (Rs Mn)	1995 (Jan - Nov) Quantity (MT)	1995 (Jan - Nov) Value (Rs Mn)
Cardamom	Yemen	-	-	7.00	2.85	-	-
	Singapore	2.50	1.68	6.00	2.23	7.22	2.26
	U.A.E.	-	-	3.75	1.45	-	-
	Sweden	-	-	3.07	0.78	-	-
	South Africa	-	-	1.40	0.68	-	-
	Maldive Islands	1.99	0.52	1.70	0.58	2.55	1.06
	Egypt	7.30	2.40	-	-	-	-
	Japan	1.01	0.70	-	-	0.07	0.007
Cloves	Saudi Arabia	775.40	42.19	362.00	17.33	468.30	31.93
	India	119.80	1.85	43.15	1.13	72.90	4.37
	U.A.E.	31.20	1.48	25.01	1.30	46.00	2.96
	U.K.	84.10	3.49	68.50	3.77	99.90	5.54
	Russia	-	-	3.03	0.43	18.40	1.25
	U.S.A.	24.10	1.95	11.17	0.64	34.00	2.19
	Singapore	111.00	7.22	1.09	1.28	1.02	1.29
	Maldive Islands	16.05	0.91	3.90	0.95	16.60	1.17
	Kuwait	-	-	3.50	0.15	15.60	1.17
	China Taiwan	20.00	0.21	33.50	0.41	30.00	0.38
	Egypt.	-	-	-	-	15.00	0.19
Cinnamon	Mexico	3658.60	763.60	3282.00	640.89	3663.10	700.59
	U.S.A.	1554.30	308.40	1280.00	256.24	812.10	165.49
	Pery	411.40	70.67	716.70	119.58	637.80	105.90
	Colombia	431.20	72.53	541.10	87.37	612.20	103.20
	Spain	339.30	74.20	365.80	81.80	322.02	60.70
	Equador	217.51	36.73	303.10	54.65	300.77	53.80
	Chile	226.10	46.32	245.60	38.34	254.20	42.60
	Gautamala	40.80	11.52	144.20	25.73	277.50	54.60
	Netherlands	120.78	15.04	120.50	18.90	100.40	16.26
	Italy	128.44	26.31	149.40	21.17	158.05	27.57
	U.K.	96.78	12.58	153.00	16.14	127.40	9.83
	Egypt	7.00	1.14	0.99	0.087	-	-

Product	Country	1993 Quantity (MT)	1993 Value (Rs Mn)	1994 Quantity (MT)	1994 Value (Rs Mn)	1995 (Jan - Nov) Quantity (MT)	1995 (Jan - Nov) Value (Rs Mn)
Pepper	Pakistan	2144.80	95.33	845.00	648.10	350.00	23.70
	India	855.00	44.24	880.00	93.10	494.60	72.00
	U.A.E.	632.90	31.22	15.10	1.20	164.70	19.60
	Germany	522.00	24.92	2.39	1.35	4.63	1.08
	U.S.A.	453.60	24.85	388.50	36.30	343.00	46.12
	Greece	439.00	24.26	78.80	7.60	33.80	5.31
	Poland	379.00	17.78	65.00	5.50	21.50	2.86
	Turkey	253.50	13.39	-	-	14.00	1.85
	U.K.	252.20	13.34	241.00	21.40	423.50	61.35
	Netherlands	247.00	12.90	49.00	4.41	14.00	1.40
	Yemen	142.00	6.92	0.05	0.001	-	-
	Saudi Arabia	110.40	4.95	27.00	3.00	53.50	7.63
	Egypt	-	-	-	-	11.0	1.80
Nutmeg	Pakistan	227.60	7.46	216.70	7.57	120.00	5.67
	U.A.E.	108.00	4.21	30.50	1.21	154.00	10.21
	Jordan	101.00	4.24	11.00	0.42	6.00	0.30
	U.K.	42.36	1.28	0.025	0.002	14.00	0.68
	Tunisia	42.00	3.37	-	-	5.00	0.35
	Yemen	42.00	1.60	45.00	1.90	43.80	2.86
	Bangaladesh	36.08	1.62	53.40	3.05	57.00	3.57
	India	25.00	0.63	85.30	3.37	162.70	10.50
	Saudi Arabia	22.50	0.85	7.00	0.50	10.00	0.61
	Russia	21.04	1.99	15.60	1.67	1.80	0.19
	Egypt	13.00	0.98	42.00	2.98	-	-
Mace	Germany	14.17	0.65	5.10	0.70	-	-
	U.A.E.	4.50	0.25	5.20	0.95	5.25	1.33
	Pakistan	4.00	0.26	3.00	1.11	-	-
	Bangaladesh	1.00	0.07	2.00	0.33	1.20	0.29
	Singapore	0.50	0.40	-	-	-	-
	U.K.	-	-	3.10	0.42	-	-
	India	-	-	-	-	1.90	0.39

Annex 15

AROMATIC PLANTS GROWN IN SRI LANKA

Scientific name	Common name	Vernacular name	Family
Cinnamomum zeylanicum	Cinnamon	Kurundu	Lauraceae
Cymbapopogan citratus	Lemongrass	Sera	Gramineae
Cymbapogan nardus	Ceylon citronella	Heen pangiri	Gramineae
Elettaria cardanomum	Cardamon	Karandamungu	Zingiberaceae
Eugenia caryophyllata	Clove	Karabu	Myrtaceae
Myristica fragrance	Nutmeg	Sadikka	Myristaceae
Myristica fragrance	Mace	Vasavasi	Myristaceae
Pinus caribaea	Turpentine	Turpentine	
Piper nigrum	Pepper	Gammiris	Piperaceae
Piper betel	Betel	Inguru	Zingiberacea
Vetiveria zizanioides	Vetiver	Savandara	Gramineae
Zingiber officinalis	Ginger	Inguru	Zingiberaceae

Annex 16

AROMATIC PLANTS COMMERCIALLY GROWN IN SRI LANKA (1995)

Scientific name	Vernacular name	Part used	Annual production (MT)	Cost US$ Million
Cinnamomum zeylanicum	Kurundu	bark	11872	31.2
		(oil)	4.73	1.4
		leaf oil	180	2.5
Cymbapogan nardus	Heen pangiri	leaf oil	150	0.76
Elettaria cardanomum	Karandamungu	fruit	1039	0.15
		(oil)	0.3	0.05
Eugenia caryophyllata	Karabu	bud	1550.53	1.3
		stem		0.03
		bud oil		0.007
Myristica fragrance	Sadikka	seed	893.7	0.91
		(oil)		0.13
Myristica fragrance	Vasavasi	aril	45	0.06
Pinus caribaea	Turpentine	resin	16	0.008
Piper nigrum	Gammiris	seed	14671	5.9
		(oil)		0.05
Piper betel	Bulat	leaves	1811	1.22
Zingiber officinalis	Inguru	Rhizome	5800	0.008

Annex 17

THE THREATENED MEDICINAL PLANTS OF SRI LANKA

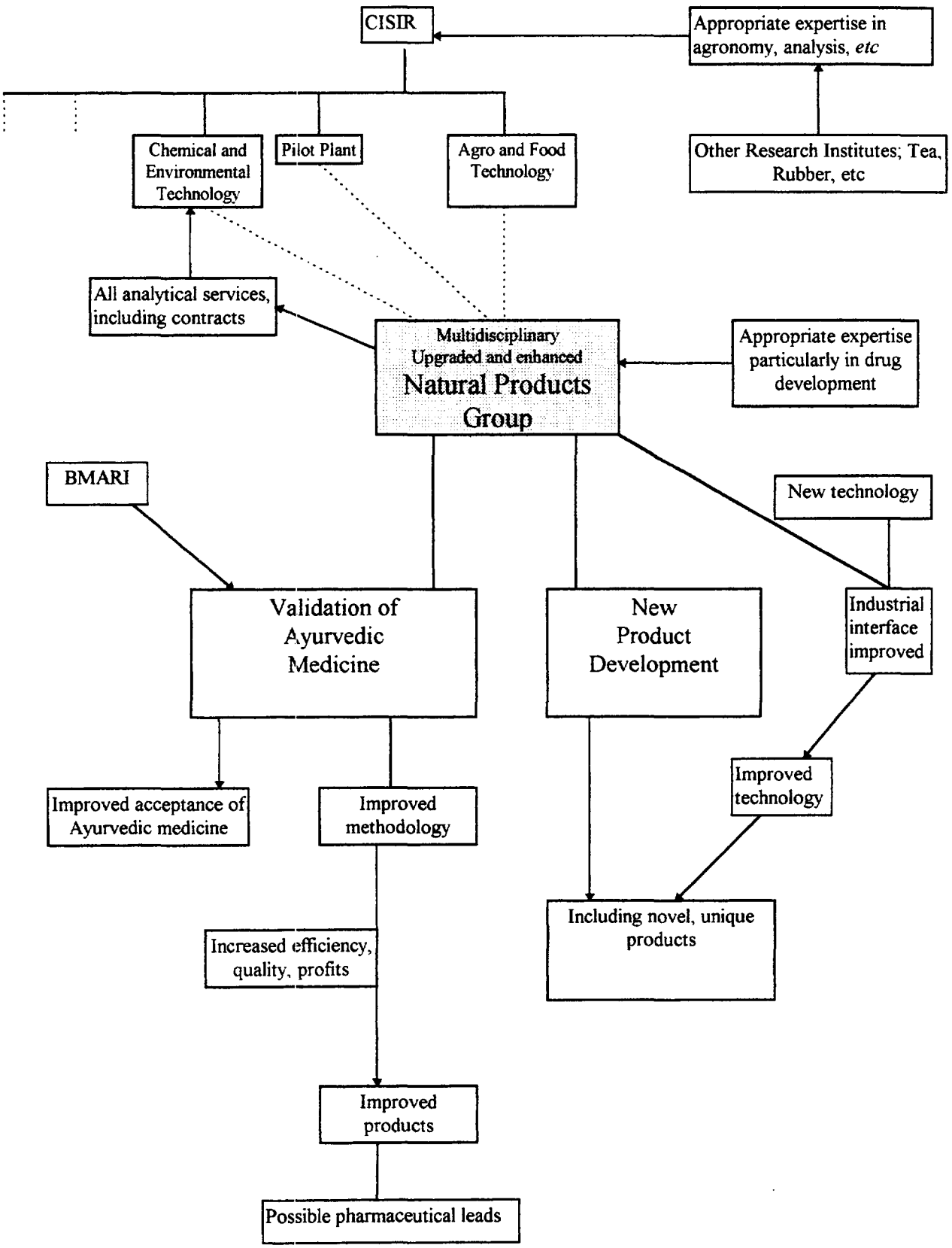
1. Lycopodium clavatum L.
2. Lycopodium phlegmaria L.
3. Actiniopteris radiata (Sw.) Link
4. Helminthostachys zeylanica (L. Hook)
5. Ophioglossum pendulum L.
6. Cycas circinalis L.
7. Semecarpus obovata Thw.
8. Semecarpus parvifolia Thw.
9. Artabotrys hexapetalus (L.f) Bhandhari
10. Polyalthia persicaefolia (Hook. f. and Thomas.) Thw.
11. Xylopia nigricans Hook. f and Thoms.
12. Hunteria zeylanica (Retz.) Gardn. ex. Thw.
13. Petchia ceylanica (Wight) Livera
14. Rauvolfia serpentina (L.) Benth. ex Kurz.
15. Cryptocoryne spiralis (Ritz.) Fischer
16. Rhaphidophora decursiva (Roxb.) Schott.
17. Hoya pauciflora Wight
18. Marsdenia tenacissima (Roxb.) Moon
19. Oxystelma esculentum (L.f) R.Br.ex Schult.
20. Balanophora fungosa J.R.and G.Forst.
21. Impatiens repons Moon
22. Gynura hispida Thw.
23. Xanthium indicum Konig
24. Kalanchoe laciniata (L.) Pers.
25. Scirpodendron ghaeri (Gaertn.) Merr.
26. Vatica obscura Trim
27. Dioscorea spicata Roth
28. Cotylelobium scabriusculum
29. Hopea cordifolia (Thw.) Trim.
30. Shorea disticha (Thw.) Ashton
31. Shorea ovalifolia (Thw.) Ashton
32. Vatica obscura Trim.
33. Diospyros atrata (Thw.) Alston
34. Diospyros attenuata Thw.
35. Diospyros oppositifilia Thw.
36. Diospyros quaesita Thw.
37. Elasocarpus montanus Thw.
38. Agrostistachys hookeri (Thw.) Hook.f
39. Cleistanthus collinus (Roxb.) Hook.f.
40. Putranjiva zeylanica (Thw.) Muell. Arg.

41. Calophyllum cuneifolium Thw.
42. Hippocratea macrantha Korth.
43. Cinnamomum litseifolium Thw.
44. Cryptocarya membranacea Thw.
45. Acacia ferruginea DC.
46. Adenanthera bicolor Moon
47. Albizia amara (Roxb.) Boivin
48. Cassia senna L.
49. Caesalpinia crista L.
50. Caesalpinia major (Medic.) Dandy and Exell
51. Cynometra iripa Kostel.
52. Desmodium gangeticum (L.) DC.
53. Pericopsis mooniana (Thw.) Thw.
54. Memecylon grande Retz.
55. Coscinium fenestratum (Gaertn.) Colebr.
56. Nymphoides aurantiaca (Dalz.) Kuntze
57. Broussonetia zeylanica (Thw.) Corner
58. Ficus trimenii King
59. Olea paniculata R.Br.
60. Dendrobium maccarthiae Thw.
61. Rhynchostylis retusa Bl.
62. Areca concinna Thw.
63. Nypa frutican Wurmb.
64. Tricalysia erythospora (Thw.) Alston.
65. Palaguium thwaitesii Trim
66. Pentpetes phoenicea L.
67. Pterygota thwaitesii (Mast.) Alston

SOURCE : The threathened plants of Sri Lanka- UNESCO-Man and the bisphere National Committee for Sri Lanka Pub. No 10.

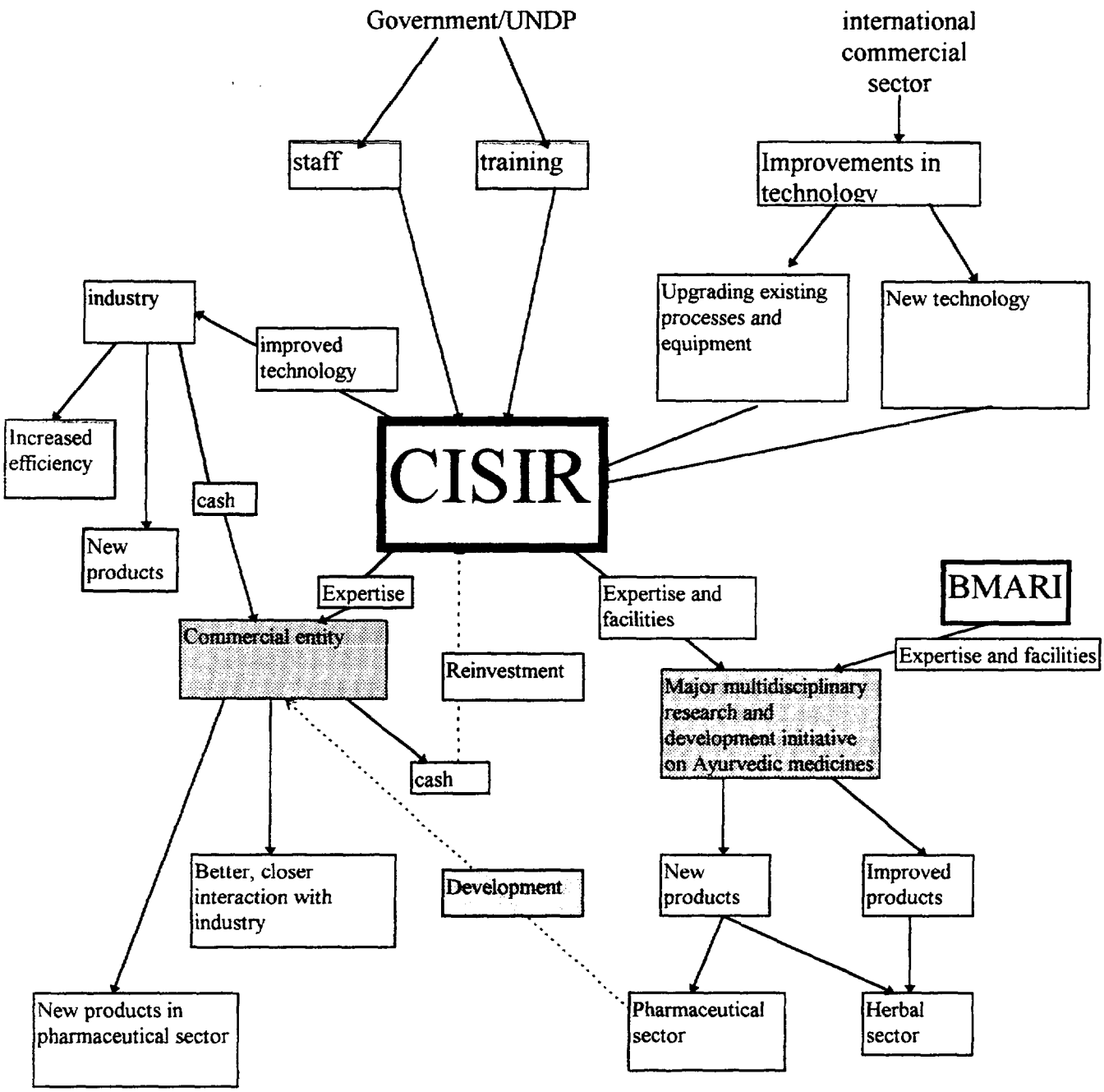
Annex 18

Diagrammatic representation of upgraded Natural Products Group within CISIR



Annex 19

Diagrammatic representation of changes proposed to facilitate the industrial interface with CISIR



Annex 20

Qualifications, experience and job requirements of Senior Scientific Manager

Qualifications and Experience	:	First degree in pharmacy plus a Ph.D in a pharmaceutically related discipline with minimum 10 years' experience of phytopharmaceutical research and development with proven dynamic leadership in the management of R&D. Industrial experience in manufacturing and/or research is an advantage.
Job requirements	:	To provide leadership to the combined agronomic, analytical, research and development activities of the upgraded Natural Products group - with special emphasis on the new key area -phytopharmaceuticals- and to liaise with industry and through the commercial arm of CISIR.

Annex 21

Development of phytopharmaceutical industry of Sri Lanka

Outline action plan

Objectives

1.1 Improvements in **organisation of CISIR** to enhance capability and technology transfer in order to become a leading 'centre of excellence'.

Introduction of **matrix management** system to strengthen Natural Products Group to maximally and efficiently utilise the expertise of CISIR as a whole (*i.e.*, analysts perform analysis, development experts carry out development, *etc.*). This will enable selection and utilisation of appropriate staff from all sections of CISIR.

1.2 Creation of new **commercial entity** within CISIR to facilitate industrial interaction.

2 Upgrading of industrial technology utilisation in the country:

- 2.1 **Improvements** in **existing** technology
- 2.2 **Expansion** into **new** areas of technology
  - 2.2.1 **extension of product ranges** into value-added sector
  - 2.2.2 **addition of new technology**.

3 Extension and upgrading of research at CISIR in two areas:

- 3.1 Research leading to the introduction of **new products**.
- 3.2 The evaluation of **Ayurvedic medicines**.

Actions

1 Detailed plan to be drawn up by international consultant in consultation with CISIR and Ministry staff and industry.

2 Implementation of administrative changes at CISIR.

3 Appointment of overall general manager for expanded Natural Products Group.

4 Senior level appointments.

5 Initiation of multidisciplinary and collaborative, research projects.

6 Junior level appointments.

7 Enhanced technology at CISIR.

8 Implementation of agronomic and pilot plant action plans.

The plan involves actions at CISIR involving both personnel and technology.

The sequence of their implementation is important in order to maximise efficiency and facilitate the changes envisaged. Changes are envisaged in the organisation at CISIR particularly the setting up of a new 'commercial arm'. In addition, personnel and resources need to be provided. Many of the activities can proceed in parallel depending on the precise priorities envisaged. The precise details will only become available after the next stage of the process - the drawing up of the detailed action plan.

Some of the actions are shown in diagrammatic form in Annexes 18 and 19 and details of the individual components are to be found in the preceeding Annexes under the appropriate sections.

Outputs

1 CISIR regains position of centre of excellence.

2 Income-generating commercial arm created leading to entry to value-added sector in herbal products and refined plant products.

3 Improved efficiency and products in Ayurvedic medicine sector, leading also to new pharmaceutical leads.

4 Systematic multidisciplinary evaluation of Sri Lankan Ayurvedic medicines.

Annex 22

Qualifications, experience and job requirements for Senior level Consultant

Qualifications and Experience	:	Degree in chemistry or pharmacy plus Ph.D in pharmaceutical science (preferably pharmaceutical chemistry) with minimum 15 years' experience in research and development in the pharmaceutical industry, preferably combined with experience in small and large companies in commercial activities as well as research management.
Job Requirements	:	Undertake a systematic comprehensive evaluation of the possibilities for the development of a phytopharmaceutical industry in Sri Lanka by interacting with academic and research institutions in the country and discussions with the relevant ministries and industrial groups. Consider appropriate funding sources in order to propose ways of financing the setting up of the new commercial entity. Provide a detailed action-orientated plan for the changes in management and administration at CISIR to facilitate its function of promoting technology utilisation in Sri Lanka. Prepare a timetable and budget for the plan's implementation. Submit a comprehensive report (in hard copy and on diskette using Word Perfect 5.1) on his findings and recommendations for the implementation of the detailed action plan.

Annex 23

Qualifications, experience and job requirements for Senior level Phytochemist/Pharmacognosist

Qualifications and Experience	:	Ph.D in pharmacognosy with minimum 5 years' experience in phytochemistry, preferably with some experience of the quality manufacturing industry, ideally with some managerial experience.
Job Requirements	:	Provide leadership to the pharmacognosy group in establishing new standards for plant starting materials and finished products in the Ayurvedic medicine and herbal product industries. Play a leading role in the establishment of a multidisciplinary, multicentre approach to research on the evaluation of Ayurvedic medicine.

Annex 24

List of initial equipment required in Natural Products Group, CISIR

CAPILLARY gas/liquid chromatograph	2
High performance liquid chromatograph (analytical)	1
High performance liquid chromatograph (preparative)	1
Diode-array uv/vis detector	1
Scanning uv/vis spectrometer	1
FT-ir spectrometer	1
Freeze drier	1

Temperature and humidity controlled room for liquid chromatographs.

It is important that as much computerisation as possible be introduced at an early stage in order to fully utilise capabilities of current instrumentation, particularly with regard to analytical validity.

Annex 25

Qualifications, experience and job requirements for Plant Analytical Support Technical Officers

Qualifications and experience	:	B.Sc with 5 years' relevant experience or M.Sc in Chemical or Analytical portions in academic or industry.
Job requirements	:	To carry out analyses and investigations leading to the establishment of Standards of Sri Lankan Plant materials.

Annex 26

Action plan - Agronomic aspects

A Crops to be domesticated from natural habitats

1 *Centella asiatica*
2 *Coccinium fanestratum*
3 *Kaempheria galanga*
4 *Woodfordia fruticosa*
5 *Phyllanthus embelica*
6 *Alpinia galanga*
7 *Trianthema decandra*
8 *Plumbago indica*

B Crops for development of agrotechnology and technology transfer

1 *Solanum xanthocarpum*
2 *Piper longum*
3 *Withania somnifera*
4 *Monronia pumila*
5 *Rauvolfia serpentina*
6 *Cassia angustifolia*
7 *Hemidesmus indicus*
8 *Andrographis paniculata*
9 *Plectranthus zeylanicus*
10 *Indigofera tinctoria*
11 *Alpinia galanga*
12 *Ocimum sanctum*
13 *Vetiveria zizanioides*
14 *Coriandrum sativum*
15 *Punica granatum*

C Crops under cultivation which require crop improvement

1 *Citronella nardus*
2 *Cinnamomum zeylanicum*
3 *Myristica fragrans*
4 *Eugenia caryophyllata*
5 *Piper nigrum*
6 *Elettaria cardamomum*

D Suggested exotic plants to be introduced

1 *Duboisia myoproides*
2 *Mentha arvensis*
3 *Mentha spicata*
4 *Citronella java*
5 *Rosmarinus officinalis*

6 *Salvia officinalis*
7 *Ocimum basilicum*
8 *Pelargonium graveolens*
9 *Pogostemon patchouli*
10 *Matricaria chamomilla*
11 *Cymbopogon martinii* var. *motia*
12 *Vetiveria zizanoides* (improved variety)
13 *Apium graveolens*
14 *Cymbopogon flexuosus* (improved variety)

Annex 27

Qualifications, experience and job requirements of agronomical personnel

A. Qualifications, experience and job requirements of senior level agronomist/consultant

Qualifications and Experience	PhD with minimum 15 years' experience of agronomical research with proven dynamic leadership in the management of research and development of medicinal and aromatic plants. Experience of working in senior research and development positions for a period of at least 10 years.
Job requirements	Providing leadership to the agronomical research and development management group on medicinal and aromatic plants at CISIR.

B. Qualifications, experience and job requirements of junior level scientists

Qualifications and Experience	MSc(Ag) in relevant field with three experience years' experience in research and development of field crops, OR PhD with experience of field experimentation.
Job requirements	To carry out research on agronomic/crop improvement/plant protections aspects of medicinal and aromatic crops.

Annex 28

Additional inputs required to Pilot Plant, CISIR

1. Modern Steam Distillation Unit:

Distillation Vessel	:	250 litre total volume
Vapour pipe line	:	62 mm dia
Condenser	:	shell and tube
Condenser shell	:	175 mm dia
Condenser bonnets	:	150 mm dia x 150 mm
Tube length	:	1500 mm
Tube dia	:	20 mm ID x 14 G.
No. of tubes	:	16 nos.
M.O.C.	:	Shell M.S.
Tubes	:	S.s. 304
Shell thickness	:	3 mm

The S.S. Shell to be provided with 3 mm thick M.S. Jacket. Condenser to be connected with vapour line horizontally at a slope of 75 mm. Primary and secondary oil separators, each separator of 300 mm diameter x 450 mm long to be provided with an internal partition. The vapour line to be provided with 62 mm ball valve.

The configuration of piping should be such that the unit should work under:

1. steam distillation under atmospheric pressure
2. steam distillation under pressure
3. hydrodistillation under cohabition.

2. Fractional distillation unit specifications:

1. Reboiler capacity, 100 litres total
2. Working capacity, 75 litres
3. Column diameter, 100 mm
4. Column height, 6000 mm
5. Packing material, schulzer or hyflux
6. Boil up rate, 50 litres/hr
7. Shell and tube condenser, 2 sqmt
8. Product cooler, 1 sq.mt.
9. Receivers, of 10 litres capacity each.

The reboiler to be provided with an M.S. jacket and internal cooling coil of 2 sq. mt. heating area. An oil sealed vacuum pump with displacement capacity of 3000 lit/min at 1 mm Hg vacuum to be connected to the top condenser through a vapour trap (chiller) which is connected to existing cooling plant.

The fractionating columnn to be provided with a solenoid valve operating on a timer to control the reflux. The unit to be provided with all inter-connecting pipe lines and mounted on a steel structure. M.O.C. of the contact parts to be S.S. 304.

The modern distillation unit and fractionating column can be fabricated in CISIR workshop which has the competence and facilities to take up fabrication work.

3. All glass Rotavac of 10 litre capacity provided with high vacuum pump of the order of 0.5 mm Hg vacuum with cryogenic trap for removal of lost traces of solvent in oleoresins.

4. A sparkler filter press having six disc plates of 300 mm diameter with a built-in high pressure feed pump for removing fine particles from a fermented broth. M.O.C. all contact parts S.S. 304.

5. Wood cutting and chipping machine to have 50 kg/hr capacity to cut and chip hard/woody material to make it suitable for disintegration in a hammer mill.

6. Tablet making machine.

7. Tablet coating machine.

8. Bottling and sealing machine.

9. Homogenizer of 50 litre capacity.

Annex 29

Job descriptions of positions required in Pilot Plant

Post: Chief Coordinator (Chemical Engineering)

Qualifications and Experience	:	Ph.D. in Chemical Engineering with 10 years of experience in research and development and production of herbal drugs in the field of phytopharmaceuticals.
Job requirements	:	The incumbent should have leadership and organising abilities to organise, guide and coordinate research and development activities in pilot production, design engineering and plant fabrication.

Post : Process Engineer - 2 posts

A first class masters degree in Chemical Engineering with 5 years experience in Process development and pilot production in the field of phytopharmaceuticals and essential oils. The incumbent should have adequate knowledge of process optimisation and scale up in producing herbal drugs and essential oils.

Annex 30

Action plan - Pilot Plant aspects

A. Immediate steps should be taken by CISIR management to look into the problems faced by the phytopharmaceutical and essential oil industry and come up with solutions to update their existing technologies and provide proven technologies developed by CISIR to bring cost effectiveness to production and improvement in quality of the products.

B. To approach industries to sponsor the projects in which they need help to adopt new technologies or improvisations of the technologies under use.

C. To develop appropriate pilot production facilities in the institute and draw action orientated research and development programme related to herbal extraction, Ayurvedic preparation, distillation of cinnamon bark, cinnamon leaves, nutmeg and cloves which are the priorities of the industry.

D. To approach the Government of Sri Lanka and other international agencies through collaborative or bilateral programmes to seek financial assistance to achieve an action oriented research and development programme in this area.

E. To set up a liaison cell in the Institute to bridge the 'missing link' between the institute and the user industry.

F. To build up sense of confidence among industrialists in the working culture of CISIR by giving on-the-spot demonstrations of the technologies developed.

G. To create an appropriate work culture among pilot plant and workshop staff by providing top leadership who can organise, coordinate and guide pilot plant and workshop activities to achieve success in time bound projects.