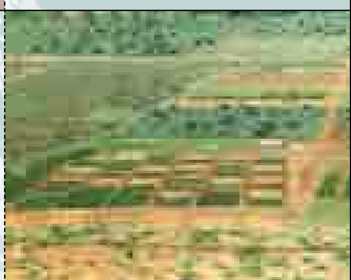
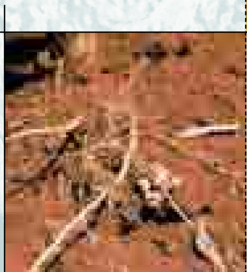
Natural Resources Systems Programme

Research Highlights 1999 - 2000





Poverty reduction through partnerships in natural resources research

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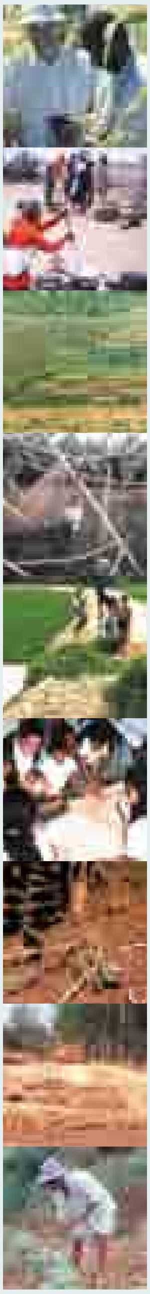

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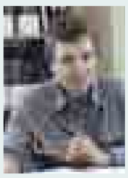

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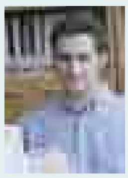

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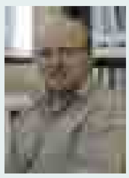

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NRSP Research highlights

Poverty reduction through partnerships in natural resources research

The Department for International Development (DFID) is the British Government department responsible for promoting development and the reduction of poverty. The central focus is a commitment to the internationally agreed target to halve the proportion of people living in extreme poverty by 2015. To contribute to achieving this objective, DFID funds a number of programmes that cover various aspects of natural resources research. One of these programmes is the Natural Resources Systems Programme (NRSP).

NRSP aims to deliver new knowledge that can enable poor people, who are largely dependent on natural resources, to improve their livelihoods. Research focuses on the improvement of the management of land covering soil, water, vegetation and organic residues in an integrated way. It aims to find strategies for natural resource management that can enable the poor to build their livelihoods and make a sustainable move out of poverty. The new knowledge that the programme generates is of varying types. It includes specific technologies for land care, better strategies for natural resource management and better methods for transferring the knowledge of these strategies to various clients ranging from poor individuals, households and communities to policy makers that are influential in various natural resource sectors.

NRSP is a 10 year programme which began in 1995. It is implemented as contracted projects that are undertaken by research institutions with expertise in natural resources management. During the past year, 22 projects that commenced in earlier years were completed and 22 new ones were commissioned. In its early years, working in a systems context, NRSP's research emphasised the identification of constraints to productivity and their resolution by integrated approaches with a central focus on biophysical interventions. Following the Government's White Paper on International Development ('Eliminating World Poverty: A challenge for the 21st Century') in November 1997, NRSP's strategy was revised in order to focus more explicitly on research on the management of natural resources that could have beneficial outcomes for poor people. This revised strategy was reflected in the new projects that were commissioned during the course of the year. Important elements of the strategy are:

- **Poverty focused demand led** research. NRSP is pro-active in commissioning research that is designed to be relevant to specific defined groups of the poor.
- Use of a **systems approach** in both the design of research and in the way it is conducted. Research pays detailed attention to the technical, social and institutional inter-relationships that pertain to a specific piece of research. In this way, the research findings have greater potential for sustained use in subsequent development-oriented work.
- **Partnerships.** In conducting the research projects, UK-based researchers work in partnership with natural resources specialists overseas. An overseas institute may lead the project in some instances. Overseas partners are drawn from national research institutes, universities, government departments and non-governmental organisations. In addition, participatory methods are used in order to involve both intermediate and ultimate beneficiaries of the research (stakeholders) from an early stage.

HIGHLIGHTS

The programme covers six production systems and articles on each system are included in this publication:

High potential production systems are found in areas with favourable soils and climate, and ground water resources in some instances. Such areas are relatively well developed, including irrigation schemes. They support some of the highest population densities in the world and have intensive use of land. They produce surpluses that feed people in both urban and less favoured rural areas. Target countries are India, Bangladesh and Kenya. *Rice: declining productivity in Bangladesh? (p12)* concerns the worries of farmers who see fertilizer inputs and hence costs, rising but rice yields remaining the same. *Improving Fallows? (p18)* looks at the supply of nitrogen to rainfed crops in Kenya and evaluates ways to improve nitrogen availability through the use of fallows involving mixed legume species.

Hillsides production systems are characterised by farming activities (crops and livestock) on steep slopes where difficult terrain results in poor accessibility, limited infrastructure and markedly impoverished communities. Use of these marginal lands has led to their degradation. Target areas include high altitude areas of Asia and Latin America and mid-altitude hills in Uganda. *Hillside farming – living at the margin (p24)* provides some answers to the important question – why do farmers in some places take up well-tried and tested technical solutions and use them successfully while in others they just continue to abandon their farms to soil erosion and move on?

Semi-arid production systems occur in the tropical dry lands where agricultural activities and livelihoods are constrained by poor natural resources (principally infertile soils and low and erratic rainfall). Production of crops must be achieved in the short wet seasons requiring intense and exhausting work. *Just one more good rainstorm (p6)* describes the resurgence of interest in rainwater harvesting in Tanzania and the changes in thinking about rainwater runoff as a valuable resource for small holder farmers rather than a problem which causes soil erosion. A second article, *Getting out of poverty (p3),* focuses on poor farmers in semi-arid Zimbabwe and the challenges they face as they try to diversify their livelihoods from a dependency on subsistence agriculture.

The **forest agriculture interface** refers to areas that are in transition between primary forest on the one hand and settled agricultural land use on the other. Such areas are found in Brazil, Nepal and Ghana. *Farming at the frontier (p15)* describes the critical influence that smallholder family farms have on the stability of this fragile area in Brazil and yet they have received so little attention in planning and policy development.

The **land water interface** refers to both coastal areas and inland aquatic systems such as floodplains. Priority areas include the Caribbean islands and Bangladesh. *Life on a floodplain (p9)* concerns the issues of farming and fishing on the floodplains of the massive river systems of Bangladesh. The complex interaction between these livelihood strategies must be understood if water control and drainage works are to be constructed and managed for the benefit of both.

The **peri-urban interface** is a very dynamic system driven by urban development. Rural activities pre-exist and, as urban activities proliferate and grow, linkages relating to them are built from either the town or the countryside. *Urban waste – a challenge for policy makers (p21)* investigates the problems of poor farmers close to an Indian city who rely on organic wastes from urban rubbish collection to improve their soils and their crops. They face an uncertain future as large-scale composting plants threaten their livelihoods by increasing prices beyond their reach.

These are just some examples of the portfolio of exciting projects that make up the Natural Resources Systems Programme and its support to reducing world poverty. A complete list of on-going projects is provided at the end of this document.

Getting out of poverty

> "I have money to travel to the local town where I buy soap. I bring it back to the village and sell it in exchange for maize. I use the maize to make beer, which I sell for cash. I then go back to the town and use the money to buy more soap."

Esther gains as much as 500% mark-up on the soap and a further 200% on the sale of beer.

"I collect seeds that people spit out as they eat fruit. I have set up my own orchard by germinating the seeds in pots and then planting them out into a garden. I also sell the pot plants to other gardeners for cash."

These are just two striking examples from this preliminary study undertaken into the ways in which poor people living in villages in Zimbabwe have been able to diversify their livelihoods from a dependency on subsistence agriculture and use their entrepreneurial skills to climb out of poverty.

A substantial number of Zimbabwe's poor are located in the semi-arid regions and despite the excellent national infrastructure, these dry regions have been neglected both by state policies and systems as well as the private sector. They have not been well integrated into markets nor are their needs and demands well articulated through the political or policy process. The severe droughts, which devastated the region in 1991-92, only exacerbated these problems to the point where many people even lost their livestock. One of the early signs of drought is the selling of livestock. Sales of goats and poultry start in the early stages but once cattle are sold then recovery becomes much more difficult. They are a key household asset and an insurance against bad times and so their loss deprives households of a major means of recovery.

This research project set out to try and understand the problems that poor rural households face in the semi-arid areas of Zimbabwe as a basis for identifying new options for improving their livelihoods.

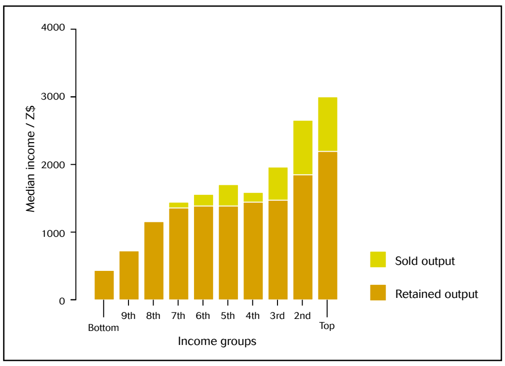
Diversification from farming into the non-farm sector is the pathway out of poverty

DIVERSIFICATION

For the poorest households, the opportunities to increase income and reduce vulnerability lie principally in diversification, within the farm enterprise, but more importantly from farming to non-farm activities.

Once a poor household has satisfied its basic food needs it usually seeks to diversify. There is a cycle of investment following a severe drought. First, farmers start to grow drought-resistant low capital and labour intensive crops, especially the small grains. They exploit natural resources and seek opportunities for casual labour to earn some ready cash. Once the means of growing food for the household is assured they then start to diversify into more risky crops and then into non-farm enterprises.

But the constraints to diversification have been severe throughout the 1990s. Rural markets in



semi-arid areas are not well organised and there is not a lot of interest in their products from the already well-organised private sector in Zimbabwe. So it is difficult for people to add

value to rural products that would bring more benefit to the village rather than to the town. Examples of this are the processing of cotton and food products which could be done equally as well in the village as in the town. There is also a chronic shortage of savings and working capital to start up and expand such enterprises and there are few success stories except for initiatives such as CAMPFIRE that enables poor people to benefit from wildlife, and the development of small-scale irrigation.

Poor farmers find it more difficult to become involved in the institutions that support agriculture. Joining a farmers' club, which the more wealthy farmers take for granted, is difficult, but there were fewer barriers to poor women farmers joining gardening clubs, which cater for women's horticultural activities. Membership of these clubs can improve access to finance and markets and help to reduce vulnerability through community based work parties and safety nets such as grain banks, fodder and seed banks.

Poor households were slow to build up their livestock resources, which indicates that families were finding it difficult to re-establish their basic assets. It also meant that they did not have enough animal power on the farm for ploughing which is a vital part of weed control. So insufficient cattle risks poor crop yields.

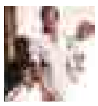
Although goats and poultry were alternative and more rapid ways of diversifying there were problems of security and a lack of veterinary services. So venturing into small stock was not without its risks.

These constraints have produced a group of chronically poor households who have found it very difficult to accumulate the resources to move out of the precarious positions they occupy. At first it was thought that they were simply at a stage in the life cycle when they had insufficient numbers of adults for labour. But this seems not to be the case and indicates that other processes are at work.

Only the richest groups have the choice to diversify away from farming into the more profitable occupations such as trading. The poor have had no such choices and have to concentrate on farming. Developing and expanding realistic 'new' options, which fit into a diverse household portfolio, is therefore critical for their well-being.

AGRICULTURE AND CPR

Agriculture and common property resources (CPR) are central to the livelihoods of the majority of poor people and so any improvements made in accessing and using these resources are likely to be more equitably distributed than non-agricultural interventions. Improving crop yields, for example, still



remains an important issue as a very substantial proportion of production is for home consumption. The benefits of genuine improvements are likely therefore to be very widespread.

The possibilities of market integration for poor households are currently dismal. They are much less able to take the risks that are necessary to achieving higher incomes. Poor households lack basic transport such as donkeys and carts and smaller households may also lack adequate adult labour for some of the more arduous farming tasks. Poor management of resources has led to a lack of raw materials for non-farm enterprises too, such as charcoal for blacksmithing and wood for carpentry.

EDUCATION

Education and better paying jobs continue to offer an alternative pathway out of poverty, though both the availability of jobs and access to post-primary education are more constrained for poor people than they were.

Broad investments to enlarge the accessibility of post-primary education would bring benefits. However, in a declining or stagnant economy this may result in the longer run in educated people increasingly taking jobs for which they are effectively over qualified. This is a classic sequencing problem. As far as poor households are concerned, equalising their chances of getting a good post-primary education would contribute significantly to their ability to diversify, even if it was at the expense of other less poor households in the short to medium term.

LIVESTOCK OWNERSHIP

Critical to coping with drought (by far the major shock for semi-arid area households) has been livestock ownership, employment opportunities and food for work. Retaining livestock through a major drought is the only widespread guarantor of post-drought recovery. The failure of livestock insurance in the 1991-92 drought was the major reason for the absence of widespread recovery.

Livestock continue to provide a variety of benefits; manure, draught power, transport, opportunity for quick distress or pre-distress sales, meat and other products add up to a range of entitlements unmatched by any other type of enterprise. For those households who lost all their livestock during the drought, the constraints to restocking were formidable. Livestock prices were high in the post drought period and have remained high during the 1990s.

Education and better paid jobs - access to both is difficult for the poor

THE NEXT STEP

Much has been learnt and is now understood as a result of this research about the issues that constrain the rural poor from getting out of poverty and possible options for improving livelihoods in semi-arid Zimbabwe. But much more needs to be understood about such factors as employment opportunities, access to markets and the structure of market systems. This might be done by using farmers' and gardening clubs more explicitly to improve access to markets and to support information flows to and from poor households.
If diversification is the way out of poverty then improved links are needed between poor farm-households and policy makers and development programme designers so as to cater properly for their needs.

R7545 – Coping strategies of poor households in semi-arid Zimbabwe

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Just one more good rainstorm

'Just one more good rainstorm' is the constant lament of farmers' who must make their living in the drier regions of the world. Water is the limiting factor and they know it is essential for producing a decent crop and for their survival.

In Tanzania the war against poverty will be won or lost in such dry areas. Over 50% of the country is classed as semi-arid and this is where most of the poor farmers live. They must contend with unreliable and highly variable rainfall, particularly an unpredictable short rainy season with no assurance of when it will start and finish and frequent long dry spells. How can farmers survive in such conditions, produce good marketable crops and generally improve their livelihoods?

Should runoff be regarded as a hazard or as a resource?

HARVESTING RAIN

One approach, which has been around for centuries but is not widely exploited, is to harvest rainfall. This means collecting rain that falls on the surrounding areas and channelling it as runoff onto farms to add to the rain that falls directly onto the crops. Interestingly, no one doubts the critical importance of rainfall, but few policy makers have recognised the importance of runoff, which is the inevitable product of excessive rain. It is a curious paradox that farmers recognise and exploit the natural concentration of rainwater in valley bottoms and local depressions, yet the overriding perception driving policy is that runoff is a hazard. This view is fuelled by the prominence given to the concerns about soil erosion, which is one product of runoff and has been the focus of research and extension efforts to curb it since the 1930s. So should runoff be regarded as a hazard or as a resource? Rainwater harvesting recognises the potential value of runoff as a resource and aims to control the process in order to mitigate the hazard.

In 1992 Sokoine University of Agriculture in Tanzania and University of Newcastle upon Tyne in UK began working together to investigate rainwater harvesting as a means of improving maize growth in the semi-arid areas of Tanzania. Although there are many documented examples of ancient rainwater harvesting systems in many parts of the world, there was very little literature about its current use and how to extend this using more science-based design procedures. In sub-Saharan Africa particularly, rainwater harvesting occupies the neglected middle ground between soil and water conservation on the one hand and irrigated agriculture on the other. Both these extremes have received far greater attention.

Rainwater harvesting is about collecting rainwater from a large catchment area and channelling it so as to increase the water available in a smaller growing area. There are micro-catchment systems, which are modest in size, where water is collected from land adjacent to the farm and channelled directly on to the fields. But there are also macro-catchment systems with large water collecting areas, often some considerable distance from the farming areas, which can serve many farms. Substantial quantities of water can be collected from barren and fallow land and channelled into the cropped fields. Unfortunately farmers have no control over the timing and quantity of harvested runoff water, which means that problems may still occur due to long dry spells or damaging high flows during exceptionally heavy rain.

DEVELOPING MICRO-CATCHMENTS

Although rainwater harvesting was at the heart of the research project, the original idea was to promote the intensification of smallholder maize production in the semi-arid lowlands of north-eastern Tanzania which are characterised by rolling plains with reddish sandy clay soils of relatively low fertility formed on basement complex rocks. Rainfall has a bimodal pattern. There is a short rainy season from November to February, locally called *vuli* (240-350 mm), and a long rainy season from March to June, known as *masika* (325-450 mm). The area also includes high-potential uplands but these are experiencing population pressures. This, together with good communication links and employment opportunities in the sisal estates, has promoted population shifts into the semi-arid lowlands. But attempts to try and change cropping from the popular maize crop to a more appropriate drought resistant crop such as sorghum have run into a lot of resistance from farmers.

Although there was some evidence in this recently settled area that farmers already exploit

naturally occurring runoff concentrations within the landscape, there was no evidence of indigenous knowledge of rainwater harvesting. A site was established with micro-catchments, which incorporated two types of areas – those producing runoff and those receiving runoff. The small scale and short transfer distance (5-50 m) between these ensured that the system could be adopted by individual farmers on individual plots and that runoff amounts were easily controllable with minimum risk of soil erosion.

TRIALS AND PREDICTIVE TECHNIQUES

Trials conducted over several seasons indicated that there was a clear yield benefit from this practice in the *vuli* season, but it was less apparent in the *masika* season. These field experiments were inevitably restricted to specific sites over a limited time interval. Given the extreme variability of rainfall patterns and their dominant influence on the performance of the system, extrapolation and transfer of the experimental results was recognised from the outset as a difficult problem. A twin-track approach was therefore adopted in which the experimental effort was linked to computer modelling. This permitted realistic simulation of reliability and risk over 20 to 30 years to be made by using historical rainfall data. The simulation study, using the PARCHED-THIRST model, which the research project developed, indicated that benefits in *vuli* could be expected 1 year in 2, whereas a benefit occurs only 1 year in 10 during *masika*.

THE MOVE TO MACRO-SYSTEMS

When invited to evaluate the micro-catchment trials, farmers understood the benefits of rainwater harvesting but were reluctant to adopt the system. They were more interested in the greater potential of using macro-catchment systems and argued in favour of more ambitious attempts to harvest runoff on a larger scale. To accommodate this view the emphasis of the project shifted toward macro-systems and a second target area was introduced in a region

where such systems were known to be widely used, albeit for rice and not maize. This so-called *majaluba* rainfed rice system is believed to have been introduced by Indian migrants in the 1920s. Its adoption was not led by external change agents nor was it fostered by external subsidies, but nevertheless it has spread steadily since the 1930s. Official data now show that the *majaluba* systems contribute 35% of total rice production in Tanzania. It was hoped that lessons could be learnt from this experience that may help bring about its successful adaptation for non-rice cropping systems.

The new Tanzania National Water Resources Management policy now includes rainwater harvesting

The limited experience to-date using macro-catchments for maize production in the original target area is mixed. Field experiments combined with simulation studies indicate that significant benefits are obtained in most *vuli* seasons, but seldom in *masika* seasons. It seems that this system can fulfil the farmers' desire for *just one more good rainstorm* since runoff may be harvested from a localised rainstorm on the distant catchment area even when there is no direct rainfall on the cropped area. But the macro-systems are not without their problems. Proper control over distribution of harvested runoff within the cropped area is more problematic for deficit-irrigated crops than is the case with *majaluba* rice systems. There is clear evidence that failure to provide proper control over the distribution of runoff can lead to serious erosion. Too much water can be as big a problem as too little. The need for cooperative group action can also give rise to disputes over water sharing. So whether farmers will continue to prefer macro-systems to micro-systems as they acquire more experience in using them for maize production remains to be seen.

DISSEMINATING GOOD PRACTICE

The research has clearly demonstrated the potential and possibilities for improving dryland maize production using rainwater harvesting and the impact at policy level has been profound. The new Tanzania National Water Resources Management Policy, which is going though its approval process now includes rainwater harvesting. However, at local level this marked shift in perceptions brings problems that must be addressed properly and urgently. Gaps in existing knowledge may lead to ill-considered attempts to tap this precious resource. The project is now moving into a follow-up phase, which aims to disseminate good practice and help in district-level planning.

R6758 Development of improved cropping systems incorporating rainwater harvesting

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Life on a floodplain

Living on a floodplain conjures up dramatic images of catastrophic flooding. In Bangladesh, about 80% of the country makes up the floodplains for the massive Brahmaputra and Ganges rivers and in 1998 almost 70% of it (100,250 km^2) was under water. Although this was an exceptional year, as much as 26,000 km^2 is still inundated annually. To add to this problem of flooding, most of the population of Bangladesh (some 80%) live and rely for their livelihoods on the floodplains.

Bangladesh is also one of the most densely populated developing countries. More than half of rural households are landless and subsist below the poverty threshold. National economic growth is starting to address poverty, but this is being undermined by rising inequality. If the many marginal households trying to make a living on the floodplains are to achieve sustainable improvements in their livelihoods, then development must target their systems of resource use. But who are the floodplain poor? And what are the key factors that influence their livelihoods?

FLOODPLAIN DWELLERS

Floodplain dwellers use production systems that are adapted to the seasonal interplay between land and water. The table below provides a summary of the two main systems, farming and fishing, but this simplification masks the complexity of how individual households depend on these activities and other income sources to make a living.

LAND BASED PRODUCTION SYSTEMS	WATER BASED PRODUCTION SYSTEMS
Agriculture	Fisheries
Private land	Common property
Mainly held by wealthier households	More important for poorer households
Access widened through sharecropping	Access restricted through leasing
Dominant for 8 months/year	Dominant for 4 months/year

FLOODPLAIN DEVELOPMENT

Food production from the floodplain has broadly kept pace with population growth. This is largely due to the investment in small-scale irrigation, which has moved cropping patterns towards rice in the dry season, and engineering works for flood control and drainage, which have helped to reduce the depth and duration of inundation in the monsoon. This has enabled farmers to grow a more secure dry season harvest as well as make use of improved wet season rice varieties. But such improvements have been at the expense of other components of the floodplain system. Notably, water-bodies, which are becoming increasingly ephemeral, and migratory fish, which enter them during inundation periods, are reducing in numbers.

Although small-scale rice production dominates the floodplain, for many, usually poorer households, flooding and floodplain water-bodies provide important livelihood options. There is general recognition of this among professionals and government agencies but progress is constrained by sectoral approaches whereby agricultural development targets farmers and aquatic resources development targets fishers.

INITIAL MAPPING WORK

The early part of the research project was concerned with developing a GIS and analysing the resource base of floodplains producers. This led to the production of agro-ecosystem maps and modelling outputs that were then validated by the producers. Researchers then undertook novel analyses by combining the mapped information with socio-economic data about households to examine the relationship between socio-economic status and resource availability and use.

MIXED LIVELIHOOD STRATEGIES

Characterising floodplain dwellers as either farmers or fishers has led to an over-simplistic view that there are two distinct and separate groups of people and that they are pitted against each other. This is not the case. It is a minority of households that only fish or only farm while the majority depend on a mixture of the two. For example, only 3.5% of households are actually headed by full-time fishermen yet many more participate in fishing. An average of 37% of income, for households with 0.2 to 1.0 ha of land, comes from fishing and as much as 75% of all households fish seasonally or for subsistence.

AMOUNT OF LAND (ha)	FISHING AS MEAN % OF TOTAL HOUSEHOLD INCOME
< 0.2	61.5
0.2 – 1.0	36.8
> 1.0	13.8

So households employ a range of natural resource-based options to sustain their livelihoods. Research has demonstrated that the simple polarised model of agriculture versus fishing, which tends to emphasise the differences between the poles, misrepresents the reality. Floodplain management strategies need to be devised that satisfy both resource use concerns.

INTERACTIONS AND INTERDEPENDENCIES

The research team also attempted to identify how different groups make use of land and water resources in their livelihood strategies. Households were stratified on the basis of land-ownership and this was combined with wealth-ranking and participatory exercises to identify locally important stakeholder groups. These groups differed between sites, but a common set of useful stakeholder categories was found to be widely applicable, namely, landless labourers, small-medium scale farmers, larger landowners/landlords and fulltime fishers.

Three key areas of dependency were found between groups: the labour market, sharecropping land and water use. Larger landowners often face labour shortages, and so hire in labour. Alternatively, they may enter into sharecropping arrangements with entrepreneurial small farmers who buy in agricultural day labour to help them. Labour is one of the few assets of the poorest households. The very poorest are unable to engage in sharecropping, as they cannot afford to buy the necessary inputs.

Water was found to be an important point of connection between people following different livelihood strategies. Some connections are complementary but others were a source of conflict. Most irrigation, for example, is supplied from groundwater, but some is drawn from surface water bodies. The use of surface water for this purpose conflicts with its use as fishing grounds and fish refuges. Another example occurs in the monsoon period. Agricultural interests wish to prevent early inundation of the land to protect crops that have yet to be harvested, while fishing interests wish to open the sluice gates so that fish and fry can enter the water-bodies. At the end of the season when floods start to recede, farmers are keen for their land to re-appear as soon as possible so that cropping can begin again. So they are keen on draining the land. But the fishing interests want to hold back the floodwaters for as long as possible. The challenge is to manage the drainage control sluices so that they meet the aims of both fishers and farmers.

STAKEHOLDER WORKSHOPS AND CO-MANAGEMENT

Getting stakeholders involved in highlighting issues of common concern, elaborating local solutions and identifying points of entry for development was achieved through a participative workshop. This maximises the representation of different types of floodplain resource user, but balances it with opportunities for groups, who are normally disenfranchised in such processes, to have a voice. Problem census exercises were also used with stakeholder groups individually to identify their key livelihood constraints. Larger workshops were then organised so that the groups could come together to discuss the issues they had identified previously. The importance of water resources emerged very strongly from the entire community as a key issue. Although fishing in many water-bodies occurs through a system of leased rights, other uses of water, such as irrigation and transport are also common rights. As one workshop participant said: *Water is not something to hold.* Its multiple uses emphasises its role as a connector between livelihood strategies. Issues such as soil fertility and availability of wild foods were of concern only to certain groups, whereas management of water-bodies was of concern to all, though different perspectives on the issue were evident. In communities around perennial water-bodies, the process resulted in action plan agreements on managing the resource together.

WIDER APPLICATION AND UPTAKE

This workshop process has been adopted by the Centre for Natural Resources Studies in Bangladesh and used for participatory planning of community-based natural resource management in the coastal zone, the deeply flooded Sylhet basin, and around shallow floodplain water bodies. It is now being tested with other organisations in the context of a community-based fisheries management project. At a different level, awareness raising has resulted in an increasing appreciation by government and development organisations of the benefits of integrated, or 'systems' approaches to floodplain management.

R6756 Investigation of livelihood strategies and resource use patterns in floodplain production systems based on rice and fish, Bangladesh

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Rice: declining productivity in Bangladesh?

Growing rice has long been an important human activity and historically it has supported large populations. Rice first became popular about 2000 BC and by the fourth century BC it was grown on a large scale following the introduction of irrigated agriculture in China. Today, rice is the staple crop throughout south and south-east Asia and increases in yield and production have kept pace with the growing population. Bangladesh is a prime example. It is one of the most densely populated countries in the world and is self sufficient in rice.

The foliage contained high levels of nitrogen but there was less than expected in the rice grains themselves

BANGLADESH'S SUCCESS

Through the 1970s and 80s, the national strategy of Bangladesh was to increase rice production by introducing high yielding modern varieties developed as part of the green revolution in Asia. Traditionally rice was grown in the summer monsoon season in the deltas and floodplains, which have long been recognised as highly productive and fertile ecosystems. It was grown from broadcast seed in low-lying areas, which were then inundated when the rains started, and from transplanted seedlings in slightly higher lying fields where farmers could have better control over water.

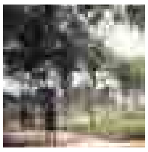
Yields were generally low (up to 3 t/ha) but reliable as these varieties where not so sensitive to random flooding of varying depths and prolonged dry spells. The modern varieties can produce much higher yields (up to 6 t/ha) but they require much more careful control over water depths and fertilizer applications. The introduction of controlled irrigation using groundwater and flood storage enabled farmers to take advantage of them. Irrigation also meant that rice could be grown in the dry season to take advantage of the higher radiation and yield potential. As a consequence rice cultivation has largely shifted away from the summer monsoon season towards what is locally termed *boro* cultivation. This is the dry season prior to the monsoon.

The strategy was successful and led to Bangladesh's self sufficiency in rice. It accounts for approximately 80% of the total cropped area in Bangladesh. But the strategy focused on wealthier medium and large landholders at the expense of smallholders farming less than 0.2 ha, who make up more than 50% of the rural population. They tend to rely as much on fishing as on farming for their livelihoods but this too has suffered due to the loss of seasonal wetlands associated with the intensification of rice production.

A FERTILITY PROBLEM?

Although rice is a success story in Bangladesh, farmers there have become increasingly concerned about the declining productivity of their rice crop. This is not so much a decline in yield as a decline in the net financial returns they get from the inputs they make. They are worried about having to put more and more in just to get the same output. So a research project was undertaken to investigate the problem. The research, carried out in farmers' fields, demonstrated that although farmers apply adequate fertilizer, the returns to its use, in respect of grain yield, were poor. At first it was thought that the problem was the classic one of poor fertilizer management or the lack of availability of nitrogen (N) to the plant. However, plant analysis indicated that this was not the case. Rather, the foliage contained large amounts of nitrogen whilst grain formation was less than expected for the amount of nitrogen available in the plant. Such findings caused the researchers to think along quite a different pathway to find out what other factors, other than nitrogen, were limiting grain yield. This directed attention to other aspects of crop growth such as possible imbalances in the supply of other nutrients, inadequate irrigation, poor pest, disease and weed control, low solar radiation, and poor seed quality or inappropriate seedling transplanting. So far there is no clear indication as to what factor or combination of factors might be the cause of the problem. But in addition to the nitrogen uptake problem, as much as 80% of the added nitrogen fertiliser was not recovered by the crop and presumably this was lost through either nitrate leaching, ammonia volatilisation or denitrification. Such losses are not just a major financial burden but they can also have serious environmental consequences.

Looking beyond Bangladesh for clues to solve the problem, the evidence is somewhat conflicting. Two recent reviews of rice experiments undertaken throughout Asia have produced different trends. One analysed experiments of yield trends in 47 long-term experiments of continuous rice cultivation and of rice followed by wheat grown in the residual moisture following the monsoon. It argued that



yield declines were not very common; particularly yield levels achieved by farmers. But another review of yields in long term rice – wheat experiments showed that rice yields were declining in eight out of eleven experiments while wheat yields were more stable with time, declining at only three sites. The controversy continues but the fact that some data indicate a decline, adds weight to the concerns of farmers at the sharp end of production in Bangladesh.

ECOLOGICAL FARMING

Chemical fertilizers are expensive and at present the returns are poor so some farmers have turned to using organic matter as an alternative fertility strategy. PROSHIKA, a major Bangladeshi NGO with widely based staff throughout the country working at village level, has been strongly promoting this as part of its programme of 'ecological' farming as a better alternative to the current dependency on chemical fertilisers.

The principle of using organic manure is to achieve controlled and rapid cycling of nutrients. This means obtaining organic waste from within the farm or from the local area. It may be from household activities such as raising chickens and livestock to the more extensive use of green manure crops grown either in rotation in the field or on bunds. Given suitable preparation, a compost with high concentrations of nutrients, particularly nitrogen, and low in bulk can be produced quickly. But there are drawbacks. Not all organic waste is easily and quickly broken down into useful compounds and the limited amount of waste available on small farms means that this source is some way from meeting the nitrogen demands of the rice crop. So supplementing with chemical fertilizer is inevitable, particularly when as much as 80% of available nitrogen is being wasted anyway.

Interestingly, tests showed that there was no observable impact of ecological farming on total soil organic matter status. This could be explained by the fact that a large proportion of the total carbon is in chemical forms that are processed over many years in the soil. Measurement of the more active fractions, which turnover in months, did however show differences in some cases. Computer models, developed as part of this research, can predict the changes in the size of these fractions and relate them to nitrogen supply enabling them to be used to evaluate how changes in management may affect soil organic matter and also provide a basis for making recommendations for soil management practices.

But ecological farming has not resulted in a more efficient use of nitrogen. Farms using ecological techniques were found to have similar problems to those using chemical fertilizers, which suggests that there is still considerable scope for improvements in nutrient management in both systems.

IDENTIFYING THE PROBLEM

Although current research has not clarified why there is low physiological efficiency of nitrogen, it has clearly identified the problems. Research is now underway to find a solution. But soil chemistry and rice agronomy are not the only issues that need to be investigated. The ways in which farmers prefer to use their land can also play a crucial role. For instance, farmers commonly remove the surface soil from some of their fields to construct embankments and to make bricks for homesteads. Why do farmers do this when they are well aware that it may affect their farm income? They may have many reasons. Perhaps they perceive that removing poor topsoil will give them access to more fertile layers below. Perhaps soil used for construction has a greater value to them than for growing crops. Whatever the perceptions and the realities, any technical solutions that do not take such farmer preferences into account are unlikely to bring a lasting benefit.

R6750 Modelling soil organic matter transformations and nitrogen availability

R6751 Soil fertility and organic matter dynamics in floodplain rice ecosystems

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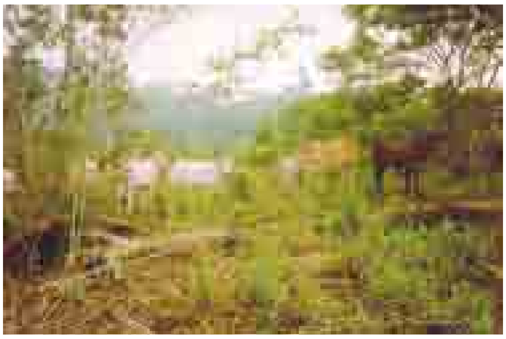
Farming at the frontier

The Amazon basin contains one of the world's great tropical rainforests, covering more than 6 million km^2. The forest frontier is where the disturbance of this forest by people is very evident. Indeed, there has been much publicity in recent years about the felling of trees and land clearance for ranching and farming and the concerns of environmental specialists who are worried about the threats this brings to the conservation of biodiversity in a critically important area. There is no doubt that the area is now vital to the livelihoods of many different rural communities but their welfare and survival depend on maintaining the ecological integrity of the forest fringe as well as producing wood products, livestock and growing crops.

SMALLHOLDER FAMILY FARMS

Eastern Amazonia, Brazil is one of the most dynamic pioneer frontiers. There are major land users; particularly cattle ranchers, indigenous groups and loggers, and these have long been the main focus of attention for promoting conservation and development efforts. But there are also many smallholder family farms in the region as well, that do not receive so much attention even though they have a critical influence on the stability of the frontier. These colonist farmers make up a large proportion of the population but they tend to be economically and socially marginalized, living close to subsistence and dependent on natural resources. Many are not indigenous to Amazonia and have migrated there from other parts of Brazil. So the frontier can be a new and



strange place for them offering a completely different physical, social and economic environment. Migrant families do not have any social ties there, and establishing networks and social infrastructure can take many years. They tend to be isolated and farms are spread widely so that any social interaction and collective action takes a huge effort.

Research and policy development has tended to overlook this important group of people and so a project was set up by the University of East Anglia in collaboration with the Laboratório Sócio-Agronômico do Tocantins (LASAT) of the University of Pará to examine the livelihoods issues of these small farming families who depend on agriculture near receding forest margins. Its aim was to put farmers' own knowledge at the centre of the research and to understand farmers' perceptions of sustainability, including how they use natural resources and view the long term viability of their farming systems and the constraints under which they farm. The outcome would be recommendations for more stable agricultural systems based on that knowledge.

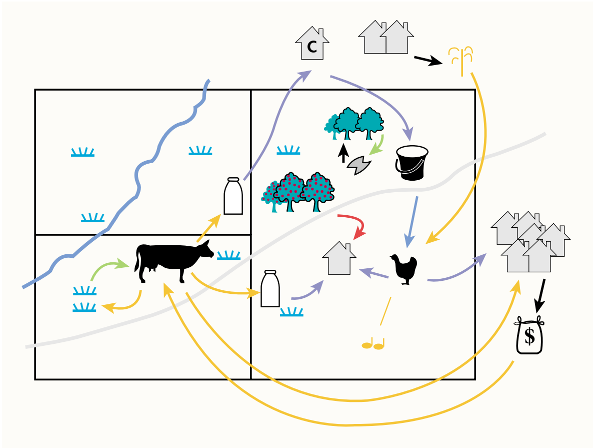
The project centred on Marabá in Pará State in eastern Brazil. In the late 1960s the region, which covers 29,000 km^2, was very isolated and almost completely covered by forest. The economy relied on the extraction of Brazil nuts. Major road developments opened up the area and stimulated the migration of over 20,000 families into the region, reducing the forests by 30%. Some communities (or localities) have now been settled for up to 25 years and although the area is characterised as ‘aging frontier’ the settlements and localities do show a diversity of environmental, social and economic conditions. By monitoring farms in three different localities it was planned to capture a range of different aspects of localities of different ‘ages’ within the region.

HOW FARMS EVOLVE

Small farms at the frontier evolve in similar ways. In the early years they tend to be small areas (up to 3ha) cleared by slash and burn and planted to rice. Forest products also play an important role in family livelihoods at this time. After 4 to 5 years farms tend to grow in size and crops such as cassava, beans and maize are grown mainly for the household but any surplus may be sold. Farmers with more initial capital tend to acquire cattle (10 to 15) and cultivate pasture with some fallow. Some farms develop further and move primarily into pasture with as many as 120 cattle and farmers start to sell cheese and milk. Crops such as cassava and rice are grown for subsistence. The effect of all this is to reduce the forest area each year as more land is claimed for farming and this brings into question the sustainability of this farming system.

FARMER KNOWLEDGE OF THE FRONTIER

When farmers are new to the region, it is often assumed that they have very little knowledge of the environment at the frontier and that they attach little or no value to the natural environment, including the forests. Investigations were made of farmers’ knowledge of the ecological processes and features on their farms and in their neighbourhoods, and how they perceived long-term stable agriculture.



One way in which this was done was to ask them to draw up diagrams of the nutrient and resource flows on their farms (see diagram).

The diagrams, drawn by farmers, showed very diversified systems of managing their pastures and farmers’ knowledge of soil characteristics, including sub-surface features. Generally, farmers were found to have very detailed knowledge of environmental resources, but their knowledge of processes and functions underlying systems was very patchy. This was not unexpected and conforms to the way in which most people develop their knowledge of ecology. Their perceptions of changes in soil fertility were related to the length of time that they had been settled and is closely linked to the presence of the forest. Overall, the majority of farmers believed they would not be able to sustain cropping in the future, and as forest and fallow become scarce the most feasible option will be for them to move to other areas. Farmers were more optimistic about pasture, with the key to long-term sustainability being weed control.

Most surprising was the amount of knowledge farmers had about forests and the utilisation of large numbers of useful tree species by even relatively recent migrants. This is contrary to much received wisdom which assumes colonists see no value in forests and are only interested in cutting them down to make way for other land uses.

INDICATORS OF SUSTAINABILITY

The results of monitoring different farms over a period of more than a year enabled a set of indicators of sustainability at farm level and at locality level to be identified. At farm level these were:

- **Forest cover:** forest acts as a nutrient bank, maintains ecological functions and biodiversity, a source of food and income, a natural buffer against fire or diseases.
- **Income:** a good indicator of family wellbeing, particularly when comparing farms within the same locality.
- **Agro-diversity:** represents different sources of food, income, flexible labour demand and safeguard to oscillations in prices and productions levels
- **Pasture quality:** an indicator of long-term productivity.

PASTURE IS A CRITICAL COMPONENT

From these indicators emerged a number of different patterns of sustainability. When these were coupled with community level factors the strategies that had potential for success in terms of providing secure livelihoods for smallholders became apparent. The most critical component was pasture quality. Three patterns of pasture use were identified:

- Farms with few paddocks, minimum rotation, low stocking rates, excess biomass production compared to consumption.
- Farms with 3 to 4 paddocks, one closest to house is used heavily, the others less frequently. Overall farm produces more forage than is needed. Pastures closest to house are in better condition.
- Farms characterised by high stocking rates, generally paddocks overused. Pasture quality improved using fire for weed control. Results are very dependant on farm management.

Contrary to received wisdom a major problem with pasture management is under-utilisation. Low stocking rates result in the accumulation of dry matter and increased weeds, which then makes the use of fire necessary for weed clearance. Under such conditions pasture becomes less productive. With more intensive management, improved forage and better planned rotations, farmers could save labour and land.

DISPELLING MYTHS

Valuable information gathered from this work has helped to dispel some prevailing myths about the development of the frontier in Amazonia. Smallholders do value forest resources, both for the useful products it produces and for the ecological services of forests, which means they have incentives to conserve forest on their farms. Farmers' learn quickly about the new environment at the frontier and adapt their practices accordingly. However, improvements in frontier farming systems are needed which take into account the constraints faced by smallholders so that they can move towards more sustainable practices. Mixed systems, incorporating livestock, cropping, fallow and forest can be made more stable and help farmers put down roots and invest in the environmental, social and physical infrastructure in these rapidly changing localities.

R6675 – Modelling the sustainability of frontier farming at the forest fringe, Brazil

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Improving fallows?

Sub-Saharan Africa is the only region in the world where the number of poor people has been increasing in the past decade. Most of the poor live in the rural areas because of the lack of job opportunities in the towns and this can

Fallows can improve soil fertility and at the same time produce a useful crop

put great pressure on the land and its productivity. In western Kenya the land and the climate are very favourable for agriculture with good annual rainfall (1200-1800 mm) and two cropping seasons. As a consequence the population density is high and landholdings are small and many men are now migrating to the towns to seek employment leaving wives and children behind to look after the farm. Pressure on the land has led to continuous cropping of basic food crops such maize and beans and yields are low and declining. The soils generally have good physical structure but lack important plant nutrients. Phosphorus in particular is limited and low levels of nitrogen and potassium also add to the problem. Use of chemical fertilisers can correct this situation but their high cost puts them beyond the reach of many farmers.

FALLOWS BENEFITS ARE NOT OBVIOUS

To help solve the fertility problem some farmers leave land fallow for a period of 9 to 15 months. This practice allows the land to 'recover' naturally with a covering of broad-leaved weeds and grasses. But there are serious doubts about the use of such fallows because the benefits are not so obvious. Farmers and researchers are now asking, if fallow periods are necessary, are there ways in which they can be better managed to improve soil fertility and at the same time produce a useful crop rather than just letting valuable land stand idle.

IMPROVING FALLOWS

A research project, undertaken by Wye College in association with two Kenyan research institutes and the international research centre, ICRAF, has investigated ways of improving fallows by planting fast-growing tree or shrub legume species like *Sesbania sesban* and *Crotalaria grahamiana*, which can significantly improve soil condition and fertility in a short time. Such species have become a central agroforestry technology for soil management with a high adoption potential among smallholder farmers in western Kenya. It so happens that these farmers have a long history of growing and using sesbania's wood products and so this tree was readily accepted. Other leguminous shrub species such as pigeon pea and tephrosia and some low growing forage species such as siratro were also investigated.

Experiments have shown that improving fallows over short periods of 6-12 months can increase the yield of subsequent maize crops by

1-3 t/ha in the first season when compared with continuous maize cropping or natural weed fallows. The main benefit from the improved fallows comes from enriching soil fertility through the process of biological nitrogen fixation. In this process the plant forms a symbiosis with a soil bacteria called *Rhizobium*, which is able to transform nitrogen from the air into chemical forms that the plant can assimilate. Plants that are effectively fixing nitrogen can be identified by the appearance of nodules on their roots. Actively fixing nodules have a pinkish interior colour. Additionally sesbania fallows have a very deep root system that effectively captures mineral nitrogen leached below the crop-rooting zone. This leads to a better recycling of nitrogen and reduced nutrient losses. The inputs from nitrogen fixation and deep soil nitrogen capture provide sufficient for the subsequent maize crop without the need for any nitrogen fertilizer to be added.

In addition to increases in fertility, improved fallows also increase soil organic matter, which improves water holding capacity and soil structure, making the soil noticeably easier to till. There is also less soil erosion because the soil surface is not directly exposed to the rain, particularly with the dense growth of crotalaria.

BENEFIT FROM MIXED SPECIES

But why is it necessary to mix species? There are several good reasons for this. Improved single species fallows might fail due to adverse weather conditions (drought, or water logging) or establishment failure (poor seed quality or lack of proper seed pre-treatment). In mixed species fallows, the more resistant species can compensate for the low yield or failure of the susceptible species. Sesbania fallows produce a large proportion of wood (80% of biomass), which is very much appreciated by farmers

who are short of firewood. However, the partitioning of resources into wood leads to a lower amount of foliage returned to the soil and this in turn leads to the removal of fixed nitrogen from the farm. This can be as much as 30%. But mixing sesbania with crotalaria can result in both the benefit of wood and also a large production of foliage biomass that returns to the soil.

The tall sesbania with an open canopy mixes well with the lower but dense growing crotalaria and this can lead to a better use of available light and the development of the sesbania's deep root system which can then exploit the deeper subsoil mineral nitrogen. In fallows where siratro was sown under sesbania, pigeon pea and tephrosia, larger yields were observed. Mixing species of different leaf qualities and decomposition rates may reduce nitrogen losses and extend the time of residual effect and hence the overall soil fertility benefit.

But the introduction of new species can also lead to a build up of new pests. Caterpillar attacks were observed on crotalaria and both sesbania and tephrosia were hosts for root-knot nematodes. These are serious pests that can also attack common beans, a popular local food crop, and so recommendations were made to avoid beans in the first season after the fallows. But in general mixed species fallows are less susceptible to such problems and so increasing the biodiversity is seen as an essential component for sustaining the production system.

NEW GUIDELINES

There is no one single answer to the question – which is the best improved fallow to use? It depends very much on what the farmer wants to achieve. Some examples of improved fallows for different farm strategies are shown in the table.

The recommended minimum duration is about 9 months with larger yield benefits obtained for longer duration fallows. The costs of fallow establishment and loss of a maize crop are

DESIRED OUTCOME	SPECIES MIX
Improving soil nitrogen, including recycling from deep soil, high inputs from biological nitrogen fixation and fuelwood production	sesbania + crotalaria
Producing maximum fallow biomass and fodder	sesbania + siratro
Producing a food crop during the fallow period	sesbania + groundnut or pigeon pea + groundnut (both pigeon pea & groundnut produce edible seeds)

offset by the increased grain yield after the fallow, reduced labour and potential savings in nitrogen fertilizer.

The table below shows the increase in maize grain yield and economic benefit over yield of continuous maize following improved fallows.

UPTAKE

Evidence so far suggests that poorer farmers (both men and women) are taking advantage of improved fallows to improve soil fertility. The

SPECIES	BY-PRODUCT (t/ha)	INCREASE IN MAIZE GRAIN YIELD AFTER FALLOW (t/ha)		ECONOMIC BENEFIT Ksh/ha FOR 3 SEASONS
		YEAR 1	YEARS 2-4	
Sesbania + crotalaria	wood 4-10	1-3	0.5-1	15000
Sesbania + siratro	fodder 1-4	1-3	0.5-1	20000
Sesbania + groundnut	groundnut 0.2	1-2	0.5-1	23000

fact that women farmers are adopting the new practices is important because of the large number of female-headed households in western Kenya.

ONE IMPORTANT OBSTACLE REMAINS

But in spite of all the advances that have been made, one important obstacle remains. The question of how to markedly increase phosphorus (P) and potassium (K) in the soil. Natural ways of doing this take a relatively long time and without these important nutrients the benefits of improved nitrogen cannot be fully realised. To overcome the natural deficiency of P and K in the acid soils of south western

Kenya, the present recommendation for a maize crop is to apply a relatively large amount of chemical fertiliser (equivalent to 50 kg P/ha and 50kg K/ha). But this is expensive. So the challenge still remains; to find affordable ways by which poor farmers can improve the productivity of their farming activities. This should include new ways to manage the soils of their farms for maize production but should also aim to explore other agriculture-related options that could benefit their livelihoods.

R7056 Nutrient sourcing and soil organic matter dynamics in mixed-species fallows

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Urban waste – a challenge for policy makers

Solid waste is a major headache for most towns and cities throughout the world. The collection of refuse from households, commercial properties, markets and street sweepings is just one problem, what to do with it once it has been collected is another. In the developed world legislation and its enforcement has seen the disposal of most municipal waste into sanitary landfill sites and incinerators, and the setting up of specialist treatment facilities that can separate waste into useable and economically viable products. But in the developing world the dumping of solid wastes on the outskirts of towns and cities continues and is becoming a serious hazard both to the environment and to public health. Even legislation cannot help, as there is often a lack of an effective administration, willingness and resources to implement it.

WASTE NEED NOT BE A PROBLEM

But solid waste need not always be a problem. It can provide substantial benefits for some. In most developing countries, municipal waste has a high organic matter content and is a valuable nutrient and soil ameliorative resource for farmers. Around the Indian twin-city of Hubli-Dharwad, farmers have used municipal solid waste for many years as a soil conditioner. The waste is taken to one of the two dumpsites on the outskirts of the city and some is sold to farmers for an agreed price. Dharwad dumpsite consists of 372 pits and, until 1997, under the management of the local authority, a number of pits would be auctioned off to farmers each year. This was an ideal way of getting rid of waste. But the auction system has not been used since 1997 because of a lack of dumpsite staff to prepare the pits. Farmers can still buy waste though on a more ad hoc basis, by approaching the managers of the dumpsites to buy a tractor load or more. Increases in contamination from plastic and glass and rising labour and transport costs have, however, reduced demand, particularly by smaller farmers and those from villages more distant from the city. So what are the ways forward that can benefit both small farmers and the municipality?

There is a growing awareness of the problems faced by small farmers who rely on organic urban waste

Very little research has been undertaken into how collection, disposal and treatment of urban waste can benefit small farmers. Interestingly, farmers are not usually considered as stakeholders when such issues are being examined. To improve knowledge and understanding a project was set up to examine these issues in and around Hubli-Dharwad. It focused on the present and past use of urban waste as a compost by near-urban farmers and used on-farm trials to pilot test the use of sorted and treated waste with the aim of generating information to feed into future policy recommendations.

BUYING MUNICIPAL WASTE

Following a Supreme Court ruling in 1997, allowing municipalities to lease land to firms for waste treatment activities and to allow experimental trials to take place, Hubli-Dharwad Municipal Corporation decided to put the provision of waste treatment facilities out to private tender. The winning company now produces high quality compost, which is a mixture of waste and animal manure. But the cost of this is much greater and although farmers are buying it, they tend to be the wealthier commercial growers who rely on cash cropping. These tend to be in other parts the State and in neighbouring States. This is potentially a source of future conflict with poorer, local farmers who cannot afford the high quality product but rely on buying waste from the same source. At present there is plenty for everyone as commercial production is on a relatively small scale. But if this increases, shortages will inevitably arise and important decisions will have to be made about how waste is to be sold and at what price.

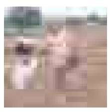
IN THE VILLAGE

Farmers on the edge of cities grow a varied mixture of crops. Rice is one of the staple crops with potatoes, groundnuts and mungbeans grown for both local consumption and for cash. Soils too are varied and solid waste is only used on land to the east of the city, where there are heavy black vertic soils, which benefit from improved workability.

Municipal waste is not generally used on the red alfisols, to the west of the city, as the soils have less need for amendments to improve workability and many of the crops grown on these soils are for subsistence and local markets. Accessibility of the dumpsites is also a factor.

One farmer has used municipal waste for over 20 years to grow potatoes and he believes it is deteriorating in quality. The high level of contamination in the waste from plastics, glass and hospital materials now means that he has to employ seven labourers per load to help him separate out the organic matter on his farm. He pays Rs30 for a load of waste, Rs200 per load for tractor hire and Rs60 per load for labour. He used to hire labourers to separate waste at Dharwad dumpsite and load it onto tractors but the higher level of contamination means that this is not economically viable any longer. The result is higher costs and contaminated waste piling up on his farm.

In one village were urban waste has been used for many years, waste pickers go to the fields and take out plastic which was not sorted before spreading. Some farmers, with their own vehicles, have even started to collect waste directly from houses and roads to avoid contamination.



Chemical fertilizers can compensate for reductions in compost but farmers are reluctant to use them. They feel that the soil can become too adjusted to chemical fertilizers, making the soil 'hard'. When mixed with urban waste, however, they believe that fertility improves, the soil becomes more 'soft' and more moisture is retained. Farmers say they would buy more if the quality improved even though it may be more expensive. Many were concerned about the private sector role and sought reassurance from the local authority that access to waste by farmers would continue.

ON FARM TRIALS

Part of the research programme involved field trials. Four villages where involved in this participatory research which first explored people's preferences regarding soil amendments and then identified potential small farmers to take part in on-farm trials. These were set up to examine four treatments, namely, sorted waste on its own, waste mixed with distillery sludge, waste mixed with cow dung and vermiculture (worms) and waste mixed with night soil. The selection of these treatments came from previous composting trials and on comments made by farmers at a stakeholder workshop. The results were ranked in their effects, so as to avoid the problems of obtaining quantitative results from plot experiments on real farms on a limited time scale and budget. In broad terms:

- The results supported the use of waste as a soil amendment, although analysis of the waste-derived composts did not point to any one as the best.
- The waste-nightsoil compost performed best in the trials based more on its role as a soil amendment rather than its nutrient analysis. This compost does, however, pose potential health risks.
- Many farmers preferred organic soil amendments to artificial fertilisers. Their residual effects last longer and they are better for soil structure and moisture retention.
- Farmers are concerned about the availability of animal manure. Mechanisation on farms is causing a decline in the number of draught animals.

CHANGING WASTE POLICY MEASURES

The issues involved in this research go well beyond on-farm agronomic trials and touch on many aspects of the waste management cycle from collection to disposal as a soil amendment. It is a complex socio-economic problem as well as a technical one but there are important

conclusions that can be drawn from the work. The most important outcome is the growing awareness in Hubli-Dharwad that near-urban farmers, who rely on organic urban waste, may lose out by being ignored as new waste policy measures are developed.

Many cities in the developing world have undertaken initiatives to increase the use of urban organic wastes in farming. But they have often failed to take account of existing users of wastes and the high quality products that usually result have tended to be too expensive for small farmers. Hubli-Dharwad may be unusual in that local farmers still use urban wastes, but increasing labour and transport costs, as well as the increasing contamination of municipal waste, are reducing this use. If access to organic urban waste is to be a means of alleviating poverty through increased agricultural productivity, then policy interventions will need to be well informed about all the users and carefully targeted to overcome the main problems that have been identified.

R7099 Improved utilisation of urban waste by near-urban farmers in the Hubli-Dharwad city region, India

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Hillside farming - living at the margin

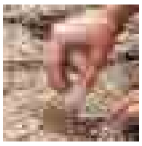
People living on hillsides, vulnerable to the impacts of soil erosion and land degradation are literally living 'at the margin' of society, environment and economic opportunities. They must learn to face an uncertain future brought about by the rapid loss of soil and depleted soil fertility which reduce both crop yields and the quality of grazing land and incur costly remedial actions. The farmers' remedy has often been to move out and so transfer the problems elsewhere; either to degrade more hillsides, or to swell the numbers of landless labourers or to inhabit urban slums. But governments and environmentalists usually try and keep people on their farms by promoting soil conservation techniques. Yet, worldwide from highland Mexico, to the Rif Mountains of Morocco and on to upland Java, most hillside dwellers ignore this option, preferring to seek a better living elsewhere.

There is no doubt that hillside farming can be practised safely when appropriate land use and conservation techniques are used. In Sri Lanka, the Kandy home gardens are renowned for their multi-storey cropping and intensive production, sustained over many centuries. In Bolivia, at over 3000 m above sea level, traditional native American potato and cereal production methods still rely on stonewalls to retain precious topsoil and produce reasonable crops. So the doomsday predictions of bare, eroded hillsides and poverty-stricken peasants seeking a meagre living there need not be a reality. The technical solutions are available but why do farmers in some places take them up and use them successfully while in others they just continue to abandon their farms to soil erosion and move on?

KEEPING PEOPLE ON HILLSIDES

At the heart of the answer to this important question lies the relative economic advantage of staying or going. Farmers have three possible choices, (1) stay on the hillside and suffer the impacts of erosion (2) stay but invest time, labour and capital in building conservation measures or (3) quit the hillside altogether.

If professionals were able to evaluate the relative economic and financial merits of hillside farming strategies, then governments could



promote the most likely measures leading both to supporting poor hillside dwellers and to maintaining a sustainable environment (see diagram). This goal does, however, raise problems of measurement and assessment. How can the evidence of erosion in the field be accurately and rapidly quantified to obtain a biophysical assessment of loss? How can the value of the soil that has been lost best be estimated? What valuation approach represents farmers' perspectives, and hence the way they are likely to judge the benefit of staying on the land and undertaking conservation?

GAINING A FARMER-PERSPECTIVE

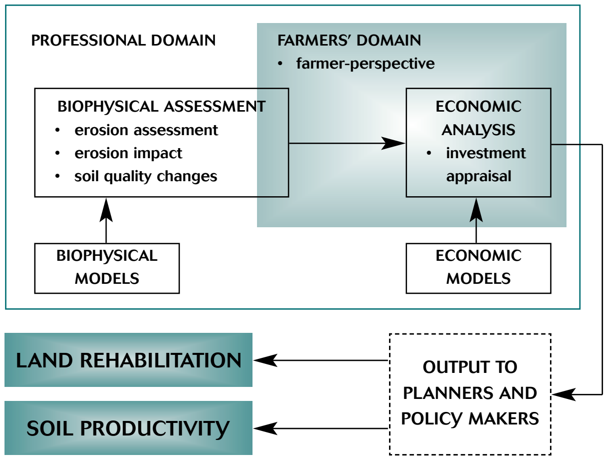
> "When I first came to the land, I got 6 to 7 gunny bags of carrots. After three years, 3 to 4 bags; and after six years only one bag. The land was then 'finished'. But with these hedges, I get up to 8 bags every year."
>
> Sri Lankan hill farmer

Sri Lankan hill farmers have particular ways of understanding and describing their situation. A detailed case study was made in partnership with a group of 50 farmers who cultivate land sloping up to 70%. Traditionally, the hills were used for millet and sesame production in a shifting cultivation system. Now, with changing market opportunities, most of the slopes are used for vegetable production such as carrots and Japanese radish.

From long involvement with their land, farmers described how they noticed more stones, soil "with no fertilizer" (i.e. no natural fertility), shallow soils and, above all, soils that produce poorer crops than before. Capturing these indicators and giving them meaning in the same quantitative terms the farmers use, exercised much of the fieldwork. A set of field biophysical assessment techniques was developed, so that field professionals could rapidly note indicators with the assistance of farmers. Techniques included:

- Depth of small surface stones or 'armour layer technique' – where fine soil has been washed away leaving a stony residue.
- Height of soil pedestals – where small capping stones protect a column of soil.
- Tree mounds – the protected remnant of original soil.
- Build-up of soil against barriers, such as field boundary walls.

Farmers who had built conservation structures provided particular interest. What triggered the construction? Usually, it was a great reliance on production from their own land. Those who had jobs elsewhere were far less likely to invest effort in maintaining the land quality. A corresponding set of production constraint indicators was developed in order to gain financial and economic data that, again, reflected the values that farmers place on allowing soil to erode or investing effort to keep it on the hillside. This led the research to seek how best to value that soil – both that lost to erosion and that retained by conservation structures - from the perspective of the farmers.



VALUING THE SOIL

Using the biophysical and financial information, three valuation approaches were tested to see which reflected the actual decisions farmers made.

Resource value or replacement cost approach

This quantifies the value of soil in terms of the cost of the nutrients if they had to be bought on the market as fertilizer. Usually only the macro-nutrients, nitrogen (N), phosphorus (P) and potassium (K) are considered. For valuing both erosion and conservation, this is an excessively artificial approach. Nutrients lost by erosion or kept by conservation structures are not necessarily of use to plants – indeed much N and P never becomes available. This approach, though by far the most common in other studies, gives very high economic values and very poor applicability to real farming conditions. It does partially reflect the very long-term sustainability of using the soil resources, and would be of more interest to wider society than to individual farmers.

Production value approach

This captures the changes in yield as a result of erosion (negative) or conservation (positive). From the case study, the changing yields were assessed from farmers' records as well as direct field observation. This approach gave more realistic values. However, there was always a

problem of gaining good quality data. In addition, there are many factors other than erosion that control yields. Nevertheless, production value can be a reasonable proxy measure for some cases. But it is probably more appropriate for intensive commercial farming situations than smallholder farmers on steep slopes.

Investment appraisal approach

Especially for evaluating the viability of conservation technologies, this approach best reflects decisions made at household level. It assesses factors important to land users both positive and negative, such as production changes, loss of planting area by the conservation structure, multiple uses of hedges, type and intensity of labour for construction and maintenance, and effect on other farming or income-generating activities. It brings them together in a simple financial cost-benefit framework at the level of the farming household and helps in making decisions about whether or not to invest in a new activity such as building a stone-faced terrace.

USING THE INFORMATION

The output of this project comprises a set of tested methodologies to assess the impact of soil erosion and the benefits of conservation from the perspective of resource-poor land users. Firstly, there are biophysical tools to assess rates of soil loss, the technical effectiveness of conservation, and the impact of erosion processes on crop production. Secondly, there is the investment appraisal approach, which uses this biophysical information and captures the complex interactions between land degradation and the livelihood security of poor people.

These methodologies, developed in Sri Lanka have now been used in an entirely different setting in Bolivia. Local field professionals applied them to promote conservation technologies that could be calculated to have real and tangible benefits to high-altitude hillside farmers. One Bolivian commented that he had not appreciated how economically costly many of the current conservation recommendations are to small farmers. Alternative, simple vegetative techniques, as well as the use of stonewalls and stone boundaries, were shown to be profitable for most households.

The United Nations Environment Programme and the Global Environment Facility in Washington DC have also applied the evaluation techniques to some of their demonstration sites of good practice in the management of biodiversity, showing that where erosion is effectively controlled, farmers are also living more secure lives as well as protecting their local environment – a true win-win situation, that needs now to be replicated to other hillsides and societies.

Land Degradation – Guidelines for Field Assessment

Available as a CD-ROM from
Michael Stocking and on the Internet at
www.unu.edu/env/plec/l-degrade/index-toc.html

R6525 Methods of economic and environmental assessment of the on-site impacts of soil erosion and conservation – a case study of smallholder agriculture, Sri Lanka and Bolivia

Michael Stocking
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Herath Manthrithilake
Environment & Forrest Conservation Div
Mahaweli Authority
Kandy, Sri Lanka

LIST OF NRSP PROJECTS

Forest Agriculture Interface (FAI)

Output 1 Planning strategies to sustain livelihoods of poor people dependent on forests adjacent to croplands developed and promoted

R6778 Community forestry: sustainability and impacts on common and private resources, Nepal
John Soussan
University of Leeds,
Natural Resources Institute (NRI),
Nepal-UK Community Forestry Project (NUKCFP) and Pakribas Agricultural Centre Nepal
Start date: Jan 1997 End date: Dec 1999

R7514 Development of process and indicators for forest management, Nepal
Yam Malla
Agricultural Extension and Rural Development Dept (AERDD) University of Reading, Centre for Natural Resources and Development University of Oxford, NUKCFP
Start date: Jan 2000 End date: Mar 2001

Output 2 Strategies to secure the livelihoods of poor people dependent on agricultural systems near the receding forest margin developed and promoted

R6675 Modelling the sustainability of frontier farming at the forest fringe, Brazil
Katrina Brown
Overseas Development Group (ODG) University of East Anglia, Laboratório Socio-Agronomico do Tocantins Universidade Federal do Pará
Start date: Sep 1996 End date: Aug 1999

R6789 Water and soil management
David Jackson
NRI, Crop Research Institute, Soil Research Institute Ghana Council for Scientific and Industrial Research Ghana, National Agricultural Research Programme Ghana
Start date: Jan 1997 End date: Jul 2000

R7446 Shortened bush fallow rotations for sustainable livelihoods, Ghana
Morag McDonald
University of Wales Bangor, Forestry Research Institute Ghana (FORIG), Ministry of Food and Agriculture (MOFA) Ghana, Ghana Organic Agriculture Network (GOAN), International Institute of Tropical Agriculture (IITA) Nigeria
Start date: Dec 1999 End date: Nov 2002

R7515 Knowledge dissemination domains in the forest agriculture interface
James Sumberg
ODG University of East Anglia
Start date: Mar 2000 End date: Feb 2002

R7516 Bridging knowledge gaps between soils research and dissemination, Ghana
Fergus Sinclair
University of Wales Bangor, FORIG, GOAN, IITA
Start date: Jan 2000 End date: Jun 2001

R7560 Review of technologies being evaluated for the forest agriculture interface
Robin Matthews
Cranfield University, Reading University, University of Science and Technology Kumasi Ghana, Nepal Agricultural Research Council
Start date: Feb 2000 End date: Mar 2001

R7577 Environmental policies and livelihoods in the forest margins, Brazil and Ghana
Steve Wiggins
Reading University, Crops Research Institute Ghana, Programme Poverty and environment in Amazonia (POEMA), Univeristário do Guamá Brazil
Start date: Mar 2000 End date: Sep 2001

High Potential (HP)

Output 1 A suite of integrated management strategies offering improved and sustainable benefits to the poor developed and promoted

(a) Irrigated
R6748 Participatory crop improvement in high potential production systems, India and Nepal
John Witcombe
Centre for Arid Zone Studies (CAZS) University of Wales Bangor, Overseas Development Institute UK, Krishak Bharati Cooperative Ltd (KRIBHCO), Western India Rainfed Farming Project, Local Initiatives in Biodiversity Research and Development (LIBIRD) Nepal, Steve Jones Associates UK
Start date: Oct 1996 End date: Jan 2000

R6750 Modelling soil organic matter transformations and nitrogen availability
John Gaunt
Institute of Arable Crops Research (IACR) Rothamsted, AAT Consultants, International Rice Research Institute (IRRI) Philippines
Start date: Nov 1996 End date: Mar 2000

R6751 Soil fertility and organic matter dynamics in floodplain rice ecosystems
Joe Rother
NRI, IACR-Rothamsted, PROSHIKA Bangladesh NGO, Dhaka University Bangladesh
Start date: Nov 1996 End date: Mar 2000

R6755 Sustainable local water resource management – meeting needs and resolving conflicts, Bangladesh
John Soussan
University of Leeds, Bangladesh Centre for Advanced Studies (BCAS) Bangladesh
Start date: Jan 1997 End date: Dec 1999

R7583 Improved livelihoods - Bihar and Uttar Pradesh
John Gaunt
IACR-Rothamsted, Silsoe Research Institute (SRI), University of East Anglia (UEA), Dept of Water Management Research (DWMR) India, International Water Management Institute (IWMI) Sri Lanka
Start date: Mar 2000 End date: May 2000

R7600 An assessment of strategies for integrated crop management
John Gaunt
IACR-Rothamsted, NRI, AERDD Reading University, PROSHIKA Bangladesh
Start date: Mar 2000 End date: May 2000

(b) Rainfed
R6731 Manure management – collection, storage and composting strategies to enhance organic fertiliser quality
Jon Tanner
Henry Doubleday Research Association, International Livestock Research Institute Kenya, Kenya Agricultural Research Institute (KARI)
Start date: Nov 1996 End date: Oct 1999

R6759 Integration of aquaculture into the farming systems in the eastern plateau, India
James Muir
Institute of Aquaculture, University of Stirling, East India Rainfed Farming Project (KRIBP-E), Central Institute for Freshwater Aquaculture (CIFA) India
Start date: Nov 1996 End date: Oct 2000

R7056 Nutrient sourcing and soil organic matter dynamics in mixed-species fallows
George Cadisch
Wye College University of London, Kenya Forestry Research Institute (KEFRI), International Centre for Research on Agroforestry (ICRAF) Kenya
Start date: Dec 1997 End date: Nov 2000

R7407 Assessment of current needs and researchable constraints of resource poor farmers and landless labourers in high potential production systems, Kenya
Paul Smith
CAZS University of Wales Bangor, Participatory Methodologies Forum of Kenya and KARI Regional Research Centre Kakamega Kenya
Start date: Oct 1999 End date: Mar 2000

PROJECTS

Output 2 Efficient systems for the provision of rural services to the poor developed and promoted

R7180 Options for use of power tillers and draught animals for primary cultivation on small farms, Bangladesh
Martin Adam
NRI, Bangladesh Agricultural University (BAU) Mymensingh
Start date: Jun 1998 End date: Oct 2000

R7323 Participatory crop improvement in high potential production system and salt affected areas of Patiala district of Punjab state, India
Sadhu Singh
Malhi Krishi Vigyan Kendra (KVK) Patiala, Punjab Agricultural University (PAU) India, CAZS University of Wales Bangor
Start date: Feb 1999 End date: Jan 2001

Hillsides (HS)

Output 1 Improved hillside farming strategies relevant to the needs of marginal farmers developed and promoted

R6525 Methods of economic and environmental assessment of the on-site impacts of soil erosion and conservation – a case study of small-holder agriculture
Michael Stocking
ODG University of East Anglia, Environment and Conservation Division Mahaweli Authority Sri Lanka
Start date: Apr 1996 End date: Oct 1999

R6621 Strategies for improved soil and water conservation practices in hillside production systems in the Andean valleys, Bolivia
Brian Sims
SRI, Cranfield University, Universidad Mayor de San Simon (UMSS), Centro de Investigacion de Agricultura Tropical (CIAT) Bolivia
Start date: Aug 1996 End date: Sep 1999

R6638 Participatory improvement of soil and water conservation practices in hillside production systems in the Andean Valleys, Bolivia
Anna Lawrence
AERDD Reading University, SRI, CIAT Bolivia, Department of Participatory Research and Development Nur University Bolivia
Start date: Oct 1996 End date: Dec 1999

R6757 Soil fertility management for sustainable hillside farming systems, Nepal
Peter Gregory
Dept of Soil Science Reading University, IACR Rothamsted, Agricultural Research Station Lumle (ARSL) and Pakhribas Agricultural Research Centre Nepal
Start date: Jan 1997 End date: Dec 1999

R7412 Incorporation of local knowledge into soil and water management interventions, which minimise nutrient losses in the middle hills, Nepal
Morag McDonald
University of Wales Bangor, Oxford University, Institute of Terrestrial Ecology (ITE), Royal Geographical Society (RGS), ARSL and LIBIRD Nepal
Start date: Oct 1999 End date: Sep 2002

R7517 Bridging research and development in soil fertility management: Practical approaches and tools for local farmers and professionals in the Ugandan hillsides
John McDonagh
ODG University of East Anglia, National Agricultural Research Organization Uganda, Mount Elgon Conservation and Development Project, Dept of Soil Science Makerere University, CIAT/TSBF Uganda
Start date: Feb 2000 End date: Jan 2003

R7536 Biophysical and socio-economic tools for assessing soil fertility
Jim Ellis-Jones
Silsoe Research Institute, Cranfield University, Reading University, Bhaba Tripathi, ARSL, Nepal Agricultural Research Council (NARC) Nepal
Start date: Apr 2000 End date: Mar 2003

R7584 Community-led tools for enhancing production and conserving resources
David Preston
University of Leeds, Accion Cultural Loyola (ACLO), Tarija, PROMETA Bolivia
Start date: Feb 2000 End date: Jan 2003

Land Water Interface (LWI)

Output 1 Improved resource-use strategies in coastal zone production systems developed and promoted

R6783 Ecological and social impacts in planning Caribbean marine reserves
Nicholas Polunin
University of Newcastle, University of Durham, Centre for Marine Sciences, UWI Jamaica
Start date: Jan 1997 End date: Jul 1999

R6919 Evaluating trade-offs between users in marine protected areas in the Caribbean
Katrina Brown
ODG and Centre for Social and Economic Research on the Global Environment (CSERGE) University of East Anglia, Department of Zoology, University of West Indies (UWI), Trinidad, Buccoo Reef Marine Park (BRMP) Trinidad, Ministry of Agriculture Land and Fisheries Government of Trinidad and Tobago
Start date: May 1997 End date: Jun 1999

R7245 Integrated lagoon management in coastal Ghana: a participatory approach
Einir Young
CAZS University of Wales Bangor, Centre for Overseas Research and Development (CORD) University of Durham, Water Resources Institute (WRI) and Soil Research Institute Ghana, Dept of Geography and Dept of Crop Science University of Ghana
Start date: Aug 1998 End date: Sep 1999

R7408 Building consensus amongst stakeholders for management of natural resources at the land-water interface
Katrina Brown
ODG and CSERGE University of East Anglia, Dept of Life Sciences UWI Trinidad, Department of Marine Resources and Fisheries Tobago House of Assembly Tobago
Start date: Jul 1999 End date: Feb 2001

R7559 Improving coastal livelihoods in the Caribbean: institutional and technical options
Yves Renard
Caribbean Natural Resources Institute (CANARI) St Lucia, Institute of Development Studies (IDS) University of Sussex
Start date: Jan 2000 End date: Dec 2002

Output 2 Improved resource-use strategies in floodplain production systems developed and promoted

R6756 Investigation of livelihood strategies and resource use patterns in floodplain production systems based on rice and fish, Bangladesh
Julian Barr
CLUWRR and Dept of Agricultural and Environmental Science University of Newcastle, CORD University of Durham, Institute of Aquaculture University of Stirling, Centre for Environmental Research, University of Rajshahi Bangladesh, Farming Systems and Environmental Studies Unit Bangladesh Agricultural University (BAU), Rice Farming Systems Division, Bangladesh Rice Research Institute (BRRI)
Start date: Nov 1996 End date: Feb 2000

R7562 Methods for consensus building for management of common property resources
Julian Barr
Centre for Land Use and Water Resources Research (CLUWRR) University of Newcastle, Dept of Anthropology University of Durham, Centre for Economics and Management of Aquatic Resources University of Portsmouth, Centre for Natural Resources Studies, CARITAS and Banchte Shekha Bangladesh, International Centre for Living Aquatic Resources Management Philippines
Start date: Feb 2000 End date: Mar 2001

Peri-Urban Interface (PUI)

Output 1 Natural resources management strategies for peri-urban areas which benefit the poor developed and promoted

R6799 Natural resources management Kumasi, Ghana
Martin Adam
NRI, University of Nottingham, University of Science and Technology Kumasi Ghana
Start date: Jan 1997 End date: Mar 2001

R6880 Development of methods of peri-urban natural resource information collection, storage, access and management
Giles D'Souza
Geographic Data Support Limited, Cranfield University, Faculty of Applied Science Bath Spa University College, Institute of Renewable Natural Resources University of Science and Technology Kumasi Ghana
Start date: Mar 1997 End date: Feb 2000

R7269 Valuation of peri-urban natural resource productivity
Fiona Nunan
School of Public Policy University of Birmingham, International Institute of Environment and Development (IIED), Dept of Geography Karnataka University India, Institute of Land Management and Development University of Science and Technology Ghana
Start date: Jan 1999 End date: Aug 1999

R7330 Peri-urban natural resources management at the watershed level, Ghana
Duncan McGregor
Centre for Developing Areas Research Royal Holloway University of London, Institute of Renewable Natural Resources University of Science and Technology Kumasi Ghana
Start date: Apr 1999 End date: Mar 2001

R7549 Consolidation of existing knowledge in the peri-urban interface system
Robert Brook
SAFS and CAZS University of Wales Bangor, Development Planning Unit University College London, International Development Department University of Birmingham
Start date: Jan 2000 End date: Mar 2000

Output 2 Strategies to improve the availability of biomass energy resources and their efficient use by peri-urban and urban poor developed

R7099 Improved utilisation of urban waste by near-urban farmers in the Hubli-Dharwad city region, India
Fiona Nunan
School of Public Policy University of Birmingham, CAZS University of Wales Bangor, SDM College of Engineering and Technology India, University of Agricultural Sciences India
Start date: Jan 1998 End date: Dec 1999

R7244 Energy constraints in production systems in peri-urban areas
Rona Wilkinson
Intermediate Technology Consultants Ltd, Kumasi Institute for Technology University of Science and Technology Ghana, EDA Rural Systems India
Start date: Jul 1999 End date: Mar 2000

Output 3 Improved resource management strategies which increase the production of food and commodities in peri-urban areas developed.

No projects in 1999-2000

Semi-Arid (SA)

Output 1 Diverse coping strategies for poor rural households in semi-arid systems developed and promoted

R7545 Coping strategies of poor households in semi-arid Zimbabwe
Andrew Shepherd
International Development Dept School of Public Policy Birmingham University, ITDG UK, ITDG Zimbabwe
Start date: Jan 2000 End date: Aug 2000

R7558 Understanding household coping strategies in semi-arid India
Czech Conroy
NRI, Society for the Promotion of Wastelands Development Gujarat Institute of Development India
Start date: Jan 2000 End date: Aug 2000

Output 2 Strategies for the integrated management of crop and livestock production systems which benefit the poor developed and promoted at the catchment level

R6758 Development of improved cropping systems incorporating rainwater harvesting
John Gowing
CLUWRR, Dept. of Agricultural Engineering Sokoine University of Agriculture and Ukiriguru Agricultural Research Institute Tanzania
Start date: Oct 1996 End date: Nov 1999

R7304 Micro-catchment management and common property resources, Zimbabwe
Bruce Campbell
Institute of Environmental Studies University of Zimbabwe, Dept of Research and Specialist Services (DR&SS) Chiredzi and CARE Zimbabwe, Centre for Ecology and Hydrology Wallingford
Start date: Dec 1998 End date Nov 2001

R7458 Project start-up phase: livelihoods and integrated nutrient management
Jon Tanner
Henry Doubleday Research Association
Start date: Aug 1999 End date Mar 2000

R7537 Demand assessment for technologies for on-farm management of natural resources
Chris Garforth
Reading University, Dept of Agricultural Economics and Extension University of Zimbabwe, Centre for Sustainable Rural Development Sokoine University of Agriculture Tanzania
Start date: Jan 2000 End date: Jul 2000

Output 3 Livelihood strategies based on the sustainable use of common pool resources (including wildlife habitat) developed and promoted

R7150 A synthesis of two case studies of common property resource management where tourism, wildlife and pastoralism interact, Kenya
Viv Lewis
ITDG Kenya
Start date: Apr 1998 End date: Jan 2000

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