









NRI

ANNUAL REPORT AND ACCOUNTS

1995-96

NATURAL RESOURCES INSTITUTE Overseas Development Administration



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Accounts for 1995–96 and April 1996

CHIEF EXECUTIVE'S OVERVIEW

This is the last Annual Report and Accounts for NRI as an executive agency of the Overseas

Development Administration, ownership having been transferred to the University of Greenwich with effect from 1 May 1996. The Report also includes supplementary accounts for the month of April, being the last in public ownership.

In last year's Overview, I noted that work had been completed on a study of likely trends in the demand for NRI's services over the remaining years of the century. The "NRI 2000" study pointed to a decline in the volume of work commissioned by the ODA, partly offset by a continuing growth in demand from other clients. The picture emerging from the study was thus of a somewhat smaller Institute than hitherto, in terms both of staff numbers and of space and facilities occupied. In terms of the overall balance of NRI's work, the study foresaw a continuing role in adaptive research, but with a shift towards the management of research expertise drawn from both internal and external sources and towards consultancy and training activities associated with the transfer of technology into the field.

The NRI 2000 study provided the basis for a downsizing and restructuring programme which provided one of the two principal points of management focus during the year. This programme saw a fundamental overhaul of the Institute's management structure, a reduction in staff members

(achieved by voluntary means and natural wastage) from 483 at the beginning of the year to 373 at the end and formulation of plans for a saving of around 50 per cent in the requirement for office and specialised accommodation.

The second area of management focus was the process of privatisation itself, which began with the announcement in December 1994 of the Government's intention to invite expressions of interest in the ownership of NRI. The following months saw the preparation and issue of an Information Memorandum (which drew substantially on the conclusion of the NRI 2000 study), detailed discussions with bidders, the selection of a preferred bidder and preparations for the transfer, culminating in a handover ceremony at Chatham on 30 April.

The transfer broke new ground in being the first of a public sector research establishment to the University sector. In the first instance, the Institute as a whole transferred to the University of Greenwich, which has based its School of Earth Sciences on part of the NRI site at Chatham since 1994. But plans were already in hand for the spinning off of parts of the Institute into a new jointventure company, to be owned equally by a Consortium comprising the Universities of Edinburgh and Greenwich and Imperial and Wye Colleges of the University of London. The new company, Natural Resources

International Limited, took on responsibility for business development and for research and project management with effect from 1 August 1996. The greater part of NRI remained an institute within the University of Greenwich.

In handing over ownership of NRI, Baroness Chalker, Minister for Overseas Development, described the transfer as an "innovative development which secures the future for NRI's staff, maintains a much valued source of expertise for the Aid Programme and will enhance and extend NRI's links across the British science base".

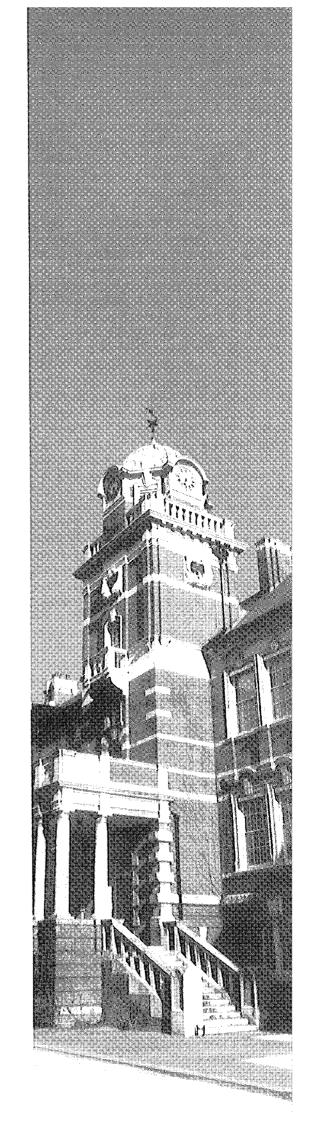
I share Lady Chalker's convictions. I leave NRI, after 10 years as Chief Executive, with much sadness but with considerable confidence in its future. I wish it and its new owners every success. To my colleagues at NRI, whose professionalism, international reputation and contribution to development have grown steadily, despite a prolonged period of uncertainty and organisational change, I record my admiration and my thanks for their support and their patience over these eventful years.

Anthony Beattie

Chief Executive (to 30.4.96)

Antony Boots

BUSINESS REPORT



THE INSTITUTE'S ROLE

NRI'S GOAL

To help developing countries to improve the productivity and sustainable management of their renewable natural resources—farming, forestry and fisheries—through the application of science and technology.

PURPOSE

As an executive agency of the Overseas Development Administration, the purpose of the Institute has been to support the objectives of the Aid Programme by helping developing countries to improve the productivity and sustainable management of their renewable natural resources through the application of science and technology.

More than 2.5 billion people in the developing world, and among them some of the poorest and most vulnerable groups, live in rural areas and are dependent for their livelihoods upon the exploitation of renewable natural resources through agriculture and forestry. On average, this sector contributes nearly a third of the gross domestic product of low-income developing countries and it has long been one of the main points of focus of the British aid programme.

In recent years, ODA has devoted substantially more than £100 million a year to aid for the renewable natural resources sector and has commissioned more than 85 per cent of the work done by NRI. But an increasingly important element of the Institute's work is on behalf of other donor agencies—including

the World Bank and the European Community—overseas governments and private sector clients and this element continued to grow in 1995-96.

EXPERTISE

NRI's special skills as a development agency rest in particular on:

- an inter-disciplinary approach to problem solving through its ability to mobilise a wide range of disciplines in the natural and social sciences and supporting professional services;
- a mutually-reinforcing link between technology generation (through basic and applied research) and technology transfer (through the provision of consultancy and advisory services);
- a collective and practical understanding of the development process, including socio-economic and institutional issues, and of the policy and practice of the aid donor community; and
- substantial experience in contracting and managing specialised services from other institutes and universities, reflecting the Institute's unique position within the British scientific community.

HISTORY

The Institute became an executive agency of the Overseas Development Administration, under the Government's Next Steps Initiative, in April 1990. It was formed—as the Overseas Development Natural Resources Institute—in 1987 by the amalgamation of ODA's two scientific units, the Tropical Development and Research Institute (formerly the Tropical Products Institute and the Centre

for Overseas Pest Research) and the Land Resources Development Centre.

The Institute moved to its present premises, on a site formerly occupied by the Royal Navy at Chatham, in the period 1988-1990. The history of the Institute and its predecessors can be traced back to the founding of the Scientific and Practical Department of the Imperial Institute in 1894 and the present-day Institute and its staff are proud of this heritage of service to the developing world.

Following a decision by the Minister for Overseas Development in December 1994 to invite expressions of interest in the future ownership of NRI, and a subsequent competitive tendering process, a bid was accepted from a Consortium comprising the Universities of Edinburgh and Greenwich and Imperial and Wye Colleges (University of London). Ownership of the Institute was transferred to the University of Greenwich on 1 May 1996. The Consortium meanwhile formed a new joint-venture company, known as Natural Resources International Limited and comprising the staff of the Institute's former Directorates of Research and Development Services, which assumed responsibility from 1 August 1996 for marketing, business development and for programme and project management.

REVIEW OF PERFORMANCE

FINANCIAL OBJECTIVES

As an Agency, NRI has not sought to make a profit on its activities but has been required, under the terms of its Framework Document, to recover the full economic costs of its ordinary operations. These costs include actual expenditure together with the notional costs of depreciation and capital, and of residual services provided by ODA Headquarters. The objective has therefore been to set charges for services provided to the ODA and to external clients at a level intended to recover these costs in full, while enabling the Institute to remain competitive in the wider market. Separate provision has been voted by Parliament to cover the cost of capital investment and of certain exceptional items of expenditure, such as the costs of relocation and restructuring.

BUSINESS STRUCTURE

In 1995-96, the ODA's Natural Resources Division continued to be the Institute's largest single customer, accounting for some 49 per cent (by volume) of the work commissioned. Most of this was applied and adaptive research under the ODA's Renewable Natural Resources Research Strategy, which guides the allocation of research funds in support of ODA objectives in the natural resources sector. The Natural Resources Division also commissioned a range of specialised services under a separate Advisory and Support Commission.

A further 31 per cent of work undertaken during the year was on behalf of country programme managers in the ODA's Geographical Divisions and took the form of advisory, consultancy and project management services, often involving the provision of expertise on a long-term basis overseas.

The remaining 20 per cent of the work (up from 16 per cent in 1994-95) was commissioned by external clients, including notably the European Commission, the World Bank and other multilateral donor agencies.

BUSINESS VOLUME AND VALUE

The volume of business is measured by the number of operational years of work commissioned by clients. For management purposes, the value of business is taken to be the income retained by the Institute: this is equivalent to turnover net of reimbursable project costs.

An analysis of business volume and value by client type is shown in box 2. The graphic in box 3 shows how the main components of the business have developed

Box 1 PERFORMANCE TARGETS FOR 1995-96

• Restructuring. To implement, by the end of the 1995-96 financial year, an agreed programme of restructuring measures identified in the light of the recently completed study of the Institute's future business prospects. Specifically: (a) to reorganise the Institute's management commands; (b) to manage a voluntary severance programme aimed at reducing staff numbers to an indicative level of 360; and (c) to formulate an accommodation strategy for the smaller Institute.

Achieved. (a) A revised management structure was brought into effect on 1 April 1995. (b) The staff of the Institute was reduced, by voluntary means, to 349 at the point of transfer, with a further 24 staff in the Library and Site Services groups transferring to the University of Greenwich under separate arrangements. (c) A strategy was developed which involved reducing the Institute's requirements for specialised and office accommodation by some 50 per cent.

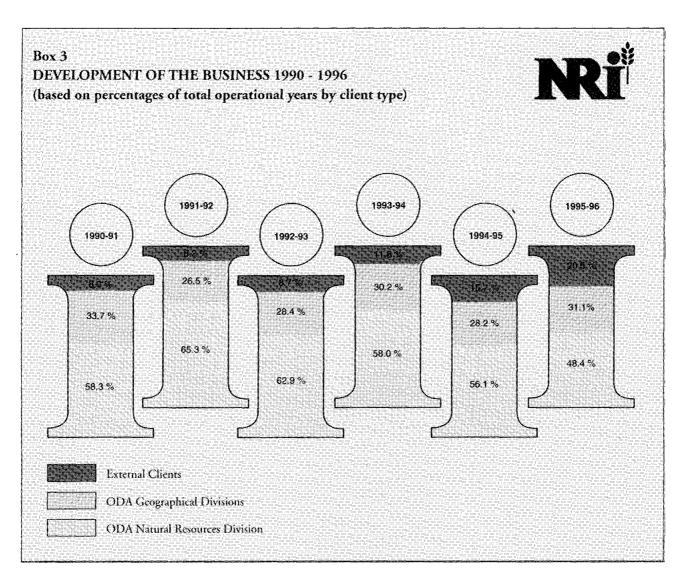
• Unit revenue. While implementing this programme, to maintain an average revenue of £67,750 per operational year of time charged to clients for a minimum of 260 operational years.

Partly achieved. A total of 264 years of operational time was charged to clients during the year. Average revenue (retained income or revenue net of project costs) per operational year came to £62,402 as per the statutory accounts. (However, if allowance is made for reimbursable project costs outstanding at the year-end but expected to be recovered, average revenue per operational year achieved target levels).

• External business. To increase the number of operational years of work for non-ODA clients, and the value of retained income from this source, by 10 per cent.

Partly achieved. Operational years of non-ODA-funded work totalled 54 (an increase of 10.2 per cent). Retained income from this source, on the statutory basis, came to £2,826,000 (compared with £3,154,000 in 1994-95). (Again, however, if allowance is made for reimbursable project costs outstanding, the target increase in retained income was achieved).

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over the six years of NRI's existence as an Agency.

BUSINESS PLAN OUT-TURN

Given the objective of achieving a reorganisation and substantial downsizing of the business within the year, it was not considered feasible, while remaining competitive in the increasingly important external market, to set charges at a level which would have recovered the Institute's costs.

The Business Plan projected a deficit of £4,508,000 on the operating account (calculated on the basis of income less overhead

expenditure, leaving aside reimbursable project expenditure assumed for planning purposes to be recoverable in-year). On this basis, time-charge income came to £18,480,000 (Business Plan target £17,582,000); non-operating income (from sale of publications, rental of facilities etc) came to £1,388,000 (Business Plan £1,309,000); and expenditure came to £22,989,000 (Business Plan £23,399,000). The operating deficit on this basis was £3,121,000.

In practice, however, reimbursable project expenditure is not fully recoverable in-year and this is reflected in the more substantial

deficit (£4,678,000) shown in the statutory accounts.

Running cost expenditure was within the limit agreed with HM Treasury and expenditure on relocation and restructuring activities (£2,260,000, as shown in the statutory accounts) was within the provision of £3,315,000 voted by Parliament.

PERFORMANCE TARGETS

NRI's principal targets for 1995-96, and performance against these, are described in box 1. In view of the impending transfer of ownership, no performance targets were set for the financial year 1996-97.

FINAL MONTH

Ownership of the Institute was transferred with effect from 1 May 1996 and figures for the month of April 1996 are shown separately in the Accounts. No Business Plan was drawn up for this final month of operation in Government ownership and no conclusions about performance in the new financial period have been drawn from this single month's figures.

CORPORATE ISSUES

The related issues of ownership and restructuring provided the dominant themes of the year.

OWNERSHIP

The movement towards privatisation began with the appointment of consultants in January 1994 to carry out a study of future ownership options. This study was undertaken against the background of the government's White Paper on Science and Technology (Cm 2250), published in May 1993, and in parallel with the Efficiency Unit scrutiny of public sector research establishments which it foreshadowed.

In the light of the privatisation feasibility study, the Minister for Overseas Development announced in December 1994 that expressions of interest in the future ownership of the Institute were to be invited. Eight such expressions were subsequently received from organisations and consortia in, or with links to, the University sector. Following a competitive tendering process which took place in the course of 1995, a consortium comprising the Universities of Edinburgh and Greenwich, Imperial College of Science and Technology and Wye Collegé (University of London)

was identified as the preferred bidder. Following the successful conclusion of negotiations, ownership of NRI was transferred on 1 May 1996.

Under the terms of the Consortium's bid, ownership of the business was transferred to the University of Greenwich, the Institute now being known as the Natural Resources Institute at the University of Greenwich. At the same time, a joint-venture company - to be owned equally by the Consortium members and to be known as Natural Resources International Limited - was formed with a view to taking on responsibility for marketing and business development and for programme and project management. These arrangements came into effect on 1 August 1996 with staff of NRI's Directorates of Research and Development Services being seconded to the new company.

Both NRI and NR International will continue to be located at Chatham Maritime, where the University of Greenwich has plans for the further expansion of its Medway Campus.

RESTRUCTURING

Plans for restructuring of the Institute were developed independently of the privatisation process and were seen to be essential to its future viability whether or not ownership were to be transferred. The restructuring proposals were based on the conclusions of the "NRI 2000" study which, following on from the first Triennial Review in 1993, assessed likely trends in the level and nature of demand for NRI's services up to the end of the century.

The key conclusions of the study

were that, over this period:

- the Institute's net income was likely to fall by about 18 per cent;
- the value of business from the ODA, NRI's main customer, would fall by some 34 per cent as a result of other pressures on the bilateral aid programme; while
- non-ODA business would continue to grow, by some 77 per cent by value over the period, from 15 to 33 per cent of total income; and
- the business mix would shift away from research towards technology transfer (advisory work, consultancy and training), the share of research falling from around 42 per cent to about 29 per cent of the total.

The restructuring programme, developed against this background and announced by the Minister for Overseas Development on 5 April 1995, consisted of three main elements:

- Reorganisation of the Institute's organisational commands into four new directorates with a view to unifying responsibility for the management of NRI's scientific and professional resources and to clarifying responsibility for the management of research services on the one hand and for marketing, business development and project management on the other. The revised structure is described in more detail later.
- Reduction in total staff numbers from 483 at the start of the year to around 360 at the end. This objective was achieved entirely by voluntary means while maintaining an acceptable balance of skills. At the point of transfer, 373 staff were in post (of which 24, in the Library and Site Services groups, were transferred to the University of Greenwich under separate arrangements).

• Development of a strategy for reducing the Institute's requirements for both specialist and office accommodation by around 50 per cent overall. This work has provided a starting point for the new owner's accommodation plans and should enable substantially more effective use to be made of the Chatham accommodation.

NRI PEOPLE

Of the staff in post immediately prior to the transfer of ownership, 57 per cent were permanently established and the remainder were on period or short-term contracts. The comparable figure for permanently established staff at the start of the year was 67 per cent and the change reflects a continuing trend over recent years as the Institute has moved in the direction of more flexible resourcing.

Contingency plans were made, in line with Government policy, for the transition to delegated pay and grading in the event that NRI remained an Agency. Work was also done on possible changes to the terms and conditions of overseas service. However, following the transfer, it falls to the new owner to negotiate any changes to the Institute's personnel regime.

Professor Rod Cooke, Director of Development Services, left the Institute at the end of July 1995 to take up his appointment as Director of the Technical Centre for Agricultural and Rural Cooperation (CTA) at Wageningen in The Netherlands. He was succeeded (for the period leading up to privatisation) by Peter Thompson, formerly Managing Director of Hunting Technical Services Limited.

INVESTORS IN PEOPLE

Plans were drawn up in the course of the year, in discussion with Kent TEC and staff side representatives, for a programme of action to achieve Investors in People status. This work was led by the Staff Training Unit. However, given the importance of a positive reaction by staff to such an initiative in the context of wider plans for the future of the Institute, no formal commitment was made before the transfer of ownership.

MARKET TESTING

Action remained suspended during the year owing to uncertainty about the implications for future service requirements of restructuring and the impending change of ownership.

CITIZEN'S CHARTER

As a supplier of services to its parent department and other public bodies, NRI's activities are outside the formal scope of the Citizen's Charter. The Institute has nevertheless sought to apply the Charter principles in the delivery of services to its clients. In its dealings with suppliers, the Institute has been committed to compliance with the prompt payment code promoted by the Confederation of British Industry and in 1995-96, 91 per cent of payments were made within 30 days of receipt of an invoice or such other period agreed with the supplier (1994-95, 95 per cent).

ECART

The European Consortium for Agricultural Research in the Tropics (ECART), launched in May 1992, established a collaborative link between NRI and three partner institutes in Europe: CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement) in France, KIT (Koninklijk Instituut voor de Tropen) in the Netherlands and IICT (Instituto de Investigação Científica Tropical) in Portugal. The founder members were joined at the end of 1994 by two partner organisations in Germany: GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit) and ATSAF (Arbeitsgemeinschaft Tropische und Subtropische Agrarforschung).

The ECART Directors-General held their sixth meeting at Chatham in September 1995, and reviewed progress on a range of joint activities. Among these were plans to support the European Initiative launched in 1994 to coordinate support for research and development activities in developing countries. The elements of this policy are intended to provide the framework for a European contribution to a global research system to be set up by the World Bank in association with the Consultative Group on International Agricultural Research (CGIAR).

The CGIAR, together with the Special Programme for African Agricultural Research (SPAAR), has drafted an outline Action Plan to strengthen the National Agricultural Research Systems-CGIAR partnership.

In this context, ECART set up a Task Force to explore ways in which the potential contribution of ECART could be realised as a component of both the European Initiative and, more broadly, the building up of the global research system. The Task Force met at CGIAR Centres Week and

provided the SPAAR Secretariat and executive staff of the African Associations with a position paper identifying ECART's interest in participating in the SPAAR Action Plan.

STRUCTURE AND MANAGEMENT

The Institute was an executive agency of the ODA until the transfer of ownership on 1 May 1996. The Institute's Chief Executive was accordingly responsible to the Minister for Overseas Development for its day-to-day management and reported via the ODA's Deputy Secretary who, in advising the Minister on policy matters affecting NRI, was able to draw upon the advice of a Steering Board which he chaired. The composition of the Steering Board is shown in box 4.

As Agency Accounting Officer, the Chief Executive was also responsible to the ODA's Permanent Secretary, as Accounting Officer for the Department as a whole, for the financial management of the Institute.

In the light of the NRI 2000 study, the Institute was restructured into four new Directorates in April 1995. The revised structure is shown opposite. The principal features of the new structure were as follows:

- NRI's scientific and professional staff were organised into ten departments within a new Directorate of Professional Resources.
- The Directorate of Development Services (building on the experience of the former Development Services Group, originally set up in September 1993) took over responsibility for marketing and development of

NRI's technology transfer activities and for the management of major projects. The Directorate, which was organised as a geographical basis, also provided a primary point of contact for clients.

- The Directorate of Research Services took over the task of bidding for and managing contracts awarded by the ODA under its Renewable Natural Resources Research Strategy. The new Directorate was also charged with exploring and developing new sources of research funding.
- The Directorate of Corporate Services continued to provide a range of corporate and supporting services in the areas of

Box 4

ODA'S STEERING BOARD FOR NRI

Chairman

Mr Robert Ainscow CB Deputy Secretary, ODA

Members

Sir Charles Reece Formerly Research and Technology Director, ICI

Professor Peter Wilson CBE Formerly Head of the School of Agriculture, University of Edinburgh

Mr Andrew Bennett Chief Natural Resources Adviser, ODA

Mr Richard Manning Under Secretary, ODA (Principal Finance Officer)

Mr Barrie Ireton Under Secretary, ODA (Head of Africa Division) personnel, finance and accounting, information technology, library and information, publishing and publicity and technical services and estate management. As before and in addition to its primary role of supporting the rest of the Institute, the Division sought to generate revenue from the provision of specialist services to external clients.

The Chief Executive and the four Directors formed the Institute's Management Board (see box 5).

This revised structure has provided the starting point for further evolution after privatisation. In the period immediately following the transfer of ownership, the Directorate of Research and Development Services operated as the Institute's International Division pending the launch of the new joint-venture company, Natural Resources International Limited, in August 1996.

Box 5

NRI'S MANAGEMENT BOARD

Anthony Beattie

Chief Executive

John Perfect

Director of Professional Resources

Margaret Gill

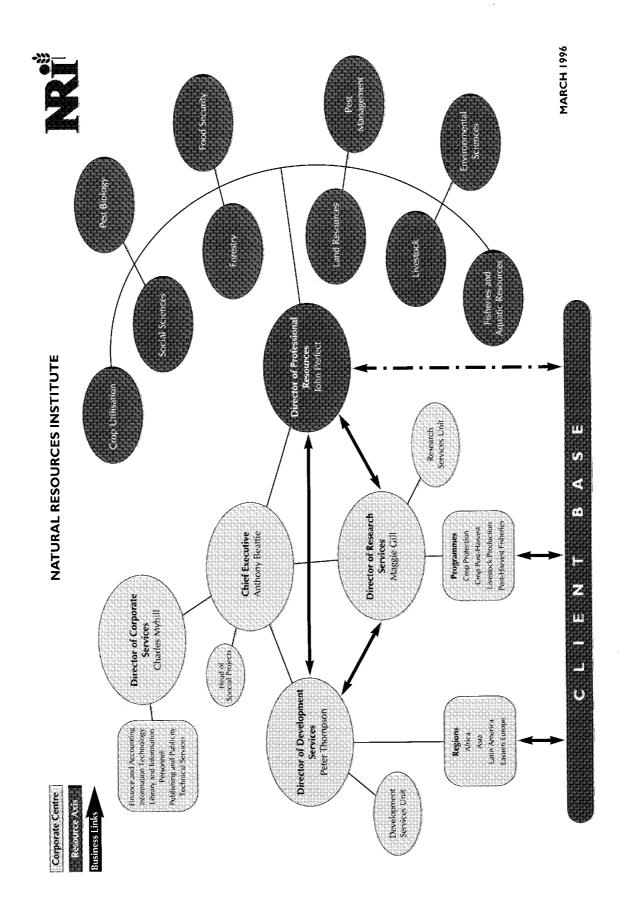
Director of Research Services

Rod Cooke (to 31.7.95) Peter Thompson (from 1.8.95)

Director of Development Services

Charles Myhill

Director of Corporate Services



DEVELOPMENT ISSUES

More than 2.5 billion people in the developing world, among them some of the poorest and most vulnerable groups, live in rural areas and depend on the exploitation of renewable natural resources for their livelihoods. The key development issues facing these people varies between the different regions of the world but a common requirement is a sustainable improvement in food security through increased food production. It is also vital for development to be both economically and environmentally sustainable. The problem donor organizations have to address is how to meet these requirements. With its experience and expertise in the management of natural resources NRI is able to assess and respond to the particular needs of the different regions of the developing world.



AFRICA

In the future, one of the main indicators of development will be a sustainable improvement in food security. This is particularly true for Africa where, between 1975 and 1995, the number of hungry people increased by 46%. Malnourishment in children is a special problem, and with a projected population growth of 2.3% per annum by the year 2020, the problems of food security are likely to increase and present an ever-growing challenge. In Africa, agricultural productivity is important not only in terms of food production but also as the principal element of economic development. Although some expansion of productive land is still possible, much of the required growth must come from increased yields and more effective utilization of existing agricultural land.

The constraints to increased agricultural productivity are well known. Soil degradation is a major concern with about 30% of agricultural land, pastures, forests and woodlands across Africa considered to be degraded. Overgrazing, deforestation, and inappropriate agricultural practices, account for most of this degradation. The depletion of soil nutrients is also a critical constraint to food production in sub-Saharan countries, but the use of fertilizer is severely limited by cost, inefficient marketing systems, and the risks associated with crop failure in marginal areas.

Sub-Saharan Africa features a wide diversity of ecosystems which

range from sparsely populated rain forests to densely populated savannahs and drylands, and from flat coastal zones to plateaux and highlands. This diversity calls for specific developmental strategies. Urbanization and the general migration towards the coastline complicates the issue further; 30 years ago there was only one city with more than a million inhabitants but by 1990, there were 18.

Although the dual role of agriculture in fostering economic development and meeting future food requirements is recognized, the 4% growth in agricultural production needed to meet future needs presents a major challenge. It is particularly difficult at a time when agriculture's share of development assistance is declining in real terms (from 20% to 14% during the 1980s). International development institutions have tended to reduce funding for agriculture because the global food supply has been sufficient to meet market demand. This trend is dangerous in terms of broad economic development and poverty reduction, and at the international level, there are signs that the policy may be reconsidered.

The shift in donor funding towards environmental issues stimulated by the Global Environmental Summit in Rio de Janeiro in 1992, has meant that most donors now direct aid towards 'environmentally sustainable development'. A recent World Bank policy paper summarized the challenges faced by Africa as:

- food security through sustainable agricultural intensification
- facilitating a demographic transition to a more stable population level
- influencing migration towards more even population distribution
- making urbanization sustainable by better planning
- managing energy, water and other natural resources
- improving education information and communication systems.

Over 50% of NRI's work is in Africa but in recent years, the nature of the work has tended to shift in line with the changed policy of clients. When providing research and development services, NRI must respond to client demand. The projects emerging from all donors, including ODA, are now related to the management of natural resources, environmental degradation, and institutional reform, rather than to agricultural production. The few projects concerned with agricultural productivity tend to be associated with farming systems and crop diversification for export. In attempting to diversify the client base, efforts have been directed towards clients other than ODA, where the shift in emphasis is even more marked. The number of projects associated with forestry, wildlife and the conservation of protected areas has been particularly noteworthy during 1995.

The changing requirements of clients have also led to changes in the method of providing NRI's services for work in Africa. These changes include the substantial increase in competitive tendering by ODA and the growing use of local consultants. Furthermore, in the winning of business from non-ODA clients, particularly the European Commission, there is a need to form consortia with other institutions in order to compete effectively.

During the past year, NRI has formed an association with local institutions or consultancies in Malawi, Kenya, Tanzania, Ghana, Botswana, Uganda, Zambia, Mozambique and Zimbabwe. In the context of international competitive tendering, we have also formed associations with a wide range of institutions and companies within the UK and across Europe. The development of these linkages and associations is now an essential ingredient of winning business and subsequently implementing projects in Africa.

NRI has a very strong track record in most of Africa south of the Sahara, and significant programmes won or implemented during 1995 have included the following:

- Pollution control and other measures to protect biodiversity in Lake Tanganyika, UNDP/GEF (value £ 5 million)
- Range Inventory and Monitoring Project, Botswana, ODA (value £ 0.95 million)

- Farming Systems Research and Training, Namibia,
 ODA (value £ 1.0 million)
- Farming Systems Integrated Pest Management, Malawi, ODA (value £ 1.7 million)
- Support to the Institute of Natural Resources, South Africa, ODA (value £ 0.65 million)
- EIA for Mutonga/Grand Falls Hydropower Project, Kenya, JICA (value £ 0.1 million)
- Farming Systems Research and Extension, Ethiopia,
 ODA (value £ 0.2 million)
- Technical assistance to the Directorate of Planning, Ministry of Agriculture, Namibia, EU (value £ 1.5 million)

The above list of projects shows their total value. All include contributions from within NRI, mostly involving several departments, and some include partners both in the UK and overseas. Two examples have been chosen to illustrate the nature of these projects.

The five-year GEF-funded project on Lake Tanganyika, which was awarded in July 1995 through competitive tender, aims to address the many cross-sectoral issues which threaten the biodiversity of the lake. The Marine Resources Assessment Group (based at Imperial College, London) and the Institute of Freshwater Ecology are participating in the implementation of the project. Project headquarters are in Dar es

Salaam with regional stations located around the lake in each of the four riparian countries (Burundi, Zaire, Tanzania and Zambia). The first aim of the project is to improve the understanding of the ecosystem and its interactions with human activities in the region, by a programme of scientific and socioeconomic studies. Based on the knowledge gained, a cross-cutting, regional and sustainable lake basin management strategy for longterm conservation will subsequently be designed and implemented. An important objective of the project is to raise awareness, among regional stakeholder groups, of the benefits of sustainable conservation and how it may work hand in hand with national development strategies.

The Range Inventory and Monitoring Project in Botswana provides support for the Range Ecology and Remote Sensing and Cartographic Sections of the Ministry of Agriculture. The objective of the project is to strengthen land use planning in Botswana and help the government to evaluate the impact of agricultural policy on the range resource. The threeyear, ODA-funded project aims to establish and implement a sustainable pilot range inventory and monitoring programme to provide reliable and regular information on the use and condition of the range resources. This will assist in the formulation of sustainable land management and grazing policies, and should generate rational utilization and management of the range.

ASIA

'Asia' is currently defined by NRI as extending from Turkey to Indonesia, i.e. it covers eastern and southern Asia and much of the Middle East but excludes the former Soviet Union. Asia is vast and culturally complex, encapsulating about three-quarters of humanity. It includes the two most heavily populated countries, China (1.2 billion people) and India (almost 1 billion), and Bangladesh, which is the most densely populated (over 800 people/km²). The region also includes some of the wettest and driest places on earth, and the resulting cultural and environmental diversity inevitably leads to contrasting development problems which are exacerbated by major divergences in wealth, even within individual countries. This is easily demonstrated by comparing the booming economies of Hong Kong and Singapore, the poverty of Laos, Cambodia and Bangladesh, the oil wealth of Saudi Arabia, and the undeveloped potential of Vietnam. The rapidly increasing population common to most of the region has provided some countries with great dynamism and an increasing productive capacity, but it has presented others, most notably in southern Asia, with the major problem of how to raise living standards above subsistence level.

Although over half the people in the world existing at or below the poverty line live in Asia, only 17% of NRI's projects are located in this region. In fact, for at least five years and probably longer, the proportion of NRI work in Asia has been declining. This decline must be partly ascribed to the significant overall contraction in ODA technical assistance. Another contributory factor is the exceptional rate of growth and wealth generation along parts of the 'Pacific Rim' which has led to the withdrawal of aid from countries such as Thailand and Malaysia. A further reason for the decline is the momentum factor; as over 50% of the Institute's work is now concentrated in sub-Saharan Africa, that is where experience is being gained and a recent track record is being established. The one exception is Indonesia where NRI's long track record is translating into continued success in winning projects. Overall, NRI development projects in Asia are still relatively few and narrowbased; over 60% are located in Indonesia, India and Sri Lanka, and about half are devoted to forestry and fisheries.

The major aid donors in the region comprise the World Bank, Japanese International Cooperation Agency (JICA), USAID, the Asian Development Bank and the EU. ODA is a significant donor in India, Bangladesh, Pakistan, Indonesia, Nepal and Sri Lanka. In some countries, the Government prefers development assistance to be concentrated on social services, health and education (as in Pakistan and Bangladesh) whereas in others, environmental concerns direct aid towards the natural resource sector (as in the drive to conserve rainforests in Indonesia).

Based on the Institute's track record in Indonesia and the

continuous succession of projects won since 1973, it was decided early in 1994 that NRI should concentrate on business development in Southeast Asia. By the end of 1995, NRI was managing major projects in Indonesia, Malaysia and Sri Lanka, and had also gained a part share in projects in Indonesia, the Philippines, China and Bhutan. Agents have been appointed to represent NRI's interests in Jakarta, Manila and Tokyo (this latter to follow JICA-funded projects), with negotiations in hand with prospective agents in Beijing and Kathmandu. Significant programmes won or initiated during 1995 have included the following:

- Indonesia Forest Sector Support Programme, EU (value £25 million)
- Qinghai Livestock
 Development Programme in China, EU (value £ 1 million)
- Environmental Management and Sustained Development in the Upper Mahaweli Catchment, Sri Lanka, ODA (value £ 1.9 million)
- Agricultural Rehabilitation Project, Vietnam, World Bank (short-term contributions in plant protection)

The project values indicated above all include significant NRI inputs. About half the natural resource programmes in Asia in which NRI has expressed an interest have been in the fields of forestry and fisheries/coastal zone management. These two areas of traditional NRI strength make use of our

substantial professional networks to identify available manpower. A third field which is generating interest is the management of protected areas such as national parks which, in the Asian context (and unlike Africa), usually implies conservation of rainforest and wetlands. NRI has also been called upon to provide expertise in pest management (Pakistan and India), locust control (in west Asia and southern Arabia), and copra processing and the use of coconut as a fuel source (Sri Lanka, Indonesia and the Philippines). During 1995, NRI undertook a short-term consultancy for the EU on fruit juice processing machinery in southern India. This may open doors to an eventual ECU 60 million horticulture programme.

Two large programmes constituted a particular management challenge during 1995. These were the EUfunded Indonesia Forest Sector Support Programme and the ODA-funded Conservation and Development of Forest Resources Programme in Malaysia. Although both programmes have forestry connotations, neither of them has a strong forestry technical content and neither employs professional foresters.

The Indonesian Programme comprises three projects and a Programme Co-ordination Unit, 10 long-term specialists based in Java and Sumatra, 94 man-months of short-term consultancy, and two separate sources of EU funding (total value £ 25 million over four years). All this is overseen by a Consortium Internal Steering Committee which, although led by NRI, also includes three French

firms (CIRAD-forêt, SCOT Conseil and BCEOM). This Committee, which meets three or four times a year, is serviced from NRI, most notably with respect to a complex system for selecting short-term consultants.

The ODA Malaysia Programme currently comprises no fewer than 22 projects, each with its own personnel (both Malaysian and expatriate) and its own budget (about £ 0.4 million/year). Projects range from a study of the biodiversity of ectomycorrhizal fungi to an evaluation of tourist numbers in Malaysian forests. NRI expertise has contributed specifically to an investigation of amphibian distribution in tropical forest and oil palm plantations, a review of international market prospects for bamboo and rattan, and an attempt to draw together the implications of the results for future indigenous forest management. One of the projects, which is investigating the economics of timber harvesting, is run from Oregon, USA. All these projects and personnel are coordinated, managed and financed via NRI.

LATIN AMERICA

Latin America covers an area of over 20 000 km² and has a population of just under 420 million. Brazil alone occupies over 40% of the land mass and accounts for over a third of the population. Although the region is rich in natural resources and environmental diversity, and per caput income levels are high, poverty and income distribution are major problems. More than

30% of the total population lives in poverty and the problem is particularly acute among indigenous peoples.

Agriculture is the key sector in the development process but production systems typically exhibit low value added, limited specialization and low productivity. With the exception of Chile, the failure of most agricultural sectors to advance at the same rate as industrial growth reflects the general urban bias in government thinking and policy making. One of the basic challenges facing agriculture in the region is the development of technologies that will help farmers to produce and earn more while minimizing environmental damage.

Aid flows to Latin America are helping to address these problems. Much of the World Bank's investment lending and Technical Assistance is orientated towards institutional strengthening, improving environmental management capacity, and promoting the increased use of the private sector (particularly nongovernmental organizations) for field level implementation. The EU is similarly prioritizing environmentally focused activities with particular emphasis on cloud forest management and integrated rural development programmes.

The Inter-American Development Bank's (IDB) new strategy is to focus on increased agricultural productivity and rationalize the use of natural resources through the development of technology transfer services. IDB loans to the natural resources and environment sectors account for more than 22% of development aid funding in Latin America.

In spite of the size and extent of the development programme in the region, only 11% by value of NRI's projects are based in Latin America, and much of the Institute's income has been derived from commissions awarded by a single client (ODA). As with Asia, NRI's work in the region has been in steady decline, largely due to contraction in the UK's bilateral programme. However, there is evidence that this trend is reversing as the Institute becomes increasingly successful at winning work funded through the multi-lateral agencies and development banks. Projects won or implemented during 1995 include the following:

- Forest Fire Monitoring Project, Nicaragua, ODA (value £ 200 000)
- Ozone Monitoring Study, Chile, ODA-British Antarctic Survey (value £ 50 000)
- Post Harvest Horticulture Training Project, Colombia, ODA (value £ 250 000)
- Feasibility Study for a
 National Technical
 Assistance System, Bolivia
 (value £ 110 000)
- Groundwater Pollution Control, Colombia, ODA (value £ 95 000)
- Pesticide Pollution in Critical Watersheds, Nicaragua, World Bank (value £ 185 000)

Most of the Latin American projects in which NRI is currently expressing an interest or implementing, involve the management of natural resources and the protection of the environment (the Tocantins Forest and Agroforestry Project in Brazil, the Nicaragua Forest Fire Monitoring Project and the Chile Ozone Monitoring Project are ongoing examples). These cover areas of traditional NRI strength and closely reflect priority funding by the development agencies. NRI is also involved in a number of projects (such as the SENA Post Harvest Training Programme) which are assisting producers and processors to make quality improvements in the production, marketing and export certification of horticultural produce. Both areas involve the use of the latest technology and require specialist analytical and training facilities.

CARIBBEAN AND THE PACIFIC

The Caribbean and Pacific countries share many of the constraints to development common to island states, i.e. small domestic markets, a narrow resource and production base, and high unit costs of production. They are also heavily dependent on external trade and vulnerable to external shocks and natural disasters (especially hurricanes and cyclones). Typically, tourism and the export of agricultural commodities account for a large proportion of their GDPs. Efforts to diversify/restructure their economies and develop alternative crop incomes have met with only partial success, and agricultural

exports need to be more internationally competitive.

The agriculture sector is important for foreign exchange and remains the major source of employment. The problems and challenges facing the sector include inefficient methods of production, widening disparities in earnings, and weaknesses in government infrastructure. Unlocking the potential of the smallholder sector is the key to increasing rural incomes, expanding agro-exports, and diversifying into new niche markets. As in Latin America, this will necessitate the development of technologies which will help farmers and fishermen to produce and earn more while at the same time minimizing environmental damage.

The main 'green' issues facing the small island states are deforestation, land degradation, loss of biodiversity, deterioration of water resources, and mismanagement of reefs and coastal fishing areas.

Environmental solutions are likely to require an upgrading of environmental planning, regulatory and implementation capacity, especially on a regional basis.

Low prices and less favourable trading relationships, which have caused economic hardship and created difficult debt-servicing problems, have been accompanied by a decline in official aid flows to the Caribbean and Pacific regions. This trend seems likely to continue as changes in the distribution of resources favour Africa and eastern Europe. In the Caribbean region, Belize and

Guyana are the main recipients of UK technical assistance (the UK is the largest single bilateral donor). The most significant bilateral donors in the Pacific region are Australia and Japan, with Papua New Guinea being the major recipient.

The EU operates regional initiatives under the Lomé agreement, with agriculture and natural resource management identified as priority sectors. Funding focuses on skills training, production and marketing efficiency, land use and water catchment management.

The World Bank actively supports human resource development, land tenure reform and poverty alleviation, but because of the small size of many of the individual projects, much of the lending is channelled through development banks as regional projects. The IDB is active in the Caribbean with priorities including critical watershed protection, forest management, conservation of coastal areas, urban pollution, and management of protected areas and national parks. In the Pacific region, the Asian Development Bank (ADB) seeks to promote infrastructural development and diversification and to strengthen the productive sectors.

NRI has a fairly successful track record in the Caribbean and the Pacific and has typically secured about 8% of its retained income through projects won in the region. However, business development opportunities are likely to decline in line with the fall in bilateral funding, and

NRI's future may rest with its ability to win projects through the multi-lateral agencies, particularly within the EU. Projects won or implemented by NRI in 1995 include the following:

- The Commonwealth Rain Forest Programme IWOKRAMA, Guyana, Commonwealth Secretariat (value £ 100 000)
- Review of the Fisheries
 Extension and Training
 Project, Vanuatu, EU
 (value £ 90 000)
- Regional Environment Study (CREP), Caribbean Regional, EC (value £110 000)
- Establishment of a National System of Protected Areas (GEF), Guyana, World Bank (value £ 20 000)
- Jamaican Banana Quality
 Improvement Project, ODA (value £ 395 000)

Most projects reflect the funding priorities of the international aid donor community and the particular strengths of NRI. Forestry protection, fisheries and environmental protection projects predominate, but NRI is also strongly involved in agricultural diversification and plant protection activities. In contrast to Latin America where most of the Institute's work involves the application of modern technology to identify and tackle development problems, NRI's work in the small island states tends to involve the building up of institutional capacity, market identification, and the raising of

the skill base in the smallholder sector. NRI is able to call on manpower from within its own resource base in all these areas. Areas in which NRI expresses interest but draws heavily upon external resources include urban waste handling projects and programmes involving ecotourism and water services development.

CEECIS REGION

The CEECIS region comprises the countries of Central and Eastern Europe (Albania, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia) and the Commonwealth of Independent States (Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine and Uzbekistan). It extends from the German border in the west to the Bering Strait in the east, and from the Arctic Ocean in the north to the Mediterranean and Black Sea in the south. It is the only NRI region to lie wholly outside the tropics.

For much of the 20th century, this vast, geographically, climatically and culturally diverse region has shared a common legacy of central economic planning. The effects of this have included:

 the creation of structural inefficiencies in the agricultural and agroindustrial sectors which have ultimately led to deficiencies in food quality, supply and distribution threats to the air, land and water resources of the natural environment which have resulted from political and economic drives for increased industrial and agricultural production.

The key development issues of restructuring the farming sector, providing support for private farmers and developing improved systems for the distribution, quality control and marketing of foodstuffs, apply throughout the region. Within this sector, donor policy has been to support the transition to market economies by providing the know-how. The main programmes are PHARE (EU assistance to Central and Eastern Europe), Tacis (EU assistance to the CIS) and bilateral aid under the British Government's Know How Fund, Joint Assistance Unit (JAU). The political and economic agendas of countries which are currently associate members of the EU (Bulgaria, Czech Republic, Hungary, Poland, Romania and Slovakia) are increasingly being set by the goal of achieving full membership within the foreseeable future. Here, harmonization with EU directives on food quality and consumer protection are additional issues. Since 1992, NRI has been actively involved in this process by providing technical assistance in the following projects:

 Restructuring of public agencies for food quality and consumer protection and project appraisal and field management for the Agricultural Development

- Fund, Poland, both projects are JAU-funded (value £ 367 000 and £ 148 000, respectively)
- Support to the freshwater fisheries industry, Romania, JAU (value £ 1 300 000)
- St Petersburg Animal Feed Improvement Project, Russia, EU Tacis (value £ 36 000).

In addition to these on-going projects (three of which involve the long-term placement of NRI staff in-country), new initiatives in 1995 included the Pilot Integrated Development Project (PIDEP) in Uzbekistan (EU Tacis). This £ 1.38 million project, which involves EU partners from the Netherlands and Italy, aims to improve agricultural productivity, post-harvest management, processing, packaging, marketing and distribution of fresh and processed food, and to increase exports.

Like the earlier projects in Poland and Romania, PIDEP emphasizes the development of human resources through a programme of seminars, workshops, practical training and study tours which expose participants to 'best practice' and management techniques within organizations in the EU. With its strong academic, institutional and research links in the agricultural and fisheries sectors and food industries, NRI's role as a training body has become increasingly evident in 1995.

Elsewhere in the region, the repair of environmental damage is seen as the priority task. The World Bank has been active in this area and has been seeking improved environmental management. In this context, it has looked to bilateral donors to co-ordinate its initiatives or provide technical assistance. Hence, the JAU has commissioned NRI to provide assistance to Programme 2 of the Bank's Aral Sea Basin Program. This addresses the environmental problems caused by the overexploitation of water resources for irrigated agriculture.

In 1995, a hydrometeorological inventory begun in 1994 developed into a project for introducing effective real-time environmental information systems to the five countries of Central Asia in order to promote the sustainable management of land and water resources. It included the installation of ground receivers for satellite data and imagery, the establishment of geographical information systems, and research on software applications. Staff training (locally and in the UK), and the delivery and maintenance of hardware incountry, are important components. The two projects have a combined contract value of £ 223 000.

VISITORS

During 1995–96, NRI received 452 official visitors from 79 different countries. Among them were several ministers of state and government officials from developing countries, and officials from overseas research councils,

international research institutes, overseas universities, research institutes, and many organizations working in the field of sustainable natural resources. Briefings were also given to members of the diplomatic service, and British Council employees taking up new posts overseas.

The visitors included: Mr Sarwono Kusumaatmadia, State Minister of the Environment, Indonesia, Mr Ernesto Guhl Nannetti, Vice Minister of the Environment, Colombia, Mr Isaac Anjos, Minister of Agriculture, Angola, Mr Ronald Sebego, Assistant Minister of Agriculture, Botswana, Mr Paul Dominguez, President's Assistant from the Philippines, Dr J. Terblanche, President of the Agricultural Research Council in South Africa, Mr Philip Dobie, Adviser UNDP, Mr Ian Bryceson, Adviser NORAD, Mr Patrick Sayer, CARE UK and Mr David Pearey,

First Secretary (Aid) Lagos, Nigeria.

The range of visitors received each year at NRI reflects the interests and changing needs of developing countries. The 1992 Conference in Rio de Janeiro raised awareness of the environment and this has been reflected in the number of visitors interested in environmental policy, environmental impact assessment and the management of natural resources. There has also been a noticeable interest in environmentally friendly technologies for solving problems such as pest control or disposal of wood chippings.

The number of visitors from Eastern Europe has increased this year, indicating a need for western expertise to revitalize the economies of Eastern European countries. In July, staff met Mr Pulat Madzhitovich

Abdurakhmanov, the Governor of Samarkand, prior to the start of a project in Uzbekistan.

Many of the visitors are decisionmakers. They come for discussions and to learn from NRI experience and expertise in the developing world, and they take away an impression which may be of critical importance to NRI's future. It takes time for the effects of a visit to be seen. For example, a visit by a South African official in 1994 led to a series of visits by a minister and officials in 1995; a similar 'chain reaction' has taken place in Belize. Personal contact and word of mouth are powerful tools in the promotion of organizations, and visitors play a vital role in maintaining a high profile for the Institute. This will be particularly true as NRI looks forward to its new situation as a privately funded body within a university framework.

RESPONDING TO THE CHALLENGE

NRI's broad disciplinary base is a major advantage in problem solving. This unique feature includes biological sciences (with an emphasis on ecology and the environment), agriculture, livestock, fisheries, forestry and social sciences (including agricultural economics and sociology). Staff specialize in natural resource management issues and problems and frequently work in multi-disciplinary teams effectively integrating skills. The Institute uses inter-disciplinary and systems approaches and a particular interest is the inter-linkages between biological, human and farming systems. Expertise lies principally in solving the scientific and practical problems of systems and taxa which are heavily utilized, often unsustainably, as a result of population growth and agricultural intensification. An extensive programme of laboratoryand field-based research underpins the problem solving skills.



INCREASING FOOD PRODUCTION

FOOD SECURITY

The concept of food security has undergone a major change of emphasis in the past two decades. Seen then as primarily a question of raising staple food supply in the global and national context, the focus of food security in the 1970s was on national self-sufficiency in cereal grain production by expansion of area planted, increased use of high-yielding varieties (HYVs), greater reliance on agricultural inputs (fertilizers and pesticides), and high levels of intervention by marketing boards. Food production remains a key factor in global food security, against a background of growing demand for food from a steadily increasing human population and unabated urban drift.

These days, however, such food production and demand issues are set in the context of a far wider definition of food security, one in which, following the widely cited World Bank definition, food security requires access at all times, by all individuals, to a sufficient quantity and quality of food for an active healthy life. The focus on access emphasizes that food availability alone is not sufficient; the ability of the individual to acquire food is at least as important. Food security thus depends on poverty alleviation and security of livelihoods, as well as on food supply. In this conceptual framework, household food security becomes at least as important as the national and global food supply; it is not

confined to food issues alone but is linked to economic and social development issues such as market performance, access to education and health care, and fertility choices. Much of NRI's work contributes directly or indirectly to food security in this wider sense, as will be evident from the sections of this report which relate to pre-harvest crop losses, postharvest food losses, livestock production, farmer livelihoods, commodity markets, resource assessment and environmental management.

The challenge of continued growth in global food supply has become greater as many of the old certainties about approaches to increased production have disappeared.

- (1) Urban and industrial growth is displacing agriculture, leaving little room for expansion of area planted except into marginal land where yields and sustainability of cropping are low and the potential for environmental damage is high.
- (2) Uptake and impact of HYVs has been limited in many low-income countries by the high cost of the necessary agricultural inputs; yields of HYVs from conventional breeding programmes show some evidence of approaching a plateau, while biotechnology has been slower than expected in delivering quantum improvements.
- (3) Resource-poor farmers often cannot afford fertilizers or pesticides, and pest resistance and environmental concerns are steadily limiting the use of the latter.

(4) As part of structural adjustment programmes, many countries have dismantled their food marketing boards (or severely curtailed their operations) without, in most cases, creating an enabling environment for the development of, and investment in, a private-sector staple food market capable of filling the void left by the marketing boards.

In addition, the global food security picture continues to change with, for example, greatly reduced production in several countries of the former Soviet Union, predicted increases in import demand from China and other Asian countries to meet growth in the livestock sector, expected reforms of the Common Agricultural Policy in the EU, and the anticipated but uncertain effects of international market liberalization following the Uruguay round of GATT negotiations.

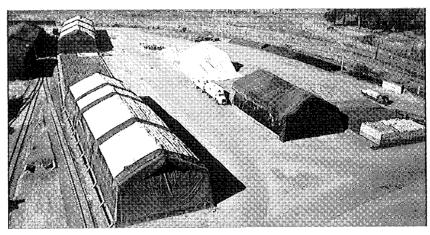
The inclusion of quality in the modern definitions of food security represents a significant change from the emphasis on quantity alone in earlier years, following the 1974 World Food Conference; it acknowledges that an adequate diet is more than a simplistic calorific minimum. A focus on quality also recognizes the opportunities for producers and processors to add value to food and thus improve livelihoods.

NRI activities which specifically address food security issues include: maintenance of quality and quantity in relation to food availability, safety and nutrition; potential for adding value to

staple food commodities; improved market access for farmers; and management of risk in agricultural production and marketing. Five examples from the joint work of the Food Security Department, Crop Utilization Department, Social Sciences Department and Environmental Sciences Department are described below.

Maize quality in national food security stocks in Africa

In sub-Saharan Africa, national food security stocks of grain, whether from domestic procurement, commercial importation or food aid, are often held in bag-stacks either in large warehouses or outdoors under tarpaulins. In recent years, such stocks of maize have increasingly been affected by 'stackburn', in which cycles of heating in large stacks cause the maize grain to become discoloured (to ochreous brown in extreme cases); this results in a downgrading of thousands of tonnes of grain to animal feed, or to complete rejection for food or feed use. Entomologists, engineers, mycologists and storage technologists from NRI, Instituto de Investigação Científica Tropical (IICT) (Portugal) and the Universities of Ghana and Zimbabwe are conducting a series of laboratory and field trials to establish the cause of stackburn, which appears to involve a complex interaction of factors including sack materials, stacking procedures, physical condition of the grain, insect infestation, and microbial activity.



Most national grain stocks in sub-Saharan Africa are stored in bag-stacks outdoors under tarpaulin sheets



A prototype ventilated stack reduced internal grain temperatures by 10 °C and no discoloration was observed after a year of storage

In Zimbabwe, the Grain Marketing Board (GMB) has estimated a loss of over £1 million due to stackburn. With assistance from NRI, the GMB has designed and tested a new stacking procedure to reduce the risk of the problem occurring. The new procedure creates a series of horizontal and vertical channels throughout a stack which allow air flows to dissipate any heat produced while maintaining the essential structural integrity and stability of the stack. Tests on the first such modified stack showed that temperatures were, on average, 10 °C less than usual and, on despatch, none of the maize was downgraded due to stackburn or other quality defects.

A cost-benefit analysis is currently being undertaken to evaluate this technical improvement to largescale maize storage.

In view of the technical success of the ventilated stacking system, GMB organized training courses in the new procedure for more than 100 stackmasters and used the technique at all its major depots in 1995.

The incorporation of ventilation channels into stacks has potential application for other food security stocks in sub-Saharan Africa, as well as for large-scale traders and relief agencies handling significant quantities of food aid.

Promotion of improved rural maize storage technology

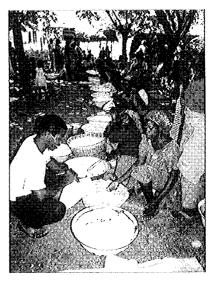
Maize stored on the farm in several countries in Africa is attacked by the larger grain borer (LGB), Prostephanus truncatus, which has been spreading across the continent for over 15 years and threatens household food security in rural areas. It was first recorded in Ghana in 1989 and for the past three years, NRI has been working with Ghana's Ministry of Food and Agriculture to develop and promote improved technology for small-scale farm storage to reduce losses due to LGB and other causes of postharvest spoilage and deterioration. Emphasis has been placed on participatory approaches to this work, and small-farmer stakeholders have been involved in the research to ensure not only that the improved technologies are acceptable, but that farmers own the improvements.

Such participatory research with farmers is increasingly used by agricultural scientists. However, it is uncommon for researchers on small-scale farming to involve traders in participatory approaches, even though the price paid by traders for farm produce is the main economic force driving the adoption of new technologies. The work in Ghana has been unusual in that it has involved traders in the research in two important areas. The first was in analysing the relationship between insect damage to stored maize and the value of the maize; the analysis also included other factors such as variety, length of storage, moisture content and colour. Trader panels from different

markets were asked to value samples of maize (and explain their valuation) and the values were then compared with the observable factors. Many traders gave a price mark-down for HYVs, newly harvested maize and wet maize, and some gave a markdown for yellow maize. Low levels of insect damage (5%) rarely attracted any mark-down but above these levels, losses in value increased in line with proportion of insect damage. Trader panels were also used to price samples for cost-benefit analysis of different maize storage treatments in field trials. Comparisons with analyses of weight losses in the laboratory showed that, above a threshold of 10% insect-damaged grains, value losses increase more rapidly than the corresponding weight losses. It was also found that trader pricing was much more effective in evaluating treatments when mould was a factor in deterioration as well as insect damage.

Traders travel widely in the rural areas and supply information, credit, and sometimes even storage chemicals to farmers. These traders are almost exclusively women and can thus communicate more effectively with women farmers than the male agricultural extension staff. Therefore, the project team has not only involved these women in the research, but has also tested their effectiveness as extension agents for the maize storage technologies. Over 300 maize traders have been given one-day training courses in storage pest control, using a combination of participatory problem-solving and formal transfer of the key

technologies for control of LGB and the other main pests.



Women traders in Volta Region, Ghana, assess the quality and value of maize samples, and answer a questionnaire from a member of the project staff

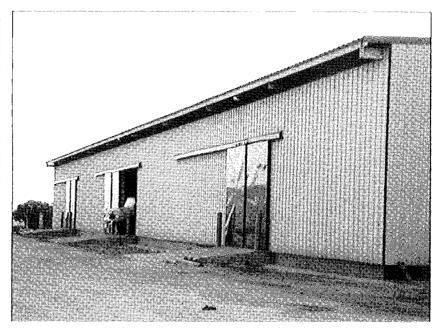
The traders have also been provided with leaflets and posters on LGB for distribution. No formal assessment of the impact of this training of traders has yet been made, but initial observations suggest that the new knowledge is being rapidly and widely disseminated to farmers, and that it is also passing upwards to large-scale traders.

Improving marketing and post-harvest handling of cassava

Participatory work with traders has also been a feature of the latest phase of work on improved handling and storage of cassava in Tanzania; this is part of a wider programme to develop and validate needs assessment methodologies for the identification and prioritization of

post-harvest technical interventions for non-grain starch staples in sub-Saharan Africa. The earlier preoccupations with global and national food supplies led to a focus on cereal grains as the durable starch staples of international and regional trade. The importance of grains in such trade remains, but the attention now given to household food security has brought the non-grain starch staples (roots, tubers, plantains and cooking bananas) into prominence as key factors in local food security in many areas. In sub-Saharan Africa, cassava is currently the most important of these non-grain staple foods, and increasing urbanization is leading to a growing demand for fresh cassava in towns and cities.

A needs assessment study based on rapid rural appraisal techniques was used to identify problems and opportunities in the cassava marketing system in Dar es Salaam. This showed that losses resulting from delays in the marketing chain were the major issue, and a programme was initiated for the adaptive transfer of low-cost cassava storage technology formerly developed by NRI and the International Centre for Tropical Agriculture (CIAT) for cassava marketing in Latin America. Considerable benefits were demonstrated for all elements of the technology: dressing of wounds or separation of damaged roots; shading of storage sites; high humidity storage (in polyethylene bags, or in clamps under plastic sheeting or canvas); and optional use of thiabendazole as a fungistat.



Safe storage for inventory credit will require modern warehouses, such as these, where grain quality can be guaranteed and security is assured

This low-cost technology has been demonstrated to a group of traders at one of the large markets in a participatory dissemination exercise. One- to two-day old cassava roots were purchased in the market and the traders were shown how to grade, clean and treat them with water and thiabendazole. The treated roots were stored in polythene or hessian bags, or both, and were then sampled weekly and scored for deterioration over three days. The demonstration showed that cassava could be stored for three weeks or more at the market.

The traders have adopted most of the techniques (though using water alone without the addition of thiabendazole). These market trials alerted cassava merchants to the possibility of storing cassava for at least a week, even without using chemicals for control of deterioration. The lessons learnt in the market need to be promoted further down the market chain, to retailers and street vendors, where small-scale temporary storage of cassava in plastic bags is also likely to be beneficial. The damage found on roots arriving at the urban market could also be reduced by more careful harvesting practices or by simple wound-dressing in the field before the roots are placed in sacks.

Enhancing farmer access to markets

Structural adjustment programmes and associated grain market liberalization have not usually been accompanied by strategies to create an enabling environment for development of the private sector in grain trading, either by enhancing marketing systems or by providing essential credit. Macro-economic policy changes, which should in principle enhance national and household

food security through efficient market liberalization, have thus often failed to do so in practice. NRI has therefore been working to develop efficient and effective marketing and credit systems for smallholder farmers by improving the performance of market intermediaries and by enhancing farmers' access to markets.

NRI's recent work has focused particularly on the use of inventory credit as a means to improve the financing of trade, and on the development of contract farming (or outgrower) schemes. An NRI mission to Zambia in October 1995 investigated the scope for inventory credit and generated considerable interest among donors and private operators; there are indications that the private sector will put arrangements for inventory lending in place. During 1995, NRI has had discussions with various international organizations and private companies which have experience and knowledge of agricultural commodity trading and the operational concept of using stored commodities as loan collateral. The feedback from these discussions has been very positive and has added to NRI's expertise in advising on the establishment of inventory credit systems.

Work on contract farming and outgrower schemes involved an initial desk review, covering sub-Saharan Africa, with support from the Commonwealth Development Corporation; follow-up studies were undertaken in Zambia in March. The desk research indicated that these schemes can

play an important role in providing smallholders with access to new markets as well as to agricultural inputs and extension services. However, analysis of past performance of such schemes shows that they can be undermined by poor design, leading to participant dissatisfaction, low production, and diversion of sales. In view of the considerable interest in these schemes being voiced in the southern African region, NRI is attempting to identify the key features of successful schemes and will be working with the Zambia National Farmers Union to disseminate its findings.

Drought risk management

The ever present threat to national and household food security in southern Africa is drought leading to failure of the main staple crop. Although the region is chronically drought prone, geographical variation usually ensures that the rains are adequate in some production areas; the region-wide drought of 1991-92 was unusual. However, although climates are always changing, there is some evidence that southern Africa is becoming increasingly drought affected, with a continued decrease in rainfall in recent years instead of the upturn which would be expected on the evidence of regional rainfall cycles during this century. Climate variability is likely to remain the single most important factor affecting the livelihoods and food security of people in southern Africa, but there is no country in the region which manages drought risk well.

Recent advances in climate forecasting techniques offer opportunities for early warning of the risk of drought. A mission has therefore recently been undertaken to determine whether the social and economic benefits of using long lead-time climate forecasting techniques to manage drought risk in southern Africa would justify the investment needed to bring such techniques into widespread and co-ordinated operational use. The mission team consulted a wide range of decision-makers, weather information users and technical specialists in Botswana, Malawi, South Africa and Zimbabwe during July 1995, and their views were markedly positive and similar; reliable drought prediction was seen as a very high priority for the peoples and economies of southern Africa. The team found that: southern Africa does appear to be becoming increasingly drought affected; for many countries in the region, a reliable indication of the quality of the next wet season is probably the most useful single item of information that could be provided to a variety of sectors (water resources, agricultural production, wildlife management, energy supplies, etc.); on-going climate research is much closer than is generally appreciated to being able to provide reliable and timely information of this kind (e.g. forecasters are already confident that they can predict four out of five droughts); in their present state, meteorological institutions in the region cannot realize the full potential of their global links so they are in need of investment and institutional development; and, while

improved long lead-time forecasts offer the prospect of significant benefits, these will not be fully realized without concurrent developments across various sectoral policies in these countries.

The mission concluded that relatively modest investments in improvement of climate prediction and strengthening information dissemination and uptake pathways, could revolutionize drought risk management, thus enhancing economic responsibility, national food security and natural resource management throughout the region. The potential benefits from the better management of strategic grain reserves alone are thought to justify the necessary investment for mitigating the effects of recurrent drought.

REDUCING PRE-HARVEST CROP LOSSES

NRI plays a central role in research on crop protection in the developing world. It is involved in shaping European and international policy by providing the secretariat for the International and European IPM Working Groups, collaborating with international agricultural research institutes (CG centres) and consultancy work in crop protection for a wide range of donors. It also manages ODA's Renewable Natural Resources Research Strategy (RNRRS) for crop protection. With a life of 10 years and a value of some £ 16.5 million over the first three years, this is the largest single crop

protection research programme in the world. It draws on NRI's considerable experience in managing crop protection projects, and its world-renowned expertise in integrated pest management (IPM) and associated technologies (notably, pesticide management, pheromone chemistry, microbials, migrant pest forecasting, ecology and control) and pest ecology and taxonomy. The programme is further supported by specialized inputs from the wider UK resource base in technologies contributing to crop protection. This new research strategy has a much stronger focus on problems which have been identified internationally as needing particular attention. Within this ambit, ODA has identified areas of particular constraint to small producers in specific agroecologically and economically defined production systems and, in recognition of the international agreement (e.g. UNCED Agenda 21, Rio) to adopt IPM and environmental conservation as policy, has emphasized that such interventions should be socioeconomically viable, sustainable with minimal reliance on agrochemical inputs, and of benefit to women and the environment.

While the new strategy is still in the implementation phase, some existing projects have continued, modified where necessary to emphasize the above criteria. Preharvest crop losses caused by pests, diseases and weeds continue to be a major source of concern for resource-poor farmers. IPM approaches which address these constraints are being developed by

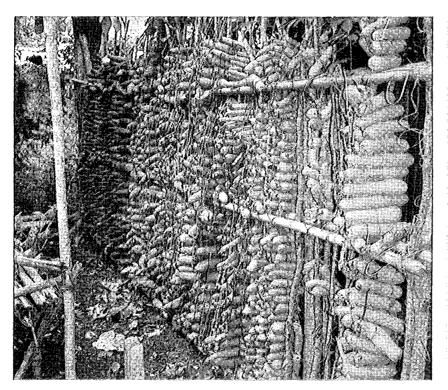
NRI, often drawing on areas in which the Institute has particular expertise.

Non-insecticidal control: cultural techniques and crop resistance

NRI's expertise in pathogen diagnostics and pest behaviour, sometimes combined with simple field techniques including indigenous methodologies, has enabled important improvements to be made. Its capability to undertake basic research in molecular biology has effectively underpinned crop resistance breeding programmes.

Propagation of healthy yams

Yams (Dioscorea spp.) are an important food crop in many developing countries but they are grown most widely throughout humid tropical West Africa, accounting for over 90% of world production. Largely grown by resource-poor farmers in relatively small plots with minimal inputs, they are vegetatively propagated through the planting of tuber pieces and this can result in the build-up of fungal, nematode and virus diseases. Traditionally, farmers have planted large pieces to increase survival. However, this is expensive and results in a very low multiplication rate. Field trials in Nigeria between 1993 and 1995, carried out to test the efficacy of a range of different preplant treatments of 25 g pieces of yam (called minisetts), indicated that untreated pieces often fail because of rotting caused by fungi. Although virus-infected minisetts usually fail to produce usable



Yams in storage. Yams are traditionally stored for up to four months in the open on racks away from attack by termites, and propagated from small pieces of the least saleable yams which tend to be the product of poor quality and unhealthy plants

tubers, treatment by dusting or dipping in a solution of a systemic fungicide, such as thiobendazole or imazalil, prior to planting increases both survival and final yield of white yam (D. rotundata) minisetts by up to 50%. As locally available fungicides are effective and only small amounts are needed, this procedure is cheap and poses little risk to the environment or the grower. By adopting the integrated strategy of selecting a reliable variety, only planting tuber material from yam vines which appeared virus-free the previous season, and treating this material with a fungicide before planting, a grower in West Africa can readily improve the general health of his yam crop, increase productivity, and thus, cover the small additional cost of the fungicide.

Molecular diagnostics for yam potyviruses

In West Africa, the two potyviruses, yam mosaic virus and yam virus I, are widespread and cause heavy losses among the most commonly cultivated yam species, the white/yellow yam and the water yam. Until recently, although the cause of the losses was known, the diagnosis of these viruses was difficult and unreliable. However, with support from the Gatsby Charitable Foundation, NRI has now developed novel molecular tests, using the polymerase chain reaction (PCR) technique, which permit the rapid and reliable detection of both these viruses in yam leaf and tuber samples. The work has now been transferred to staff at the International Institute of Tropical Agriculture (IITA) in Nigeria where the tests are being used in

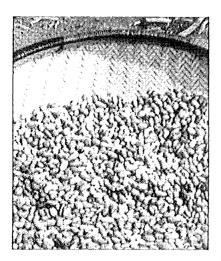
epidemiological studies and yam breeding to screen material and ensure that it is virus-free before it is supplied to breeding programmes in other countries.

Sweet potato weevil control

In another example, a very simple addition to routine crop husbandry has been shown to reduce losses. NRI has been working on soil pests in Malawi in collaboration with staff and students of Chancellor College, Zomba. As part of this work, it was noticed that when sweet potato is grown in the traditional way, cracks which may appear in the sides of the mounds or ridges expose the young tubers and allow infestation by sweet potato weevils (Cylas spp.). In experimental trials, the level of tuber damage was compared in rows in which soil cracks were closed by scooping soil over them with the side of the foot and those in which the cracks were left open. Closing the cracks produced a highly significant increase in the number of undamaged tubers.

Rice leaf scald: pathogen characterization

Rice leaf scald, which is caused by the fungus *Monographella albescens*, is a locally serious disease of rice crops around the world. Cultivars bred for resistance to the major rice disease rice blast (caused by *Magnaporthe grisea*) tend to be susceptible to leaf scald, and this has serious implications for the deployment of blast-resistant cultivars in rice development projects.



Range of bean landraces from Tanzania harvested from a single plot

Biochemical studies at NRI and with the West African Rice Development Association (WARDA) have shown that M. albescens produces host-specific toxins which may contribute to the weakening of the host plants' defences against infection, but which require exposure to daylight in order to function. Studies have also demonstrated that characteristic patterns of pathogenicity towards a range of rice cultivars can be determined for individual M. albescens isolates. The ability to characterize isolates in terms of their pathogenicity towards a given set of rice cultivars is an important development. It means that the variability of pathogen populations can be assessed, something which had not been done with this disease before.

Exploiting indigenous technologies: beans

In long-established and stable farming communities, indigenous technologies have developed which provide a fair degree of yield protection under a range of local conditions. With rapid increases in population density, or changes to soil fertility and weather patterns, many of these technologies fail to be as effective. However, they may provide insights which can be exploited with the help of new technologies. Selection of bean seeds is an example.

The common bean (Phaseolus vulgaris L.) is the most important food legume in eastern Africa, particularly in the eastern highlands where it provides up to 40% of the population's protein intake. Subsistence farmers in these areas, who are very often women, commonly grow mixtures of landraces characterized by great genetic diversity which is manifested as seed colours, patterns, shapes and sizes, and which has resulted from both natural and farmer selection over a considerable period of time. Landrace mixtures usually have several different markers which the farmers use as indicators of taste. use, yield, storage characters, resistance to environmental stresses, and time to maturity. Work by NRI with Horticultural Research International (HRI) (Wellesbourne) has shown that there is also a considerable variation in disease (fungal, bacterial and viral) response, both between and within the different bean mixture components. Extensive field trials in Tanzania to quantify the effects of diseases on beans grown either as mixtures or in pure stands, and to evaluate disease-resistant beans, showed that one line was resistant to all nine races of the bacterial pathogen which causes halo-blight and the four strains of the fungus

which cause anthracnose. Genetic studies are in progress to find out how the resistance genes are inherited, and these sources of resistance are already being used in the Tanzanian national breeding programme to improve local commercial varieties.

Identification and transfer of technology

Before action can be taken to reduce crop loss, the nature and cause of the problem need to be defined. Problem definition can take many forms. It may range from field surveys to estimate extent and severity and rapid rural appraisal techniques to ascertain farmers' knowledge and responses, to taxonomic studies and laboratory investigation involving sophisticated molecular techniques to identify pest organisms. Once such techniques have been developed and tested, they need to be transferred to staff working in national crop protection institutes. This may involve appropriate modification of the techniques and the provision of the necessary infrastructural support and advice, including the production of suitable books or instruction manuals, to make this possible.

Transfer of diagnostic methods for detection of plant-pathogenic bacteria to Indonesia

At the invitation of the Research Institute For Food Crops Biotechnology (RIFCB) in Java, NRI helped to organize a national workshop on the detection of bacterial plant pathogens. The 25 participants were trained in the application of techniques to identify bacteria; these included isolation and identification methods and the use of the NRIdeveloped BACTID kit. The BACTID kit consists of a series of standard bacterial identification media tests which have been modified to reduce the cost of preparation and media reagents. Associated computer software allows identifications to be made. Serological (ELISA) and molecular (PCR) tests for Pseudomonas solanacearum, the causal agent of bacterial wilt, were also demonstrated.

As they did not require the purchase of expensive equipment or consumables, the BACTID and ELISA tests were considered by the majority of participants to be the most suitable techniques for their laboratories. A two-week training course in ELISA and PCR for *P. solanacearum* was given to RIFCB staff after the workshop. These techniques are now being used in an ACIAR/CIP project to aid identification of

clean potato planting material for use by farmers.

Phytoplasma and virus-like diseases of Gliricidia sepium in Latin America

Gliricidia sepium (Madre de Cacao), an important woody legume native to Central America, is being widely promoted by agroforesters in many tropical countries. It has a range of uses which includes live fence posts, firewood, animal fodder and shade for cocoa and coffee. In parts of Honduras and Guatemala, the plant was found to be affected by a serious, unknown disease with symptoms of general decline (little-leaf) which suggested that a phytoplasma (mycoplasma-like organism) might be the cause.

In 1995, studies undertaken as part of a Forestry Research Programme-funded project have shown that this disease is now present in El Salvador and parts of southern Mexico as well.

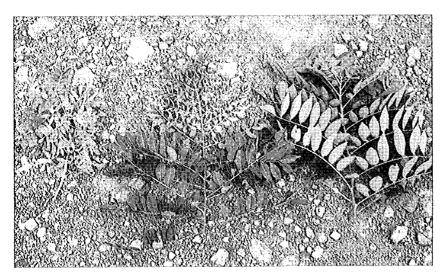
In Honduras, where the condition was first observed, it is now so severe that smallholders and farmers are often having to replant. More seriously, the disease has been found in some of the Gliricidia provenance trials and this may have serious phytosanitary consequences for the distribution of germplasm. Further evidence has been obtained that the decline is caused by the same, or a very similar, phytoplasma as that causing witches-broom in pigeonpea (Cajanus cajan).

Grasshoppers and locusts

Traditional taxonomy, the description and classification of organisms, has always been recognized as a key element in pest biology and most recently, in the study of biodiversity. The devastating but sporadic effects of locust plagues are well known but in many tropical agro-ecosystems, the less dramatic but more localized damage caused by grasshoppers may be more important to the small-farmer in the long-term. NRI is producing The Handbook for the Identification of Grasshoppers and Locusts of Eastern Africa which covers the faunas of Ethiopia, Eritrea, Somalia, Kenya, Uganda and Tanzania. So far, 754 species have been described, of which 86 (over 11%) are new to science. In addition to their tendency to become pests following the development of agricultural systems, grasshoppers are becoming increasingly important as indicator species in environmental studies of grassland management and over-grazing (as in the Serengeti and Mkomasi



Working in the laboratory in Indonesia



Little-leaf symptoms, leaf yellowing and a normal leaf

National Parks). The book will reach its final draft during 1996.

Laboratory facilites in Uganda

Laboratory facilities have been set up at Kawanda Agricultural Research Station in Uganda, and local staff have been trained in the principles and use of PCR diagnostics for monitoring Black Sigatoka. A detailed laboratory instruction manual has been produced with an easy-to-follow protocol. This has enabled a survey of banana growing areas to determine the distribution of the disease on local varieties. The test is particularly useful for identifying the pathogen in samples which are impossible to diagnose by visual symptoms alone.

Emergencies, problem assessment and advice

In some cases, pest infestations result from changes in weather patterns, or as an indirect result of hostilities. In such instances, emergency action may be needed before a detailed assessment of the problems affecting crop production can be made. For sustained and effective crop protection, detailed follow-up studies are nearly always necessary. During 1995, NRI staff have been involved in such activities and two examples are given below.

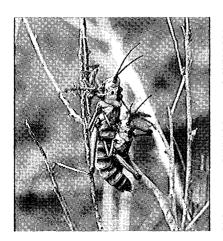
Ethiopia

The Wollo bush cricket, Decticoides brevipennis (known locally as Degeza), causes serious cereal crop losses in the highlands of Ethiopia. Following a natural disaster and the effects of war, ODA supported the Save the Children Fund's Emergency Pest Control Project (EPCP) in the North Wollo and Wag Hamera regions of Ethiopia, through funding inputs and training by NRI in the safe and effective control of Degeza using conventional insecticides. Since its launch in June 1994, the project has reached over 10 000 farmers. Concerns over the possible effects of the insecticides on bees led to an evaluation of Dimilin

(diflubenzuron), an insect growth regulator which is safe to bees and mammals, by NRI in close collaboration with the EPCP and local Ministry of Agriculture staff. Initial results indicated that a single treatment of Dimilin was as effective as malathion for controlling Degeza in wheat, barley and tef.

Georgia

Since independence in 1991, the collapse of the collective farming system has put social, economic and nutritional pressures on rural communities and left villagers without access to agricultural inputs and technical assistance. In addition to infrastructural breakdown and an influx of internally displaced persons (IDPs), the Colorado beetle, Leptinotarsa decemlineata, has invaded potato crops in northwest Georgia, causing devastating losses to this very important cash, food, and animal feed crop. A project funded by CARE and the ODA **Emergency Aid Department** aimed at providing training, protective clothing, sprayers, and safe and effective pesticides to enable farmers to implement control measures against the Colorado beetle in the 1995 season, was subsequently reviewed. Although the impact on Colorado beetle had been considerable, much of the potato crop was subsequently severely infested with late blight, Phytophthora infestans, which reduced tuber size and resulted in greater than normal losses in winter storage. However, unexpected benefits were the cooperation fostered within and between villages through the

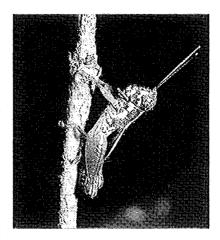


Mating pair of the rare Eritrean grasshopper Paraphymateus roffeyi Dirsh 1962 (Orthoptera, Pyrgomorphidae)

appointment of 'Point Farmers' with the responsibility of distributing inputs and services, a better understanding of farm economics, and a more business-like approach to agricultural production.

Safe and effective use of conventional insecticides

There are always likely to be crop pests which can only be controlled with chemicals. Tree crops pose particularly difficult problems for the safe and effective application of pesticides, and satisfactory deposition of spray over the leaf canopy is difficult to achieve using low-cost equipment. Problems with pesticide run-off or drift are common, giving rise to operator exposure and environmental contamination. Safe and effective techniques need to be developed to suit the diverse application equipment used by tree crop managers and their different levels of financial resources.



Flightless forest and thicket species
Kassongia rufogeniculata Grunshaw
1986, probably not collected before
because of the nymphal appearance of
the adult

Thailand

NRI has established strong links with the Thai Department of Agriculture, the Thai-GIFAP Safe Use Project and the Thai-GTZ IPM Fruit Tree Project, and this has enabled a detailed, primary evaluation of current application practices. Studies on pesticide application using airblast sprayers have demonstrated reductions in rates of pesticide use, to an average of 80% of previous levels, without significant effects on the level of foliage spray cover; spray run-off has been reduced by 80% at lower application volumes. The potential savings on pesticide use/purchase from such treatments is initially estimated at 25%; operator exposure levels were also significantly reduced.

Kenya

A survey of labels on pesticides being retailed in Nairobi revealed a range of different, and often highly confusing, methods of stating dose recommendations for, in this case, use on vegetables (summarized in the table opposite). Some labels did indicate the area which must be covered by each knapsack load, or a guide volume to be applied over a given area, but farmers may be unable or unwilling to follow these instructions. More practical and effective methods of stating dose rates have been recommended through the appropriate channels.

Microbials and pheromones (biorationals) in insect pest management

Biorationals can be important components of IPM and their use can lead, both directly and indirectly, to reductions in conventional pesticide applications. Reductions can be achieved indirectly by ensuring more rational pesticide use; for example, insect pheromones have been used to monitor pest populations so that the timing and frequency of chemical control can be improved. Reductions can also be made directly by using microbial preparations to induce diseases, or pheromones to reduce mating, in pest populations. Biorationals, particularly pheromones, are non-toxic to plants and animals, generally effective in very small amounts, and typically show a high degree of specificity for the target pest. NRI and its predecessor institutes have established an international reputation for work on pheromones, and have recorded many successes with their use in IPM.

| Α | В | С | D | E | F | G | Н | | j | K | L |
|--------------|-------------------|-------------------|--------------------------|------------------------------|--------------------------|-----------------------|------------------------------|------------|------------------------|-----------------|---------------------------------|
| Trade name | Common name | g a.i./l or kg | rec dose g a.i./ha | rec rate I/ha or kg/ha | calç dose g aa:/ha | rec rate ml/20l | calc dosage at 5001/ha | rec VAR | calc assumed VAR | PHI on label | comments |
| Diazinon | diazinon | 600 | | | 0 | 60 | 900 | | 0 | none | "to wet all parts of the plant" |
| Malathion | malathion | 500 | | 2.8 | 1400 | 75 | 938 | | 747 | 7–14 | • |
| Fenitrothion | fenitrothion | 500 | | | 0 | 30 | 375 | | 0 | 14 | "spray until plant drips" |
| Dimethoate | dimethoate | 400 | | 0.95 | 380 | 30 | 300 | 750-1000 | 633 | 14 | |
| Dursban | chlorpyrifos | 480 | | 1.25 | 600 | | 0 | | | 15 | |
| Marshall | carbosulfan | 250 | | 0.95 | 238 | 50 | 313 | | 380 | | |
| Actellic | pirimifosmethyl | 250 | | | 0 | 40 | 250 | | 0 | 7 | |
| Kelthane | dicofol | 180 | | 2.75 | 495 | 75 | 337.5 | | 733 | 15 | |
| Tafgor | dimethoate | 400 | | 0.685 | 274 | 40 | 400 | | 343 | 14 | |
| Antracol | propineb | 700 | | 2.25 | 1575 | 45 | 788 | | 1000 | | |
| Acrobat | dimethomorph | 90 | | 2 | 180 | 50 | 113 | 400-1000 | 800 | 7 | |
| | mancozeb | 600 | | 2 | 1200 | 50 | 750 | | 800 | 7 | |
| Orthion | fenitrothion | 500 | | 0.7 | 350 | 40 | 500 | | 350 | none | |
| Saprol | triform | 190 | | 1.25 | 238 | 17.5 | 83 | 400-600 | 1429 | | |
| Dithane | mancozeb | 800 | | 2 | 1600 | 50 | 1000 | 500-1000 | 800 | none | |
| Karate | lambdacyhalothrin | 17.5 | | ý | 0 | 100 | 43.75 | | 0 | none | |
| Rhodicide | ethion | 500 | | 2 | 1000 | 50 | 625 | 750-1000 | 800 | 21 | |
| Lannate | methomyl | 900 | 750 | 0.8333 | 750 | 15 | 337.5 | 2501000 | 1111 | 5 | in 100g sachets for 50-100l |
| Metasystox | oxydemeton methyl | 250 | | 0.55 | 137.5 | į. | 0 | 'suitable' | | 10-21 | • |
| Brigade | biphenthrin | 25 | | 0.5 | 12.5 | 24 | 15 | 300-600 | 417 | 3 | |
| Decis | deltamethrin | 25 | | 0.4 | 10 | 40 | 25 | 200 | 200 | 1 | |
| Lebaycid | fenthion | 500 | | 1.07 | 535 | 22.5 | 281.25 | 11000 | 951 | 14 | |
| Ambush | cypermethrin | 50 | | 1 } | 50 | 100 | 125 | 222 | 200 | 0 | VAR given as 201/35 by 35 pace |
| Thiodan | endosulfan | 350 | | 1.5 | 525 | 30 | 262.5 | | 1000 | 14 | "100-200ml/1001 water" |

= calculated cells

N.B. In some cases, average figures have been used for the purposes of the calculations e.g. if the recommended rate is given as 30–50 ml/ 20I sprayer, this is expressed as 40 ml/ 20I.

Support and training in the use of microbials

NRI has been developing the use of microbials, viruses, entomopathogenic bacteria and nematodes in developing countries for many years. However, although the success of some biorationals has led to indigenous commercial production, product quality is often poor and this can lead to control failures and a loss of confidence amongst disappointed users. In response to concern over the variable quality of some baculovirus insecticides being produced in India, NRI staff have refurbished an existing insect virus production unit and established a new diagnostic laboratory at Tamil Nadu Agricultural University (TNAU). The unit is now producing a standard high quality Helicoverpa armigera nuclear polyhedrosis

virus (HaNPV). A short training course on baculovirus production and quality control targeted at commercial and public sector virus producers was held in collaboration with the International Crop Research

Institute for the Semi-Arid Tropics (ICRISAT) Asia Centre and TNAU; it was very well received and there has since been substantial demand for further courses.



Students on a baculovirus quality control course at ICRISAT receive training in the use of microscopes to assess virus concentration

Pheromones in the management of rice pests

During 1995, work has been consolidated on the use of pheromones for: the control of yellow rice stemborer, Scirpophaga incertulas, in collaboration with the ICAR Directorate of Rice Research in India; the monitoring and control of white rice stemborer, Scirpophaga innotata, in collaboration with the Central Research Institute for Food Crops, Indonesia; and the control of maize stemborer, Busseola fusca, in collaboration with the Kenya Agriculture Research Institute (KARI). In the laboratory, significant progress has been made on the identification of the pheromone of the legume pod borer, Maruca testulalis; field trials have been carried out in collaboration with ICRISAT in India, IITA in Nigeria and the Asian Vegetable Research and Development Centre (AVRDC) in Taiwan.

Cotton pest management

As a result of work carried out by NRI in Egypt from 1979 to 1992, pheromones are now used to control pink bollworm, Pectinophora gossypiella, over the whole cotton crop of approximately 293 000 ha (725 000 acres). NRI has continued to support the sensitive and economic use of both pheromones and pesticides, and a staff member was seconded to the American University in Cairo to develop and apply a computer simulation model of the cotton/cotton pest system. The model now runs within a specially developed 'Windows' style management shell which has both

English and Arabic versions. A weekly report is provided to cotton managers covering early-, middle- and late-planted cotton for each of the 26 cotton districts in the middle Egypt governorates of Fayoum and Beni Suef. The reports detail the present and expected fruiting curves, physiological stress and pink bollworm numbers, enabling cotton managers to test the likely effects of their actions before making pest management decisions. The ability to model pheromone release rates, and hence, the effects of different mating disruption strategies, has been of particular interest to the Ministry of Agriculture (MoA), because of its commitment to this method of pest control. Extension of the model to cover one third of the cotton growing areas in Egypt, managed by NRI through a joint Egyptian MoA/GTZ project, is planned in 1996.

The use of pheromones against pink bollworm in Egypt has reduced insecticide use against this and secondary pests, and this has led to a change in attitude towards the use of toxic chemicals for agricultural pest control. The approximately £ 12 million paid annually for pheromonal control of pink bollworm should be seen in the context of an overall reduction in the volume of cotton insecticides used by over 65% (from a value of over £ 50 million in the mid-1980s).

Weeds: the ever present competitor

Weed management has featured prominantly in NRI's

undertakings in crop protection, particularly against the parasitic weeds in semi-arid Africa and perennial grasses, such as *Imperata* and *Rottboellia*, which dominate more humid zones. Combinations of cultural and chemical techniques, and the biochemistry of resistance, have all contributed to the development of management strategies for this important production constraint.

Striga

The parasitic weed, Striga hermonthica, causes average yield losses of 40% in cereal crops such as sorghum, millet, maize and rice in Africa. Although it is the major constraint to cereal production in the semi-arid tropics, research has so far failed to identify economically feasible and sustainable control methods which are both acceptable and suitable for use by the small farmer. The breeding of resistant/tolerant host lines offers the prospect of effective control, but this has been hampered by the wide variation in the parasite's ability to attack different host genotypes which allows populations to adapt quickly; a detailed understanding of the mechanisms of host selection is therefore important. The screening methodologies developed by NRI will provide plant breeders with the necessary tools to assess new host lines and plan rational strategies for the deployment of novel host germplasm.

Bolivia

Declining soil fertility, increasing weed infestations, and a lack of income-generating opportunities,

are serious constraints to the establishment of sustainable cropping systems in the forest margins of Bolivia. The Bolivian national programme is being helped to address these issues using a farming systems approach. As part of its extension network, an NRI-led project established 158 on-farm validation plots to test farming system models which incorporate technologies for weed control, soil fertility maintenance and improved income-generating opportunities, with a crop protection focus on improved weed control in rice and ricelegume intercropping systems. Data management support by NRI includes providing a computer-based method for handling the data from the validation plots. Satisfactory results which are applicable to local farmers have been obtained on the use of legume covers for weed suppression in rice, perennial crops, pasture renovation, and the control of Imperata contracta.

Dissemination of techniques and control recommendations

An important method of extending the outputs of research is through workshops and conferences. In 1995, NRI staff convened an international workshop which brought together representatives of research groups, national scientists, international specialists and policy makers from 15 countries concerned with lethal yellowing and related diseases of coconut palm (International Workshop on Lethal Yellowing-Like Diseases of Coconuts, Elmina, Ghana, 6–11 November,

1995). The main aims of the workshop were to report on progress, and disseminate results of work carried out under an EC STD3 project on the etiology and control of lethal yellowing of coconuts in Africa which NRI coordinates with partners in the UK, France, Ghana, Tanzania and Côte d'Ivoire. Funding for sponsored participants was secured from CTA and an EC Sponsorship Grant, and the costs of organizing the conference and publishing the proceedings were supported by ODA,

Contributions highlighted progress in field research on lethal yellowing in Africa, based mainly in Ghana and Tanzania, and provided an opportunity to compare results with delegates from Mexico and Jamaica where epidemics of the disease have decimated coconut production in recent years. NRI scientists have made considerable progress in the development and application of molecular diagnostic techniques for detecting and diagnosing the causal phytoplasma, and these are now being used to study its epidemiology and transmission.

Policy initiatives: integrated pest management

One of the most effective ways of stimulating and sustaining changes in approach to pest management practices is through policy initiatives with governments and international agencies. IPM is now accepted as the most effective underpinning approach to crop protection, and development institutions worldwide are promoting and applying the IPM

approach from the project concept stage through to the implementation of agricultural development schemes. NRI provides the secretariat for the International and European IPM Working Groups and has been actively involved in initiatives to encourage incorporation of the principles of IPM into the development programmes of multi-lateral development agencies in 1995.

A guiding report on integration of IPM strategies into country development programmes was prepared for UNDP. It covers the principles of IPM, the strategy needed to integrate these principles into development programmes, and the possible training needs associated with effective implementation strategies. The document will be published early in 1996.

Country IPM profiles for 20 African countries were developed in collaboration with a British NGO, The Pesticides Trust, as part of the EC IPM initiative under DG VIII. Initial collection, preparation and formatting of data on IPM activities by country was carried out by NRI, and then passed to The Pesticides Trust for inclusion of additional information on aspects of pesticide management and regulation. The IPM profiles were presented at a consultation meeting held for EC officers and national experts of the EC IPM Working Group; they received enthusiastic support, their usefulness being seen as a pulling together of information from a wide range of sources into individual country-specific reference texts which could be

readily updated to include new initiatives and future developments.

The track record of projects in achieving sustained adoption of IPM strategies by farmers has often been disappointing, but this has increased the commitment of development agencies to promote, with more vigour, farmer participation and training in farmlevel research. A new ODA bilateral project pursuing this approach within Malawian farming systems will build on the outputs of a six-year study by NRI and Chancellor College on soil pests in smallholder crops. The project, which aims to improve the income of resource-poor farmers through the adoption of low-cost, sustainable pest management strategies, will produce a series of IPM recommendations for major crops grown in three agroecological zones of southern Malawi.

INCREASING LIVESTOCK PRODUCTION

Livestock form an integral part of many land use and farming systems in developing countries. Their critical roles in the promotion of sustainable agriculture are increasingly recognized. They contribute to sustaining the livelihoods of rural people not only through the provision of high quality foods such as milk, meat and eggs, but also as sources of soil nutrients (through manure and composts) and draught power to support crop farming systems. In these roles, livestock frequently make use of agricultural by-product

feeds, poor quality crop residues and grazing resources that might otherwise be wasted, allowing greater overall efficiency of resource utilization.

At the same time, livestock are a major source of income for both smallholder farmers (often providing cash resources for inputs to crop farming activities) and landless livestock keepers and pastoralists, and they have important roles in ensuring the security of household incomes and subsistence in times of drought and crop failure.

Livestock also provide raw materials for many small-scale and developing commercial enterprises (for example in hide, skin and fibre processing industries, and milk and meat product preparation). As incomes rise in many developing countries, so the demand for livestock products increases, and issues of supply and marketing become of greater concern, particularly to growing urban populations. Opportunities exist in many areas for increasing the productivity of livestock to supply this demand by the appropriate combination of improved feed supplies and feeding systems, making better use of locally available resources, improved animal health, improved breeding stock, and more intensive management.

The Livestock Department at NRI undertakes a programme of research and technical cooperation to support the development of livestock in all these roles. Present research and development work focuses especially on aspects of feed resources and nutrition in livestock, feeding for improved milk production, reproduction and draught power, the roles of livestock in nutrient cycling and the sustainability of farming systems, the environmental impacts of livestock production systems (in rangelands, mixed crop-livestock systems, and through the supply of concentrate feeds), and the supply, processing and marketing of livestock products (particularly into urban areas).

In the following sections, some of these work programmes are reviewed to illustrate how they contribute to the objective of increasing livestock production for improving farmer livelihoods and the availability of livestock products.

Improved assessment of feed values and feeding practices leading to better utilization of scarce feeds

Farmers are faced with the perennial problem of ensuring the supply of a balanced mix of feeds to satisfy the nutrient requirements of their livestock. To complicate matters, nutrient requirements vary through the productive cycles of animals, while the mixtures and amounts of available feeds often change seasonally. Therefore, farmers and extension advisers need methods of assessing the nutritive values of feeds to match nutrient requirements, to make the best possible use of available feeds, and to improve the productivity of animals in cost-effective ways. Given the shortage of feeds in

many situations, additional feed resources, which are constantly being sought, need to be evaluated and fitted into feeding systems.

Assessment of nutritive values

In order to provide farmers and extension workers with approaches to help solve these problems, NRI has been undertaking research, funded by the ODA Livestock Production Programme (LPP), into methods of evaluating feeds and feeding systems. Traditional methods for assessing nutritive value have proved less useful for describing some important tropical feeds and their interactions, particularly forages and tree fodders and especially those containing anti-nutritive factors such as tannins and alkaloids. These factors may affect the critical features of feeds, such as palatability, intake and digestibility, in ways which cannot be predicted from standard proximate analyses. Thus, antinutritive factors may affect the ability of rumen organisms to digest feeds and may reduce the degradability of some nutrients (tannins, for example, bind with proteins and make them less available in the rumen).

Research has recently focused on the application of the gas production (GP) method and on analyses which test the content and biological activity of antinutritive factors. The GP method has the potential to provide a simple test of the rumen degradability of feeds (including accounting for effects of antinutritive factors). In combination with acid digestion methods, this may provide a better predictor of

the intake and digestibility of feeds for ruminants, with applications in the assessment of germplasm of new forages, and in better formulation of diets for animals. A second major advantage of the GP method is that it can be used to test the effects and interactions of feed mixtures, with the potential for testing improvements in feeding systems such as supplementation of poor quality roughages with high quality fodders. In such applications, it may be able to replace some expensive feeding trials, or at least to narrow the options for testing in subsequent trials.

Results so far have illustrated the potential value of the method for selecting the most nutritious accessions of Gliricidia (in a programme partly funded by the **ODA Forestry Research** Programme, FRP) and tree fodders with different tannin contents in Colombia and Nepal (with CIAT and Pakhribas Agricultural Centre, respectively). In the evaluation of feed mixtures, work with collaborators in India and Zimbabwe, which has compared the results of feeding trials and GP, has illustrated some situations where GP methods have provided good correlations with digestibilities in animal trials. In other cases, the effects of the increased degradability of feed mixtures seen in GP bottles may be more evident in changes in feed intakes and rates of passage than in feed digestibilities in animals. The interpretation of the GP method in these circumstances is still under investigation, but the ultimate aim is to package combinations of those analytical

methods most appropriate for different kinds and mixtures of feeds, and for different evaluation purposes.

Most recently, the combinations of analytical methods which provide farmers with the most useful assessments of the feeding value of tree fodders have been investigated in Nepal (with the Pakhribas Agricultural Centre and the School of Agricultural and Forest Sciences at the University of Wales, Bangor). This has involved the comparison of a range of analytical techniques with farmers' own assessments of feeds based on their long-term experiences of feeding animals for different productive purposes (for example, for milk production, draught power and survival). By this means, analytical packages can be developed for making relevant assessments of nutritive values of new feed resources (such as introduced fodder trees), and for advising farmers about the incorporation of these feeds into diets for different classes of animals and seasons (when a different mix of feed resources may be available).

Preliminary results suggest that measures of fibre content, tannin contents and gas production (or dry matter disappearance) are major indicators of differences between species in the values of tree fodders (interestingly, not crude protein or ether extract). Further work is required to define the appropriate indicators for different productive purposes and for different seasons when other combinations of feeds may be available. The GP method, however, looks likely to feature in

the necessary combination of methods.

Assessments of feed intakes

A critical feature of the value of a feed is its likely intake by animals. A complex of animal and feed factors determines the actual level of intake and these require longterm and expensive animal feeding trials to measure. A technique for measuring the short-term intake rate (STIR) of feeds and feed mixtures is currently being tested by NRI to see if STIR can be correlated with actual long-term intakes or with other features of the nutritive value of feeds. The method, which is in the early stages of development, uses a wide range of fresh and dry forages; feeds clearly differ in their STIRs, but correlations with important features of nutritive value remain to be tested. Future work will test the effects of feed mixtures and explore the utility of the method in combination with GP and other methods for the evaluation of feeds and improved feeding systems.

Improvement of feeding systems

The development of improved feeding systems relevant to farmers' needs requires not only information on the nutritive values of feeds, but also a much better understanding of farmers' production objectives and constraints than has often been the case in the past. Farmers in many mixed farming systems in developing countries need to maintain a range of different livestock for various purposes, including food production and sales (milk and meat), and draught

power and manure, in the face of seasonally variable and often insufficient feed supplies. Therefore, the formulation of diets is rarely a question of conventional maximizing of outputs, feed efficiency or net returns, but more often a case of making least risk compromises between competing classes of livestock. Equally, the identification of critical seasonal shortages of nutrients or feeds in farmers' systems needs to recognize these same realities, for example, for the introduction of appropriate new feed resources.

NRI has accordingly been conducting a programme of research in Nepal (with Pakhribas Agricultural Centre under ODA LPP funding) to investigate the primary constraints and factors which affect farmers' choices on feed allocation amongst their multi-species livestock holdings, and to explore possible methods of deriving better extension advice on feed allocation and new feed resources. The first part of the work included a year-long study of feed resources and allocation in a range of different farming systems and environments in the mid-hills of Nepal. The second part has included the development of a modelling approach to test the consequences of different feed allocation decisions. Preliminary results illustrate that farming systems and locations clearly affect the feed resources available and the diets of different classes of animals, and that the wide range of constantly changing feed resources used by the farmers further complicates allocation decisions.

Additional analyses will explore the factors which influence farmer responses in order to understand their priorities and options. The analyses have already illustrated the major feed and nutrient gaps in certain locations and seasons, and have provided research and extension workers with the challenge of improving feed supplies in ways which are relevant to the farmers' needs. One of the important preliminary findings of the modelling work (which has been based on prediction equations derived for temperate area feeds and animals) has been that traditional diet formulation systems do not always adequately describe feed values or animal responses for tropical feeds and production systems. In particular, although the effects of liveweight changes of animals through seasons and productive cycles are shown to be important components of feeding systems, they are difficult to predict and require a better understanding of both the nature of nutrient partition to different maintenance and productive functions in animals, and the relationships between seasonal liveweight changes and other productive functions. It is also clear that farmers' aims are not necessarily to optimize efficiency of production or to promote productivity, but may include other objectives such as to ensure survival of as many animals as possible through certain periods of the year, regardless of liveweight changes.

The recognition of problems in traditional feed rationing approaches has led to further research work to develop improved practical rationing systems for the tropics. This work is being undertaken with the Institute for Grassland and Environmental Research (IGER), UK, and EMBRAPA-CNPGL in Brazil, supported by the ODA LPP. The initial focus of this research will be the intensification of dairy systems where feed rationing decisions are most needed. The approach will be based on modelling rumen functions, inputs and outputs, and will use feed descriptions which take account of anti-nutritive factors and interactions, including the GP method described above. Farmers and extension workers in Brazil and Bolivia (in the associated ODA-funded ADELPE project) are involved in the project and are interested in applying the results to improve their use of the variety of seasonally available feeds.

Improved supplies of feeds and their incorporation in feeding systems

Fodder trees

It is recognized that in many developing farming systems, there are at least seasonal shortages of feeds of suitable quality to satisfy animal requirements. Increasing effort has been directed towards finding additional resources which fit into both crop farming and livestock feeding systems. Tree fodders in agro/forestry systems have been widely promoted as one solution. They potentially provide fodders during dry seasons when grazing is restricted, or high quality feeds which may be used to replace expensive purchased feeds or

supplement available poorer quality feeds.

In recent years, a number of promising indigenous and exotic tree species have been identified for use as livestock feed on smallholder farms in the East African highlands; these include leguminous species such as Leucaena leucocephala and Calliandra calothyrsus (calliandra). The effects of these tree fodders on the productivity of ruminants and non-ruminants, and their replacement value in terms of commercial feeds, are being studied in a project funded jointly by the ODA FRP, LPP and the Natural Resources Systems Programme (NRSP). The work is based at KARI Regional Research Centre, Embu, Kenya, and is implemented in collaboration with KARI, the International Centre for Research in Agroforestry (ICRAF) and the Kenya Forestry Research Institute (KEFRI).

The project has conducted onstation and on-farm feeding trials with Ayrshire and Friesian grade dairy cows to test local commercial concentrate feed and calliandra supplements to Napier grass and maize stover diets. Results have shown that during the August-October period when feed is scarce, calliandra can replace all concentrate feeds and be fed successfully at rates of at least 20% of diet dry matter. Calliandra was able to substitute for commercial concentrates (with 16% crude protein) at the rate of 3 kg of fresh calliandra/kg of commercial dairy meal without affecting milk yields. At the same time, feed costs were reduced and

butterfat levels increased (much appreciated by farmers). Alternatively, calliandra fed in addition to concentrate supplements supported further additive increases in milk yields at the same rates. In other long-term feeding trials, dairy heifers consuming about 3 kg/day of fresh calliandra have shown higher and seasonally maintained growth rates, with the prospect of earlier and more successful first calving.

The feeding of dried calliandra leaf meal has also been tested for laying hens at inclusion rates varying from 5 to 15% (fresh weight basis) in mixes with commercial poultry feeds. These trials showed that while acceptable to the birds (as indicated by increases in overall feed consumption), inclusion of calliandra resulted in slightly reduced egg yields and feed efficiency, especially at the higher inclusion rates, and gave no overall financial advantage. Calliandra was, however, a very effective source of pigmentation for improved yolk colour and might usefully be included at low levels for this purpose.

An impact assessment of calliandra in the Embu area (conducted by ICRAF and KARI) has shown a very rapid spread of planting material from farmer to farmer, from 100 to over 400 farmers in five years. Over 80% of the original 100 farmers have increased their plantings of calliandra in the same period, and 31% have established nurseries for the propagation of seed. Farmers now have an average of 216 trees/farm, mainly intercropped with Napier grass or other crops,

or on farm boundaries. Most farmers feed calliandra to milking dairy cattle, two-thirds to increase yields and one-third to reduce feed costs, but almost half also feed it to goats and growing heifers. Further work will be conducted to establish the most effective feeding systems for all these classes of livestock, and to extend the approach to the more semi-arid areas nearby, if suitable fodder tree species can be found.

Locally available feeds for poultry

For many years, NRI has conducted research into the use and improvement of feeds derived from local crop sources in the tropics, such as root crops and oilseeds. A considerable body of experience has been established on the assessment of nutritive values and inclusion of these materials in diets for poultry, particularly for the small-scale poultry sector in the rural and peri-urban areas of developing countries. These enterprises have potential for intensification and increased productivity, often using locally available by-product feeds from agro-processing industries.

Most recently, field projects have got underway in Cameroon and Zimbabwe. In Cameroon, the use of sweet potato tubers and cassava root meals are being investigated under ODA LPP funding. In Zimbabwe, the prospects for introducing different small-scale (village or farm) methods of mechanical processing of oilseeds, particularly sunflower seeds, are being investigated under a programme jointly supported by the ODA Crop Post-Harvest Programme and two NGOs

(Intermediate Technology Development Group and Appropriate Technology International).

In preliminary work in Cameroon, the most appropriate drying and preparation methods (grits or flour) for cassava and sweet potato roots have been tested. Diets formulated with these ingredients and supplemented by locally available protein sources, such as cotton seed cake and oil palm kernel meal, have been tested on-station with both laying and broiler chickens. For laying hens, root crop-based diets could be formulated which, although cheaper than maize-based diets, supported similar or improved productivity. For broilers, results were more variable, though a diet based on sweet potato and cotton seed cake was able to provide equivalent performance at reduced cost, with liveweight gains per 100 FCFA of 353 g compared to 272 g for maize-based diets.

However, these trials showed that literature estimates of nutritive values of ingredients may not always be reliable. Further laboratory assessments and detailed feeding trials to estimate metabolizable energy values were subsequently carried out at NRI to enable revised diet formulations. Some of these new diets now contain over 50% of either cassava or sweet potato, plus cotton seed meal, oil palm kernel meal and fishmeal, and cost almost half the conventional local maize-based diets. A range of formulations will now be tested on-farm in Cameroon to determine their feed and financial

efficiency. The project aims to provide farmers with a range of possible diets and performance results to suit their individual circumstances.

In Zimbabwe, similar investigations are underway to assess the nutritive values of sunflower oilseed residues produced by different small-scale presses and screw mills. Although they have slightly reduced nutrient densities, diets with these and other ingredients available locally to poultry farmers can be formulated at 85% of the cost of commercial layer and broiler diets. The impacts of such diets on productivity and financial efficiency remain to be determined in on-farm feeding trials.

Improved feeding systems to raise livestock productivity

The purpose of work on the assessment of the nutritive values of feeds, and the introduction of new feeds to feeding systems, is to improve livestock productivity or reduce costs in ways which are relevant to farmers' own objectives and resources, as outlined in preceding sections. Major outputs of ruminant livestock which are the targets of such research include milk, draught power and reproductive performance. A three-year, ODA-funded programme of nutritional research into these components of productivity and the interactions of disease and nutrition in trypanotolerant cattle has recently been completed with the International Trypanotolerance Centre (ITC) in The Gambia.

A new project is investigating nutritional impacts on reproductive performance and milk yields in cross-bred dairy cows with the University of Reading and the Tanzania Livestock Research Institute at Tanga.

Feeding for draught power and milk production under trypanosomosis challenge

This research has had two objectives: one is to improve understanding of the nutritional requirements and necessary feeding interventions for trypanotolerant cattle under trypanosomosis challenge; the second is to help develop practical feeding interventions for farmers to achieve their production objectives. Research into the first objective was conducted through formal feeding trials with milking cows and working draught oxen on representative local diets under artificial infection with trypanosomosis. Results have shown that infected animals are generally unable to maintain their intakes of poor quality feeds. Supplementation with high quality feeds allows recovery from infection provided that production or working stresses are not too great. However, some infected working oxen are unable to self-cure, and milk yield and reproductive performance are still affected in supplemented cows.

Translating such results into practical feeding and disease control advice for farmers requires a good understanding of available feed resources and farmers' objectives. Past research has concentrated on demonstrating

biological responses to feed supplementation using crop residues, oilseed cakes and tree fodders. However, few of these innovations have been adopted by farmers, particularly those aimed at increasing the milk production of breeding cows. Recent studies of the social, economic and practical constraints to the supplementation of Gambian livestock have illustrated some of the reasons for this.

Participatory rural appraisal (PRA) and financial appraisal methods were used to determine farmers' objectives and requirements for keeping each type of livestock, and to examine the availability of feed resources and current feeding systems. The relative rankings of objectives by farmers suggested that the primary objective of livestock owners is the generation of savings and assets for security. Manure was considered to be as valuable an output as the milk produced for domestic consumption. For security and manure production objectives, maintenance feeding for seasonal survival of as many animals as possible becomes important. The production of milk for sale was not regarded as important as markets are limited and prices low. The high value placed on manure was one reason (besides high labour requirements) why farmers allowed herds to graze low-value crop residues in fields after harvest, rather than collect and store them for later use. Highvalue residues, such as groundnut hay, were collected for feeding the draught animals which had to be maintained at the home compound so that they were available for work and kept in

good condition.

Financial analyses demonstrated that short-term dietary supplementation of N'Dama cows for milk production was only financially attractive if both milk and liveweight gain were valued by the producer (which generally, they were not). Supplementation was financially attractive for draught oxen and draught cows because of their contributions to household food security and cash income (through crop production and sales). Returns to feeding draught oxen included animals which were in good condition for work and for subsequent sale for slaughter. The extra returns potentially available from supplementation of draught cows were financially very attractive (including milk, calf and work outputs). The use of draught cows is already accepted by a small but growing proportion of farmers. These animals alone might justify the use of purchased off-farm feeds, such as oil cakes, and would clearly be the preferred target of improved feed supplies and feeding systems.

Enhancing the roles of livestock in sustaining farming systems

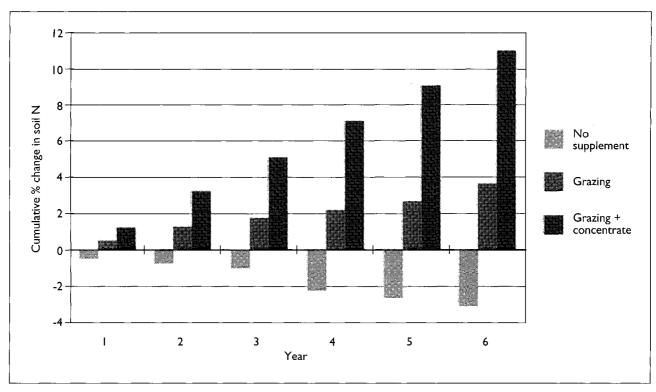
In many parts of the developing world, crop production in smallholder mixed farming systems is limited by inadequate levels of soil nutrients including nitrogen (N), phosphates (P) and potash (K), and by poor soil conditions resulting from low organic matter contents. In the past, forest and rangelands have been a significant source of nutrients, imported to croplands

via the fodder-animalmanure/compost pathway. However, expanding human populations have increased the demand for crop production and have encroached on forest and rangeland both physically, and by the removal of trees for firewood; this has seriously reduced the availability of these sources of nutrients. The use of inorganic fertilizers has been successful in addressing the problem to some extent, but the high cost, uncertain supply and inability to maintain and fortify soil organic matter and physical properties, has meant that they do not provide a complete solution. Therefore, in order to enable further intensification of crop production, the efficiency with which nutrients are recycled has to be improved and the availability and roles of manure and composts enhanced.

These issues form the focus of a growing programme of work both at NRI and in collaboration with various UK and overseas partners. The project discussed below aims to explore the nitrogen pathway and determine the potential influence of different feeding strategies and feeds on the availability of N through manure, urine and composts. Other work has included studies on the importance of livestock in mixed farming systems in the forestagriculture interface and semi-arid rain-fed areas in India, in association with ODA-funded forestry and farming development projects. These projects seek to recognize the need for livestock to support farming systems, and to determine the feed, grazing and compost material requirements for these purposes.

Implications of livestock feeding management for long-term soil fertility in mixed farming systems

The effects of animal feeding practices on the dynamics of nutrient flows in farming systems are poorly understood. Therefore, the formulation of reliable management strategies for optimum livestock production and nutrient cycling cannot be guaranteed. A joint project under LPP funding with Wye College, UK, and KARI and the International Livestock Research Institute (ILRI) in Kenya, aims to study these flows and strategy options. The project will take a modelling approach by coupling the existing separate models of soil nutrient dynamics, crop production and livestock productivity (including feed inputs and urine and faecal outputs). Field trials will test and verify alternative feeding, manure



Simulated cumulative effects of livestock under grazing and supplementary feeding systems on soil nitrogen status

and soil management strategies with farmers so that practical interventions to improve the sustainability of mixed farming systems can be developed.

Initial modelling studies have shown that livestock feeding strategies can have significant impacts on long-term soil conditions. The figure below shows that the inclusion of livestock in farming systems without any off-farm grazing or supplementary feeding (and at typical levels of productivity and off-takes) can result in the gradual depletion of soil N, while the addition of grazing and supplementary concentrates results in progressive accumulation of soil nutrients.

REDUCING PRE-HARVEST CROP LOSSES

Food handling and processing in many parts of Africa, Asia and Latin America was traditionally characterized by large, often inefficient, state marketing boards and processing companies on the one hand, and small-/micro-scale private sector enterprises, often within the informal sector, on the other. As structural adjustment and market liberalization policies have become widely adopted, state enterprises have, in many cases, been abolished and efforts have been made to improve the enabling environment for private sector developments. This is leading to an increase in activity and development in the commercial sector, often resulting in small-scale enterprises growing

in both size and importance. These changes have been occurring at the same time as the national research system and international research agencies have become increasingly aware that it is no longer sufficient to focus on productivity (defined as yield at harvest) but that what is important is the net utilizable production (the proportion of the yield at harvest that reaches endusers). This realization is partly attributed to the fact that a plateau has been reached in productivity increases in many crops, and that degradation of the environment and productivity increases are often closely linked. Making best use of current production has therefore become increasingly important. NRI's work on the utilization of crops has been evolving in parallel with these factors. Reduction of post-harvest losses, once seen as a largely technical matter, is now viewed by most people in the context of the social and economic environment in which the system is placed. Post-harvest losses will only be properly addressed in the context of these factors and therefore, issues such as enterprise development, off-farm employment, gender (many smallscale food processors are women), availability of finances, etc. are very much to the fore. Some illustrations of the activities undertaken by NRI in addressing these problems over the last year are given below.

Small-scale coconut oil extraction

NRI is the executing agency for a three-year project, co-financed by

the Common Fund for Commodities and ODA, aimed at developing, field testing and promoting improved techniques for extracting coconut oil at the small rural and domestic scale for which traditional methods are arduous, time consuming and inefficient. Small-scale coconut processing is extremely important in tropical coastal Africa. In Tanzania for example, approximately 1 million women produce about 12 000 tonnes of coconut oil annually (using traditional manual techniques) for sale and for home consumption. The income generated is important to the women, but the oil extraction process is arduous, time-consuming and inefficient. The project is subdivided into the following technical components.

- Improvements to aqueous processing This traditional 'emulsion' technique involves adding water to coconut gratings, squeezing out the 'milk' and then leaving the gratings to stand to allow an oil-rich cream to rise to the surface. The cream is skimmed and boiled to produce oil. The residual gratings from the process still contain between 40% and 60% oil. This material is usually discarded as a casual feed for poultry.
- Hot oil immersion drying of coconuts This process is found in Indonesia and Ghana. Coconut pieces are fried in coconut oil to remove moisture. The dried coconut is then processed using an expeller to obtain oil.

- Use of waste heat
 technology This process is
 used for copra drying and
 charcoal manufacture. The
 production of charcoal
 generates a lot of heat which
 is normally wasted. Waste
 heat technology harnesses
 this energy for drying
 purposes and is being used
 in Sri Lanka to produce
 desiccated coconut.
- Use of a manually operated ram press The ram press was developed in Tanzania by an American-based NGO (Appropriate Technology International). This lowcost, manually operated press is widely available throughout Tanzania and was developed for use by smallholder farmers and women to process sunflower seed. The project is promoting the use of the press to extract oil from the dried coconut products, especially the residue remaining after traditional aqueous processing. Over 70% of the oil left in the dried residue can be extracted using the press. This oil is being used for soap manufacture, although oil extracted from dried fresh coconut can be used for edible purposes.
- Intermediate moisture content method This method is being applied for the extraction of oil from grated coconut. When specific amounts of water are added to dried oilseed pastes, high yields of oil can be extracted using relatively low pressures. For instance,

if about 12% water is added to dried coconut gratings, about 65% of the oil can be extracted using a manual press such as a bridge press.

One of the project's objectives is to identify the improved processing methods best suited to the varied environments which exist within the various countries targeted, and to assess those technologies which have potential for transfer elsewhere. Collaborators in Tanzania, Ghana, Côte d'Ivoire, Sri Lanka, Indonesia and India are involved in specific project activities; not all countries are carrying out research on all the technologies. Three of the processing activities are being carried out by African collaborators.

Aqueous processing

Each collaborator has carried out a detailed survey of the aqueous fresh coconut processing methods used for the production of oil in that country. NRI has conducted similar surveys in South America, covering Brazil and Guyana. The extent of aqueous processing varies between countries. In Ghana, Côte d'Ivoire and Guyana, the level of operation is about 100-500 coconuts/batch with most of the oil being sold commercially. By contrast, the batch size in Tanzania is frequently about 15 nuts which is sufficient for household needs only. Household aqueous processing is virtually unknown in Brazil, although several large factories exist for the production of packaged coconut milk and cream as convenience foods. The project focuses on small-scale processing techniques

aimed at smallholder farmers and women, and a key intervention has been the local manufacture in Tanzania of a low-cost, manually operated rotary coconut grater. This grater was developed in consultation with the women who process coconuts and their views were taken into account when producing the prototypes which led to the final product. The grater reduces grating time when used by experienced operators; it also assists in the extraction of up to 20% more coconut oil and up to 20% more protein in the milk (also used in cooking), and is less arduous to operate than traditional graters. Project work is being focused on encouraging local workshops to make the grater, and providing linkages between manufacturers and purchasers of the grater to ensure that it is widely available for sale.

The ATI ram press

Field trials of the technology for extracting oil from dried aqueous processing residues (for soap) and dried fresh coconut gratings (for edible use) are underway at women's groups in Tanzania, Ghana and Côte d'Ivoire (using smoked dried coconut-copra). Data on throughput of raw material, yield of oil and ease of operation are being collected and results will be analysed and disseminated in reports and at workshops.

The intermediate moisture content method

Experimental work by collaborators in Ghana and Tanzania has confirmed the technical efficiency of this low-

pressure method for partially dried coconut gratings. The oil produced has received favourable consumer comment on its pronounced and distinctive coconut flavour. In Tanzania, sundrying the gratings before pressing is considered to be a possible source of difficulty at certain times of the year, and the cost of the bridge press could be an obstacle to its widespread use. Bridge/spindle presses are widely available in Ghana as they are used in the rural palm oil industry. The procedure drastically reduces the need for water, and fuelwood is unnecessary. The method therefore has potential benefits over the traditional aqueous method. The project is investigating ways of decreasing the price of presses, and is looking at alternatives to the spindle or bridge press for the extraction of oil.

Dissemination of project results

This is provided by the African Oil Palm Development Association based in Abidjan, and the Asian and Pacific Coconut Community based in Jakarta, who distribute copies of all project reports to their members and include news items on project findings in their own publications. The project will generate numerous documents and three workshops are due to be held early in 1997 to disseminate information between the collaborators and identify areas for further research and development.

Reduction in physical and economic losses during cassava starch storage in India

The production of cassava for starch and sago processing represents an important source of employment and income in Tamil Nadu. Two specific problems for the industry are the storage of extracted wet starch and environmental pollution. The inability to dry all the starch (and sago prepared from the starch) extracted from cassava at the height of the season means that up to 40% of annual starch production is stored for four to five months. Loss of quality during storage results in a 20% loss in income.

The changes in quality during starch storage, and their causes, were investigated in collaborative work between NRI, SAGOSERVE (the industry co-operative association) and the Tamil Nadu Pollution Control Board. Detailed chemical and microbiological analyses of starch samples during storage at a factory site demonstrated that quality losses were attributable to the growth of amylolytic (starch-degrading) lactic acid bacteria.

Laboratory experiments and field trials have shown that low concentrations of acetic acid (2%) can be used to prevent the growth of these micro-organisms. Other treatments, such as citric and phosphoric acid, could prevent microbial growth, but these acids adversely affect starch quality. The treatment of starch with 2% acetic acid during storage resulted in a product with a viscosity 32% higher than the minimum value specified in the Indian standard for

textile starch; conventionally stored starch had a viscosity value 14% below the minimum value.

Full-scale factory trials were successfully carried out in the 1995/96 processing season. Two additional advantages of the improved storage technique, which were not previously evident, have been demonstrated. Physical losses of around 10% (by weight) are quite typical of conventional starch storage. These losses are probably caused by starch degradation as increases in soluble sugars have been detected. Storage of starch with acetic acid (2%) eliminates this weight loss. In addition to the 10% loss of product with conventional storage and processing, a further 10% is lost during re-washing and sedimenting before final sundrying. When artificially acidified stored starch was processed, this loss was reduced to 3.75%.

In summary, the causes for the reduction in the quality of cassava starch during storage have been determined. Based on this knowledge, a means of overcoming the problem has been rationally developed, tested at a pilot-scale, and shown to be technically and economically viable. It will now be promoted by SAGOSERVE to enable its members to benefit from the improved technology.

Improving rice processing in Sri Lanka

Consumer expectations of product quality are increasing throughout the world. In Sri Lanka, parboiled rice produced by traditional methods often results in a poor quality product with a

high odour and unpleasant taste. Many rice millers are now addressing this problem by introducing new technologies and processing techniques.

NRI, in collaboration with the Sri Lanka Paddy Marketing Board's Rice Processing Research and Development Centre (RPRDC), has adopted an integrated approach, involving rice producers, processors, traders and consumers in the researching of methods to improve rice quality. The approach takes into account the quality of paddy destined for milling, the rice milling technique and the rice grading system, and is intended to encourage the producer and processor to produce a superior quality rice.

A quality/value study was made of the parboiled rice market in Sri Lanka in which rice obtained from commercial processors was assessed for quality and then evaluated by wholesale traders. Laboratory trials, initially carried out at NRI and subsequently tested in Sri Lanka, indicated the technical viability of an improved process involving the application of a partial vacuum during the first stage of soaking prior to parboiling. Traditional parboiling technologies require a long soaking period to achieve hydration of the rice grains. The vacuum method allows the water to penetrate the grains much more quickly and thus reduces the soaking time. A market study of laboratory-produced rice showed an associated rise in the market price.

A concept design for a pilot-scale technology was realized.

The equipment was manufactured at NRI, freighted to Sri Lanka, installed and commissioned. Pilot-scale operations were carried out over a period of nine weeks, producing approximately 6 tonnes of parboiled rice by both the traditional and the enhanced method. The rice was assessed for quality and evaluated by selected traders; comparisons were made with industrially produced samples.

Results indicated that the pilotscale equipment was unsuitable for commercial operations in its initial form so the design was revised, manufactured locally, and the prototype re-tested. Initial results indicate that the revised design is suitable for production of high quality parboiled rice. It has been calculated that a price premium of 0.5% in the value of rice would justify the capital investment required for the installation of this technology. Market studies of the rice produced indicate projected premia in excess of this viability threshold, suggesting that the technology could be commercialized. The current test marketing exercise is being continued as the value given to the rice by traders and consumers will ultimately determine the commercial possibilities for the technology. It is also proposed that the new technology should be operated in a commercial situation to assess its performance while taking into account seasonal variations in paddy quality, climatic conditions and working practices.

The control of moulds and mycotoxins

Mycotoxins continue to attract worldwide attention because of their perceived impact on human health, the economic losses accruing from condemned foods and feeds and decreased animal productivity, and the impact of mycotoxin contamination on internationally traded commodities. It is estimated, for example, that the annual loss arising from the contamination of foods and feeds on the North American continent is approximately US\$ 5 billion. Over 50 countries now regulate against the occurrence of mycotoxins (especially aflatoxins) in foods and feeds. The mycotoxins currently considered to be of major importance include the aflatoxins, ochratoxin A, T-2 toxin, deoxynivalenol, zearalenone and the fumonisins. Exposure to these toxins may cause the development of cancers, genetic mutations, birth defects and suppression of the immune system.

The control of mycotoxins requires an integrated package of sampling, sample preparation, analytical and detoxification procedures which can be incorporated into appropriate surveillance, quality control and monitoring systems. The development and application of these systems continues to be an important component of NRI's programme for reducing postharvest food losses. For example, an on-going project carried out in collaboration with European partners addresses the need for effective, practicable sampling and sample preparation procedures which can be applied to large shipments of animal feeding stuffs entering the EU. Ten 500 tonne batches each of copra meal pellets, copra cake, corn gluten-feed pellets and palm kernel cake are being examined to determine the effect of incremental sample size on sampling efficacy, and to define a selection of sampling and sample preparation options for discussion with EU representatives.

The surveillance of the mycotoxin content of key foods and feeds in Bangladesh has shown that the most contaminated commodities are maize and groundnuts. In collaboration with the Institute of Food Science and Technology, a carefully designed surveillance programme showed that 54% of the groundnuts sampled were contaminated with aflatoxin, some containing in excess of 500 mg/kg. Maize, which is used mainly as an animal feed, was highly contaminated with a variety of mycotoxins. Aflatoxins, for example, occurred in 75% of the samples, while a further 20% were contaminated with one or more of the major mycotoxins listed above. Although aflatoxins occurred in 28% of the rice samples collected from local markets, the mean contamination in this major food staple was only 1 mg/kg. Also, 200 blood samples have been collected, and in collaboration with co-workers in Bangladesh and Europe, blood biomarkers are being used to evaluate the exposure of individuals to the aflatoxins and determine whether there is a correlation between exposure and disease status.

In collaboration with the University of Greenwich, two novel quality control tools are under development. A rapid, lowcost, micro-titre, dish-based bioassay has been developed using the yeast, Kluyveromyces marxianus var. marxianus, which detects a variety of mycotoxins. The bioassay exploits an intracellular enzyme, b-galactosidase, which is vulnerable to inhibition by toxicants at a wide range of cellular locations; it showed particular sensitivity to the trichothecene mycotoxins. The assay has a number of potential uses: as a research tool to determine cellular and molecular modes of action of toxicants: as a quality control tool in the agrifood industry; and as a field kit for toxin detection. An amperometric biosensor for aflatoxin is also under development. This compact device combines enzymelinked immunosorbent assay (ELISA) and amperometric principles and exploits inexpensive technology transferred from the printed circuit industry. The immobilized antibody can be effectively regenerated by a controlled wash to permit multiple re-use.

Reducing losses through improved quality

In order to bring about a sustained reduction in losses of all foods for human consumption, appropriate quality systems should be adopted by small-, medium- and large-scale food handlers and processors. Consideration should be given to the introduction of quality management systems based on internationally recognized

standards: the BS EN ISO 9000 series, Good Manufacturing Practices (GMP), and the Hazard Analysis Critical Control Point (HACCP) concept. HACCP is a systematic approach to hazard identification, assessment and control. It is a management tool which provides a more structured approach to the control of identified hazards than those available by traditional inspection and quality control procedures. The application of such guidelines provides a method of demonstrating that product quality/safety objectives are continuously achieved with a minimal loss of raw materials. Three examples of work in this area are described below.

The agro-industrial sector of Central America and the Caribbean

A three-year programme is underway to assist CITA (Centro de Investigaciones en Technologia y Alimentos) in Costa Rica to become a centre for development and to strengthen the agroindustrial sector of Central America and the Caribbean region. NRI is introducing basic quality systems to small- and medium-scale meat processors which are based on a combination of GMP and HACCP concepts. Following the introduction of appropriate monitoring systems, the quality and safety of meat products manufactured for the local market will improve with a corresponding reduction in losses of raw materials. Courses on HACCP, Total Quality Management (TQM) and the BS EN ISO 9000 series were

presented to CITA staff and representatives of the meat processing industry. A series of courses on quality management in selected areas is being planned for the food industries of the region.

Horticulture export development

Horticultural exports are an important source of foreign revenue which, in keeping with national policies for the encouragement of private sector development, are being increasingly targeted for accelerated development by many governments. However, export of fresh horticultural produce to distant export markets has been constrained by difficulties in providing consistent supplies of high quality produce. NRI has continued its activities in support of the export sector by research, training and consultancies to assist in the implementation of horticultural export quality assurance. The Manual for Horticultural Export Quality Assurance (available in French and English), published by NRI in 1994 and now widely disseminated, has been supplemented with an update pack to reflect the changes in European legislation which affect exports. A new supplement has been compiled to provide detailed information on the export markets in the Middle and Far East which are important to many exporters in Africa and Asia. A one-year research study has focused on gaining an improved understanding of constraints to implementation of quality assurance systems using case studies of exporters in the Nasik region of India. The studies have

included an importer survey in the UK and detailed field studies of exporter operations in Nasik. A number of constraints, and follow-up actions required to support more extensive implementation and development of horticultural exports in India, have been identified. The findings of these studies are expected to help government and trade associations to develop national export strategies. During the year, training courses and presentations on horticultural export quality assurance have been conducted in St Lucia, Colombia, India, Ethiopia, Mauritius and Europe.

Strengthening the Indian export seafood industry

There are increasing demands from developed country markets for high quality fish products. These demands have resulted in the imposition of strict international standards (for instance, the European Directives) which cannot easily be achieved in developing countries under existing infrastructures. A key requirement for meeting these standards is the establishment of quality assurance procedures, including GMP and HACCP, in exporting countries.

A training course on Fish Inspection and Quality Assurance was organized and presented by NRI at the Central Institute of Fisheries Technology (CIFT), Cochin, from the 30 January-10 February 1995. The main objectives centred around strengthening the ability of CIFT to assist the Indian seafood industry in meeting the needs of the world markets for seafoods.

A further training course on Fish Inspection, Quality Assurance and Hazard Analysis Critical Control Points, held at the Veraval offices of CIFT by NRI, was attended by 17 participants from CIFT, the Marine Products Export Development Authority (MPEDA), the College of Fisheries in Veraval and numerous seafood processing plants. Two further courses on Quality Assurance and HACCP were presented at CIFT in Veraval and Visakhapatnam. The trainees should now have the knowledge and expertise necessary to advise and assist local companies to meet the new and exacting standards, providing good long-term prospects for maximizing revenue generation from India's fishery resources.

Choice of plant varieties as a tool to reduce post-harvest horticultural losses

The Brong Ahafo region of Ghana is a leading supplier of vegetables for the major cities of the country, especially Kumasi and Accra. However, the region is rather distant from these important markets and as a consequence, the vegetables have to travel for many hours before they reach their destinations.

Farmers tend to harvest in advance of the arrival of the traders who will purchase their crops for transport to market and as a result, many products arrive in a rather poor condition, being over-ripe and frequently blemished.

Farmers in the Brong Ahafo region grow a range of crops including tomato, garden egg (a type of aubergine), okra and hot peppers. For many years, they have been growing tomatoes, for example, from seed that they have saved from the crop. This practice of sowing saved seed tends to result in a reversion of the qualities of the variety to the original unimproved type. The rate of reversion is influenced by the methods used by the farmer to select the seed, and by local stress factors which affect the performance of the variety. Over time, the original varieties develop into a mixture of landraces adapted to the local environment. These mixed landraces are not always, however, the best choice when it comes to a quality product with a long shelf-life and tolerance to poor transport conditions. A varietal maintenance and improvement programme can reduce these effects, and this is one strand of an NRI Integrated Food Crops Systems project in this region to reduce post-harvest losses.

In collaboration with the Ministry of Food and Agriculture and Ghana's scientific research institutes and universities, a collection was made of the available vegetable germplasm in the region. This was studied for its production and post-harvest characteristics with a view to selecting and purifying those lines with preferred qualities. Emphasis was placed on characteristics, such as yield potential, storage and processing qualities, and transportability, which would reduce post-harvest

losses and improve economic returns; these issues had been identified as major concerns by farmers, traders and consumers alike. A parallel programme has also been investigating the performance and adaptability of tomato varieties from around the world to the production and post-production environments in Ghana. Assessments are continuing and are to be extended to include other economically important vegetables produced in the country.

Fisheries loss assessment

One of the most effective ways of reducing the growing gap between global fish production and demand for fish products is to optimize the utilization of fish resources after harvest, i.e. to reduce post-harvest fish losses.

In order to tackle the significant problem of post-harvest fish losses, policy makers and planners must have accurate and up-to-date information on which to base judgements and interventions. NRI has recently undertaken research to develop methodologies which are capable of providing the sorts of information required for assessing post-harvest fish losses.

One methodology is based on a questionnaire survey and can be used to produce data on

> financial value of fish losses for fisherfolk or processor

- percentage levels of physical loss, economic loss and total loss
- the reasons why losses occur
- what happens to fish classified as a loss.

It involves regular questionnaire interviews with the fisherfolk, processors and traders representing particular stages in the fish distribution chain, i.e. fishing, processing, transport and retailing. The questionnaires are designed to suit different types of fishery and specific distribution stages. This method can provide accurate data on loss levels.

The second methodology is designed to generate indicative quantitative data and qualitative data on the following:

- indicative physical and economic loss levels
- socio-economic issues
- estimates of monetary losses
- reasons for losses
- seasonal variations in loss levels
- the perceptions of fish losses by those who are affected by them
- importance of fish losses compared to other issues
- historical levels of fish losses.

This is based on the tools and techniques of rapid and

participatory rural appraisal (RRA and PRA). It can produce quick results and takes only a short time to set up and use. The core of the methodology is semi-structured interviews or dialogue with fisherfolk, backed up by a variety of data collection techniques including mapping, seasonal calendars and ranking.

Several tools developed by NRI were specifically designed to assess post-harvest fish losses. An example is load tracking. A sample of fish is assessed for quality, using demerit score systems, at different stages of the distribution chain while data are recorded concomitantly on the critical factors which influence quality during handling, processing and distribution of the fish load.

The research project was undertaken in collaboration with the Government of the Republic of Tanzania and lasted three years. Much of the work was done in the Lake Victoria and inshore Indian Ocean fisheries. The methodologies have been developed for use in small-scale fisheries in developing countries, but there is scope for them to be used by people in high investment private sector business, to characterize losses in their particular operation for the purpose of increasing efficiency and profit.

At the present time, the methodologies are being written up in a manual. The manual is being designed as a practical guide for anyone who wishes to investigate post-harvest fish losses. Although the methodologies were developed in the context of

artisanal fisheries, there is scope for the manual to be used by those in the private sector who may wish to characterize losses in their particular environment for the purpose of increasing efficiency and profit.

The development of these methodologies has also generated a tremendous amount of data on post-harvest losses in Tanzania. These have led to a second phase of the project in which losses are being modelled to provide potential users (policy makers) with a tool for predicting, at least on a macro-level, where in their fishery the level and type of loss may occur.

Clearly, once a loss has been identified, the most important question is what can be done about it. In nearly all cases, the major factor determining the type and level of action will be the cost-benefit of intervention. Therefore, decision-makers require a tool to assess the 'cost' of recovering the lost 'quantity' or 'quality' of the fish resource. Once this information is available, an appropriate and very likely, sustainable intervention can be implemented. In the genesis of this Quality Costing Model, it was decided that the widely adopted quality assurance and HACCP approaches would lend themselves admirably to its development. The work is now underway and is already generating much interest from both development agencies and private companies.

ECONOMIC SUSTAINABILITY

FARMER LIVELIHOODS

Staff of the Social Sciences
Department (SSD), particularly
those in the Social Development
Group and the Production
Systems Economics Group, have
continued to work in collaboration
with technical colleagues, and on
stand-alone assignments, to
incorporate an understanding of
farmers' changing livelihoods into
the development process.

Three themes have been particularly important in this work: farmer participatory research; analysis and strengthening of the institutions which work with farmers; and the link between rural livelihoods and environmental conservation.

Farmer participatory research

Social scientists have a key role in involving farmers and other rural people in the research process. In this role, they increasingly make use of informal, qualitative and participatory methodologies to maximize the involvement of rural people in prioritizing problems and finding solutions. Through such methodologies (which can by-pass the problem of farmer illiteracy), the knowledge and creativity of farmers, which has traditionally been disregarded by researchers, can be harnessed. These methodologies are not only available to social scientists but can also be transferred cost-effectively to scientists and others, promoting inter-disciplinarity and shared

responsibility for farmer participation.

The participation of farmers in the research process has been promoted both by NRI's UKbased staff and those on long-term overseas postings. Short-term visits have ensured the incorporation of farmer perceptions and practices into research projects within the Crop Protection Programme on, for example, rice tungro, banana viruses and maize diseases, thus increasing the relevance of research to farmers' livelihoods and hence, the prospects for uptake. At the same time, members of SSD have worked long-term in roles specifically designed to promote participation in the Dryland Adaptive Research and Extension Project, Kenya, the Zanzibar Cash Crop and Farming Systems Project, the Kavango Farming Systems Research and Training Project, Namibia, the NRI/ActionAid Farmer Participatory Research Unit, Uganda, and the Larger Grain Borer Project, Ghana.

The Larger Grain Borer Project has been highly successful in carrying out research which is both inter-disciplinary and participatory. The larger grain borer (LGB), a pest of stored maize, spread into the Volta region of Ghana in 1989. The project initially assumed that locally adapted treatments for shelled maize were the priority. Participatory research by the project team (including members of NRI's Food Security and Social Sciences Departments) showed that for a variety of reasons, farmers were unwilling to shell

maize, and the emphasis shifted to the treatment of cob maize within traditional storage structures. Further work, such as a longitudinal study of losses and decision-making among a sample of farmers, and the valuation of samples of damaged maize by traders, highlighted the socioeconomic differences between farmers with regard to maize storage, and the complex relations between levels of infestation and the relative benefits of storing and selling maize. Maize prices show strong seasonal fluctuations and there is also a particular, nonlinear relationship between the degree of damage to maize and the proportion of the full price obtainable in the market. As a result, different farmers have very different incentives for treating their maize. Many poorer farmers, who dispose of their crop quickly after harvest, may have little need of protection against LGB. For others, a key need for advice emerged; when, or at what threshold of externally visible damage, should they dismantle the traditional stack of maize and shell, or sell, the remainder. The project team has continued to integrate participatory work and scientific trials on-station and in the laboratory. Farmer suggestions for control methods, largely based on traditional methods of controlling other insect pests, have been tested on-station; the farmers have been asked to evaluate these. and trials of chemicals, on traditional storage structures. Some of the most promising approaches were then selected for participatory on-farm trials, using the farmers' own maize, on their farms or in their houses, and under their control.

All the research has pointed to the great variation in farmers' situations and storage strategies and thus, in the recommendations most suited to them. In 1995, the project team worked with the government extension service to incorporate this understanding into extension practice which has up till now been characterized by single recommendations. Extension workers have been trained in participatory approaches, and particular extension tools, such as decision trees, have been developed to assist the process of matching the recommendation to the farmer. Despite the additional work involved in this approach, it has been enthusiastically welcomed at all levels of the extension hierarchy.

ODA funding for the NRI/ActionAid Farmer Participatory Research Unit in Uganda was extended so that the Unit could focus on documenting and analysing its experience and thus inform the debate about farmer participatory research. The Unit had been running participatory trials on soil fertility and cassava varieties resistant to African Cassava Mosaic Virus (ACMV) since 1992, as these two issues had been identified by farmers as their most serious agricultural problems. The trials, which were brought to a close in 1995, showed the usefulness of the legume, mucuna, in restoring soil fertility. During the trials, farmers had experimented with intercropping mucuna with various food crops, and mulching it rather than digging it into the soil; this has become the generally accepted recommendation now.

Mulching the leaves has the important advantage of allowing conservation of seed. The cassava trials, which tested the tolerance and resistance of different varieties to ACMV as well as management practices aimed at reducing the impact of the disease, were less conclusive as the dynamic disease challenge complicated the experimental situation. However, it seems clear from these trials that the Unit has encouraged farmers to examine their own situations more closely than many had been doing previously, and has helped them to explore solutions to their agricultural problems.

The Unit also continued to develop more participatory and effective tools, based on semi-structured checklists, for monitoring participatory trials; these were expanded from the concentration on technical indicators to include the socio-economic factors which had influenced the trial process, and other issues which the farmers considered to be relevant. Final participatory evaluation meetings with farmers were planned.

The Unit considered that the development of relationships and dialogue between potential participants in agricultural research was vitally important. Therefore, contacts were maintained with the National Agricultural Research Organization, and discussions were held with individual researchers, to explore their perceptions of the opportunities for, and constraints to, linking with NGOs and becoming involved in farmer participatory research. Farmer participatory

research has also been better institutionalized within the other activities of ActionAid Uganda, and a project publication entitled *Participatory Rural Appraisal-Practical Experiences* has met with widespread demand in Uganda, other African countries and Europe.

Institutions

The improvement of farmers' livelihoods means engaging with the many institutions which interact with farmers. NGOs originating both in developing countries and in the North are now seen as key players in the development process. As donors explore alternatives to those government structures which have been weakened by financial crisis and bureaucratization, NGOs are seen as low-cost but highly costeffective delivery mechanisms both for development and rural services. They are also seen, sometimes rather optimistically, as intrinsically more likely to promote popular participation in development.

NRI has provided assistance to Northern-based NGOs in the planning and implementation of projects. For example, CARE-India was helped to prepare a major project on tribal women's development in Andhra Pradesh. However, much of the most interesting work in 1995 involved working with NGOs based in developing countries and strengthening their capacity to work with farmers and other rural people.

An NRI team carried out a study for ODA on 'Opportunities for Developing Assistance to the

RNR Sector in Nigeria through Nigerian Non-Governmental Organizations'. Regional workshops were attended by representatives of nearly 80 NGOs, and rapid assessments were made of the capacity of 10 NGOs. Based on the workshop findings and field discussions, the team recommended a programme of funding and capacity-building, initially of a small number of 'focus NGOs'. The capacitybuilding recommendations included: practical training in PRA and gender analysis for needs assessment and participatory problem solving; support for lowinput sustainable agriculture with appropriate training; training in management (including financial), leadership, fund raising and office administration; training in project planning, monitoring and evaluation.

Work with NGOs has also been carried out in the very different environment of postindependence South Africa. The Land Development Unit (LDU), a joint project of FARM Africa and the Cape Land Development Trust, provides support to smallholder farmers through research, training and extension, and seeks to strengthen national research and extension institutions by sharing experience. A member of NRI led a review of the first three years of the LDU. This review noted its positive achievements in field activities and farmers' training. It also advised on the need for greater strategic planning, including a clearer definition and prioritization of client groups, and the need for the replicability of approaches to be taken into account when

identifying grassroots projects. Such needs necessitate both external consultancy support and improved use of university resources within South Africa. With regard to field operations, there was a need to define entrance and exit criteria for LDU's involvement in grassroots projects, a need to understand the different levels of farmer participation appropriate for different objectives and at different stages of agricultural research, and an urgent need for gender training. The review also stressed the importance of posttraining support, both to government workers and to the farmers which LDU has trained in the past, so that they can be supported in new, participatory approaches and apply what they have been taught.

Government institutions, especially agricultural extension services, were not neglected in SSD's work. Government extension services, particularly those modelled on the Training and Visit System, have been much criticized in recent years for their top-down orientation, their inability to transmit complex messages, their inequity, and their financial unsustainability. A research project carried out by SSD and the Livestock Department addressed some of these questions in the particular context of extension on animal production. Animal production extension is growing in importance as production is intensified and animal health constraints are gradually overcome, but it is still frequently institutionally marginalized between crop extension and

animal health concerns and their associated interest groups. A large number of government, cooperative and NGO extension systems were investigated in Kenya, Burkina Faso and India through discussions with researchers and extension managers, and participatory discussions with livestock producers. Specific areas for reform of the Training and Visit systems were highlighted. Attention was also drawn to the potential for rapid moves towards cost-recovery in much peri-urban livestock extension, and the piloting of more participatory approaches by a number of NGOs and bilaterally funded projects.

Also on extension, an SSD staff member participated in the midterm review of CARE Sri Lanka's Integrated Training and Safe Use of Pesticides Project. This involved an examination of the 'farmer-field schools', season-long intensive campaigns involving demonstration plots and a variety of other methods to transmit the complex techniques of IPM in rice and vegetables. This approach is now used successfully by both government organizations and NGOs in Sri Lanka. While the number of farmers who can participate directly is very limited, there is evidence of significant secondary dissemination by school participants to others. The IPM package for rice, already highly developed, can be successfully adapted to local conditions. In the case of vegetable farming, the schools have already shown a capacity for generating as well as delivering messages, but this could be improved further.

Rural livelihoods and the environment

In 1995, SSD staff worked on a number of projects which addressed the problem of conflict between local people's livelihoods and 'environmental conservation' variously defined. A mission to the Turks and Caicos Islands to examine the National Protected Areas System highlighted local people's fears, sometimes exaggerated, that the demarcation of marine protected areas would involve the prohibition of fishing. Despite the damaging effects of tourism on the marine environment, the more powerful, expatriate-owned tourist industry has been less subjected to environmental pressure. The mission proposed, among other recommendations, a move to 'comanagement' of protected areas by local communities.

Two NRI staff members participated in a mission to review the Ghana Forest Inventory and Management Project and prepare a successor project. The project has had to deal with common issues in the forestry sector including: employment provided by legal and illegal felling operations; the involvement of traditional authorities in authorizing felling, and the transparency of the distribution of the derived benefits; farmers' lack of rights over trees on-farm or in fallows; and the great importance of non-timber forest products, especially to the poor and landless. The review sought to strengthen the project's existing capacity for dealing with such issues through collaborative management, particularly through community

inputs into the management of forest reserves, the provision of incentives for individual farmers to undertake rehabilitation of fire-degraded areas, and better liaison between the Forestry Department and 'admitted farms' within reserve boundaries.

The problem of rural livelihoods and environmental conservation is demonstrated in a different form by the depletion and degradation of aquifers. Technical choices on rates of groundwater exploitation, and the frameworks of the institutions, regulations and incentives which govern extraction, have profound effects on the livelihoods of those who depend on groundwater for irrigation and other activities. SSD staff have worked with hydrogeologists from the British Geological Survey on an interdisciplinary approach to these problems, both in an ESRCfunded research project focusing. on several case-study countries, and in an ODA-funded project in China. Within the context of profound institutional change and the return to a household system of agricultural production, the Chinese project aims to develop solutions to problems of aquifer over-exploitation and salination in an irrigated scheme on the desert margin.

THE MARKET

NRI has a strong interest and a good research and development record in marketing issues which affect the RNR sector. Its Social Sciences Department (SSD) has particular skills in areas of commodity market analysis,

analysis of systems, and associated policy issues. This expertise complements the scientific skills within the Institute which cover the analysis of post-harvest systems and the interface with production systems. Economic sustainability is the underlying goal of structural adjustment and economic reform, with the expectation that appropriate policy can foster growth by creating an environment in which the private sector can respond to market opportunities. This is therefore the context for much of NRI's current work on markets, particularly in sub-Saharan Africa.

The SSD continues to undertake substantial consulting and research assignments on markets and marketing. The Marketing Systems Economics Group embarked on a number of major assignments in 1995. Two studies have examined the opportunities for exports; one of these concerned rattan and bamboo furniture from Malaysia and the other focused on the potential for non-canned tuna exports by Pacific island states. In two further studies, the emphasis was on the potential for exports while also incorporating export diversification as a strategic option. This work focused on the opportunities for banana exporters in the Caribbean, and the appropriate marketing strategy for the Zanzibar clove sector.

The Marketing Systems
Economics Group has also
become increasingly involved in
work centred on domestic markets
and marketing systems within
developing countries. Within the

past year, two studies have been initiated. The first concerns the actual and potential markets for non-timber forest products in Cameroon. The second has involved analysis of the urban demand for animal proteins with particular reference to selected major cities in sub-Saharan Africa. The group has also continued to work on the liberalization of grain markets in Africa as a major theme within this market research. Meanwhile, two members of the group in overseas postings have continued to work on crop diversification, in the Philippines (Cebu) and Zanzibar.

Agricultural markets in sub-Saharan Africa: improving the market access of traders and smallholders

In recent years, structural adjustment programmes have reduced the direct role of the state in marketing, and in many African countries, agricultural marketing systems have been reformed.

The assumption underlying this process has been that the withdrawal of inefficient public marketing agencies will open the way for the development of a competitive private sector which will assume the marketing functions previously under state direction. These functions include not only procurement and exchange but also storage, processing and secondary services (finance and insurance) on which marketing heavily relies.

For a number of years, NRI has been involved in research into the process of liberalization with a special focus on grain markets in sub-Saharan Africa. As this work has progressed, the emphasis has shifted from the diagnosis of the constraints which reduce market efficiency and make it difficult for farmers to gain access to markets, to the search for practical solutions to these problems.

Trader financing

Early work involving case studies in Ghana, Tanzania and Mali, indicated that a recurring problem throughout sub-Saharan Africa is the absence of formal financing mechanisms for grain storage and trade. This gives rise to interseasonal price variations which are much higher than one would expect in countries where trading and financial systems are well integrated. No rapid solutions to these problems have presented themselves because of weaknesses in the financial systems and surrounding policy framework, and the inherent risk of lending. However, a promising approach has been identified for increasing the willingness of banks to lend to cereal traders. It consists of a technique of historical origin called 'warehouse receipt financing' or 'inventory credit'. Using this approach, banks can greatly reduce risk by lending against farmers' or traders' stocks (insured against fire, theft and damage due to unusual weather conditions) held by a trusted third party storekeeper or 'collateral manager'.

Building on previous experience in other countries, NRI investigated the feasibility of introducing this approach to

Ghana. In-country desk research and a literature review were carried out, and the trading networks linking grain surplus and deficit regions were investigated. Proposals for inventory credit were then promoted at a seminar organized for this purpose by the Ministry of Agriculture. The seminar was attended by a range of interested parties including bankers, traders, prospective warehouse operators, traders, farmers and government representatives. An important component of the approach was to ask banks to finance loans from their own deposits rather than introduce any donor money; experience of an earlier scheme in Mali suggested that this could have an adverse effect (e.g. it could reduce the incentive for pursuing institutional reform and involving local institutions in the inventory credit system). The outcome of the seminar was a unanimous endorsement of the inventory credit concept, on the basis of which one bank (the Agricultural Development Bank) started lending against warehouse receipts on a pilot basis in the same year; a second bank (Barclays) followed suit in 1994.

Having been piloted for two seasons without any default, inventory credit is now an accepted form of lending in Ghana and is being extended to commodities other than maize, e.g. frozen fish. The challenge is now to widen access to the service from the present pilot scale–11 borrowers in 1994/95 with a total turnover of not more than 10 000 tonnes of maize of which 2800 tonnes were stored under loan to become a major form of trade

financing. To achieve this, solutions are required to various problems at the policy and technical level, e.g. the need for appropriate storage technologies (especially for new commodities introduced under the system). Appropriate policies are needed to ensure that farmers are encouraged to participate while avoiding the re-enforcement of state control or the promotion of unsustainable farmer-controlled bodies. Finally, there is a need to find suitable entrepreneurs for the collateral management function. Over the next two years, NRI will assist Ghana to address these challenges.

The most significant achievement of this work has probably been the acceleration of changes in public sector perceptions towards private traders, and the encouragement of new, relatively well-educated entrants who now feel that the policy context is conducive to their activities. The long-term benefits of this change cannot be calculated but it is believed that they will be large, as the new entrants contribute to the modernization and efficiency of the business.

NRI has recently appraised the case for inventory credit in Zambia under the ODA Crops Post-Harvest Programme. A first diagnostic study showed that restricted trader access to formal sector credit in 1995/96 was creating serious marketing problems and hampering the country's ability to cover its food deficit. A subsequent NRI mission held discussions with various interested parties, notably the government, the leading banks and

the grain trade, which showed that there was considerable interest in implementing an initiative in inventory credit. SGS (Ghana) Ltd is offering to provide collateral management services and NRI is waiting to see what practical steps are taken by this and other parties. Further work is planned to facilitate the process. NRI will provide backstopping for a series of activities to be undertaken by institutions in Zambia, including a series of visits to the key stakeholders involved. It is anticipated that these activities will include: a feasibility study of appropriate warehouse design and operation; government negotiation of leases for appropriate stores; take-over of warehouses by warehouse operators; and implementation of full commercial operation.

NRI has published its findings jointly with FAO and although the technique has been used since ancient times, this is the first internationally available text on this subject.

Building on trader financing

As a result of the inventory credit exercise in Ghana, NRI has helped to moderate the traditional government-to-government relationship which used to be the hallmark of all aid-funded research and technical assistance. This relationship did a great deal of damage in Africa by building up unsustainable public sector institutions which later became public liabilities. NRI has been working principally with the Ghanaian banking, trading and warehousing sectors (some of the more significant participants in

this scheme are: Agricultural Development Bank, Yahwe Shalom Farms Ltd, GFDC, SGS (Ghana) Ltd, Letus Produce Co. Ltd, Commodity Traders Ltd and various Malian traders from the Gao community), and at the same time has enjoyed a good rapport with the government whose policy-setting role is central to the whole activity.

NRI is now seeking to broaden these relationships from a narrow focus on financing to cover a series of related constraints which hinder the operation of food marketing systems in Ghana, notably difficulties with logistics, grain-drying, quality, grading, and trade with other countries. Another important issue for the government to consider is the effective utilization of the country's best grain storage facilities which are presently in the hands of an undercapitalized parastatal. In this case, the government has a key role in the creation of a policy framework whereby the maize trade can be rapidly modernized to benefit both producers and consumers.

In Ghana's 'maize triangle', maize is harvested at high moisture levels and drying facilities are needed in strategic locations to prevent quality deterioration. At the same time, there is a need to cut the cost of the fossil fuels used in drying and here, Ghana's sawmills, which produce vast quantities of sawdust waste, may provide an answer. Grading systems are needed so that banks can assess the quality of the grain against which they are lending their money, and so that end-users, who are becoming increasingly quality conscious, can order to a

specification instead of having to painstakingly sample every truckload they buy.

Apart from addressing these constraints, it is hoped to further explore ways of improving farmer access to markets, in this case, linking up with the NGO TechnoServe which has worked on the provision of inventory credit to farmer groups.

In such ways, it is hoped to create a model of the use of actionresearch through the 'commodity systems approach' whereby those who will be directly affected by research can participate in the process. This means that a research institute such as NRI can work in an indigenous private sector (including farmers, trading intermediaries, millers and service providers), with government and NGOs, to progressively modernize an entire commodity system (in this case, the maize system) from seed to plate.

Improving the access of smallholders to agricultural markets

Another concern identified by NRI's diagnostic work was the need for small farmers to cooperate in order to gain access to agricultural services, whether by bulking-up their produce to get a better price, or by purchasing fertilizers or implements on credit. The prospective benefits of such co-operation are large, but the potential hazards of creating weak and donor-dependent organizations are just as large. As yet, the failures of 'group enterprise' seem to far outnumber the successes.

For this reason, NRI is currently involved in a joint research project with the Plunkett Foundation to investigate the potential for such groups in sub-Saharan Africa, the characteristic features of successful groups, and the donor's role in establishing them. (The Plunkett Foundation is an independent charitable trust whose objectives are to promote and develop cooperative enterprises and farmer groups.) The research is funded under ODA's Policy Research Programme and involves a desk review and consultancy exercise which draw on recent experiences of farmer group activity, and four country case studies in Ghana, Uganda, Mali and Zimbabwe. The first phase of the research will be completed in June 1996.

Early indications are that groups can play an important role in providing farmers with access to markets, particularly financial ones. Success seems to be dependent, above all, on the internal cohesiveness of the group and on its having a clear sense of mission; these characteristics can be fostered by outsiders but cannot be planned for in largescale development programmes (although there are many such programmes which implicitly assume that they can). Success also seems to be linked to the type of activity chosen by the group, its internal organization and its links with the wider economy. Promotional strategies by external agents (governments, donors, NGOs) appear to be more successful when they pay proper attention to the wider economic context and promote self-reliance in preference to disbursing grants or soft loans.

This work has also highlighted the potential for contract farming or outgrower schemes, whereby farmer groups work in concert with the trading companies which supply inputs and market outputs. These schemes can take many forms and are relevant to diverse crops ranging from horticulture and spices, through oilseeds, to beverage crops. With the recent liberalization of exports in some southern Africa countries, these are becoming increasingly common as a means of promoting agricultural diversification away from the narrow range of crops which was encouraged in the past (e.g. maize and smallholder tobacco in Malawi). However, internal experience of operating such schemes is limited. NRI's recent work in Malawi and Zambia has indicated some serious operational difficulties and a need for research to identify the elements and conditions which give rise to success.

As a first step, a desk review analysed secondary material on contract farming and out-grower schemes in sub-Saharan Africa. The key factors which were found to influence the success of a scheme were access to markets (including physical infrastructure and profitable market opportunities) and the degree of competition facing the buyer. Outgrower schemes can collapse in the face of strong competition as sales are diverted by producers to other buyers. In terms of the organizational features of the schemes themselves, the key elements were: (i) the contractual relationship between the parties involved (what services are provided by the company and on

what terms, and what commitments are made by the producer in return); (ii) the appropriateness of the promoted technology in relation to existing farming systems among smallholders, and the prevailing patterns of labour allocation and resource availability within households; (iii) attention to issues of food security; (iv) the distribution of risk between the company and farmers; and (v) the degree to which farmers can organize and bargain collectively with the company to influence the distribution of benefits or allocation of managerial responsibilities.

NRI will undertake a programme of field research into existing outgrower schemes in Zambia and Malawi to test these findings against more recent experience, and to develop guidelines for helping local people to organize future schemes and increase their effectiveness. Researchers will work with implementing companies, participating farmers, governments, and NGOs with an interest in the schemes. Subsequently, it is hoped to work closely with these parties to fieldtest certain innovations using an 'action-research' approach similar to the one used in Ghana for inventory credit.

Linking with other institutions

In developing this work programme, NRI has extended its links with a range of organizations pursuing similar ends. A strong bond has been forged with the Agricultural Services Division at FAO, cemented by the joint publication on inventory credit.

More recently, UNCTAD has entered the picture, having identified warehousing as a vital missing link for attaining its goal of improving the management of producers' risks in internationally traded commodities. From here, links are being developed with international banks, legal specialists, and others with an interest in commodity finance and trade.

CDC has contributed its experience in the area of contract farming. In future projects under the Crops Post-Harvest Programme, NRI hopes to work closely with the Food Security Group, who have knowledge of the process of market reform in southern Africa, and with Wye College, who are investigating the role of private sector intermediaries in the agricultural marketing systems in Ghana, Tanzania and Pakistan. Through consultancies to the World Bank and FAO, NRI is helping Mozambique to develop policies, strategies and practical programmes for the development of post-harvest and marketing systems for foodgrains.

In African countries, it is not always easy to find strong, local, public sector institutions or NGOs with which to collaborate in the post-harvest field. Local capacity is largely concentrated in pre-harvest areas, and skills in marketing are particularly hard to come by. Nonetheless, valuable links have been built with several institutions, notably the Economic Research Institute (IER) in Mali, the Market Development Unit (Tanzania), TechnoServe (Ghana) and the

Zambia National Farmers' Union. In Ghana, an important contribution has been made by a staff member of the Ghana Institute of Management and Public Administration.

Through such links between cooperating researchers and institutions, it is hoped to create a critical mass of activity resulting in long-term solutions to key constraints affecting the development of agriculture in Africa.

ENVIRONMENTAL SUSTAINABILITY

RESOURCE ASSESSMENT

Management and monitoring of the environment and natural resources are fundamentally important to the human population. Events in the Horn of Africa during the last decade demonstrate all too clearly the need for effective environmental monitoring so that the best use can be made of available resources. The growing number of nations ratifying Agenda 21 and its associated environmental declarations means that developing countries, perhaps more than any others, need up-todate information about the environment so that they can make better decisions regarding the management of their natural resources.

In these countries, where dependence on fundamental natural resources such as land and water can be acute, remote sensing is ideally suited to providing regular, timely and extensive environmental monitoring. NRI's work in the use of remote sensing to improve resource management in developing countries is illustrated below with respect to the four principal elements of earth, air, fire and water. Satellite and airborne remote sensing techniques, coupled with integral geographical information systems (GIS), have much to offer local natural resource departments in developing sustainable, integrated, environmental management. Regular, repetitive coverage of huge areas, and the potential for directly extracting useful information about fundamental resources such as soil, vegetation and water, are major advantages of remote sensing. Key issues are:

- weather forecasting for rainfall estimation and drought early warning
- coastal and marine resources surveys
- forest assessment for sustainable use and conservation
- mapping of crop areas for pest management
- training in remote sensing interpretation and analysis.

Satellite data received locally can provide cost-effective means of continuously monitoring the natural resource base for management purposes, planning, protection, and early identification/warning of important threats and changes. Over the past few years, NRI (with collaborators) has developed

and successfully deployed lowcost, robust receiver stations capable of interpreting the realtime High Resolution Picture Transmission (HRPT) data which are continually transmitted from the orbiting satellites. This has enabled NRI to build significant expertise in the direct (in-country) reception and utilization of low resolution (approximately 1 km and 5 km) satellite image data for natural resource assessment and monitoring in developing countries. Over two dozen installations of NOAA and Meteosat data reception equipment have been established in countries (principally in Africa) where the acquisition of data was previously difficult or badly served. Installations are scheduled to increase during 1996/97.

Earth

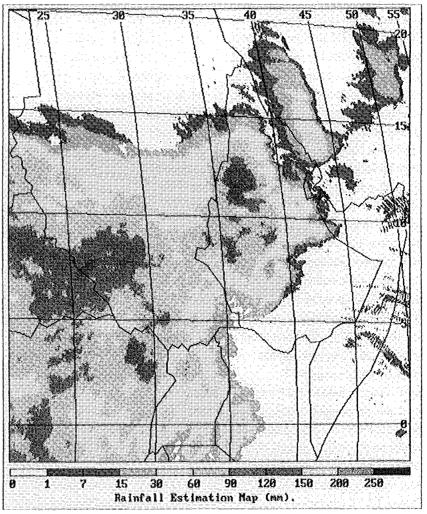
Dissemination of meteorological and vegetation data derived from weather satellites is being used to provide routine rainfall and vegetation (drought) monitoring in Ethiopia. In the early 1990s, NOAA and Meteosat satellite receiving systems were installed at Ethiopia's National Meteorological Services Agency (NMSA). This was the first stage of a national rainfall and vegetation monitoring project run by NMSA with support from the ODA via NRI. One of the aims of the project was to share information on vegetation and rainfall, derived from remotely sensed imagery, with a broad range of beneficiaries. Key requirements are that the information must be:

- cheap and quick to compile
- easy to understand
- renewable at regular (10day) intervals
- circulated as widely as possible to reach decisionmakers.

AVHRR HRPT data from the NOAA series and data from Meteosat are both received in real-time at NMSA. The Meteosat data are calibrated to produce rainfall estimation (RFE) images covering 10-day periods. NOAA AVHRR data covering all of Ethiopia are processed to produce normalized difference vegetation index (NDVI) images.

Colour prints of the RFE and NDVI images, supported by a brief description and assessment, are combined to produce a dekadal (10-day) bulletin entitled Rainfall and Vegetation Assessment from Satellite Data. The bulletin is distributed free of charge to a large number of government offices, including those of the President and the Prime Minister. Various other organizations based in Addis Ababa also subscribe to the bulletin.

Some clients prefer to receive the data in digital format so that they can carry out further work on the information. Therefore, the next stage in the development of the



Ten-day rainfall estimation map for the Horn of Africa, 2nd Dekad, August 1990

service is to provide the bulletin in digital format *via* E-mail. An increasing number of NMSA's clients are also connected to the PADIS network. Although money received for the bulletin (NMSA only charge for the 'value-added' part of the product) goes directly to the State, NMSA prefers payment in kind, e.g. production consumables.

The main beneficiaries, however, are the recipients who would otherwise have little or no access to regular, country-wide data of this quality. Such information is of huge value in a country where the effects of weather and changes in vegetation can have crucial consequences. In turn, most of the clientele disseminate the data to a wider audience. The Christian Relief and Development Association (CRDA), for example, hold monthly meetings which are attended by representatives of nearly all the aid agencies active in Ethiopia. The Rainfall and Vegetation Assessment from Satellite Data bulletin is central to discussion at these meetings.

In terms of national data collection, the ability to monitor dynamic environmental events on a country-wide scale in real-time, is virtually impossible by any other method. Despite early user scepticism, more than two years of operation have proved that NMSA can generate and disseminate reliable environmental information at regular and frequent intervals. This project would be severely impaired if the primary data sources were not free. However, current EUMETSAT (European Organization for the Exploitation

of Meteorological Satellites) plans include the encryption of Meteosat PDUS broadcasts.

In 1995, Meteosat and NOAA receiving systems were also installed in the neighbouring country of Eritrea to enhance the newly independent country's weather and environmental monitoring capacity. One of the main reasons for installing these systems (at the Civil Aviation Authority in Asmara) was to provide the vegetation and rainfall information necessary for forecasting upsurges and plagues of the desert locust which intermittently affect an area of 28 million km² between Mauritania in Africa and northwest India. Desert locusts live in generally arid areas and require moisture and vegetation to breed successfully. As the Red Sea coastal plain of Eritrea provides some of its most important breeding habitats, improved information about vegetation and rainfall conditions in this region will not only assist Eritrea's ability to control threatening locust populations, but also help FAO which has the mandate to coordinate desert locust information and disseminate it worldwide.

Air

The example of rainfall estimation (and related vegetation monitoring) for drought early warning in Ethiopia is typical of the kind of application that can be developed from relatively simple remote sensing observations of the atmosphere. In other parts of the world, however, different (simple and reliable) remote sensing

observations of the atmosphere are required. In Chile, for example, monitoring ultraviolet (UV) radiation hazards due to atmospheric ozone depletion is just as important as drought early warning.

The development of the ozone hole over Antarctica has received worldwide attention and is now recognized as one of the most significant threats to the global environment. Since it was first discovered by scientists from the British Antarctic Survey (BAS), the ozone hole has got much bigger and now extends over southern areas of Chile and Argentina. Evidence strongly suggests that the ozone hole which occurs annually over Antarctica is also increasing in size, and is appearing more quickly and lasting for longer. One of the most important global environmental changes presently occurring at high latitudes is the increase in UV radiation resulting from ozone depletion. It has been found that levels of UV radiation in southern Chile increase significantly during the period that the ozone hole forms each spring. UV radiation is known to cause a variety of health problems, including non-melanoma skin cancer, and may also affect marine phytoplankton (which form the basis of most of the world's ecosystems) in the Southern Ocean. Until now, southern Chile has had no way of predicting when the ozone hole would appear.

Since September 1994, NRI has been involved in a collaborative project with BAS, the University of Wisconsin and Bradford

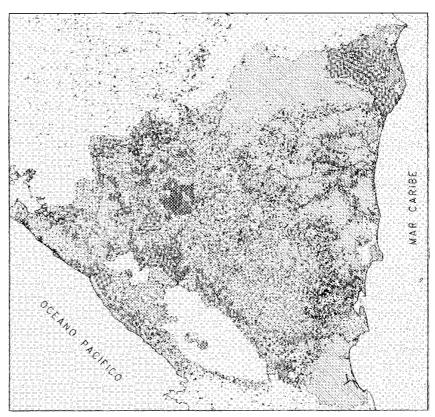
University Remote Sensing Ltd (BURS) to install appropriate hardware and software at the Universidad de Magallenes (UMAG), Punta Arenas, Chile. This will be used to process TOVS (Tiros Operational Vertical Sounder) data from a NOAA HRPT receiving system to help monitor the ozone hole over southern Chile. The project will provide technical assistance and equipment to the UMAG so that a predictive model can be developed which will enable the Regional Ozone Committee to establish an early warning service to the local community. A preliminary system for forecasting ozone levels above Punta Arenas for two days in advance has been established using locally received TOVS data and the output of a UK Meteorological Office atmospheric forecast model. Information on predicted levels of UV radiation will enable people living in affected communities to take more informed decisions and to be more aware of the health implications of changes associated with the seasonal development of the ozone hole over Antarctica. Awareness of this link has led to considerable concern among the general public of the region.

Fire

Fire is a key indicator of anthropogenic activity and associated biomass burning. Clearance of vegetation for agriculture, logging access, settlement, hunting, poaching and even, regeneration of some tree species, all involve fire to some extent. Vegetation fires are a

global problem affecting most of the world's ecosystems. They lead to increased soil erosion and a loss of species, habitats and biodiversity. In recent years, significant vegetation fires have occurred in North America, Australia, the Mediterranean and Southeast Asia, and the marked rise in the global population over the last 50 years or so has resulted in a corresponding increase in pressure on vegetation resources. The presence of too many fires over time can lead to a loss of biodiversity, and uncontrolled and natural wild fires can consume vast areas of vegetation, causing a significant loss of biomass. As well as the physical loss of biomass, burning also releases large amounts of gases (e.g. CH₄, CO, CO₂, N₂O, NO), volatile compounds and aerosols into the atmosphere.

By far the most practical and feasible means of quantifying and monitoring these biomass burning events at the national, regional or global scale is to utilize earth observation remote sensing and GIS technologies. Preliminary verification of a joint project between the Brazilian Space Agency (INPE) and the Brazilian Institute of Natural Resources (IBAMA) showed that over 90% of the fires identified by AVHRR were matched by field-located burn scars or active fires within 500 m of given AVHRR fire locations. The AVHRR instrument is particularly sensitive (in Channel 3) to hot spots on the ground. It has been used operationally (in Africa, USA, Australia and South America) for detecting fires over large land areas, for monitoring forest fires, and for estimating forest cover and



NOAA satellite observed fire events in Nicaragua

condition. Collaborative work in the savannah zone of Côte d'Ivoire between NRI and the Joint Research Centre (JRC) of the European Commission, showed that grassland savannah fires as small as 50 m in length could be detected, and by linking *in situ* AVHRR satellite observations to ground observations in real-time, some of the key problems of characterizing, managing and assessing the impact of fire events could be addressed.

In addition to detecting hot fire events, the wide area coverage and local reception capabilities of NOAA, make the data more appropriate for fire early warning operations. The 12 hour repeat coverage capability is a major advantage of NOAA platforms. It is the only practical way of attempting to detect short-lived fire events operationally and providing enough observations, over time, to extract longer term trends of fire activity. Even though NOAA imagery offers neither the spatial (at best 1.1 km samples) nor spectral resolution required to identify detailed, transient fire events, it remains the only readily available and inexpensive imagery for detecting burning fires and monitoring vegetation over vast tracts of land.

NRI receives many requests from forest departments around the world for information and support on satellite forest fire monitoring techniques. This is because experience in real-time fire detection has been developed over the last five years through a number of different operational and experimental projects in a variety of (largely tropical) regions

(in particular, Côte d'Ivoire, Central African Republic, Indonesia and Nicaragua). These projects have all been in areas where fire and biomass burning has a direct impact on natural resources and the environment, and thus, on the local population. The results of project activities to date have demonstrated the value and practicability of local satellite fire detection methods. These, in turn, have stimulated utilization by provincial forest department staff and concessionaires, and provoked specific demands for improvements in the quality of information, the reliability of supply and the speed of information dissemination so that they can be routinely incorporated into operational fire management activities.

Related research work with the European Commission Joint Research Centre on a global vegetation fire product (GVFP) has led to the development of new, improved (automatic) contextual techniques for cloud removal and fire detection which will enable more reliable burn regime analysis. These techniques have provided a sound technical platform from which to develop more robust local fire detection capabilities, particularly under tropical weather conditions.

Water

The temperature and circulation of surface waters can be detected *in situ* from research vessels, but regular, wide area measurements are neither easy nor cost-effective by these means. However, reliable daily water surface temperature

monitoring is now a reality using real-time remote sensing techniques. The satellite data used for temperature monitoring can also be used to provide qualitative estimates of sediment load and, possibly, of surface chlorophyll *a* concentration. The ability of NOAA data to provide daily, synoptic measurements over large areas of open water is an important input to the monitoring and management of aquatic resources.

Projects in Lake Malawi, Namibia and Indonesia are addressing the need for real-time monitoring of potential fisheries. The aim of these projects is to use real-time, satellite-derived measurements of water temperature and circulation features (from direct, local NOAA data capture systems) to help assess potential fisheries in Lake Malawi, off-shore Namibia and Indonesia, and to forecast the location of fishing zones.

In each location, data from the AVHRR instrument on the NOAA polar orbiter are received via a BURS PC-based receiver system. The image data are then combined with results of field calibration and data on atmospheric and environmental factors (e.g. wind speed and direction) to generate images of lake/sea surface temperature (SST) variation. The radiometric properties of the data are automatically calibrated using onboard telemetry and are then enhanced by various algorithms designed to locate coastlines, remove cloud and retrieve SST observations. Atmospheric corrections are applied to retrieve accurate calibrated surface

temperatures. Under cloud-free conditions, split window and triple window techniques enable the measurement of the bulk surface temperature of a water body such as Lake Malawi to an accuracy of between ± 0.4 °C and ± 0.7 °C. In Namibia, further enhancement has included the animation of time series of SST images to derive flow and trajectory information on eddies and other circulation features.

The projects have demonstrated that large lakes and coastal regions can be monitored on a day-to-day basis, both efficiently and costeffectively, by local capture and processing of free satellite data. The automatic reception and processing systems installed in Malawi, Namibia and Indonesia have reliably provided these data, and the projects indicate the potential value of real-time remotely sensed data for local fisheries management. Work is on-going to examine the relationships between fish catch data and observed temperature phenomena, and between surface temperature and chlorophyll content (i.e. primary biomass production, red tides, etc.), so that more comprehensive synoptic information on water column characteristics can be provided. Other applications linked to observing ENSO weather events are also being developed.

The imminent launch of future instruments, such as SeaWiFS, ENVISAT, MERIS and ADEOS, will provide new, complementary data sets for these and other projects. NRI will continue to assist in the promotion of effective dissemination of environmental

information to decision-makers in developing countries.

ENVIRONMENTAL MANAGEMENT

Environment and development are inextricably linked. Sustainable development is dependent on the maintenance of a productive natural resource base. Protection and conservation of the natural resource base is therefore fundamental to ensuring long-term livelihoods of rich and poor throughout the world.

For the poor in developing countries, environmental degradation makes poverty more acute; at the same time, poverty, and the need to survive in the short term, often forces people to over-exploit and degrade the very resources on which their future livelihoods depend. The challenge is therefore to improve and maintain the living conditions of millions of people in the developing world while at the same time, protecting and safeguarding the environment for present and future generations.

This people-centred approach to environmentally sustainable development is at the core of international development aid policy and central to all NRI's work.

The new international agenda

In 1992, the Earth Summit in Rio de Janeiro identified major environmental strategies and challenges for the 1990s and into the next century. The comprehensive action plan, Agenda 21, was agreed, which sets out the steps that governments, international organizations and others should take to protect the environment and promote longterm sustainable development. The donor community is now refocusing its aid programmes to respond to, and align itself with, Agenda 21. NRI, too, is developing its environmental capability and re-orientating its expertise towards the implementation of Agenda 21. A multi-disciplinary crossdepartmental Environment Group has been set up to steer this development.

NRI's environmental capability

NRI is well placed in this era of international concern for environmentally sustainable development. It has a universally recognized track record in natural resource assessment, planning and development, effected through a wide range of technical expertise and skills across many disciplines. Experts include ecologists, zoologists, foresters, plant taxonomists, wildlife specialists, land use and water resource planners, rangeland managers, specialists in resource assessment and remote sensing, toxicologists and environmental impact assessment practitioners. Their technical capability is complemented by socio-economic expertise in natural resource management.

NRI staff work at all levels from localized grassroots projects to international policy making.

They provide technical expertise and advice, and managerial and facilitating skills at all stages of a project and production cycle, in the preparation and implementation of national and regional environmental plans, problem-solving research, and research management.

This wide-ranging mix of capabilities and experience for enhancing the sustainable productive capacity of the natural resource sector gives NRI its comparative advantage. As a result, the Institute is successfully broadening its client base in the environmental field.

As the interactions between ecological processes and environmental impact are complex and often far-reaching, NRI focuses its environmental expertise into integrated, multi-disciplinary teams who address issues and problems on a demand-led basis. This approach is adopted both for project and programme consultancy work, and for indepth strategic or adaptive research. It also enables NRI to take the broad view necessary for making policy-level recommendations.

Environmental impact assessment in the natural resources sectors

NRI has extensive experience in environmental impact assessment (EIA) at various levels. These include:

 studying the impact of a proposed intervention as an integral part of the project cycle and project design

- assessing the impact of past and present resource use or interventions (e.g. impact studies of ground spraying with DDT)
- reviewing the environmental impact implications of sectoral policies and technologies, and defining indicators of environmental pressure for better future monitoring (e.g. multidonor study of the interactions between livestock production systems and the environment).

NRI's expertise in EIA goes beyond the application of the usual donor guidelines and procedures; it extends to the detailed specific technical knowledge needed to interpret these procedures within the particular natural resource context under study. As a result, NRI staff are frequently asked to provide this specialist expertise to EIA teams run by private consultancy firms.

NRI is also commissioned to provide overall management of EIA studies.

Grand Falls Hydropower Project, Tana River, Kenya: NRI provided two environmental consultants for environmental supervision and management of the EIA of the proposed Grand Falls Hydropower Project funded by the Japanese International Cooperation Agency (JICA). The EIA examined options based on three possible dam sites within the middle catchment of the Tana River basin. In addition to the obvious impact of flooding a large

area of communally held farm and bushland necessitating a resettlement and compensation programme, the study has indicated that a significant reduction in the frequency and volume of normal flooding patterns would have potentially serious negative impacts on the downstream production systems and habitats which are dependent on periodic flooding. The production systems include flood recession farming, livestock production and freshwater fisheries, and the habitats, a biologically diverse delta, mangroves, and the protected riverine forest in the Tana River National Primate Reserve which supports two endemic and endangered species. The study recommended that any construction option should incorporate the capacity to manage the controlled release of artificial floods which would follow the normal flooding pattern, a feature which had not previously been included as an integral design component of large hydropower dams. In this way, the reservoir could be built and managed so as to minimize damage to the adjacent reservoir and the downstream human and natural environment, albeit at some cost in power production. JICA have accepted this recommendation. By including an analysis of environmental impact early in the project cycle, engineering designs can be adapted to environmental requirements at the planning stage, obviating later revisions and thus minimizing time delays and extra costs.

In recognition of its expertise in EIA, NRI has recently been invited to join the United Nations Environment Programme's (UNEP) expert working group on Environmental Impact Assessment. NRI will contribute to UNEP's programme of workshops in developing countries for the promotion of EIA as a development and planning tool for decision-making, and for strengthening national EIA capabilities.

NRI has taken advantage of its EIA experience to develop postgraduate courses and incountry, capacity-building training in environmental assessment. In co-operation with Wye College, NRI runs a postgraduate course in 'Environmental Assessment and Management' for administrators and specialists working in the agricultural and natural resource sectors, and contributes EIA teaching input to a training course entitled 'Development and the Environment' organized in cooperation with the Environmental Engineering Department of Southampton University and the consultancy firm, Mott MacDonald.

From DDT impact assessment of tsetse control to community-based wildlife management in Zimbabwe: NRI has had a long-term involvement (from 1987 to the present) in monitoring the tsetse fly control programme in Zimbabwe. The monitoring project, funded by ODA, has itself evolved, and each stage has required a different expert input. In its initial phase, NRI staff conducted detailed studies of the

environmental impact of ground spraying with DDT (used in earlier eradication programmes) and the economics of tsetse control. The study included: monitoring bat, bird, lizard, fish and insect populations; microbial processes contributing to soil fertility; and residue concentrations. It concluded that the prognosis for full recovery within 10-20 years of the end of spraying is good; in fact, wildlife populations were affected less by DDT than by seasonal changes in climatic variation and habitat loss due to human settlement and elephant damage. Today, habitat loss rather than pesticide pollution is the main threat to wildlife in the Zambesi valley. Economic evaluations indicate that the extra cost of substituting deltamethrin, a less persistent insecticide, for DDT is almost equal to the cost of providing adequate national park management.

In a second phase of the project, the changes in land use following tsetse control were monitored using remote sensing and ground truthing. The project is now studying the potential for community participation in wildlife management.

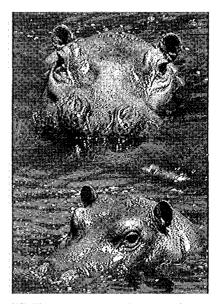
NRI's expertise in pesticide pollution and risk assessment continues to be in demand. In December 1995, the Institute won a competitive World Bank tender to supply consultancy services to the Nicaraguan Ministry of the Environment and Natural Resources to determine the level of pesticide pollution from agricultural uses in critical watersheds, basins and coastal zones, and to assess the risk to the

environment posed by present agricultural uses of pesticides. Proposals for mitigation of pesticide effects will be developed.

In addition to this area of expertise, NRI has been at the forefront of developing and testing more environmentally benign methods of pest control, including insect pheromones and microbial pesticides. NRI has developed training courses, based on practical experience, on the techniques involved in producing and formulating microbial organisms as insecticides.

Protection of wildlife and biodiversity

This has gained much prominance as a result of the signing of the Convention on Biological Diversity in Rio. Increasingly, NRI is being asked to supply technical, planning and management expertise on a wide range of wildlife and biodiversity topics.



Wildlife management and conservation are important activities in Botswana's national parks

Wildlife and national parks management in Botswana (1990-95): NRI experts have been responsible for co-ordinating and managing the following: the staff and activities of the Department of Wildlife and Natural Parks relating to national parks and reserves, wildlife research, wildlife management and utilization, poaching and other illegal activities, wildlife conservation, and education; the Wildlife Training Institute; and departmental development and administration in line with the 1986 National Wildlife Conservation Policy, the 1990 Tourism Policy, and the National Development Plan 7 (1991–97).

Caribbean Regional **Environmental Programme** project proposal: NRI has provided the team leader and terrestrial parks expert for the preparation and identification of the first regional EU-funded programme to contribute to the integrated and sustainable management of the terrestrial, coastal and marine resources of the Caribbean. The emphasis is on supporting the on-going or proposed programmes and projects of other donors through two programme components: protected areas and biodiversity; and capacity for environmental management. Examples of projects include: monitoring the health of coral reefs; economic valuation of environmental assets; preparation of action plans for protected areas; training of trainers in park management and support for community management of natural resources; development of a Caribbean Trust Fund to support locally based projects; a review of

EIA legislation; the strengthening of Capacity 21 Sustainable Development Councils; development of national environmental strategies; formulation of a hazardous waste protocol; and development of methods for the surveillance of water pollution. Collaborating agencies include UNDP, UNEP, IUCN, OECS and CARICAD.

Pollution control and other measures to protect biodiversity in Lake Tanganyika: In 1995, NRI won the contract, through international competitive tender, to manage and provide multidisciplinary cross-sectoral technical expertise for the development of a regional biodiversity conservation management plan for Lake Tanganyka. The US\$ 7.9 million project, funded by the Global Environmental Facility (GEF), aims to improve understanding of the complex scientific, technical and socio-economic factors and interactions which affect biodiversity. Studies carried out over the first three years of the project's life with support from the Marine Resources Assessment Group and the Institute for Freshwater Ecology will form the basis of a long-term management plan which will include a strategy for the control of pollution and lake sedimentation. With the support of the British Council and extensive NGO participation, the project will set up a programme of environmental awareness and training. If local livelihoods are to be protected and the lake's biodiversity maintained, a focus on lakeside communities will be crucial in terms of fostering an understanding of the need to protect the environment.

NRI's activities in addressing global environmental problems

Environmental problems can have both local and global impacts. Local actions can contribute to global problems, and global effects can have a major impact at the local level. Many governments have recognized this and have agreed to comply with international conventions and protocols aimed at safeguarding the global environment. NRI's expertise is contributing to the implementation of these international agreements by providing technical assistance to developing countries and countries in transition

A second major international agreement launched in Rio was the Framework Convention on Climate Change (FCCC). This includes commitments which all countries will need to make to alleviate the 'greenhouse effect', the gradual warming of the earth's atmosphere caused by the increase in the atmospheric concentration of 'greenhouse gases' such as water vapour, carbon dioxide and methane. In 1995, the Berlin Mandate was agreed in support of the FCCC. This requires a reduction in carbon dioxide emissions to 1990 levels by the year 2000; they will then have to be reduced by a further 10% by 2010, and by a further 5% by 2020.

NRI has been involved in a variety of research and technology development projects aimed at assisting developing countries to fulfil their commitments under the FCCC and Berlin Mandate. These include:

- research designed to increase understanding of the underlying processes which affect the release of methane from rice fields (which are thought to contribute at least a third of the annual increase in atmospheric methane)
- the application of remote sensing technology to monitor forest fires which are a source of carbon dioxide
- research into the potential for improved energy efficiency and fuelwood saving in wood-consuming industrial activities, such as (i) the development and promotion of energy efficient technology for use in developing countries, e.g. a fuel-efficient wood-fired air heater for use in engineering and tea industries, and a woodwaste-fired kiln for timber drying, and (ii) decentralized energy production from biomass in Eastern Europe and the potential for biomass power using 'setaside' land in the EU.

Methane research at NRI:

Methane is a potent greenhouse gas and its concentration in the atmosphere is increasing at about 1% per annum. If methane concentrations in the atmosphere are to be stabilized, the considerable contribution from rice fields to the global methane budget will have to be reduced by 10–30%. Reliable data, obtained directly from field measurements,

have only recently become available, and the underlying soil processes are still poorly understood. Funded by ODA's Environment Research Programme, NRI and collaborators at the International Rice Research Institute (IRRI) in the Philippines and the University of Oxford have been investigating the options for developing rice production technologies which reduce methane emissions from rice fields without compromising productivity. NRI's research has focused on the impact of farming practices on the oxidation of methane at the soil/water interface in rice fields, and thus, the effect on the methane production/oxidation balance. Factors investigated include: the amount of organic matter in the soil; temperature fluctuations; rice root biomass; and the role of soil mesofauna in mixing the soil. It was found that the different pathways by which methane escapes from the soil have a major influence on the proportion which is oxidized. This information has been used by NRI's collaborators to produce and improve predictive models of carbon and methane dynamics.

Research into the potential for fuelwood saving in Sri Lanka's desiccated coconut and tea industries: Funded by ODA's Forest Research Programme, NRI researchers have examined the nitrous oxide and carbon dioxide emissions from industrial biomassfueled thermal plants in Sri Lanka and the potential for fuel-saving. Results have indicated that the average energy efficiency of the industrial system was only 50%. The main reasons for the loss of efficiency were: high moisture

content of fuels; excess air; disrepair of equipment; and irregular furnace stoking owing to inadequate training of operators and supervisors. It was estimated that with the equipment currently in use, efficiency could be increased to 70% and that this gain would result in: reductions of about 21% and 25% in nitrous oxide and carbon dioxide emissions, respectively, from industrial combustion sources (excluding possible improvements in the use of fuel oils and other biomass); a 40% reduction in industrial fuelwood use; and annual savings in fuelwood consumption of up to the equivalent of 38 km² of standing forest (in Sri Lanka, this represents about 10% of the national fuelwood consumption and a 9% reduction in deforestation).

The project was implemented in the context of Sri Lanka, but the methodology could be applied elsewhere. The NRI team is currently developing a training programme to generate savings in fuelwood consumption. The adoption of such measures could contribute to national obligations under the FCCC and the Berlin Mandate while allowing for substantial growth in industrial activity. Not only does improvement in the industrial use of fuelwood contribute to a reduction of greenhouse gas emissions, but by reducing pressure on forests, it also helps to preserve their function as 'carbon sinks'. It also assists compliance with the UNCED statement of Forest Principles agreed at Rio to curb deforestation and conserve natural forests.

NRI is helping to predict and manage the consequences of climate change. Work is currently underway in southern Africa to improve drought risk management. In dryland agriculture zones, locally applicable remote sensing techniques are being used to improve weather forecasting with the aim of predicting the risk of drought for the forthcoming cropping season and developing coping strategies.

Another major international environmental agreement, the Montreal Protocol on Substances that Deplete the Ozone Layer, which was adopted in 1987, has been ratified by over 100 countries. These countries have agreed to institute measures for eliminating the production and consumption of ozone-depleting chemicals by 1996; developing countries have been given a 10year grace period. In 1990, it was decided to establish the Multilateral Fund for the Implementation of the Montreal Protocol to help developing countries meet the agreed incremental costs of phasing out ozone-depleting substances. In December 1995, parties of the Montreal Protocol agreed measures to phase out ozonedepleting substances. One target chemical is methyl bromide which is widely used as a pesticide fumigant in food storage, and as a soil fumigant.

NRI has been working in support of the Montreal Protocol at various levels including:

 real-time monitoring of changes in the ozone layer

- above Chile using remote sensing technology (Chile will be allocating resources provided by the Multi-lateral Fund to priority phase out projects)
- conducting a survey for UNDP with Montreal Protocol funding, to assess the use of methyl bromide in developing countries
- UK membership of the Technical Options Committee for methyl bromide organized by UNEP
- providing in-country training in the use of alternatives to methyl bromide for grain storage. Emphasis is being placed on ensuring that the remaining fumigant, phosphine, is used efficiently and safely. NRI has produced a publication on the use of phosphine as an effective commodity fumigant, and is currently preparing a training video on good practice for phosphine fumigation.

Policy

As well as providing inputs to specific problem-orientated research and projects, NRI works in the field of environmental policy analysis. Increasingly, this policy analysis is contributing to the development of environmental policies and guidelines in multilateral aid agencies.

As a leading international centre for the development and implementation of IPM policy and practice, NRI has contributed to the adoption of IPM by the multi-lateral donors. NRI was commissioned to write the UNDP operational guidelines for IPM programming, and has recently won a further four years of support from EU DGXII to run the European IPM Working Group which promotes environmentally sound crop protection in European development aid. On behalf of ODA, NRI has had extensive international involvement in IPM through a multi-donor task force established in 1989 with USAID, CIDA, ACIAR and FAO.

NRI led, and provided technical and socio-economic input to, the preparation of a study on ecological carrying capacities and stakeholder analysis for inclusion in the World Bank's Natural Habitats and Ecosystem

Management Handbook series.

Following UNCED, a multidonor group and steering committee comprising the World Bank, FAO and the development agencies of Denmark, France, Germany, the Netherlands, UK and USA, initiated a series of studies on the positive and negative environmental impacts of livestock across a range of livestock production systems and agro-ecological zones. These studies aimed: to describe and quantify the impacts of livestock; to review policies and technologies for enhancing positive, and mitigating negative, impacts; and to develop planning and evaluation approaches which allow better project design and environmental monitoring. NRI was commissioned to undertake

studies on the effects of livestock in mixed crop-livestock farming systems, and of the effects of demand for feed concentrates. A key output of the studies was to define direct environmental, and indirect socio-economic, indicators of environmental pressures and conditions for future monitoring.

NRI manages the Scientific and Environmental Monitoring Group funded by the EU's European Development Fund.

Environmental research management

NRI staff manage ODA's Environmental Research Programme and Natural Resources Policy Research Programme.

FORESTRY

Activities undertaken by NRI in the forestry sector are aimed at helping developing countries to bring their forest estates under productive and sustainable management. This is achieved through adaptive research and technology transfer in areas such as forest policy, planning, conservation of biodiversity, resource assessment, and forest management. NRI staff in overseas postings are involved in project preparation, project development and management, and the transfer of specific skills to developing countries.

Tropical forest management

With the ever-increasing pressures caused by agricultural expansion and urban development, the management of the tropical high forest in a sustainable manner is a matter of continuing concern. In Belize, NRI forestry staff have been directly involved with the Forest Planning and Management Project since 1992, working in association with Fountain Renewable Resources. This project has attempted to pull together three important strands of forest management: the realization that land has an optimum use and that detailed land use planning is essential for the correct allocation of land for forestry or agricultural purposes; the assessment of the sustainable yield, formation of a harvesting plan, and strong field management to ensure that contractors adhere to the restrictions imposed in the felling plan; and the incorporation of social planning to ensure that the management of the forest meets the widest needs of the surrounding population. The project therefore incorporates the more traditional forestry activities of management plan preparation, and the setting up of a permanent sample plot system. It also assists the Land Information Centre in the operation of a geographic information system (GIS) for development planning and activities such as the registration of land titles, and is working with forest user groups to develop income generating activities. The NRI team will be enlarged in 1996 to provide specialist advice on the development of participatory forest management

and on the ecological effects of logging. The existing permanent sample plots are providing an important insight into the changes taking place in the forest both with and without the intervention of man. In 1995, measurements taken in plots located within the nationally and internationally important Chiquibul National Park showed that over the last four years, there has been a slow reduction in the stocking of live trees while total standing tree volume has gradually increased from 105.7 m²/ha to 113.5 m³/ha. Tree mortality is speciesdependent, leading to a gradual change in forest composition. Growth of the economically important mahogany trees (Swietenia macrophylla) is noticeably faster than that of the remaining forest species.

The theme of involving the wider community in the management of the high forest has been extended to Cameroon, where an NRI forestry expert is the project manager for the Community Forestry Development Project. This project has the overall objective of testing and demonstrating community-based forest planning, and continues a long association between forestry in Cameroon and NRI staff. In Sri Lanka, staff have been leading two important ODAfunded projects: the Forest Management Plantation Project and the Forest Research and Information Project. The first was designed to provide institutional strengthening in a range of activities, and has been assisting in the management and expansion of existing plantations; over 900 ha were planted in 1995. The

mapping phase of the project has been completed, with all the plantations in the country now mapped in detail. Assistance has been provided for in-country training to support the Sri Lanka Forest Institute in the development of courses and the provision of training for Institute staff.

Forest research activities

NRI forestry staff have been engaged in various research activities either directly, or by providing institutional support to a research institute. In Sri Lanka, the Forest Research and Information Project referred to above has been operating since 1991, assisting the Forest Department in the development of an effective research programme aimed at providing the information required for plantation development and the improvement of forest management. The project has also been assisting in the completion of the Flora of Ceylon and providing support to the Botanic Garden.

In Malawi, two staff members have been assisting the Forest Research Institute of Malawi (FRIM) to develop a more structured research programme and tailor research to client need. Emphasis is being placed on the development of a research database of all past and present activities, using the software package, SISTEM, developed by the Oxford Forestry Institute (OFI), and on the expansion of the seed production, seed storage and dissemination capabilities of

FRIM. Staff development through in-country and external courses is receiving particular attention. The research programme at FRIM is concentrating on the improvement of farm forestry activities, and on management aspects of the natural semi-arid miombo woodland, including nontimber forest products. These products are now of paramount importance to the local communities who may regard the woodland principally in terms of grazing, fruit collection and honey production, and reservoirs of fuelwood, poles and timber. Two of the postgraduate studies being undertaken by FRIM staff supported by the project are focusing on the species Uapaca kirkiana and Moringa oleifera, both of which produce a range of fruit and products. A third officer is examining the silvicultural management options for increasing the productivity of the natural woodland using such management interventions as coppicing and protective burning. In Honduras, an NRI staff member is conducting investigations into the use of live barriers for the reduction of soil erosion and for water conservation. The work is being carried out in close co-operation with research staff of CATIE and the ODA-funded Project for the Conservation and Silviculture of Forest Species of Honduras (CONSEFORH). Local NGOs are also assisting, as the studies include an assessment of the socioeconomic obstacles to the adoption of selected technologies.

Following the declaration of the Forest Principles at UNCED in 1992, there has been a growing

recognition of the importance of the full participation of forest users in the management of forest resources. ODA contracted NRI to undertake a detailed review of the experience of participatory forest management to date, and the lessons to be learned for the future. Work has concentrated on the regions of West Africa, Latin America and India-Nepal, with local workshops being held as a focus for the observations and inputs from NGOs, government departments and user representatives. The study will be completed in mid-1996. Several research programmes funded under the ODA Renewable Natural Resources Strategy (RNRRS) are managed by NRI, including the Forest/Agriculture Interface (F/AI) System of the Natural Resources Systems Programme (NRSP). Activities in the first year have focused on defining a strategy for the system, and have involved the commissioning of reviews to look at soil fertility and issues concerning common property, tenure and access to resources at the forest/agriculture interface. Identification and prioritization of key research topics, such as phosphorus cycling as a limiting component of soil fertility, are used as the basis for research proposals in specific areas. With regard to common property resource management, encouragement, enablement and monitoring of sustainable management have been identified as the key issues. These encompass consideration of policy issues such as equity, the capability and orientation of a country's forestry institutions, existing resource management



Peach palm (Bactris gasipaes) is a native species of Bolivia with commercial potential

arrangements and the pressures upon them, the nature of farming systems/resource use, and tenure relationships.

The project, Sustainable Agriculture in Forest Margins in Bolivia, was inherited from the previous Resource Assessment and Farming Systems (RAFS) Programme. Project objectives have been reformulated around the prescribed outputs of the F/A I. Agroforestry, and cover and winter crop systems, are being investigated for the maintenance of soil fertility, weed control, production of livestock feed and increased income generation. Covercrops: a Manual for Field Workers, which includes a database for suitable species selection, has just been published as an output from this project.

Under the Biomass Programme, work on two projects funded by the ODA through the OFI were completed. One has been looking at new combustion systems for wood residues capable of reducing

the level of emission of nitrous oxide compounds, and the other has been examining indirectly fired gas turbine application to biomass-fuelled furnaces, comparing their efficiency with traditional steam-fuelled systems.

Work on the introduction of timber drying systems in Honduras and Kenya has continued, with joint funding from the ODA through the OFI and from the Centre for Development of Industry, Brussels. Recently, the potential for using sawdust waste in the main timber industry areas of Ghana has been reviewed. A specific application is the use of sawdust as an alternative fuel for maize drying, but scope has also been found for introducing the NRI sawdust burning timber drying kiln.

Funding has been provided for an investigation into the use of wood from coppiced plantations, and residues generated in forestry industries, for the decentralized production of electricity in Eastern European countries. A new study has recently begun in collaboration with colleagues from the Netherlands and Denmark into the use of indirectly fired gas turbines for rural electrification. In Sri Lanka, the use of sawdust as a fuel is being investigated with funding from the German Government (GTZ) and the Energy Conservation Fund of Sri Lanka. The need for this work stems from the environmental problems associated with the uncontrolled dumping of sawdust and other debris by the forest industries in the Upper Mahaweli region. In

addition to creating environmental problems, dumped sawdust is washed into the Mahaweli river and its tributaries. The floating debris creates operational problems for the power stations situated in the area. The project complements a much wider programme on environmental management and sustained development in the Upper Mahaweli catchment area supported by ODA and GTZ. Also in Sri Lanka, trials have been conducted on the use of fuelwood in coconut oil production. NRI has assisted in the commissioning, training and testing of a new furnace system in a factory. The work was funded by the Common Fund for Commodities and was carried out in co-operation with the Institute for Research and Development of Agro-based Industries, Indonesia.

Advisory work

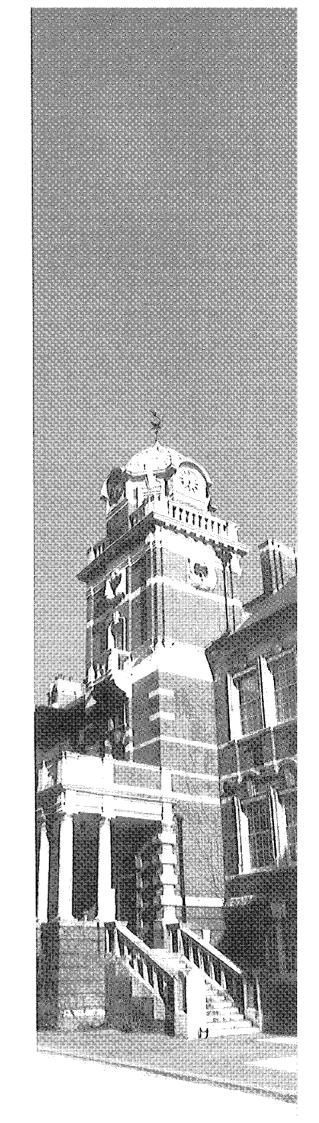
Senior staff have been assisting in the implementation of the ODA forestry programme in key field locations, and supervising the ongoing development and research activities in Brazil, the Caribbean and West Africa. These staff members are responsible for ensuring that the bi-lateral forestry programme meets its technical objectives and financial targets. In the Solomon Islands, an NRI forester had been helping to develop the National Forestry Action Plan (NFAP) and a new forest policy, but unfortunately, this work could not be completed because of a change of government and a reduced commitment to the objectives of the NFAP. A central planning role was undertaken in Malawi by a staff member attached to the Planning Section of Forest Department HQ. Work centred on the preparation of harvesting plans as well as on the formulation of a new forest policy and initial preparation of the NFAP. A further staff member has been posted to the EU, Brussels, to advise on the design and implementation of forest projects funded under DG1.

NRI acts as the host institute for the co-ordinator of the UK Tropical Forest Forum, a major grouping of public, nongovernment and private bodies, and individuals involved in the conservation and management of tropical forests. The Forum now has over 800 participants; the majority are from the UK but there are good links to Europe and the tropics. It acts as the UK node for the EU-sponsored European Tropical Forest Research Network, and hosts meetings and workshops for discussing current activities, initiatives and policies concerning tropical forests. This year, discussion has focused on: the timber trade and timber certification, indicators and criteria for determining good forest practices, conservation of biodiversity, the management of

the forest-agriculture interface for the stabilization of forest boundaries, and the role of business in valuing forest products. The Forum has been following the policy initiatives emanating from UNCED which currently concern the Intergovernmental Panel on Forests.

An interesting development towards the end of the year was the posting of a colleague from NRI's Social Science Group to South Africa where he will assist in the development of the new ODA forestry initiatives in that country.

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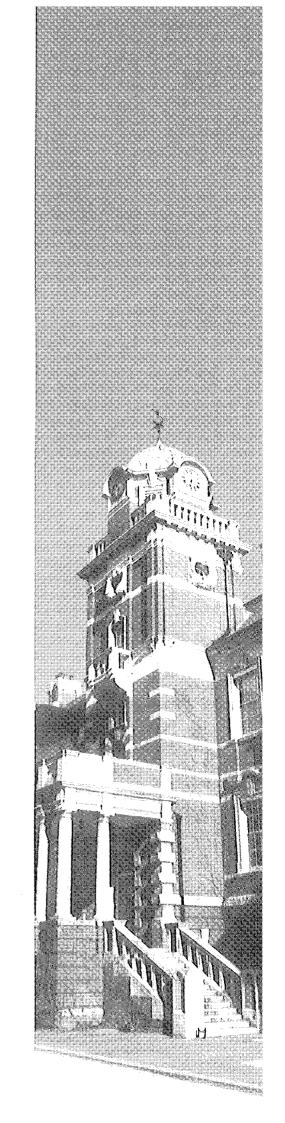
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ACCOUNTS FOR 1995-96 AND APRIL 1996



FOREWORD TO THE ACCOUNTS

AUDIT

The accounts for the year to 31 March 1996 are attached, together with supplementary accounts for the month of April (the Institute's last month in public ownership). They have been prepared in accordance with a Direction given by H M Treasury in pursuance of section 5 of the Exchequer and Audit Departments Act 1921 which is appended to these accounts. Accounts for the year to 31 March 1995 are also shown for purposes of comparison.

HISTORY

The Institute became an executive agency of the Overseas Development Administration, under the Government's Next Steps Initiative, in April 1990. It was formed - as the Overseas Development Natural Resources Institute - in 1987 by the amalgamation of ODA's two scientific units, the Tropical Development and Research Institute (formerly the Tropical Products Institute and the Centre for Overseas Pest Research) and the Land Resources Development Centre. The origins of the Institute can, however, be traced back to the founding of the Scientific and Practical Department of the Imperial Institute in 1894. Ownership of the Institute was transferred to the University of Greenwich on 1 May 1996.

PRINCIPAL ACTIVITIES

NRI works in and with developing countries to improve the productivity and sustainable management of their renewable natural resources through the application of science and technology. The Institute provides research, consultancy and project management services under customer/contractor arrangements to the ODA and to external clients, including notably the multilateral donor agencies.

BUSINESS DEVELOPMENTS

The Institute incurred a deficit of £7,386,000 on its ordinary activities in 1995-96 (£4,678,000 before capital charges and restructuring and relocation expenditure) and £652,000 for the month of April 1996. The deficit reflects the impact of a major reorganisation and downsizing programme implemented in the course of the year.

While the ODA's Natural Resources Division remained the Institute's largest single customer, the overall volume of ODA-funded work decreased from 84.3 per cent of the total in 1994-95, to 79.5 per cent. There was a corresponding increase in the volume of work for non-ODA clients from 15.7 to 20.5 per cent of the total. These trends are expected to continue in 1996-97.

PERFORMANCE AGAINST KEY TARGETS

The Institute achieved its restructuring target with implementation of an agreed programme of reorganisation and downsizing and formulation of an accommodation strategy for the smaller organisation. The target level of operational years charged to clients was exceeded (264 against 260) but, on the basis of the statutory accounts and without allowance for reimbursable costs outstanding at the year end, average revenue per operational year fell short of the target (£64,402 against £67,750). The target increase in operational years of work for non-ODA clients was also achieved (54 against 53.9) but, again on the basis of the statutory figures, the target increase of 10 per cent in retained income from this source was not achieved.

EVENTS OCCURRING AFTER THE YEAR END AND LIKELY FUTURE DEVELOPMENTS

Following a decision by the Minister for Overseas Development in December 1994 to invite expressions of interest in the future ownership of NRI, and a subsequent competitive tendering process, a bid was accepted from a Consortium comprising the Universities of Edinburgh and Greenwich and Imperial and Wye Colleges (University of London). Under the terms of the consortium's offer, ownership of the Institute was transferred to the University of Greenwich on 1 May 1996. The Consortium had meanwhile formed a joint-venture company, to be known as Natural Resources International Limited, which assumed responsibility from 1 August 1996 for marketing, business development and for programme and project management.

ACTIVITIES IN THE FIELD OF RESEARCH AND DEVELOPMENT

The work of the Institute takes the form of technology generation (research) and technology transfer (development services) in the field of renewable natural resources. This work is undertaken on behalf of clients and is fully funded by them.

SIGNIFICANT CHANGES IN FIXED ASSETS

There have been no significant changes to the Institute's holdings of fixed assets during the year, but a physical inventory of assets was undertaken prior to privatisation and appropriate adjustments made to the fixed assets register and to the accounts.

MARKET VALUE OF INTERESTS IN LAND

The Institute does not own the land or buildings which it occupies at Chatham Maritime (except for the greenhouse facilities) and rent payable for the site is charged to the operating account. Rent was also payable during the year to Property Holdings, on the basis of an assessment of market value, in respect of a site at Culham which was surplus to requirements and in the process of disposal.

DIVIDENDS AND RESERVES

No dividend has been paid. The deficit of £7,386,000 on the operating account for 1995-96 and of £652,000 for the month of April have been carried to reserves.

MANAGEMENT BOARD

Membership of the Institute's Management Board, prior to the transfer of ownership, was as follows: Mr Anthony Beattie, Chief Executive; Mr John Perfect, Director of Professional Resources; Professor Margaret Gill, Director of Research Services; Professor Rod Cooke (to 31.7.95) / Mr Peter Thompson (from 1.8.95), Director of Development Services; and Mr Charles Myhill, Director of Corporate Services.

CHARITABLE DONATIONS

No cash donations have been made, although the Institute's facilities are occasionally made available for charitable or community purposes.

POLICY TOWARDS THE DISABLED

As an Agency, NRI has observed the Civil Service Code of Practice on the Employment of Disabled People and has been committed, more generally, to a policy of equal opportunity which seeks to ensure that access to employment and advancement is based upon ability, qualifications and suitability of the work and that working conditions are such as to encourage the full participation and retention of staff.

EMPLOYEE INFORMATION AND CONSULTATION

A monthly newsletter provides information to staff about the business. This supplements periodic letters from the Chief Executive to all members of staff about specific issues of interest or concern. Regular meetings have been held with representatives of the Local Trade Union Side and informal communication between the Management Board, line managers and their staff has been encouraged.

Anthony Beattie

Chief Executive (to 30.4.1996)

Antony Brattz

17 January 1997

OPERATING ACCOUNT YEAR ENDED 31 MARCH 1996 AND FOR THE MONTH OF APRIL 1996

| | | April 96 | 1995-96 | 1994-95 |
|--|------|----------|----------|----------|
| | Note | £'000 | £'000 | £'000 |
| Turnover | 2 | 1,149 | 31,054 | 33,666 |
| Cost of sales | | (1,029) | (27,809) | (27,307) |
| Gross surplus | | 120 | 3,245 | 6,359 |
| Other operating income | 2 | 78 | 1,388 | 911 |
| Administration expenses | 3 | (774) | (9,311) | (6,789) |
| Operating surplus/(deficit) | | (576) | (4,678) | 481 |
| Restructuring and | | | | |
| relocation costs | 4 | (39) | (2,260) | (3,360) |
| (Deficit) before interest | | (615) | (6,938) | (2,879) |
| Interest on capital | | (37) | (448) | (386) |
| (Deficit) on ordinary activities | | | | |
| for the month/year | | (652) | (7,386) | (3,265) |
| Statement of total recognised gains and losses | | | | |
| (Deficit) for the month/year | | (652) | (7,386) | (3,265) |
| Unrealised (deficit)/surplus on revaluation of tangible fixed | | | | |
| assets | | | 27 | (28) |
| Fotal recognised gains and loss | | (652) | (7,359) | (3,293) |

The notes on pages 98 to 105 form part of these accounts

BALANCE SHEET AT 31 MARCH 1996 AND AT 30 APRIL 1996

| | Nore | April 96 £2000 | 1995-96 | 1994-95 £'000 |
|--|----------------------|-------------------|---------|------------------|
| | | | £'000 | |
| Fixed assets | | | | |
| Tangible assets | 7 | 2,988 | 3,058 | 4,045 |
| Assets in the course of | | | | |
| construction | | 16 | 16 | IŠ |
| | | 3,004 | 3,074 | 4,060 |
| Current assets | | | | |
| Stocks and work | | | | |
| in progress | 8 | 178 | 181 | 184 |
| Debtors | 9 | 5,0 95 | 5,365 | 5,010 |
| Cash at bank and in h | and | 1,138 | 1,981 | 1,618 |
| Total curtent assets | | 6411 | 7,527 | 6,812 |
| Creditors: amounts fa | lling due | | | |
| within one year | 10 | (2,027) | (2,391) | (3,066) |
| Net current assets/ | | | | |
| (liabilities) | | 4,384 | 5,136 | 3,746 |
| Total assets less curren | | | | |
| liabilities | | 7,388 | 8,210 | 7,806 |
| Creditors: amounts fa after more than one y | Illing due ear 10 | (467) | (467) | (605) |
| | Car F.V. | | | |
| Total net assets | | 6,921 | 7,743 | 7,201 |
| Capital and reserves | | | | |
| Reserves | 11 | 6,921 | 7,743 | 7,201 |

The notes on pages 98 to 105 form part of these accounts

Anthony Beattie

Director and Chief Executive (to 30.4.96)

Antony Brattz

17 January 1997

CASH FLOW STATEMENT YEAR ENDED 31 MARCH 1996 AND FOR THE MONTH OF APRIL 1996

| | | April 96 | 19 | 95-96 | 1994-95 | |
|---|-------|-----------------|---|---|---------|--|
| | Note | £'000 | £' | '000 | £'000 | |
| Net cash inflow/(outflow) | | | 11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 3 3 3 3 3 3 3 3 3 | | |
| from operating activities | a(ī) | (680) | (6 | ,867) | (3,554) | |
| Investing activities | | | 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 | | | |
| Purchase of fixed assets | | | *** *** *** *** *** | (722) | (1,178) | |
| Net cash outflow before financing | | (680) | (7, | ,589) | (4,732) | |
| Financing: | | | | | | |
| ODA advance funding | b | (163) | 7 | ,952 | 3,753 | |
| Increase/(decrease) in cash | C | (843) | 5.5 1 5.6 5.6 5.7 5.7 5.7 5.7 5.7 5.7 | 363 | (979) | |
| | | | | | | |
| Note a(i) Net cash inflow from | | | | | | |
| pperating activities: | | | | 206 | | |
| Operating surplus/(deficit) Amortisation of fixed assets | | (652) | = (/, | 386) | (3,265) | |
| | 723 | | | 847 | 822 | |
| Net book value of disposals Increase)/decrease in stocks | a(ii) | | I. | ,482 | 37 | |
| and work in progress | | | N. 9 1 P 1 P 1 P 1 P 1 P 1 P | 3 | (83) | |
| Increase)/decrease in debtors | | 270 | (| (355) | (1,000) | |
| ncrease/(decrease) in creditors | | (364) | (| (813) | (65) | |
| Depreciation written back | | | <u> </u> | 645) | | |
| | | (680) | (6, | 867) | (3,554) | |
| Note a(ii) Net book value | | | | | | |
| of disposals: Replacement cost of disposals | | | 1 | 055 | | |
| Depreciation | | | | 855 373) | 385 | |
| | | | <u></u> | | (348) | |
| | | | | ,482 | 37 | |
| Note b Movement in ODA funding: | | April 96 Change | 1996 | Change | 1995 | |
| unding ¹ | | (2,019) (2,927) | 908 | 764 | 144 | |
| /ote charge ² | | 14,907 2,702 | 12,205 | 6,442 | 5,763 | |
| Notional costs reserve 3 | | 3,179 62 | 3,117 | 746 | 2,371 | |
| Seneral reserve ⁴ | | 616 - | 616 | : — !! ! — !! | 616 | |
| | | 16,683 (163) | 16,846 | 7,952 | 8,894 | |

^{1.} Comprises advances by ODA of voted running cost expenditure.

^{3.} The cumulative total of notional costs incurred since inception

^{4.} The cumulative total of balance sheet adjustments in earlier years.

| | April 96 | 1995-96 | 1994-95 |
|---------------------------------------|----------|--|---------|
| | £'000 | £'000 | £'000 |
| Note c Analysis of changes in | | | |
| cash during the month/year: | | 01 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | |
| Opening balance | 1,981 | 1,618 | 2,597 |
| Net cash outflow | (843) | 363 | (979) |
| Closing balance | 1,138 | 1,981 | 1,618 |
| Note d Reconciliation to vote charge: | | | |
| Voted expenditure 1995-96 | | 5,672 | 5,087 |
| Other ODA | (163) | 2,280 | (1,334) |
| Financing | (163) | 7,952 | 3,753 |
| | | 11 | |

NOTES TO THE ACCOUNTS

1. ACCOUNTING POLICIES

These accounts have been prepared, on an accruals basis, in accordance with guidance issued by H M Treasury on financial reporting and on full-cost charging. Payments and receipts on a cash basis are reported in the Appropriation Account for the Overseas Aid Vote (Class II, Vote 5). To facilitate reconciliation with the Vote account, these accounts reflect, where appropriate, prior-year adjustments to balances between the Institute and ODA Headquarters after the year end.

(a) Accounting conventions

The accounts have been prepared under the historical cost convention modified to include the revaluation of tangible fixed assets using appropriate indices.

(b) Depreciation

Depreciation is provided for in respect of tangible fixed assets owned by the Institute at rates calculated to write off their revalued costs evenly over their expected lives. The asset lives generally adopted are shown below (different lives may be assigned to particular assets if appropriate):

| Land and buildings | 20 years |
|-----------------------|-----------|
| Scientific equipment | 5-10 year |
| Computers | 3-5 years |
| Office equipment | 5-7 years |
| Fixtures and fittings | 15 years |
| Vehicles | 5 years |

(c) Capital equipment for use on projects

The Institute purchases certain capital equipment on behalf of clients for use on projects commissioned by them. Clients retain an interest in this equipment and the right to give instructions as to its disposal when no longer required for the project. Such purchases are written off as an expense in the operating account in the year of purchase, a matching amount in respect of reimbursement by the client is included in turnover.

(d) Rented accommodation

The Institute occupies a property owned by the Urban Regeneration Agency (English Partnerships) and leased by the Secretary of State for the Environment. In line with the general treatment of interests in property, no capital value or depreciation cost for this lease is included in the accounts. Rental costs are dealt with on an accruals basis as an expense in the operating account. The cost to the Institute in 1995-96 was £4,252,000 (1994-95 £4,161,000) and in the month of April 1996 the sum of £352,000. During this period, the Institute also paid a rent to the Department of the Environment (Property Holdings) for a Crown freehold site which was vacated by the Institute in 1989-90 and was in the process of disposal. Rental costs are treated as a relocation expense. The Institute sub-let part of the Chatham site during the period and this income is shown in the Operating Account under other operating income on an accruals accounting basis.

(e) Stocks and work in progress

Stocks and work in progress are valued at the lower of cost and net realisable value. Stocks consist of chemicals, stationery and other consumable items. Work in progress cost consists of direct materials, salaries and attributable overheads.

(f) Long-term contracts

For contracts extending over more than one year, undertaken for ODA clients, turnover is recorded on the basis of work actually carried out and invoiced during the year, irrespective of the stage of completion; no work in progress is carried forward. Long-term contracts other than for ODA are stated at the value of work done less progress payments received on account. The net balances are shown as debtors (amounts recoverable on long-term contracts)

and creditors (advance payments on account of contracts). In accordance with SSAP 9, amounts recoverable on long-term contracts and payments in advance have been netted off.

(g) Research and development expenditure

Research and development work carried out under contract for clients as part of the Institute's programme of work is recorded as turnover or (in the case of non-ODA clients) as turnover or work in progress according to the stage of completion. No such work was carried out by the Institute on its own behalf.

(h) VAT

As an Agency, the Institute had the same VAT registration number as ODA Headquarters and no VAT was therefore charged on services to ODA. Output VAT was charged as appropriate on commercial services. VAT recovered was accounted for through ODA. Irrecoverable input VAT is included in expenditure as shown in the accounts.

(i) Foreign currencies

Transactions in foreign currencies are recorded at the rate ruling at the time of the transaction. Exchange rate gains or losses are reflected in the income and expenditure account.

(j) Notional costs

In accordance with Treasury guidance on fees and charges, expenditure includes the estimated cost of services provided to the Institute by ODA and by other Government Departments for which no cash payment is made. Allowance is also made for the notional cost of insurance.

(k) Interest on capital

A notional charge for interest on capital is calculated at a rate of 6 per cent on the average net worth throughout the year.

2. TURNOVER AND OTHER OPERATING INCOME

Turnover represents VAT-exclusive amounts invoiced to clients for the provision of research and development and consultancy services in the field of renewable natural resource development and exploitation. It includes reimbursement of the cost of materials and services bought in on behalf of clients and miscellaneous income, mainly from the sale of publications.

Other operating income includes rental income of £1,055,000 (1994-95 £911,000) and £64,000 for the month of April 1996. This was received in respect of sub-letting of the Chatham site.

Turnover by client for the year was as follows:

| | April 96 £'000 | 1995-96 | 1994-95 £'000 |
|----------------------------|-------------------|--|------------------|
| | | £000 | |
| | | | |
| Institute: | | | |
| Natural Resources Division | 429 | 15,508 | 19,805 |
| ODA Geographical Divisions | 537 | 10.22.4 | 9,316 |
| Non-ODA | 183 | 532 | 4,545 |
| Total Institute turnover | 1,149 | | 33,666 |
| | OYs | | OYs |
| Natural Resources Division | 4.11 | 127.56 | 175.24 |
| ODA Geographical Divisions | 5.72 | 82.18 | 88.31 |
| Non-ODA | 3.59 | 54.13 | 49.10 |
| Total Institute turnover | 13.42 | | 312.65 |
| | | 1 22 23 000 00 00 00 00 00 00 00 00 00 00 00 0 | |

3. EXPENDITURE

Operating account charges for cost of sales and for other expenditure (administrative, marketing and other indirect overheads) are analysed below. Cost of sales represents the costs of the Institute's operational divisions; administrative expenses are the costs of central services, after apportionment of overheads but not including any charging of central services to operational groups.

| | April 96 | 1995-96 | 1994-95 |
|-------------------------|-------------|--|---------|
| | £,000 | €000 | £'000 |
| Cost of Sales: | | | |
| Staff costs | 568 | 8.988 | 10,070 |
| Accommodation services | 208 | 3.286 | 3,347 |
| Other costs | 24 | 382 | 886 |
| Depreciation | 36 | | 531 |
| Direct project costs | 193 | 14.580 | 12,473 |
| • / | 1,029 | 27.809 | 27,307 |
| Notional costs | | | . — |
| | 1,029 | 27.809 | 27,307 |
| Administrative expenses | | | |
| Staff costs | 377 | 4.535 | 3,334 |
| Accommodation services | 147 | 2350 | 1,909 |
| Other costs | 198 | 1854 | 1,005 |
| Depreciation | 27 | 2/ | 291 |
| | 749 | 9013 in 10 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 6,539 |
| Notional costs: | | | |
| ODA HQ charges | 15 | 200 | 150 |
| Insurance | 3 | | 41 |
| Auditors remuneration | 7 | 80 | 30 |
| Internal audit charges | | 29 | 29 |
| | 774 | | 6,789 |
| Total expenditure: | | | |
| Staff costs | 945 | 1352 | 13,404 |
| Accommodation services | 355 | 5,636 | 5,256 |
| Other costs | 222 | 226 | 1,891 |
| Depreciation | 63 | | 822 |
| Direct project costs | 193 | 14,580 | 12,473 |
| Notional costs | 25 | | 250 |
| | 1,803 | | 34,096 |
| | | | |

4. RESTRUCTURING AND RELOCATION COSTS

| | April 96 | 1995-96 | 1994-95 |
|---------------------|-------------|--|-------------|
| | £'000 | ************* | £'000 |
| Restructuring costs | 25 | ************************************** | 2,817 |
| Relocation costs | 14 | 364 | 543 |
| | 39 | | 3,360 |
| | | | |

Restructuring costs consist of redundancy pay, salary in lieu of notice and outplacement costs for staff made redundant, together with the costs of internal relocation associated with subletting of part of the Chatham site.

Relocation costs include rent of a site at Culham pending disposal and the residual cost of allowances relating to the Institute's relocation to Chatham.

5. DEFICIT

(a) In 1995-96 the deficit on ordinary activities for the year was £7,386,000 (1994-95 £3,265,000). The deficit for the month of April 1996 was £652,000.

The deficit is stated after charging the following:

| | April 96 | 1995-96 | 1994-95 |
|--------------------------|----------|--|---------|
| | £'000 | 1 | £'000 |
| Depreciation | 63 | The second secon | 822 |
| Auditors remuneration | 7 | | 30 |
| Staff costs (see note 6) | 945 | 13,522 | 13,404 |

(b) During the year, and in the month of April 1996, the Institute wrote off to other costs the sum of £NIL owing from clients, such sums now being deemed to be irrecoverable. In 1994-95 a sum of £133,000 owed by a procurement agent was written off.

6. STAFF COSTS

| 6. STAFF COSTS | April 96 £'000 | 1995-96 | 1994-95 | |
|--|-------------------|---------|---------|--|
| | | €'000 | £'000 | |
| (a) Staff costs during the year amounted to: | | | | |
| Salaries | 792 | | 11,089 | |
| Social Security costs | 49 | | 755 | |
| Pension costs | 110 | 1,554 | 1,421 | |
| Other employment costs* | (6) | 107 | 139 | |
| | 945 | 13,522 | 13,404 | |

^{*} Other employment costs include overseas allowances, honoraria, transfer grants etc.

(b) The average number of staff employed by the Institute during the month/year was:

| Professional and Technical | 301 | | 371 |
|----------------------------|-----|--|-----|
| Administrative | 66 | | 120 |
| | 367 | ************************************** | 491 |
| | | F | |

- (c) The total remuneration of the Chief Executive during the year was £65,315 (1994-95 £62,215) and for the month of April 1996 was £61,265 pro rata. The Chief Executive was an ordinary member of the Principal Civil Service Superannuation Scheme.
- (d) The following number of senior employees received remuneration in the ranges as follows, April 1996 being shown pro rata:

| | April 96 | 1995-96 32 | 1994-95 |
|------------------|----------|---------------|---------|
| £40,000 - 49,999 | 20 | | 24 |
| £50,000 - 59,999 | 1 | | 1 |
| £60,000 - 69,999 | 1 | | 1 |

(e) Pensions:

Prior to privatisation, NRI employees were for the most part Civil Servants to whom the conditions of the Superannuation Acts 1965 and 1972 and subsequent amendments apply. For 1995-96, contributions of £1,559,845 were paid to the Paymaster General at rates determined from time to time by the Government Actuary and advised by H M Treasury (1994-95 £1,404,013), April 1996 being £110,673. For 1995-96, and April 1996, the rate varied from 11% to 19.5% according to grade. For 1994-95 the rate was 13% for all staff.

One member of staff was a member of another pension scheme. Total contributions in respect of such staff in 1995-96 were £9,390 (1994-95 - 2 staff totalling £17,368) and in April 1996 £748 in respect of one member of staff.

The total pensions liability up to normal retirement age in respect of an employee taking early retirement or early severance is charged to the operating account in the year in which the employee leaves and a provision for future pension payments is created. Pension and related benefit payments to the former employee until normal retirement age are then charged annually against the provision.

In 1995-96 £NIL, April 1996 £NIL (1994-95 £2,050,000) was charged to the operating account and credited to the severance costs provision. A sum of £1,000,000 was paid in respect of prepayment of early retirement costs and charged to the operating account under restructuring and relocation costs. At 31 March 1996 the provision stood at £826,000 (1994-95 £826,000).

7. FIXED ASSETS

| £'000 | Land & Buildings | IT Equipment | Science Equipment | Fixtures & Fittings | Others | Total |
|---------------------------------|---------------------|-----------------|---|------------------------|--------|---------|
| Historic Cost | | | | | | |
| As at 1/4/95 | 800 | 2,801 | 3,146 | 735 | 839 | 8,321 |
| Additions | _ | 240 | 267 | 4 | 211 | 722 |
| Disposals | _ | (1,490) | (275) | _ | (88) | (1,853) |
| As at 31/3/96 and at 30/4/96 | 800 | 1,551 | 3,138 | 739 | 962 | 7,190 |
| Revaluation | | | | | | |
| As at 1/4/95 | 14 | 35 | 1,216 | 152 | 382 | 1,799 |
| Revaluation | _ | (96) | 43 | (1) | (3) | (57) |
| Disposals | _ | (1) | _ | - | (1) | (2) |
| As at 31/3/96 | 14 | (62) | 1,259 | 151 | 378 | 1,740 |
| April movements | (7) | 2 | (1) | (1) | _ | (7) |
| As at 30/4/96 | 7 | (60) | 1,258 | 150 | 378 | 1,733 |
| Current cost | | | ··· — · · · · · · · · · · · · · · · · · | | | |
| As at 1/4/95 | 814 | 2,836 | 4,362 | 887 | 1,221 | 10,120 |
| Additions | | 144 | 310 | 3 | 208 | 665 |
| Disposals | _ | (1,491) | (275) | _ | (89) | (1,855) |
| As at 31/3/96 | 814 | 1,489 | 4,397 | 890 | 1,340 | 8,930 |
| April movements | (7) | 2 | (1) | (1) | — | (7) |
| As at 30/4/96 | 807 | 1,491 | 4,396 | 889 | 1,340 | 8,923 |
| Depreciation | | | | | | |
| As at 1/4/95 | 26 | 1,859 | 3,057 | 342 | 791 | 6,075 |
| Charge for year | 41 | (755) | 518 | 75 | 291 | 170 |
| Disposals | _ | (100) | (232) | - | (41) | (373) |
| As at 31/3/96 | 67 | 1,004 | 3,343 | 417 | 1,041 | 5,872 |
| April movements | 3 | 24 | 22 | 6 | 8 | 63 |
| As at 30/4/96 | 70 | 1,028 | 3,365 | 423 | 1,049 | 5,935 |
| Net book value | | | | | | |
| As at 1/4/95 | 788 | 977 | 1,305 | 545 | 430 | 4,045 |
| Additions | (41) | 899 | (208) | (72) | (83) | 495 |
| Disposals | _ | (1,391) | (43) | | (48) | (1,482) |
| As at 31/3/96 | 747 | 485 | 1,054 | 473 | 299 | 3,058 |
| April movements | (10) | (22) | (23) | (7) | (8) | (70) |
| As at 30/4/96 | 737 | 463 | 1,031 | 466 | 291 | 2,988 |

During 1995-96, in preparation for privatisation, a physical inventory of fixed assets was undertaken with a view to identifying discrepancies between assets counted and assets recorded in the fixed assets register. As a result of the exercise, various adjustments were made, assets re-categorised and a net sum of £325,000 written off to other costs in the operating account.

At historic costs the net book value of assets as at 31/3/96 was £2,886,000 (1994-95 £3,801,000) and for April 1996 £2,821,000. The historic cost depreciation charge for the year would have been £1,190,000 (1994-95 £740,000) and April 1996 £65,000.

The net depreciation charge of £170,000 for 1995-96 is charged as £847,000 to the operating account for the year's depreciation charge, with £32,000 credited to the revaluation reserve and £645,000 accumulated depreciation written back to other costs in the operating account in line with the adjustments noted above. In 1994-95 £865,000 was charged as £822,000 to the operating account and £43,000 to the revaluation reserve. The April 1996 depreciation charge of £70,000 was charged as £63,000 to the operating account and £7,000 debited to the revaluation reserve.

8. STOCKS AND WORK IN PROGRESS

| | April 96 £'000 | 1995-96 = = = = = = = = = = = = = = = = = = = | 1994-95 £'000 |
|--------------------------------------|-------------------|--|------------------|
| Stocks: Chemicals | 14 | | 14 |
| Other laboratory equipment | 47 | | 49 |
| Stationery | 33 | | 34 |
| | 94 | | 97 |
| Work in Progress: Salaries | 18 | | 44 |
| Materials | 56 | 59 | 24 |
| Overheads | 10 | | 19 |
| | 84 | A 11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 87 |
| | 178 | The state of the s | 184 |
| | | | |
| 9. DEBTORS | | | |
| | April 96 | 1995-96 | 1994-95 |
| | £'000 | £000 | £'000 |
| Debtors for external contracts | 1,628 | | 1,731 |
| Amounts recoverable in respect | 1.077 | | 711 |
| of long-term contracts | 1,077 | | 711 |
| Prepayments | 2,390 | | 2,568 |
| | 5,095 | | 5,010 |
| | | | |
| 10. CREDITORS | | | |
| | 4 | | 100 / 05 |
| | April 96 £'000 | ************************************** | 1994-95 £'000 |
| Amounts falling due within one year: | 2.000 | | £ 000 |
| Trade creditors | 874 | 1 | 2,474 |
| Accruals | 503 | | 79 |
| Provision for severance costs | 359 | | 221 |
| Prepaid contract income | 291 | | 292 |
| | 2,027 | | 3,066 |
| Amounts falling due after one year: | | | |
| Provision for severance costs | 467 | | 605 |
| | | | |

The amount payable after five years is £104,000 (1994-95 £158,000) and April 1996 £104,000.

11. RESERVES

| II. RESERVES | £'000 |
|--------------------------------------|----------|
| General reserve 1 | |
| Balance as at 1/4/95 | 616 |
| Movement in year to March 1996 | _ |
| Balance as at 31/3/96 | 616 |
| Movement in month of April 1996 | |
| Balance at 30/4/96 | 616 |
| Profit and loss reserve ² | |
| Balance as at 1/4/95 | (3,399) |
| Movement in year to March 1996 | (7,386) |
| Balance as at 31/3/96 | (10,785) |
| Movement in month of April 1996 | (652) |
| Balance at 30/4/96 | (11,437) |
| Notional Costs reserve ³ | |
| Balance as at 1/4/95 | 2,371 |
| Movement in year to March 1996 | 746 |
| Balance as at 31/3/96 | 3,117 |
| Movement in month of April 1996 | 62 |
| Balance at 30/4/96 | 3,179 |
| Revaluation reserve ⁴ | ·- ·- · |
| Balance as at 1/4/95 | 1,706 |
| Movement in year to March 1996 | (25) |
| Balance as at 31/3/96 | 1,681 |
| Movement in month of April 1996 | (7) |
| Balance at 30/4/96 | 1,674 |
| ODA Balances 5 | |
| Balance as at 1/4/95 | 5,907 |
| Movement in year to March 1996 | 7,207 |
| Balance as at 31/3/96 | 13,114 |
| Movement in month of April 1996 | (225) |
| Balance at 30/4/96 | 12,889 |
| Total reserves | |
| Balance as at 1/4/95 | 7,201 |
| Movement in year to March 1996 | 542 |
| Balance as at 31/3/96 | 7,743 |
| Movement in month of April 1996 | (822) |
| Balance at 30/4/96 | 6,921 |
| | |

- The cumulative total of miscellaneous balance sheet adjustments in earlier years.

 The cumulative total of NRI's
- operating surpluses and deficits.
- 3. The cumulative total of notional costs incurred since inception.
- 4. The cumulative total of annual revaluations of fixed assets in line with current cost accounting conventions.
- 5. This is the cumulative total of advances of running cost expenditure and funding of NRI's activities since its inception as an agency.

12. POST BALANCE SHEET EVENT

Following the Government's decision to seek expressions of interest in the future ownership of NRI and a subsequent competitive tendering process, a bid was accepted from a consortium comprising the Universities of Edinburgh and Greenwich and Imperial and Wye Colleges of the University of London. Under the terms of the bid, ownership of the Institute was transferred to the University of Greenwich with effect from 1 May 1996.

STATEMENT OF AGENCY'S AND ACCOUNTING OFFICER'S RESPONSIBILITIES

Under section 5 of the Exchequer and Audit Departments Act 1921, H M Treasury has directed the Natural Resources Institute to prepare a statement of accounts for each financial year in the form and on the basis set out in the Accounts Direction appended to these financial statements. The accounts are prepared on an accruals basis and must give a true and fair view of the Agency's state of affairs at the year end and of its income and expenditure and cash flows for the financial year.

In preparing the accounts the Agency is required to:

- observe the accounts direction issued by the Treasury, including the relevant accounting and disclosure requirements, and apply suitable accounting policies on a consistent basis;
- make judgements and estimates on a reasonable basis;
- state whether applicable accounting standards have been followed, and disclose and explain any material departures in the financial statements;
- prepare the financial statements on the going concern basis, unless it is inappropriate to presume that the Agency will continue in operation.

The Accounting Officer for the Overseas Development Administration has appointed the Director of the Natural Resources Institute as Accounting Officer for the Agency. His relevant responsibilities as Accounting Officer, including his responsibility for the propriety and regularity of the public finances for which he is answerable and for the keeping of proper records, are set out in the Accounting Officers' Memorandum, issued by H M Treasury and published in *Government Accounting* (HMSO).

THE CERTIFICATE OF THE COMPTROLLER AND AUDITOR GENERAL TO THE HOUSE OF COMMONS

I certify that I have audited the financial statements on pages 94 to 105 under the Exchequer and Audit Departments Act 1921. These financial statements have been prepared under the historical cost convention as modified by the revaluation of certain fixed assets and the accounting policies set out on pages 98 to 99.

RESPECTIVE RESPONSIBILITIES OF THE AGENCY, THE DIRECTOR AND AUDITOR

As described on page 106, the Agency and the Director are responsible for the preparation of financial statements and for ensuring the regularity of financial transactions. It is my responsibility to form an independent opinion, based on my audit, on those statements and on the regularity of the financial transactions included in them, and to report my opinion to you.

BASIS OF OPINION

I conducted my audit in accordance with Auditing Standards issued by the Auditing Practices Board. An audit includes examination, on a test basis, of evidence relevant to the amounts, disclosures and regularity of financial transactions included in the financial statements. It also includes an assessment of the significant estimates and judgements made by the Agency and the Director in the preparation of the financial statements, and of whether the accounting policies are appropriate to the Agency's circumstances, consistently applied and adequately disclosed.

I planned and performed my audit so as to obtain all the information and explanations which I considered necessary in order to provide me with sufficient evidence to give reasonable assurance that the financial statements are free from material misstatement, whether caused by error, or by fraud or other irregularity and that, in all material respects, the expenditure and receipts have been applied to the purposes intended by Parliament and the financial transactions conform to the authorities which govern them. In forming my opinion I also evaluated the overall adequacy of the presentation of information in the financial statements.

OPINION

In my opinion:

- the financial statements give a true and fair view of the state of affairs of the Natural Resources Institute at 31 March 1996 and at 30 April 1996, and of its deficit, total recognised gains and losses and cash flows for the year ended 31 March 1996 and the month ended 30 April 1996 and have been properly prepared in accordance with the Exchequer and Audit Departments Act 1921 and directions made thereunder by the Treasury; and
- in all material respects the expenditure and receipts have been applied to the purposes intended by Parliament and the financial transactions conform to the authorities which govern them.

I have no observations to make on these financial statements.

John Bourn

Comptroller and Auditor General

National Audit Office 157-197 Buckingham Palace Road Victoria London SWlW 9SP

10 February 1997

Appendix

NATURAL RESOURCES INSTITUTE

ACCOUNTS DIRECTION GIVEN BY H M TREASURY

H M Treasury, in pursuance of section 5 of the Exchequer and Audit Departments Act 1921, hereby gives the following Direction:

- 1. The statement of accounts which it is the duty of the Natural Resources Institute (NRI) to prepare in respect of the financial year ended 31 March 1995 and in respect of any subsequent financial year shall comprise:
 - (a) a foreword;
 - (b) an income and expenditure account;
 - (c) a balance sheet;
 - (d) a cash flow statement; and
 - (e) a statement of total recognised gains and losses

including in each case such notes as may be necessary for the purposes referred to in the following paragraphs.

- 2. NRI shall observe all relevant accounting and disclosure requirements given in *Government Accounting* and in the H M Treasury booklet *Trading Accounts: A Guide for Government Departments and Non-Departmental Public Bodies* (the "Trading Accounts booklet") as amended or augmented from time to time.
- 3. The statement of accounts referred to above shall give a true and fair view of the state of affairs of NRI at the end of the financial year and of its income and expenditure and cash flow for the year. Subject to the foregoing requirement, the statement of accounts shall also, without limiting the information given and as described in Schedule 1 of this Direction, meet:
 - (a) the accounting and disclosure requirements of the Companies Act;
 - (b) best commercial accounting practices including accounting standards issued or adopted by the Accounting Standards Board with the exception of the requirement contained in FRS 3 for the inclusion of a note showing historical cost profits and losses;
 - (c) any disclosure and accounting requirements which H M Treasury may issue from time to time in respect of accounts which are required to give a true and fair view; and
 - (d) any additional disclosure requirements contained in *The Fees and Charges Guide*, in particular those relating to the need for appropriate segmental information for services or forms of services provided,

insofar as these are appropriate to NRI and are in force for the financial period for which the statement of accounts is to be prepared.

- 4. Additional disclosure requirements are set out in Schedule 2 of this Direction.
- 5. The operating account and balance sheet shall be prepared under the historic cost convention modified by the inclusion of:
 - (a) fixed assets at their value to the business by reference to current costs;
 - (b) stocks at the lower of cost, or net current replacement cost if materially different, and net realisable value.

Signed: T J Burr

Treasury Officer of Accounts

Dated:

12 March 1994

SCHEDULE 1

APPLICATION OF COMPANIES ACT REQUIREMENTS

- 1. The disclosure exemptions permitted by the Companies Act shall not apply to NRI unless specifically approved by H M Treasury.
- 2. The Foreword shall contain the information required by the Companies Act to be disclosed in the Directors' Report, to the extent that such requirements are appropriate to NRI.
- 3. In preparing its operating account and balance sheet, NRI shall adopt respectively the profit and loss account format 1 and the balance sheet format 1 prescribed in Schedule 4 to the Companies Act 1985 to the extent that such requirements are appropriate to NRI. Regard should be had to the examples in Annex C of the Trading Accounts booklet, in particular the need to strike the balance sheet totals at 'Total Assets less Current Liabilities'.
- 4. The Foreword and Balance Sheet shall be signed and dated.

SCHEDULE 2

ADDITIONAL DISCLOSURE REQUIREMENTS

- 1. The Foreword shall, inter alia:
 - (a) state that the accounts have been prepared in accordance with a direction given by H M Treasury in pursuance of section 5 of the Exchequer and Audit Departments Act 1921; and
 - (b) include a brief history of NRI and its statutory background. Regard should be had to Annexes B and C of the Trading Accounts booklet.
- 2. The notes to the accounts shall include a statement of the performance against the key corporate financial target(s).
- 3. This Accounts Direction shall be reproduced as an appendix to the accounts.

KEY CONTACTS at 31.12.96

| Director | David Wills | 01634 883270 | | |
|-----------------------------|----------------------|--------------|--|--|
| Deputy Director | John Perfect | 01634 883393 | | |
| Heads of Department | | | | |
| Environmental Sciences | Ian Grant | 01634 883204 | | |
| Food Security | Chris Haines | 01634 883795 | | |
| Natural Resource Management | Barry Blake | 01634 883550 | | |
| Pest Management | Dick Cooter | 01634 883311 | | |
| Social Sciences | Martin Hebblethwaite | 01634 883047 | | |
| | | | | |

| Chief Executive | Maggie Gill | 01634 883939 |
|--|--------------------|--------------|
| Research Programme Managers | | |
| Crop Post-harvest | Nigel Poulter | 01634 883572 |
| Crop Protection | Simon Eden-Green | 01634 883630 |
| Livestock | Richard Matthewman | 01634 883962 |
| Post-harvest Fisheries | John Ryder | 01634 883611 |
| Regional Directors | | |
| Africa & Eastern Europe | John Disney | 01634 883026 |
| Asia, Latin America, Caribbean & Pacific | Geoff Norman | 01634 883543 |



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