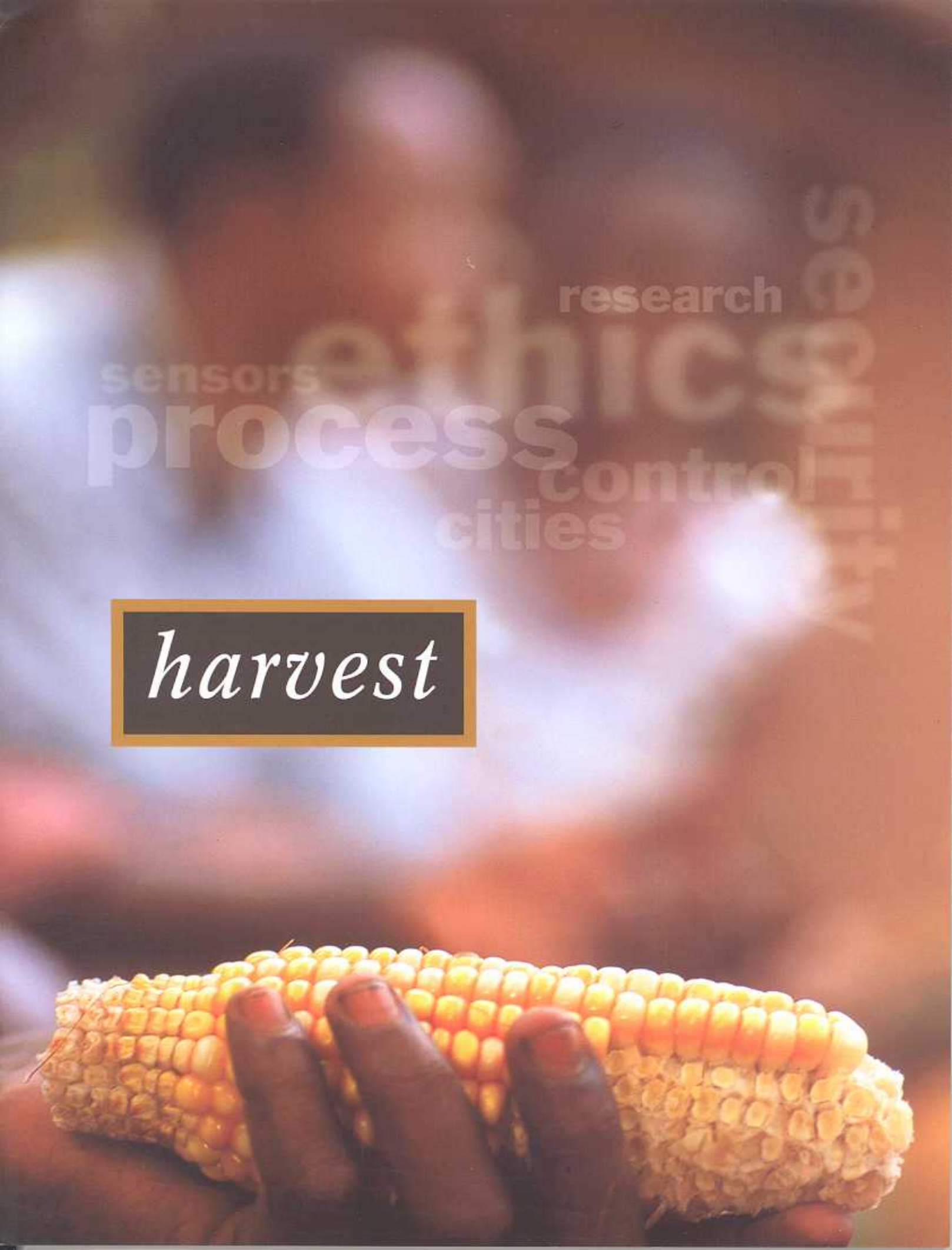
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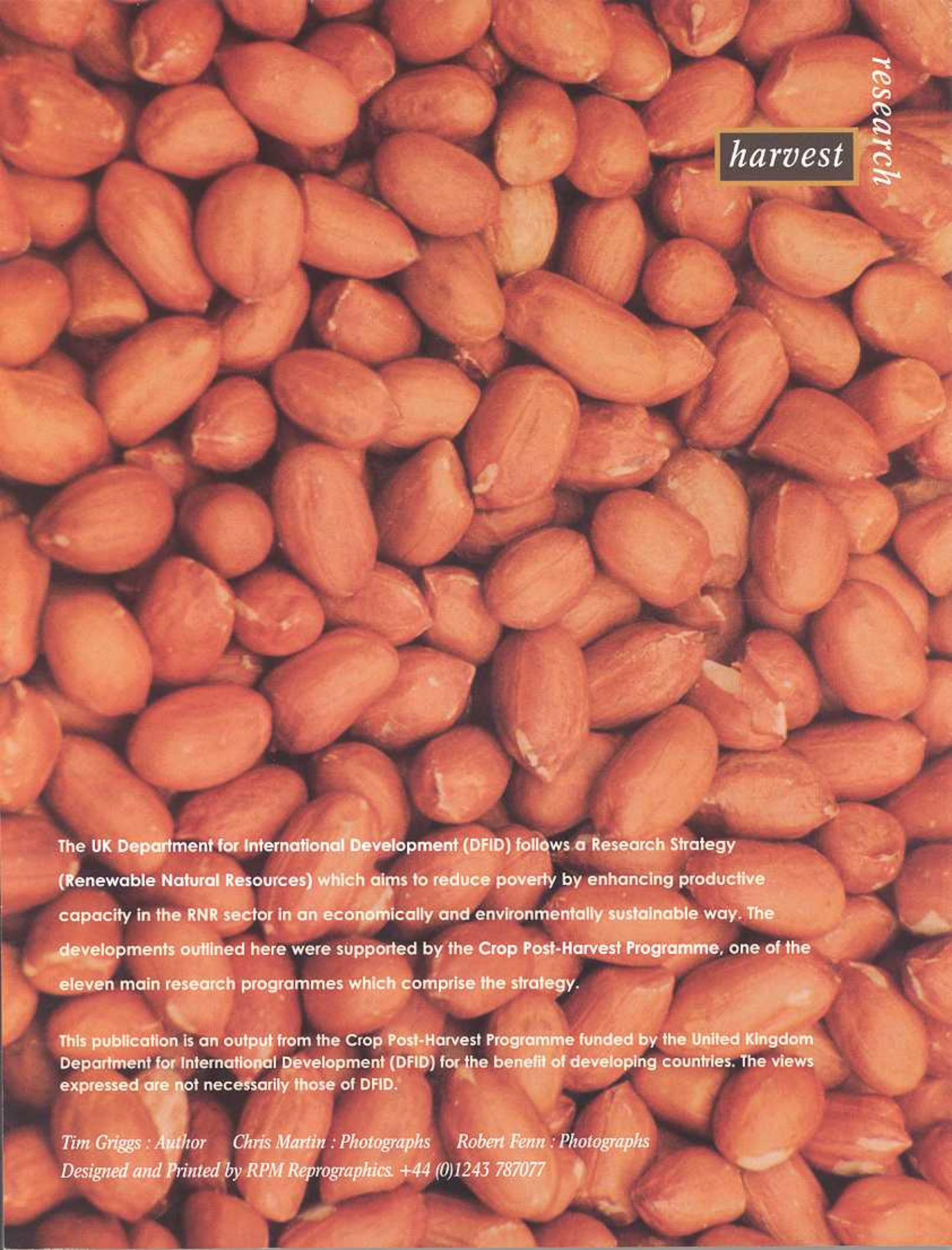

The UK Department for International Development (DFID) follows a Research Strategy (Renewable Natural Resources) which aims to reduce poverty by enhancing productive capacity in the RNR sector in an economically and environmentally sustainable way. The developments outlined here were supported by the Crop Post-Harvest Programme, one of the eleven main research programmes which comprise the strategy.

This publication is an output from the Crop Post-Harvest Programme funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID.

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Most people are familiar with the international development targets set by world leaders under the auspices of the United Nations. The most important of these targets is to halve the proportion of people living in extreme poverty by 2015. The UK Government's White Paper on International Development, published in November 1997, recognises that scientific research has an important role to play in achieving this target, combined with the need to improve access to new knowledge and technologies. Indeed the White Paper stresses the need for continued investment in research to meet this demand.

The Department for International Development (DFID) invests in a wide range of research activities to improve the livelihoods of poor people, by providing them with better opportunities and by protecting and managing the natural environment. People who are able to resist threats to their productive capacity are more likely to have livelihoods which are sustainable. The focus must be on research which is geared to the needs of the many poor people who live in developing countries and whose livelihoods depend on natural resources.

DFID's strategy for research (renewable natural resources) is based on three important principles.

The work must be relevant: It must tackle the clearly defined problems of specific groups of poor people and there must be a clear demand for the work;

People must have access to the results and be able to take up and use knowledge and technologies so that there is an impact on poverty;

Research must be of high quality and it must be cost effective.

These principles require close collaboration between researchers and the intended beneficiaries, often working with or through internal or international organisations. Participation and partnerships are promoted strongly throughout DFID's research strategy.

harvest

contents

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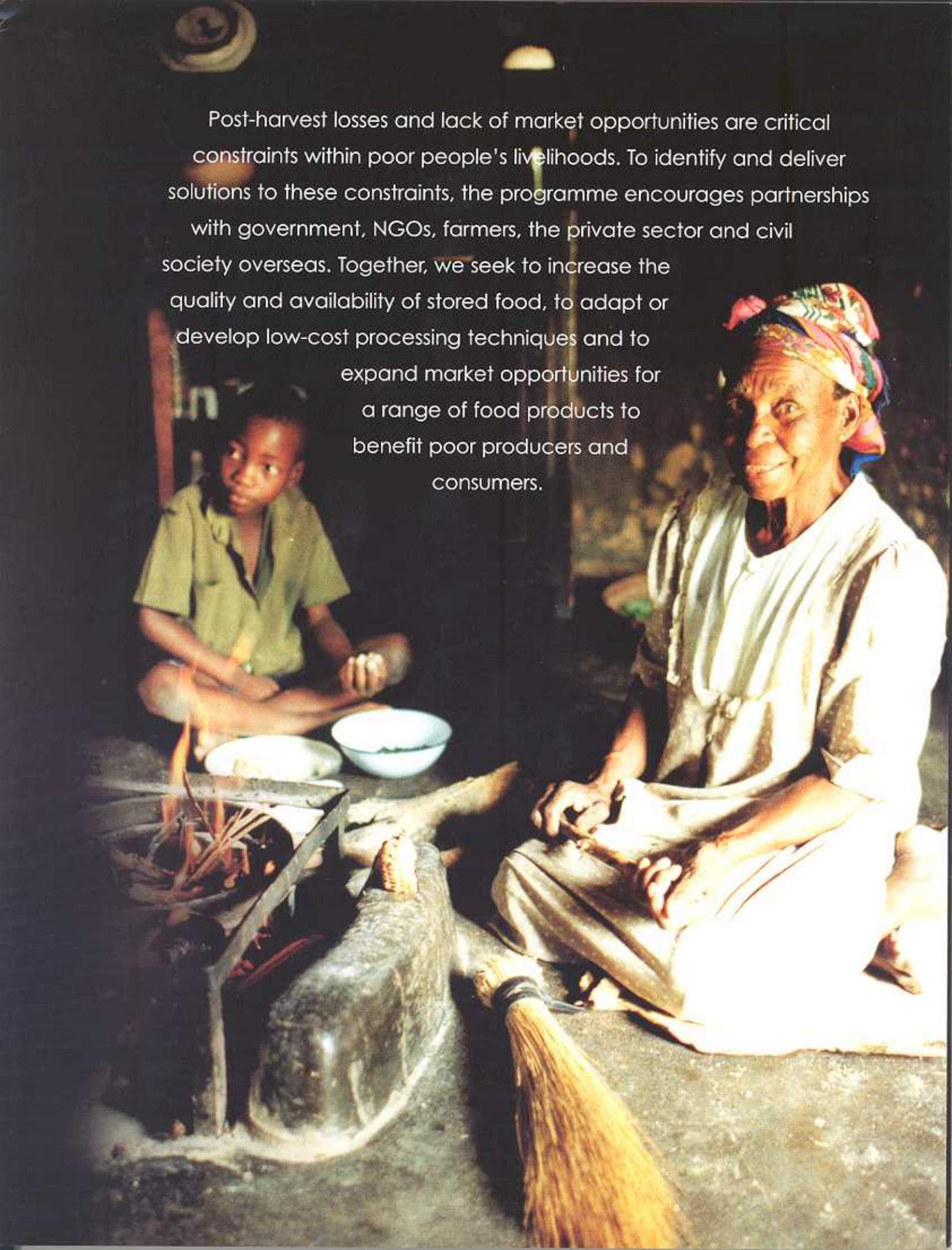
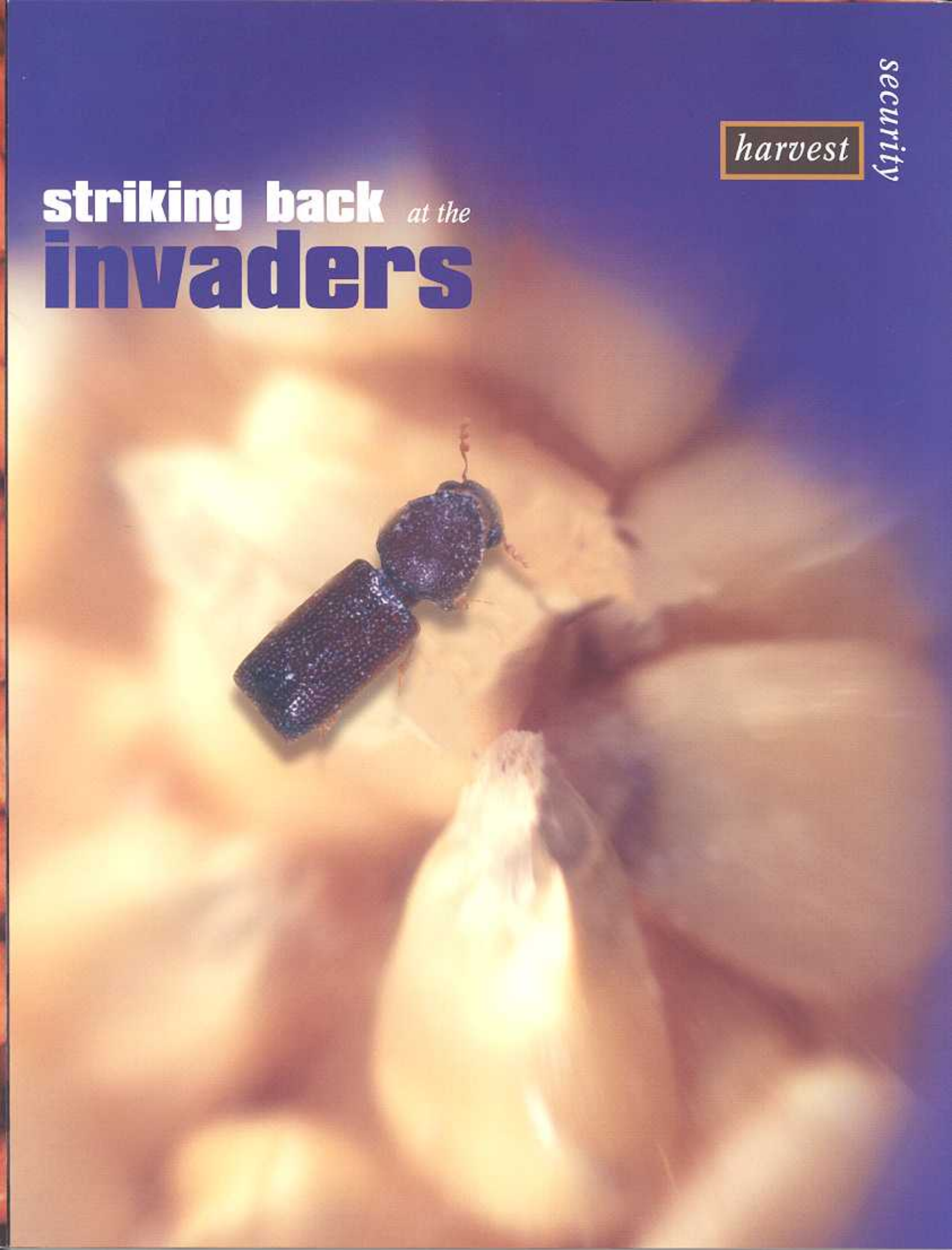


Post-harvest losses and lack of market opportunities are critical constraints within poor people's livelihoods. To identify and deliver solutions to these constraints, the programme encourages partnerships with government, NGOs, farmers, the private sector and civil society overseas. Together, we seek to increase the quality and availability of stored food, to adapt or develop low-cost processing techniques and to expand market opportunities for a range of food products to benefit poor producers and consumers.

harvest security

striking back *at the* invaders



It doesn't look like much of a problem: an insignificant little beetle just 3 mm long.

But when the larger grain borer (LGB) was accidentally introduced into Tanzania from Central America twenty years ago it was a very unwelcome guest indeed.

By 1981, it was infesting grain and cassava stores in 100 out of 120 villages surveyed in western Tanzania, often reducing the stored crop to dust. The situation became so desperate that farmers marched to the capital Dar es Salaam to plead for Government help.

Since then LGB has chewed its way through countless tonnes of stored cassava and maize - devouring or spoiling food which resource-poor African farmers can ill afford to lose. LGB has spread all over West Africa, and is now moving rapidly south. It was reported in South Africa for the first time in 1999.

Today LGB is a hard fact of life in Africa, and its relentless advance cannot now be halted. But for nearly 20 years DFID and its local and international partners have been demonstrating that it is possible to fight back against the pest, slowing its advance and controlling it when it does appear. The weapons are painstaking research, clever science, and appropriate tactics on the ground. Teams of researchers identified the most effective kind of grain store to deter the beetle. A public awareness campaign across several African countries warned farmers of the pest and advised them what to do about it. And a natural predator of LGB was introduced into Africa from Mexico.

One of the problems with fighting LGB is its unpredictability. For reasons no-one quite understands, the population fluctuates wildly from one year to the next. It's very expensive for farmers to provide consistently high levels of protection every year. But if they are caught unprotected in a bad year, losses may be devastating. If farmers knew in advance which years were likely to be bad ones, then they could concentrate their efforts much more effectively.

A DFID-funded project has made this a real possibility. A program of carefully targeted trapping, using inexpensive pheromone traps, can give warnings to farmers of impending LGB attack. The same is now working on the causes of population fluctuation, which may be linked to climate. More information on this could lead to even more accurate intelligence on LGB's activities, and to an even better early warning system.

DFID and its partners have also looked at the impact of biological control. A beetle called *Teretrius nigrescens* (Tn for short) hunts down LGB and kills it. It made good sense to introduce Tn into Africa to keep down the pest's numbers, and in 1994 this was done with apparent success. Tn settled in well, has proved to be self-sustaining, and does indeed attack LGB and nothing else. Early surveys were encouraging.

But could this lead to complacency? The research team suspected that Tn was not quite as effective as everyone hoped, and further studies tend to back up this concern. A particular problem is that insecticide used in grain stores kills the predator just as effectively as the pest.

The answer may be to adopt a pesticide strategy which gives the Tn predator its best chance. Fortunately, this seems a practical possibility.

The DFID research team made a significant breakthrough when they discovered that LGB tends to launch its initial attack on stored grain from the bottom of the grain store up. They reasoned that farmers ought to get good protection against LGB by applying pesticide only in the base layers of the store. The advantages are obvious: the farmer needs to buy less pesticide, and, because most of the crop in store does not need to be treated at all, health and environmental risks are reduced. Meanwhile throughout most of the grain store the predator Tn will survive to hunt down any LGB which escape.

Early results show the technique works extremely well, even when pesticide use is cut by up to 80%. Now efforts are under way to bring together this exciting result with the work on LGB early warning techniques and with a proper understanding of Tn's role as a predator. That promises to give rise to the first integrated pest management strategy against LGB which is truly effective at farm level.

The war against LGB is not cheap. In Tanzania and Ghana over £15 million has been spent on research to date by a wide range of local and international funding organisations, DFID and its partners among them. But that work has saved stored crops worth an estimated £25.2 million over the same period in those two countries. The savings are greater still when the figures from other LGB-affected African countries are taken into account. These benefits in harvest value lead directly to better nutrition and health in the rural communities concerned. They even lead to better education, since families with higher incomes can afford to pay school fees.

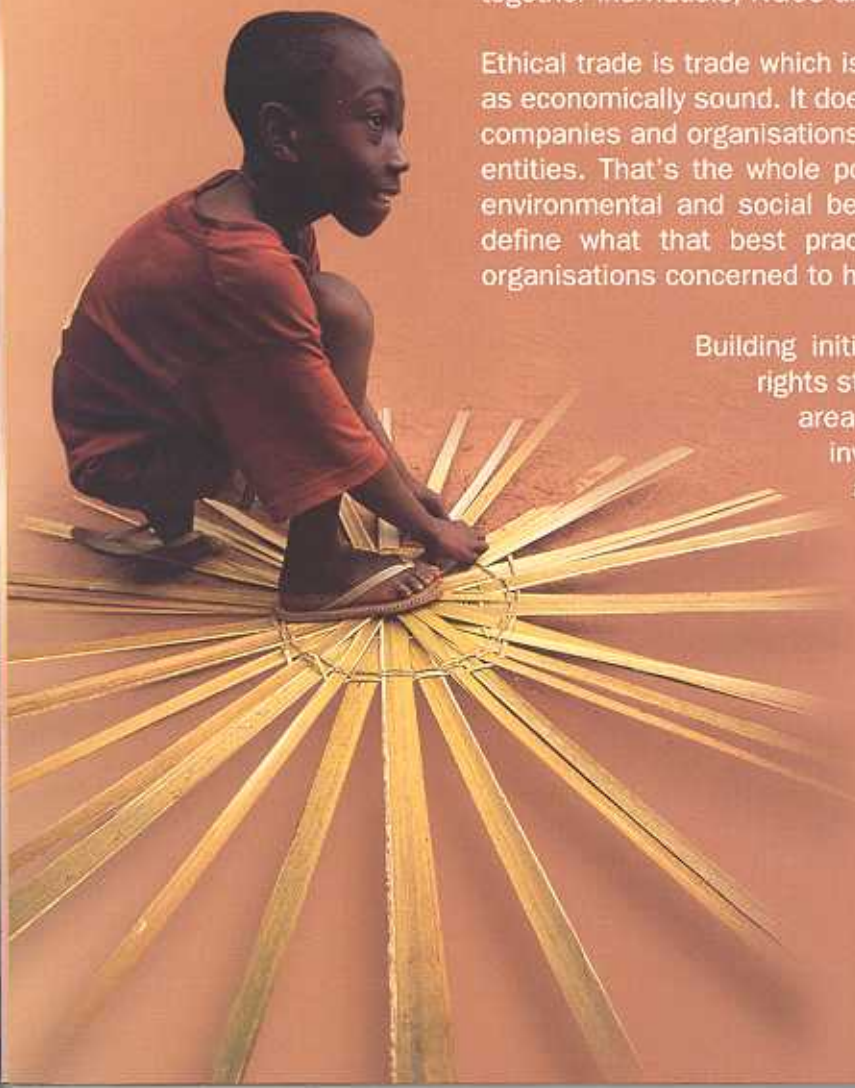
ethical business *is* good business

In international development, few concepts polarise views more sharply than that of 'ethical trade'.

Many people - perhaps most - imagine that ethical trade involves bending the rules of economics in some way in order to satisfy philanthropic goals. Unsurprisingly there is a sharp philosophical divide between supporters and opponents.

That's unhelpful. The truth is that very few people understand what ethical trading really means. This confusion leads to unrealistic optimism on the one hand and baseless concerns on the other.

DFID supports work which aims to clear up this confusion and to define the ethical trade concept clearly. Where ethical trade can be shown to be viable, DFID and its partners support it with monitoring and training, and help to bring together individuals, NGOs and companies which can make it work.



Ethical trade is trade which is socially and environmentally responsible as well as economically sound. It doesn't necessarily imply corporate philanthropy. The companies and organisations involved aren't charities: they are normal trading entities. That's the whole point. However, they do need to be committed to environmental and social best practice. Part of the DFID team's work is to define what that best practice is, and then to consult closely with the organisations concerned to help them incorporate it into their core operations.

Building initially on various international labour and human rights standards, the work of DFID and its partners in this area now goes much further. In particular, they seek to involve local growers in consultation much more actively than before, to challenge and test Western assumptions about what constitutes a benefit to the developing world.

Most of this work currently applies to the export of fresh agricultural products from Africa to the UK. Ghana and Zimbabwe, for instance, both export large quantities of fresh fruit and vegetables to Britain. In both of these cases the ethical business initiative has helped bring together consultative groups of NGOs, growers' organisations, civil societies such as church groups, various promotional bodies, exporters and major UK retailers who import the products.

Business in general is supportive. All major British retailers are involved in ethical trading consultation. Some companies, partly as a result of the DFID-funded work, are learning for the first time how great an impact their practices can have on the ground, even when they thought they had no development function at all.

The result is an understanding that, for any product, responsibility for ethical standards spreads right along the value chain and no longer stops at the interaction between buyer and seller.

In some cases the effect may be direct and obvious. Poor handling of airfreighted produce, for example, leads to big losses which push up costs and increase the financial pressure on farmers. Airlines had not thought of themselves as playing a development role before, but they are now joining in consultations about ethical trading. In other cases the process is more subtle. Consumers in Britain demand that their fruit and vegetables are unblemished, though this has nothing to do with quality or taste. The effect of this purely cosmetic consideration is to force resource-poor farmers to use more chemical pesticides, which are expensive and pose risks to health and to the environment. If British consumers were aware of the human cost of their cosmetically perfect fruit and vegetables, would they moderate their demands?

There is nothing unbusinesslike about these considerations. Experience shows that while the great mass of consumers may be unaware of any ethical dimension to their supermarket shopping, protests from quite small groups of concerned people attract a great deal of attention and may quickly affect buying patterns, employee morale and even share prices. Building up an awareness strategy for all stakeholders in the process is a key part of the DFID-supported work. This is one reason why the team has been instrumental in setting up a virtual information network on ethical trade. The initiative involves church groups, charities, NGOs, British Government agencies and major UK wholesalers and retailers.

Ethical trade alone is not an answer to sustainability.

There are plenty of problems with it, and still a good deal of confusion about its goals and its impact. But key interest groups - consumers and investors in particular - are beginning to see that there is no inevitable clash between good business on the one hand and social and environmental responsibility on the other. Quite the reverse. As a result there is a growing realisation that, at least in some circumstances, ethical trade can play an important role in building sustainable rural livelihoods.

CONTROLLING PESTS WITHOUT CHEMICALS

Chemical pesticides work - but they cannot be the only answer.

In many developing countries the right pesticides just aren't available. Where they are, resource poor farmers cannot afford them. And by definition pesticides are toxic: misuse can lead to health risks and environmental problems.

Yet pests cause devastating damage to stored crops, and pose serious health risks of their own.

In parts of Mozambique, for example, between 50 and 100 rats live in the roof of an average thatched village hut. They come down at night to feed on the grain which farmers store in their homes.

Rats bite people. They spread diseases which kill humans - most notoriously bubonic plague, but also a wide variety of viruses and parasites. One hundred rats produce about a million droppings and one hundred litres of urine every year. Most of this falls from the rats' nests in the thatch onto the family which sleeps in the same hut.

While they're about it, a hundred rats will eat about 200 kilograms of stored grain every year. That's an astonishing loss for a resource poor family to bear. In Zambezia Province in Mozambique DFID and its local and overseas partners are studying ways of reducing rat numbers without using pesticides.They are testing a cheap and simple new trap which is much more effective than the home-made types used

by most Mozambique farmers. Now, DFID-funded researchers are able to advise farmers on how many traps to set for best results, and how often to set them. They have also identified simple measures which farmers can take to help deter rats - clearing vegetation from around the huts, for example, or renewing the thatch more regularly. Where resources allow it may be an option to replace thatch with tin or other material which gives less shelter for rats.

First results suggest that the work will significantly cut grain losses and reduce health risks - without using any chemical pesticides at all. Meanwhile another DFID-backed team is reporting excellent results in combating insect pests which infest stored grain - also without using chemical pesticides. The answer may be to treat stored grain with a very fine mineral dust instead of a chemical insecticide. The dust is mostly silica, and is derived from the remains of tiny organisms known as diatoms. Huge deposits of such diatomaceous earths occur naturally around the world, which means they are relatively cheap and abundant.

The dust is not toxic. Instead of poisoning the insects, it works by damaging the waxy coating of their hard outer skin, so that the pests die of dehydration.

This isn't a new idea in itself. The ancient Aztecs used lime dust to achieve the same effect, and Filipino and Honduran farmers to this day use lime dust against storage pests. Rural people elsewhere use ash, sand and crushed dried plant material.

The difference with diatomaceous dust is that it can be used in very much smaller concentrations than these traditional materials. The first trials involved very low concentrations - between 0.1 and 0.2 per cent - of dust mixed with grain. At these levels virtually all the dust is removed in the process of winnowing. It may even be possible to reclaim it for later use.

In these field trials, held over a ten-month period, the inert dust proved to be just as effective against insect pests as insecticides.

This is an exciting result. The dust is non-toxic, relatively cheap, and easy to apply. Overall the use of dust in insect control offers a practical, affordable and very specific solution to the needs of rural families who need to protect their precious food supplies. In Africa, more than one commercial company has already shown interest in the results of the DFID-funded trials.

A new series of trials is now under way to test the effectiveness of the dust at even lower concentrations and to experiment with different application methods. But whatever the results of these, it now seems certain that for some crops at least, diatomaceous dusts can be an effective substitute for synthetic chemical pesticides.

PROCESSING FOOD *at the* VILLAGE LEVEL

Backbreaking manual labour is the bane of village life everywhere in the developing world.

Development agencies have always been anxious to relieve such drudgery, and at first sight technology has often seemed to offer the answer. The work can be done by a machine: so introduce one.

But experience shows that it is counterproductive to introduce technology which is inappropriate to local conditions. A clever machine may offer hope of relief - but is it simple to use? Does it fit into traditional work patterns? Can it be made locally, and even if it can, will farmers be able to afford it?

DFID and its partners faced just such questions when they sought to make life a little easier for West African village women who gather and process shea nuts for local markets. Shea nuts grow wild across sixteen African countries. Traditionally, rural women harvest the nuts, remove the kernels, and extract the oil in a process which takes hours of pounding and boiling. The oil is sold as a form of butter for cooking, and as a cosmetic.

Shea nuts often provide the sole independent source of income for village women. But the processing is slow and laborious, and consumes fuelwood and water - both scarce commodities. The returns are pitiful.

At first the answer looked obvious: to design a simple press to take some of the labour out of processing. So as a preliminary move the DFID-supported team designed, built and tested just such a press. It could be made locally from simple and relatively inexpensive components, it reduced both labour and resource use, and it produced good quality oil. It even made blocks of fuel from the shea nut residue as a by-product.

Yet despite all that, the new press failed to achieve its goal of alleviating poverty among village women.

However promising it looked at the start, economic analyses by DFID and its partners show that the press is not economically viable for village level shea nut industry. The returns are so marginal that the village women cannot afford even the modest level of investment needed to have such presses made.

Building on this experience, the DFID-supported team is now exploring an entirely new approach: the potential for women shea nut gatherers to sell directly to a commercial operation in Ghana. That may offer far better returns than the women currently achieve by selling on local markets. At the same time the team is exploring new uses for shea nut 'butter' with a view to finding wider markets for it - in soap, for example, or as a substitute for cocoa butter in chocolate.

This flexible thinking looks like paying off. Prospects for making a real difference to the lives of rural women and their families are now much more hopeful.

In another promising initiative, DFID has worked with local and international partners to study the quality of rice harvested and processed in Ghana, where consumption of the crop is rising by 20% per year. The quality of Ghanaian rice is consistently lower than that of imported product. But the DFID-funded study shows that improved practices and training could significantly lift the quality of local rice. And that would lift the very meagre profits of small millers and farmers, and - by replacing some imported rice - would lead to greater self-sufficiency and savings in foreign exchange.

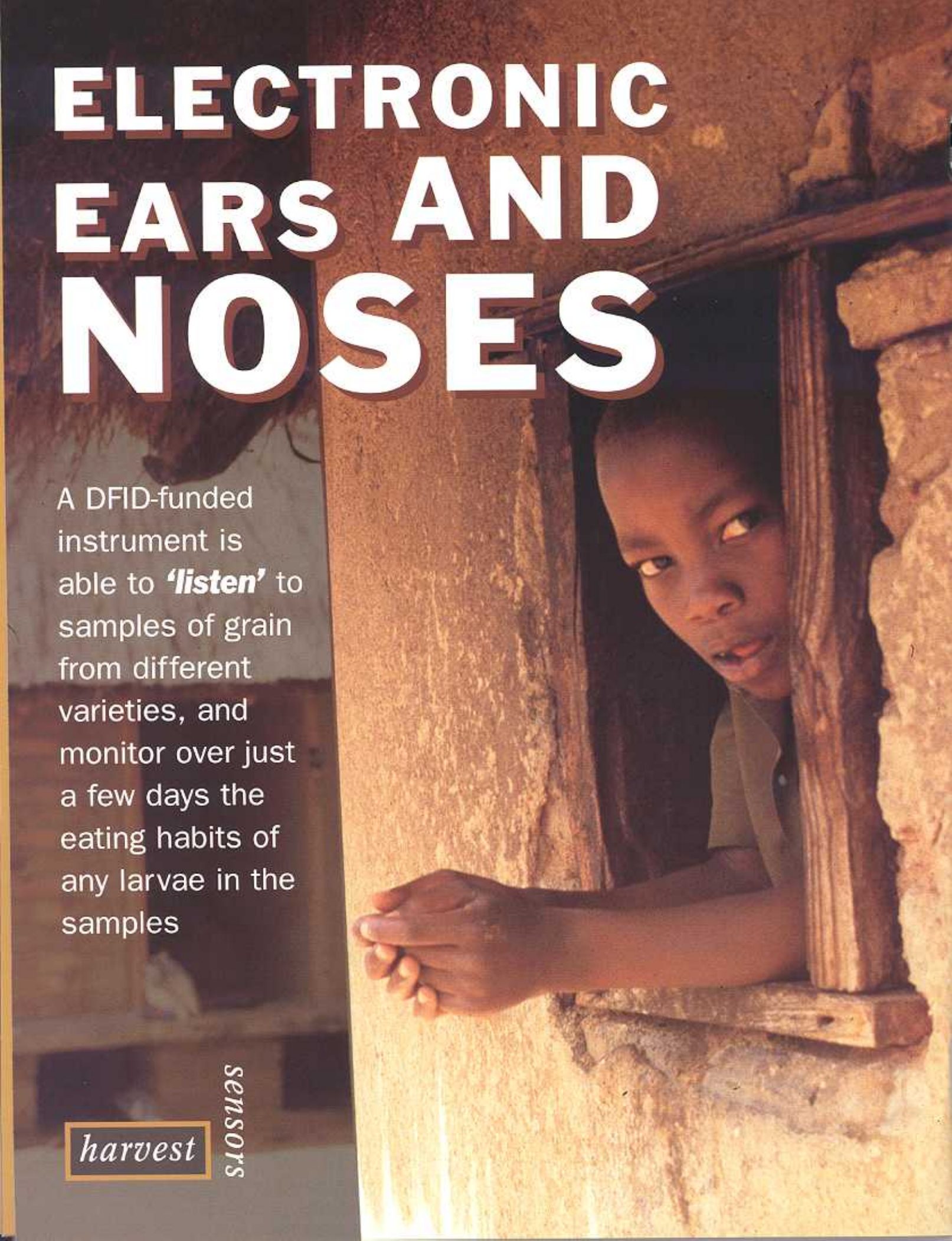
Other studies in Ghana have examined various simple methods of processing cassava into flour and into cassava chips as food for both humans and animals. Using a new and improved chipping machine, the research teams have produced smaller cassava chips which can be quickly sun-dried into a high quality product. Initial results show that these new 'minichips' find favour among many consumers. The research also shows that poultry and pig farmers could profitably substitute processed cassava minichips for some of the maize they currently use in feed, at least for several months of the year.

The same team has also explored a number of other semi-industrial markets for cassava processed into flour or starch. As a result, processed cassava could find new uses baked in biscuits; as a fuel in ethanol; as an adhesive for paper-board manufacture; and as a glue extender in the production of plywood. In all these applications it could substitute for valuable wheat flour and cut down on expensive imported products which Ghana can ill afford.

Cassava is not a high value cash crop but it is economically important because it can be grown and harvested all year round. It is frequently planted as a supplementary crop but its full potential has not yet been exploited. Indeed for much of the year it could be described as the most underutilised resource available to farmers. If new uses and new markets are found for it, cassava could have a useful impact on the incomes of millions of rural farming households right across Africa.

ELECTRONIC EARS AND NOSES

A DFID-funded instrument is able to ***'listen'*** to samples of grain from different varieties, and monitor over just a few days the eating habits of any larvae in the samples



harvest

sensors

We automatically let our noses test food for us - to tell if fruit is fresh or over-ripe, for example, or to compare the quality of tea, coffee and wine.

But although the properly trained human nose can be remarkably good at sniffing out information like this, it isn't a practical testing instrument for commercial use.

Which is a pity, because it is increasingly important to be able to judge the ripeness of fresh produce and the quality of foodstuffs of all kinds.

Exporters and importers alike need to know how long fruit and vegetables will keep in store or in transit. Retailers need to be sure of the shelf life of the produce they buy. Everyone, from health authorities to quarantine inspectors to the farmers themselves, wants to be able to monitor the freshness and quality of foodstuffs. That information affects price, transport, marketing and even consumer safety.

A DFID-funded project is taking a novel approach to this challenge. The team has developed a prototype 'electronic nose' capable of sniffing out the level of ripeness of various different kinds of produce. It works on the same principle as the human nose. Air is drawn in across a number of sensors, which detect the concentrations of various natural chemical compounds. That information is processed using some smart software built into the same unit. This software automatically compares the digital 'fingerprint' of the aroma it detects, and by comparing this with a library of stored 'fingerprints', it can determine the condition or quality of the product concerned.

Sensor technology is not in itself new. Various commercial 'electronic noses' are already on the market, and they are widely used in industries as far apart as brewing, perfumery and pollution control. But such equipment is typically expensive, complex and bulky, and operators need thorough training to use it properly.

The researchers of the DFID-backed team, however, have designed a prototype of a cheap, lightweight instrument which is easy to use and can be customised for testing particular foodstuffs. Now they are hoping to collaborate with commercial or industrial partners to manufacture it on a large scale.

Appropriately enough, while one team is developing the 'electronic nose', another – also supported by DFID - is hard at work on an 'electronic ear', though for rather a different purpose.

Scientists have known for some time that, using extraordinarily sensitive equipment, it is possible to hear the larvae of insect pests as they munch their way through stored grain. This is important. Many grain pests can't be spotted by eye even during a thorough inspection because their larvae develop entirely within the grain itself.

The electronic listening technology was originally developed with quarantine inspectors in mind: they needed to be able to detect hidden pests in stored or imported grain. But now the research team has built on the earlier work and have taken the technique much further. Working with a commercial partner they have developed an instrument which can help determine the pest resistance of different crop varieties.

In recent years it has become vital to establish which varieties are resistant and which are susceptible. Internationally funded crop breeding programmes have developed a wealth of improved crop varieties with yields dramatically higher than traditional ones. But many of the new crops are much more susceptible to grain-boring pests than the varieties they replace. That disadvantage can only be overcome by using pesticides, which are expensive and sometimes even dangerous to the very people who are supposed to benefit.

The result has been a massive on-going international effort to breed resistance back into the improved crops. That in turn requires very large scale screening programmes. Thousands of different varieties are observed in the field and under laboratory conditions to see how badly affected they are by pests. Precisely because pest larvae remain hidden inside the grain, such screening programmes are enormously time consuming. Observers have to wait weeks or months to see if the pest will emerge as an adult before they know how resistant the sample is.

The DFID-funded instrument, though, is able to 'listen' to samples of grain from different varieties, and monitor over just a few days the eating habits of any larvae in the samples. In resistant varieties, feeding activity will be reduced or delayed. By careful analysis of the pulses of sound and the statistical patterns they form, it will be possible to determine the resistance of a given variety very much more quickly than in the past.

The equipment is currently being developed for cowpea but the researchers are also looking at methods to test maize and sorghum, with other grain crops a possibility for the future. The commercial instrument will probably sell to international research centres and universities where the crop breeding programmes take place. Ultimately, it will help provide poor farmers with high yielding resistant crop varieties. That in turn will give them a secure food supply for themselves and their families, and perhaps give them access to export markets.

Harvest

Today about three billion people live in cities, or a little under half the world's population. By 2025 the number of city dwellers will almost double, to some 5.5 billion - 60 per cent of a global population which will by then have reached eight billion.

This represents a massive change in the way people live. Most of this change will take place in the developing world. There the drift of people from the country to the cities will increase every year, and whole new cities will be born as existing smaller towns swell to absorb new migrants from the country.

This demographic shift has profound implications for the way food is stored, processed and distributed after harvest. That in turn has led DFID and its partners to launch a series of intensive studies on urbanisation in an attempt to discover just what the phenomenon could mean over the next few years.

Urbanisation goes hand in hand with economic development, and most economies in the world are expected to grow in the years ahead. It follows that tomorrow's city dwellers will be generally wealthier than today's rural populations. One result will certainly be a rise in spending on food, and a shift in demand from staples to higher value foods, especially fruit, vegetables and meat. In Taiwan, where incomes per head grew more than fivefold in the twenty years to the mid-1990s, rice and sweet potato consumption dropped by more than half in that time, while meat and fruit consumption more than doubled.

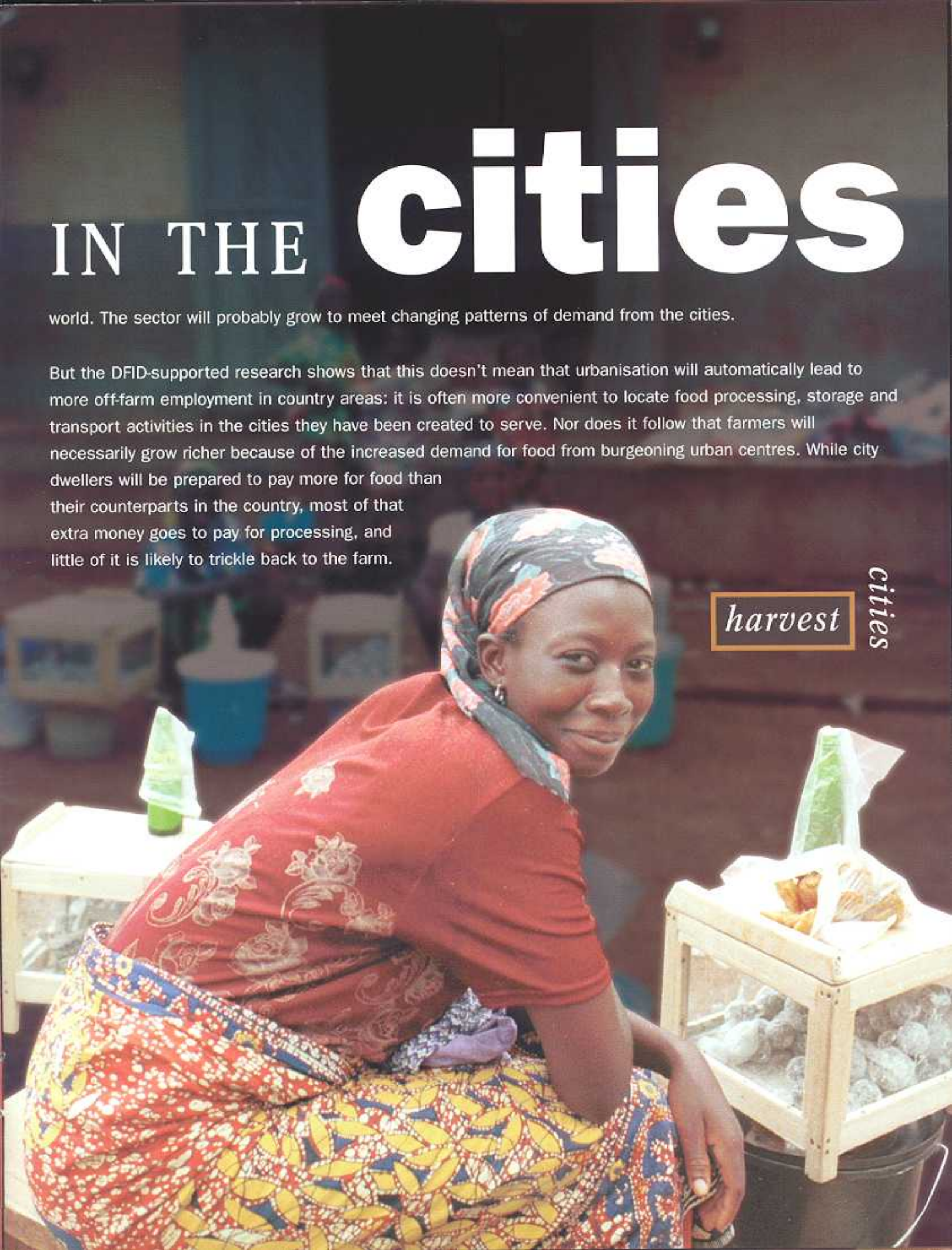
The growth of cities is also bringing about striking changes to that pattern of eating habits among the people who live there. More people tend to eat outside the home, often because they can't get home from work for a midday meal. At the same time, city families tend to be smaller, nuclear units than their rural equivalents and women of the household are much more likely to go out to work, rather than to spend time at home preparing food. As a result, city dwellers eat more snack foods and processed foods of all kinds. They are increasingly prepared to pay for semi-processed foods which were once prepared entirely at home. In Nigeria, for example, city dwellers buy less fresh cassava than rural Nigerians and more of the ground cassava meal known as *gari*. In Mexican cities *tortillerias* now sell ready made the flat maize *tortilla* pancakes which were once ground, kneaded and baked in every household.

The drift to the cities will also mean striking changes in patterns of employment for those who remain in the country. In most developing nations the number of people actually engaged in work on the farms will probably continue to rise for some time to come, although slowly. But the really rapid growth will be in the 'rural non-farm sector' (RNFS) which embraces a wide variety of activities other than farming – among them food processing, food storage, manufacturing, transport and services. This sector already accounts for somewhere between a quarter and half of all economic activity in rural areas in the developing

IN THE cities

world. The sector will probably grow to meet changing patterns of demand from the cities.

But the DFID-supported research shows that this doesn't mean that urbanisation will automatically lead to more off-farm employment in country areas: it is often more convenient to locate food processing, storage and transport activities in the cities they have been created to serve. Nor does it follow that farmers will necessarily grow richer because of the increased demand for food from burgeoning urban centres. While city dwellers will be prepared to pay more for food than their counterparts in the country, most of that extra money goes to pay for processing, and little of it is likely to trickle back to the farm.



we acknowledge the many contributions of our *partners*

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Banaras Hindu University, India
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Bangladesh Institute of Development Studies
Bangladesh Rice Research Institute
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Centre for Applied Social Sciences, Zimbabwe
Centre for Arid Zone Studies, UK
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Centro Internacional de la Papa, Uganda
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Grain Marketing Association of Ghana
Grain Marketing Board, Zimbabwe
Harvest Help, Zambia
Hedley Technologies Incl., Canada
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Horticultural Promotion Council, Zimbabwe
Horticultural Research Centre, Zimbabwe
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Sokoine University of Agriculture, Tanzania
Tamale Archdiocese Agricultural Project, Ghana
Tamil Nadu Agricultural University, India
Tanzania Food and Nutrition Centre
TechnoServe, Ghana
The Acheta Partnership, UK
The Agricultural Policy Secretariat, Uganda
The Cotton Company of Zimbabwe
The North Bukedi Cotton Company, Uganda
Tropical Pesticides Research Institute, Tanzania
Tulimara Speciality Foods, Zimbabwe
Ukiriguru Agricultural and Training Research Institute, Tanzania
University of the North, South Africa
University of Bath, UK
University of Dschang, Cameroon
University of Durham, UK
University of Ghana
University of Leicester, UK
University of Malawi
University of North, South Africa
University of Nottingham, UK
University of Reading, UK
University of Science and Technology, Ghana
University of Sussex, UK
University of Swaziland
University of Venda for Science and Technology, South Africa
University of Zimbabwe
V&M Import & Export Agents (Pty) Ltd, Mozambique
VECO/COOPIBO, Zimbabwe
World Vision International, Mozambique, Zimbabwe
Wye College, UK
Zambia National Farmers' Union
Zimbabwe Council of Churches
Zimbabwe Farmers' Union
Zimbabwe Oil Press Project

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