NATURAL RESOURCES SYSTEMS PROGRAMME
FINAL TECHNICAL REPORT[1]

R8496 Synthesis of RNRRS knowledge on adaptive capacity to climate change

ANNEX A

Synthesis of RNRRS knowledge on adaptive capacity to climate change

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CONTENTS

Annexes: separate electronic folder

Acronyms

AFG	Aquaculture and Fish Genetics Research [Programme]
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CBO	Community-based Organisation
CIFOR	Centre for International Forestry Research
CGIAR	Consultative Group on International Agricultural Research
COB	Client-oriented Breeding
COP-7	Conference of the Parties
CPP	Crop Protection Programme
CPRs	Common Pool Resources
CRD	Central Research Department [of DFID]
DFID	Department for International Development [UK]
ENSO	El Nino Southern Oscillation
ESCOR	Economic and Social Committee for Research [DFID]
FMS	Fisheries Management Science [Programme]
FRP	Forestry Research Programme
FTR	Final Technical Report
ICM	Integrated Crop Management
ICRAF	International Centre for Research in Agro-Forestry
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IDS	Institute for Development Studies
IIED	International Institute for Environment and Development
IITA	International Institute for Tropical Agriculture
IUCN	World Conservation Union
LPP	Livestock Production Programme
MAS	Molecular Assisted Selection
MDGs	Millennium Development Goals
NGO	Non-Governmental Organisation
NR	Natural Resources
NRPRI	Natural Resources Policy Research Initiative [DFID]
NRSP	Natural Resources Systems Programme
PAPD	Participatory Action Plan Development
PL	Project Leader
PM	Programme Manager
PSP	Plant Sciences Programme
PT	PARCHED-THIRST [Model]
PVS	Participatory Varietal Selection
RNRRS	Renewable Natural Resources Research Strategy
RWH	Rain-water Harvesting
SAPS	Semi-arid Production Systems
SHG	Self-help Group
SUA	Sokoine University of Agriculture
SWMNET	Soil and Water Management Network
UNDP	United Nations Development Programme

Research Lines cited in the text

***Bold** font shows key projects considered in the Line descriptions*
In some Lines, integral linkages with NRIL projects are shown by ZF numbers

Line AFG-1 Enhanced promotion of aquaculture on riverine, floodplain and small basin sites as a means of diversifying and enriching farming systems (R4681, R6721, **R6380Cb,** R7064)

Line AFG-2 Achieving sustainable aquaculture in coastal ecosystems based on carrying capacity criteria (R6011, **R8094**).

Line CPP-1: Improved understanding of migrant pest behaviour and ecology and strengthening institutional capacity for their control in Southern Africa. Armyworm: R6762, R7966; Quelea: R6823, R7967; Brown locust: R7779.

Line CPP-2 Managing risk through development of disease and pest-tolerant varieties: Groundnut (R6811, R7445, R8105); Pigeonpea (R7452, R8205)

Line FMS – 1: Sustainable livelihood strategies from fluctuating fisheries resources and under conditions of environmental change (7336, R7042, R8118; **R8475, R4778J**)

Line FRP-1: Tree species for farm planting and ecological restoration; a compendium for application across a range of conditions (**R7588).**

Line FRP-2: Sustainable agroforestry decisions, adapted to local conditions and species, developed through modelling (FLORES) to maximise water use efficiency and productivity (R5651; **R6348, R7315**, R7635)

Line FRP-3: FLOWS Project Cluster on upper catchment management for optimising water conservation and use under a range of rainfall conditions and land-uses (ZF0167, **R7937**; **ZF0173,** R7991, R8171, R8174, ZF0176)

Line FRP-4: Sustainable community forest management with incentives to provide carbon sequestration services (R6320, **R7274**, R7374, ZF0167; ZF0202)

Line LPP-1: Increasing or enhancing the technical options and economic benefits available to smallholders integrating livestock with crop production (R 4338, R5732, R6153, R6536, R6619, **R7955, R6781**)

Line LPP-2*(a)*: Modelling, understanding and optimising asset management decisions by small-scale livestock keepers (R5183, R6606, R6774, **R6982,** R7823) Annex E

Line LPP-2*(b)*: A modelling approach to optimising decision-making by livestock keepers – the SimSAGS model (**R6984**) Annex D1, D2

Line NRSP-1 (LWI, Bangladesh Suite 3): Promoting integrated floodplain management (IFM) based on rice and fisheries in Bangladesh (R6756, R7868, R8195, R8306)

Line NRSP-2 (LWI, Caribbean Suite 1): Developing livelihood strategies and institutional mechanisms for integrated coastal zone management will enhance preparedness in the event of climate change impacts adding to pressures on the ecosystem (R7408, R7559, R8134, R8317)

Line NRSP-3(a): *A 'dialectic approach' to local institutional development* NRSP-3(a) (R7583, R7830, **R7839**)

Line NRSP-3(b): Information approach to rural service provision for enhanced productivity by poor farmers through integrated crop management, ICM (R7600, **R 8083**)

Line NRSP-3(c) (HP, East Africa, Suite 2): Micro-credit approach to rural service provision for enhanced productivity by poor farmers through integrated crop management, ICM (**R7962**)

Line NRSP-4 (HP, India, Suite 1): Practice and policy changes for promoting aquaculture, as an income enhancing and risk-spreading strategy, in rainfed farming systems in eastern India (R6759, **R8100**)

Line NRSP-5: Achieving democratic and evidence-based governance of natural resources, strengthening the livelihoods of poor people and their capacity to manage the environment sustainably, with potential for managing variability and change (R7577, **R7856,** R7957, **R8258**)

Line NRSP-6 (SAP, East Africa Suite 1): Consolidating and extending the benefits of rainwater harvesting as a strategy for using scarce water more efficiently in crop production, and developing the PARCHED THIRST model for climate change applications (R5170, R5752, **R6758**, **R7888**, R8088A, R8088B, R8116, R8381). Annexes C1, C2

Line NRSP-7. Enabling of NR-based livelihoods in semi-arid areas (R7304, R7537, R7545, R7805, R8192, R6051 & R7093)

Line NRSP-12**:** Effectively communicating improved seasonal weather forecasts to potential users with enhanced capacity to benefit livelihoods (R5156, R5981, R5982, R6712; PD100; PD139). Annexes B1, B2

Line NRSP-13 Diversification strategies adapted to market and environmental risk in peri-urban systems (R7867, R8084, India; R7854, R8090. Ghana)

Line PSP-1: Seed priming (with associated practices) to facilitate more efficient use of constrained rainfall (R6395, **R7438,** R7440, R7540)

Line PSP-2: Participatory Varietal Selection (PVS) and Participatory Plant Breeding (PPB), involving farmers from the outset in selection and testing of improved varieties (R6748, R6826, R7324, **R7657**, R8099).

Line PSP-3: Molecular Assisted Selection (MAS), or the use of molecular markers to improve desired qualities of pearl millet varieties in Africa and India (R6451, R6667, R7375, R7379, R8183)

Details of the research projects referred to in this study may be accessed through the respective programme websites (see page 3)

1 Purpose, approach and method

This study is an analysis of selected RNRRS projects to assemble, develop and promote new knowledge on poor peoples' capacities to adapt to climate change and variability, in order to formulate research questions and guide policy priorities within or outside DFID.

1.1 Purpose and logframe outputs

The Purpose is as follows:

> Capacity of DFID's policy makers and research managers to make evidence-based decisions within DFID's area of comparative advantage on poor peoples' livelihoods under climate change improved through insights from RNRRS programmes.

This statement of purpose may be elaborated as follows:

(1) To select, from the range of current and completed research in the RNRRS programmes, lines that realise or offer potential benefits for planning future research on adaptation to climate change [Climate Change was not included in RNRRS logframes]
(2) To link natural resources research, climate change adaptation and poverty reduction within a developmental framework, for implementation in partnership with national or international institutions and local stakeholders

The project has four outputs:

Output 1: A body of knowledge from RNRRS projects that is specifically relevant to DFID's principled interest in the poor and their capacity to adapt to climate change and its impacts identified
Output 2: Implications for DFID's future research and development policy with regard to adaptation to climate change pinpointed
Output 3: Knowledge gaps identified, and research questions formulated with respect to an appropriate model of natural resource-based livelihood systems under climate change, that capitalise on DFID's comparative advantage
Output 4: Communications effected with stakeholders within constraint imposed by time

1.2 Adapting to what?

In a developmental context in poor countries, climate change may take one or more of the following forms:

- *increasing average temperatures (certain signals) and more frequent extremes:* affecting the tolerance limits of farm, woodland, rangeland and wild plant species, evaporation from water surfaces and evapo-transpiration from plants;

- *lower (but sometimes higher) average rainfall; where lower, more frequent droughts:* affecting plant bio-productivity, increasing yield variability, and stressing dependent animal (and human) populations;
- *changing sub-surface water conditions:* lowering of water tables, increasing costs of extraction and risk of pollution;
- *more frequent storms, extreme flooding events:* risk of landslides, accelerated erosion, inundation, and damage to coastal ecosystems; and
- *rising sea levels:* risk of inundation and coastal damage.

Two implications follow:

(1) Increased variability, chiefly in rainfall amount and distribution, may have negative impacts on any agro-ecosystem, but especially in arid, semi-arid and sub-humid areas with seasonal regimes. In these areas variability is already an accepted risk and a barrier to poverty reduction; any increase may threaten food security and will have a major impact on the livelihoods of very large resident populations.
(2) Long-term changes in temperatures, precipitation and hydrological regimes, though hard to detect at the local scale as they are obscured by short-term variability, pose a cumulative risk to ecosystems on which flora, fauna and human populations depend. If critical thresholds are passed, whole production systems may be threatened and the adaptive challenge correspondingly increased.

Poor people are aware of short-term variability and risk but cannot be expected to be aware of longer term risk of cumulative ecological change (on which scientific uncertainty understandably exists), except where such change can be recalled from memory (e.g., in the Sahel).

The focus of this study, therefore, is on enhancing the management of variability. However climate change does not operate in isolation. Variability from non-climatic sources also imposes risk on livelihoods and the concept of 'double exposure' has been fielded to describe the resulting complexity.[2] It is not always possible to control for multiple causes in analysing impacts of variability, but for present purposes, research is considered to be relevant to climate change if it addresses climatic variability – a narrower focus than that of development (see Chapter 7 for further discussion).

1.3 Approach and sampling

This study is complementary to two other reviews of climate change research commissioned by DFID from the IIED *et al.* and the IDS.[3] Our more restricted purpose is to interrogate research carried out by the RNRRS in 1995-2006 with respect to its contribution to climate change knowledge for development. This necessitates an essentially inductive approach based on project analyses. Given that

[2] O'Brien, K.L. and Leichenko, R.M. (2000) "Double exposure: assessing the impacts of climate change within the context of economic globalization." *Global Environmental Change* 10: 221-232.
[3] IIED and partners (2005), *Climate change and development. Consultation on key researchable issues;* IDS (2005), *Linking climate adaptation: a research agenda.*

the RNRRS commissioned 1,617 projects during this period,[4] screening was necessary. The sample was chosen on the ground of perceived relevance to the management of variability by poor people. The use of programme managers' advice, titles, website summaries and key words provided the basis for the selection. In total, 105 projects were reviewed from seven programmes:

Aquaculture and Fish Genetics Research Programme, www.dfid.stir.ac.uk/afgrp
Crop Protection Programme, www.cpp.uk.com
Fisheries Management Science Programme, www.fmsp.org.uk
Forestry Research Programme, www.frp.uk.com
Livestock Production Programme, www.lpp.uk.com
Natural Resources Systems Programme, www.nrsp.org.uk
Plant Sciences Programme, www.dfid-psp.org

Indirect use was made of Socio-Economic Methodologies projects (which were managed by the NRSP until 1999). The Animal Health Programme and the Crop and Fish Post-Harvest Programmes were considered marginal to the purpose of the study.

It was intended to sample from DFID's six Production Systems using the *Systems Characterisation Study* published by the NRSP,[5] which weights each system on the basis of area, population and other criteria as a guide to allocating research resources. However, the sample proved to be strongly self-selecting on the basis of climate change relevance. Later, a tabulation of Research Lines by system and by programme was carried out as an indicator of representation.

It is worth emphasising that the work reviewed forms a small fraction of RNRRS outputs during the period, and since climate change was not central to the purposes of any of the sampled studies, and does not feature in any programme logframes, this review is in no sense an evaluation of the research on its own terms.[6]

1.4 Sequence of activities

This study initially adopts an inductive approach to the existing stock of knowledge built by the RNRRS during eleven years. A set of simple questions has been used to interrogate research projects on their relevance to climate change adaptation, focusing on increased variability as the core challenge thrown up for poor people and their institutions. Twenty-six Research Lines have been identified which bring together projects that offer scope for taking forward.[7] Consultations with programme managements, selected project leaders, other scientists, and representatives of DFID have aimed to eliminate any eccentricities and utilise available advice as fully as possible in the short time available. The output is a platform on which a climate change adaptation research strategy may be built for the future.

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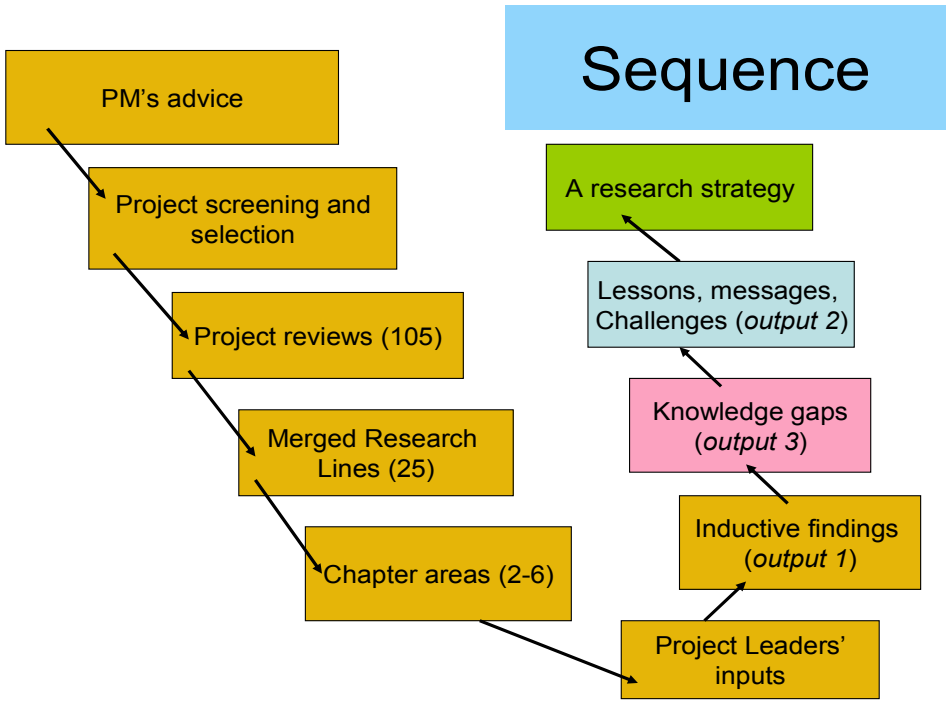
[4] *Evaluation of DFID Renewable Natural Resources Research Strategy* (2005), LTS International/ NORAGRIC/OPM.
[5] Taylor, J., Tang, M., Beddows, C., Quin, F.M. and Stocking, M.A. (2003), *The characterisation of six natural resources production systems.* DFID/NRSP.
[6] The nearest analogy that occurs to its authors is that of an archaeological rescue dig: in this case, the hunch that important finds would emerge was not (we believe) misplaced.
[7] The selection is not necessarily final, and, depending as it does on the authors' judgements, may be open to additions.

The sequence of activities is shown in the diagram below.

Step 1: PMs' advice. Interaction with programme management in each of the programmes included in the study was variable. PMs were asked to advise on project selection and review draft Research Line documents. (See Output 4 Activity 1.)

Step 2: project screening and selection (see above). In practice, projects were not all selected in a single operation; some were added up to the end of November, 2005 in the light of new information.



Step 3: project reviews. This step formed the major input to the study in terms of time and contribution to outputs. Each project was interrogated in terms of four questions as follows:

- New knowledge of local (community, household or individual) adaptive capacity under climatic variability and its impacts.
- New or improved technologies or management systems, with a significant uptake, that contribute to sustainable livelihoods better protected against climatic variability
- Enhanced institutional capacity to measure, forecast or manage short-term impacts of variability on productivity and livelihoods, and develop adaptive capacities.
- Pointers to the research needed to address constraints to capacity enhancement of the most vulnerable social groups.

A negative answer to all four questions led to exclusion from the sample. The reviewed projects were recorded on standard forms ordered by project (R) number.

This archive of 105 entries is accessible on request. The sampled projects often form suites or sequences and in such cases key projects only were reviewed.

Step 4: merged Research Lines. Projects associated by sequence, theme, or parallels were then merged into Research Lines which identify an integrating title, the numbers of the projects included, and a short statement linking the projects, identifying the common interest, highlighting key findings relevant to climate change, and ways of taking the research forward. There are 25 such Lines.

Step 5: Research Areas. The Research Lines were grouped into five Research Areas each comprising a chapter of this Report (2 – 6). These Research Areas comprise an integrative framework for the new knowledge and can form a platform for a broad-based research strategy (Chapter 7.3).

Step 6: project leaders' inputs. It was not practicable with the time and resources available to recruit advisors for every Research Line. What appeared to the authors to be emerging as ten key Research Lines with clear potential for further development were sent to project leaders for a second round of consultation. Critique, revision and additional materials were provided in generous measure, and the documents were much strengthened in this exercise (Annexes B *et seq.*). (See Output 4 Activity 1.)

Step 7: inductive findings (Output 1). Steps 1 – 6 fulfilled the requirements of Output 1 (see above). During the course of this work, preliminary findings were presented to a DFID audience as requested by the client. Output 1 is presented in Chapters 2 – 6 of this report.

Step 8: knowledge gaps and research questions (Output 3). The critiques of Research Lines helped to point up knowledge gaps and the authors contributed their own perspectives and experience to identify some key areas of potential and need. This however is a provisional exercise, as such assessments are dependent not only on internal evidence but also on external variables beyond the scope of this study. The assessment of priorities will be an ongoing activity and needs an interactive process between purchaser, provider and stakeholders. Output 3 is synthesised in Chapter 7.4 of this report.

Step 9: lessons, messages, challenges (Output 2). A model of adaptation within development emerges naturally from this analysis (Activity 1), and is developed as a basis of the strategy in Chapter 7.5 of this report.

Step 10: a focused research strategy (Output 2). Lessons, development messages and challenges are summarised in a strategic framework (*Activity 2*) in Chapter 7.6.

1.5 *Country visit* *(Output 4 Activity 3*).

The PL was able to make brief visits to Kenya and Tanzania in order to interact with stakeholders in research supported by RNRRS (NRSP) over a long period, and which directly addresses climatic variability (rainwater harvesting, RWH) in a development context. The visit included Nairobi (Prof. N Hatibu of SWMNET), Morogoro (Soil and Water Management Group, Sokoine University of Agriculture, Prof. H.Mahoo)

and Same in Kilimanjaro Region (research sites, accompanied by Dr S Tumbo). (See Annex J.)

1.6 Outline of chapters.

As already explained, following this introductory Chapter, Chapters 2 – 6 present the new knowledge and future challenges in five Research Areas of adaptation research. They form a sequence from new technologies through enhanced asset management, institutions and rural services, and environmental governance to the enabling of livelihood diversification. In Chapter 7, adaptation is situated within development (7.1), the approach of this study is distinguished from alternative approaches (7.2), a broad-based strategic option is identified (7.3), generic knowledge gaps are synthesised (7.4), the articulation of, and response to demand are presented as a model framework(7.5), a focused strategy is based on this framework(7.6) and links with other research and development policy are briefly discussed (7.7), with a concluding note (7.8). This document (Annex A) is the Scientific Report of the R8496 Final Technical Report (FTR) and the FTR Annexes B *et seq.* provide additional material (not widely available in publications) on selected Research Lines.

2. *Research Area: technologies for supporting enhanced NRM under variable conditions*

Introduction to Chapters 2 – 6

In Chapters 2 – 6, the five Research Areas are introduced and the contributory Research Lines described. In Chapters 2 and 3, the Research Lines focus on *finding solutions:* in the form of *technologies* for enhanced management of natural resources and *strategies* for managing assets (most of them based on modelling approaches). In Chapters 4, 5 and 6, the emphasis shifts to *enabling process* through facilitating institution building and service provision, strengthening participation in governance, and supporting resilient livelihoods. Each of these two groups of chapters is allocated about the same amount of space although individual chapters vary according to the number and complexity of Research Lines included. (This distinction will be referred to again in Chapter 7.) In order to allow the reader to engage more deeply with the research, a few Lines are supported by Annexes (B *et seq.*) or citations, but these are not intended to be comprehensive.

Summary of Chapter 2
This chapter highlights RNRRS work on new or improved technologies or tools to address the challenge of managing variability – crop varieties resistant to drought or pests, agronomic methods that enhance the efficient use of scarce moisture, and the control of pest outbreaks.

2.1 Development and promotion of better adapted crop options for drought and pest/disease resistance

Line CPP-2 Managing risk through development of disease and pest-tolerant varieties: Groundnut (R6811, R7445, R8105); Pigeonpea (R7452, R8205)

Identifying, evaluating and promoting pest and/or disease resistant breeding lines mitigates a significant risk element in agriculture. Provided there is low-cost, efficient and equitable seed access for resource-poor farmers, this approach has important advantages over pest and disease management prescriptions in terms of capital and time investment. Combining such breeding lines with other traits that are desirable for economic, cultural and environmental reasons augments the adaptability of the crop. A cluster of CPP projects in Sub-Saharan Africa and South Asia have successfully promoted pest and/or disease resistant breeding lines exhibiting pluri-trait advantages in groundnut and pigeonpea respectively.

To date, a major focus of additional trait advantages has been reducing the risk from terminal drought through using breeding lines with short to medium duration maturity (90-150 days). For example, R6811 enables the identification and development of rosette and vector resistant genotypes with short duration and high yielding characteristics; R7445 released two short-duration, rosette-resistant groundnut varieties, which incorporated several traits farmers considered important, in a study of farmers' management of rosette disease; and R8205 refined screening methods for identifying pigeonpea genotypes resistant to sterility mosaic disease with short to medium maturation.

The assumption that the principal manifestation of climate change in rainfed cropping systems will be a reduction in the length of the rainy season needs to be validated. Climate change is also likely to alter the biogeography and impacts of crop pests and diseases and thus increase (but sometimes decrease) the need for resistant lines in new crops and new locations. Breeding programmes, rather than seeking to modify single traits (such as virus or herbicide resistance), should therefore aim to combine pest or disease resistance with early to medium maturation. This increases the relevance of breeding work to adaptation. However, the possibility that differential uptake, according to economic circumstances, may influence impact on poverty needs to be investigated.

Line PSP-2: Participatory Varietal Selection (PVS) and Client-Oriented Breeding (COB),[8] involving farmers from the outset in selection and testing of improved varieties (R6748, R6826, R7324, **R7657**, R8099).

Variety releases often fail to achieve uptake owing to farmers being ignorant of their availability, unable to obtain them, preferring traits associated with their old landraces, or finding them unsuitable for local, off-station conditions. PVS involves them at the outset instead of only asking them to endorse releases at the end of the breeding process. Local knowledge and practice are systematically sought out by the researchers and an enlarged range, usually including both local and released varieties, are tested by the farmers in their fields under normal management. In COB, selections according to farmers' and researchers' criteria are crossed with promising parents to obtain desired traits and brought back for field testing immediately the cross has produced finished varieties. On the basis of this round of trials the best performing varieties are multiplied for wider adoption.

'Mother'and 'baby' trials use nurseries and farmers' fields to test new varieties for acceptability; in Ghana, seed banks (100% 'interest' in seed repayable after the harvest) have played a key role; in some areas private suppliers (farmers) have begun to produce seed for the market. Releases in several countries include: in Ghana, better-performing upland rice, in six of ten regions (R6826, R7657) and mosaic-resistant cassava, bred in collaboration with the IITA (R7565); in Nepal, maize (R7281) and several other food or fodder crops (R7542); and in India, finger millet (R7324), chickpea (R7838), sorghum (R7409), rice and maize (R8099). Impact assessments of various releases in India, Nepal, Bangladesh and Ghana report yield increases of 30% or more, improved drought tolerance, reduced disease losses, command of higher prices, and better culinary traits, as well as rapid uptake and high satisfaction ratings. Varieties which were successfully transferred from Nepal to Bangladesh enhance the efficiency of nitrogen uptake and use, potentially reducing dependency on industrial fertilizer, always a risky investment under uncertain rainfall.

The strengthening of local capacity in NR management, as well as improved productivity, may be expected to reduce household vulnerability to agricultural droughts. The methods, once accepted, will permit rapid response at both institutional and farmer to farmer levels. A challenge facing the technology is the need to obtain endorsement of the new, low cost methods from extension services accustomed to

[8] Formerly called Participatory Plant Breeding (PPB)

traditional methods. NGOs may play a critical role in extending the methods to additional areas and crops.

Line PSP-3: Molecular Assisted Selection (MAS), or the use of molecular markers to improve desired qualities of pearl millet and upland rice varieties in Africa, India and Bangladesh (R6451, R6667, R7375, R7379, R8183)

These crops are grown by large numbers of the poorest farmers in tropical rainfed farmlands. Improving productivity through inputs is costly, so instead varietal improvements were sought which can reduce the impact of terminal drought and downy mildew, a major disease of millet in India, and strengthen root development and thereby the drought resistance of upland rice. Quantitative Trait Loci (QTLs) were identified with associated molecular markers and back-crossed with parents from elite lines using advanced laboratory techniques developed for the purpose. This offers the possibility of more assured yields under variable rainfall and reduced disease losses. For upland rice, although improved rooting was not achieved, other genes that were introgressed brought significant advantages. In conjunction with PVS and COB, farmers' and consumers' requirements can be taken into account. Though this approach is not essentially participatory, it backstops PVS and COB. It has been developed in collaboration with CGIAR institutions and strengthens the capacity of extension systems in persistently low-yielding and high risk environments such as the Sahel. Research is needed on further adaptation to drought, low nitrogen and heat in specific environments in Africa and Asia.

MAS, PVS and COB offer the possibility of more rapid breeding of improved varieties than is possible with conventional methods. This means an institutional capability to respond to climatic variability, together with a tested procedure for farmer trials. It is reported that the 12-14 years usually needed to take a research product to the marketing stage has been truncated by about 7 years in this research. Effective validation, multiplication, and distribution, are necessary to bring full benefits to farmers in many different regions whose livelihoods depend on what they can produce in risky environments, and the economic and livelihood issues deserve to be investigated in depth.

2.2 Improvement of crop water use efficiency by seed priming

Line PSP-1: Seed priming (with associated practices) to facilitate more efficient use of constrained rainfall (R6395, **R7438,** R7440, R7540)

Seed priming in water overnight is instrumental in achieving earlier germination and emergence, leading to better crop stands and improved seedling vigour; earlier flowering, pod or head formation and maturation; and primed crops also required less labour for weeding (fewer cultivations) than the same crops grown at the same time using dry seeds. Farmers in Zimbabwe and India (R6395) reported better drought tolerance and higher yields using primed seed. Systemic effects were also reported: reduced labour demand for weeding; greater incentive to apply fertilizer to good stands; earlier harvest of *kharif* (rainy season) crops (allowing *rabi* or dry season crops to be sown sooner, thus avoiding the penalties of late sowing); earlier harvest of *rabi* crops (allowing earlier migration in search of paid work). Crops known to benefit

include: Bambara groundnut, barley, chickpea, cowpea, groundnut, lentil, linseed, maize, millets, mung bean, pigeon pea, rice, sorghum, soybean and wheat. Impact is not confined to marginal areas. Recently, adding nutrients (P, Zn, Mo and rhizobia for N-fixation) to the water has been shown to have additional positive effects at far lower cost than conventional fertilization. The promotion of the method through community evaluation and farmer-to-farmer spread in a range of agro-ecosystems and DFID target countries is the focus of R7438.

By improving the efficiency of soil water use under low or erratic rainfall and the timeliness of growth cycles, the technique offers an adaptive resource for farmers in areas where climate change scenarios are predicting an increasing frequency of droughts. To take this work forward, enhanced promotion and applications in new agro-ecosystems and countries have been identified as priorities (addressed in R7438). Collaborators around the world are working on new aspects such as nutrient supplementation.

2.3 Community-based pest control

Line CPP-1: Improved understanding of migrant pest behaviour and ecology and strengthening institutional capacity for their control in Southern Africa. Armyworm: R6762, R7966; Quelea: R6823, R7967; Brown locust: R7779.

Weather-related migrant pest outbreaks (armyworm, brown, desert or red locusts, quelea birds, Senegalese grasshoppers) may be affected by climate change either positively or negatively in terms of their severity and geographical extent. This is especially important regarding migrant pests such as locusts, as opposed to chronic sedentary pests, since they are capable of wiping out whole crops in a region. Poorer farmers (or livestock owners) are more vulnerable to loss because their holdings are smaller, their access to common resources may be constrained, and their asset reserves fewer. Progress in the control of migrant pests is not satisfactory particularly in Africa (as shown in the extent of locust damage in the Sahel in 2004-5). Climate change introduces additional uncertainties that should be addressed without delay.

Key findings which point to priorities for future research are:

(a) Regional approaches to forecasting and control are a necessary supplement to national ones. Collaborative internet-based networks for information exchange and training have been proven to be effective (Information Core for Southern African Migrant Pests, ICOSAMP initiative) and could function on an Africa-wide basis. However some regional organisations have lost momentum through a lack of funds.
(b) Improvements have been achieved in short-term forecasting capabilities (e.g., brown and desert locusts and quelea birds). These methods will be sensitive to climate change and the models should be linked to scenarios issued by the IPCC, in order to predict changes in land use, vegetation and other determinants of pest outbreaks. For armyworm, community-based forecasting has been developed using simple data gathering techniques and rule-of-thumb formulae that can be revised as necessary in the light of climate change scenarios.

(c) Control methods, based on community action (armyworm) or control teams (quelea birds) have been developed, and technologies investigated (e.g., 'Green Muscle' fungus against locusts, organophosphate avicides and fire-bombing against quelea). More work is needed on the effectiveness, environmental impacts and social acceptance of control methods.
(d) Most of the work supported by RNRRS has been carried out in Southern and Eastern Africa, but the lessons learnt are applicable in West Africa and, in some cases, to the Yemen and some Asian countries.

To take this work forward for the benefit of the poor will require focussing on improving their capacities to react to forecasts, in particular by community mobilisation and improved access to low-cost control materials. At the institutional level, there is need for capacity to plan for medium and longer term rainfall predictions which alter the expected frequency of droughts/ floods, the determinants of pest migrations, and possible impacts on the cropping options available to farmers. [This Line links with weather forecasting, Line NRSP-12]

3. Research Area: strategies for managing assets under variable conditions

Summary of Chapter 3

This chapter highlights RNRRS work on modelling asset management and natural resource decision making, with an overall aim of optimising poor peoples' asset strategies, improving their livelihoods, and increasing their capacity to manage variability. These Research Lines include more accurate weather forecasting, assistance in managing scarce moisture on farms, optimising smallholder livestock keeping and grazing strategies for mobile herds, protecting fisherfolk against fluctuating stocks, tree planting strategies and land use management in river catchments.

3.1 Crop management with improved weather analysis and forecasting

Line NRSP-12**:** Effectively communicating improved seasonal weather forecasts to potential users with enhanced capacity to benefit livelihoods (R5156, R5981, R5982, R6712; PD100; PD139). *Annex B*.

Climate change scenarios are likely to have impact on poor people in rainfed arid, semi-arid and dry sub-humid production systems through increased variability, principally in the amount and distribution of seasonal rainfall. Considerable efforts have been invested (by different agencies) over several decades in developing weather forecasting capability. Until recently three major limitations have affected the use of this knowledge:

- forecasts have been insufficiently reliable to generate the confidence of potential users and sustain the credibility of forecasts;
- barriers impeding effective communication of forecasts have not been overcome; and
- the capacities of potential users to respond to forecasts with technical or management decisions that can have positive effects on their livelihoods are unproven in many areas. Forecasts may not include the critical data needed for rational decisions on, e.g., planting dates, purchases of seed, whether or when to plough.

By the early 1990s, African meteorological services were seen as central to many national early warning efforts but were weak in adapting to modern techniques. A group of NRSP projects reported on this problem in 1995-1996:

R5156 aimed to enhance the capacity of African meteorological services to adapt to modern techniques and deliver satellite remotely sensed data, by installing Meteorological Data Distribution Systems and Natural Resources International (UK) Media Systems, and providing training, materials and techniques. This work was carried out by the Natural Resources Institute as part of its Local Application of Remote Sensing Techniques (LARST) initiative. Collaboration with the UK Meteorological Office and the World Meteorological Organisation was an essential part of the project.

R5981 was a much smaller project which aimed to develop a methodology for short to long term forecasting of weather regimes to help farmers increase agricultural productivity in West Africa (Ghana and the Gambia). New datasets and methodologies were produced and it was hoped that a predictive model for forecasting weather regimes could be developed in a Phase 2 project. However an associated study of correlations between Cold Cloud Data from satellites and rainfall distribution in Namibia was inconclusive.

R5982 applied the same methodology to southern Africa (Zimbabwe). Datasets of cloud formation and rainfall were assembled from satellites and numerical prediction models and a model for forecasting weather regimes in Africa were produced and distributed to meteorological services in the region.

R6712 was a workshop on the identification and monitoring of weather regimes in southern Africa, with the aim of discussing the possible mechanisms for further dissemination of improved forecasts. It was expected that given better medium range forecasts, farmers would adjust their practices by adopting, e.g., rainwater harvesting, conservation tillage and integrated catchment management. Tailored weather forecasts, linked to agricultural advice and aimed at small-scale farmers, broadcast by radio stations, would be the most effective communication mode. Since further work was not funded through RNRRS programmes, it is not known to what extent the limitations mentioned above were overcome. However, the FTR of R5982 contains the following important qualification:

> A particular shortcoming of this study is that none of the findings have been rigorously tested or placed on a quantitative basis. Nevertheless several important results have been obtained which are able to hint where forecasters should look to improve their skills. Also several specific areas are noted where further focused studies may be expected to yield useful results. As with any broad ranging short term research more questions are raised than answered (p.26).

Given the focus of DFID's Climate Change Theme on adaptation, a legitimate claimant for research attention is the communication and uptake of seasonal weather forecasts which, since 1996, have been put onto a stronger basis through the modelling of sea surface temperatures and analysis of ENSO events. Only one project was designed to address the uptake of weather forecasting in a specific regional context (R7584: Community-led tools for enhancing production and resource conservation). A technical report to this project, 'The Southern Oscillation and rainfall in SW Tarija [Bolivia]' (2000) however concluded that the accuracy of forecasts was still inadequate – 'farmers need more detailed information than can be provided by seasonal climate forecasts' – and the project team concluded that progress was unlikely in the short term. It is a matter for regret that this initiative had to be written out of the project before completion, as strong emphasis was to be placed on the use of local radio, NGOs and professionals in dissemination.

In work still in progress at time of writing, NRSP Project Development Funds are being used for 'Developing capacity for applied agricultural meteorological data collection and analysis in Eastern Africa' (PD 139, 2005). The approach of this project is different: given an abundance of climatological data in Kenya, recent

upgrading of infrastructure in the Kenya Meteorological Department, access to staff training, and decentralisation of staff to local centres (where they can contribute more effectively to development projects), it aims to continue the provision of skills to out-station staff, improve the supply of routine data, and enhance skills through the use of Marksim software and Apsim crop growth models. The last two have potential relevance to forecasting and evaluating impacts of and adaptive strategies to climate change, and delivering climatological inputs to farmers and others in a decentralised framework.

An East Africa inter-agency Consortium, which includes institutions that have collaborated with RNRRS in the past, now proposes a major new Programme: *Investing in rain-fed farming systems of Sub-Saharan Africa: evaluating the agricultural implications of current climatic variability and planning for future climate change.* This programme accepts that rainfed agriculture will remain vital to the achievement of food security and that present variability and its management may provide keys to adaptation in the future. Action is proposed on:

- impact of seasonal climatic forecasting to enable farmers and support agents to plan and perform more effectively
- participatory agro-meteorology extension to support the use of forecasts
- use of information on climatic risk by stakeholders and investors
- enhancing institutional capacity to use climate data in agricultural development
- partnerships to scale up the impact of climate risk management strategies and support farmers and their support agents

Preliminary work in support of this proposal found that in Machakos, Kenya, a representative sample of farmers not only expressed a preference for qualitative advanced seasonal rainfall probabilities (average, above or below average, rather than numerical values they cannot rely on), but have a coherent set of options they propose to implement (e.g., planting dates, choice of maize variety). Not enough is known elsewhere of such strategic options and farmers' ability to implement them.

Further work on weather data analysis or seasonal forecasting – made possible by a computer software, models and datasets – offers potential livelihood benefits to families living under conditions of continuing or worsening variability. Model and technology development are one part of the challenge, which however does not end there. The three themes identified at the beginning of this section represent adaptive challenges to development strategies which attempt to use this new knowledge. They have been relatively neglected. They may be summed up as (1) credibility (which presupposes reliability), (2) communication barriers and (3) capacity to use. Each of these challenges requires action-research in specific production systems.

The management of increased variability in seasonal rainfall and other climatic parameters can be enhanced through more effective vertical linkages between (1) improved seasonal rainfall forecasts that are credible to farmers (proposal above), (2) institutional capacity building (PD139) based on decentralisation of meteorological staff, (3) tools for advising optimal management strategies for farmers, e.g. PARCHED-THIRST (see NRSP-6), and (4) adaptive strategies identified and

implemented by farmers themselves in response to information demanded of service providers.[9]

3.2 Optimising RWH decisions under semi-arid conditions

Line NRSP-6: Consolidating and extending the benefits of rainwater harvesting as a strategy for using scarce water more efficiently in crop production, and developing the PARCHED THIRST model for climate change applications (R5170, R5752, **R6758**, **R7888**, R8088A, R8088B, R8116, R8381). *Annexes C1, C2.*

RWH is a group of technologies that concentrate surface water from rainfall on to a growing medium for crops, in order to improve soil moisture and enhance growth, or a water storage facility for livestock. The term includes the diversion of streams from relatively large catchments onto the fields of a water users' group, the channelling of run-off from uncultivated ground into an adjacent field or tank, and the micro-management of surface water within the field itself. Although some of the RWH techniques are already well-known in indigenous practice in some areas of Tanzania, there is room for improvement in the efficiency of water use, in optimising the size of catchment area in relation to field size and rainfall distribution, and in promoting RWH in other areas and under different conditions.

In a context of climate change and the possibility of increased rainfall variability, RWH addresses the need to make the best use of rainwater in semi-arid areas, where season-to-season and year-to-year variability dwarf the impact of long-term trends. Evidence is reported, though inconclusive, of rainfall diminution and more frequent or longer dry spells in the *vuli* season ('short' rains, October-December), and spatial variability over distances of 50 km is commonly observed. There is an urgent need to improve the precision of farmers' responses to low and erratic rainfall, close a stakeholders' knowledge gap on the risk of variability, and strengthen policy emphasis on water (and specifically rain water) management.

More than ten years' work has identified the relevant technologies, tested them under a range of conditions (R5170), and promoted them among stakeholders (R6758, R7888), including farmers, extension services, some district governments, and national policy makers. A doubling of adoption 1990-2000 and an extension of improved management to 28,000 households in Maswa District are claimed. RWH is now recognised as a policy objective in key national documents, though there is still much to do at district level. For example, livestock applications of RWH are being developed by an NGO in Kilimanjaro Region (SAIPRO Trust Fund). The latest project in the series takes uptake promotion to the regional scale, with an aim to 'institutionalize a culture of promoting uptake, scaling-up and effective use of results from soil and water management research in Eastern and Central Africa' (R 8381).

From its outset this work has incorporated a strong experimental component in the form of the PARCHED THIRST simulation model for facilitating spatial and

[9] DFID has committed to investing in climate data and services in Africa through the Global Climate Observing System (GCOS), and plans to collaborate with the International Research Institute for Climate Prediction (IRI) in making sure the investment serves the needs of development, particularly relative to the MDGs.

temporal extrapolation (R5170, R6758). The model (based on the PARCH crop-growth model which was developed at the University of Nottingham), was developed by the University of Newcastle into a tool for water resource management, and the code for the model was transferred to Sokoine University of Agriculture (SUA) through an adaptive and interactive process from 2001. At SUA, considerable additional work was undertaken to make it more user-friendly and reliable in operation (R7949), to determine and address its clients' needs and communicate it to target users through a 'Help Office' (R8088A), and to promote its use (R8088A-UP). A plan has been prepared, for example, for implementing the use of the PT software by Same District Council. However, major barriers remain to be surmounted as with the technologies themselves, including those of communication, upscaling, and integration into planning – creating an 'institutional culture of uptake' (R8381).

The model incorporates the important biophysical processes, using data that can be easily measured or estimated, including: crop, planting density, weeding regime, standard soil properties, surface characteristics, catchment area, season, planting date and weather variables. It has been run on historical rainfall data to predict yields, run-off, transpiration, or other parameters. Specific applications are on record for drought analysis, determining appropriate water management practices for maize production, matching catchment area to cropping area under specified rainfall, determining optimal planting dates, and forecasting maize yields. These problems were specified by extension staff working with groups of farmers in different locations.

In principle there is no reason why the PT model cannot be further extended to take account of economic variables, as cost-benefit variables were given recognition in promotional work (R7888). A permanent help office and continuing interaction between the SUA team and users are preconditions for further extending its use. It is also possible that in time some farmers may be able to operate it themselves. Its potential as a tool for managing the effects of climate change lies in assisting the farmer to increase the efficiency of water use and reduce losses to livelihoods resulting from mistaken decisions; equally, in facilitating opportunistic benefits in good seasons. There is, therefore, a link to improved weather forecasting capability (Line NRSP-12).

RWH uptake has exposed two priority areas for research. First, on reducing the water constraint in semi-arid farming systems, renewed emphasis falls on nutrient supply as a determinant of crop yields. Some farmers report that nutrient deficiencies in soils under cropping can be resolved by fresh nutrients carried in from the catchments in run-off water. However, even where this is so, integrated fertility management will be necessary in the long term (R8115). Second, the development of RWH has opened up issues of access rights to water from common catchments as well as those to cultivable land (R8116). Large stream diversions are usually managed by user groups whose members must agree on access to the 'cascading' system downstream from the source through different owners' fields, and compensation (if any) owed to end-users who receive little or no water in a bad season. Smaller schemes assume rights to the run-off water from common land adjacent to private fields. Institutions as well as tenure are involved, and there is a long body of 'case law' which has evolved since the 1940s or earlier.

RWH addresses the limiting factor of production in rainfed systems (water). Use of the PT model offers the potential of greatly enhanced efficiency and reduced risk. The specific applications referred to above illustrate its potential as a tool for managing climate change. After a long period of development it is now user-friendly for recommending changes in practice to farmers, 'tailor-made'. The model has been validated but it is considered that nutrient sub-routines are needed for improved uptake. In addition to such further work on the model, taking the work forward calls for promotion and uptake by partner institutions within and outside Tanzania, and under different soil conditions, institutional and legal environments. Uptake of the model, notwithstanding its proven potential, on a scale sufficient to impact on poor peoples' livelihoods over a wide area, still remains to be demonstrated.

A final qualification is that dryland livelihoods are increasingly dependent on off-farm incomes and risk insurance mechanisms (see NRSP-7), and these are likely to remain beyond the scope of a water management model based on biophysical data in the foreseeable future. However, diversification is not an argument for neglecting the natural resources sector. On the contrary, complementary resource allocations and investment linkages within the framework of a livelihood strategy depend for their success on reducing the risk in natural resource-based enterprises.

3.3 Optimising the decisions of livestock keepers

Line LPP-2*(a)*: Modelling, understanding and optimising asset management decisions by small-scale livestock keepers (R5183, R6606, R6774, **R6982,** R7823) *Annex D.*

Livestock are assets, not only supporting consumption or earning income but also held in reserve against seasonal fluctuations, cash emergencies or investment requirements. Given the constraints under which they must operate, small-scale livestock keepers need to ensure efficient allocation of their feeding resources, labour and other inputs. Livestock can also offer pathways out of poverty. Potentially strategic development interventions may assist in such decisions; however, many livestock development projects have failed in the past.

A loosely related group of projects carried out in Nepal and in Latin America addresses feed allocation, dairying and breeding decisions. Managing variability is a central issue for very many small-scale livestock keepers owing to seasonal fluctuations in fodder supply. A modelling approach is taken to optimising feed allocations during seasonal variations on mixed species farms (the FRAME model, Nepal and Bolivia, R5183). This model predicted live-weight changes in the dry season, using feed resource-use data over five months, and showed that decisions based on the model give a 3-5% enhancement, which may be critical in reproduction. If climate change exacerbates dry season feed shortages, more efficient resource allocations – whether derived from a model or from sample field studies (R6606, Bolivia) - may improve adaptive capacity, especially in dairying. Management improvements may also yield productivity gains (R6774, Bolivia). However none of these studies investigated economic costs and benefits in detail, nor issues of acceptability and uptake.

In order to achieve a better understanding of the roles of livestock in the livelihoods of poor people, and better identify entry points for beneficial interventions, an assets

analytical framework has been developed (R6982, R7823, Bolivia and Mexico). This is used to understand new knowledge and livelihood strategies of differentiated social groups. In its essentials this is a model of asset functions and attributes in livelihood strategies, which recognises

- *Functions,* including production (products or services for income or consumption), savings (for buffering, insurance or accumulation), collateral, and social integration;
- *Attributes,* including productivity, utility, security, holding costs, life, convertibility, complementarity and control; and
- *Activities,* appropriate to each function and attribute.

Varying from species to species and from household to household, these functions, attributes and activities are employed in the pursuit of livelihood aspirations which are broadly classified as

- *'Hanging in'* where activities aim to maintain livelihood levels, often in the face of adverse circumstances;
- *'Stepping up'* where activities, with investments to expand these activities, aim to increase production (e.g., by accumulating productive livestock) and income, and improve livelihoods; or
- *'Stepping out'* where activities aim to accumulate assets as a base or 'launch pad' into new activities where initial investment leads to higher and/or more stable returns (e.g., using livestock as savings against financing children's education (investing in the next generation), purchasing vehicles or buildings, migration, or social or political contacts and advancement.

The model has been developed into a detailed methodology with a manual for practitioners and researchers to use in participatory work with local communities.

Different people with different strategies have different preferences with regards to their asset function mix, the importance they assign to these functions and their attributes, and their activities. Opportunities (e.g., market access, agro-ecological potential) and constraints (low potential, poor access) are key. Where conditions are very difficult, livestock keeping may play an important role in 'hanging in' strategies as livestock, compared with crop-based activities, can hold value and provide income at different times or seasons. The management of variability is critical, not only that in natural fodder, but in seasonal changes and unpredictable shocks affecting livestock directly (e.g., animal disease, reproductive cycles) and indeed their keepers' circumstances. These range from changes in prices (e.g., livestock and livestock products), feed stocks (e.g., maize) held by the household, local demand for meat (e.g., for fiestas), cash needs for school fees or other expenses (e.g., medical costs).

Taking this work forward, on the basis of entry points in poor peoples' complex frameworks of asset management, offers a new possibility of improving this capacity (and on the disappointing performance of many past livestock development projects). Strengthening capacity at the household level to make wise decisions is very relevant to managing climatic variability in the longer term. In designing interventions, such questions as the following arise:

- what improvements in managing livestock assets can strengthen poor peoples' capacity to manage variability?

- which activities are complementary or substitutes (e.g., small livestock versus micro-finance as buffering strategies)?
- how can poor people better articulate demand for technologies and services that will assist them to manage variability?
- can livestock be made more effective as a form of insurance against risk, and for capitalising diversification?

Line LPP-2*(b)*: A modelling approach to optimising decision-making by livestock keepers – the SimSAGS model (**R6984**). [10]

Adaptation to climate change under diminishing (and therefore increasingly variable) rainfall scenarios requires livestock breeders to find strategies for coping with periods when forage supply is critically limited. Livestock breeders must choose between fixed stocking rates, to minimise risk of loss in drought, on the one hand and opportunistic selling, as an alternative to bearing high mortality, on the other. They must also know how access to forage is constrained by the availability of drinking water, and other constraints on range use; choose what resources to use in which season, and when and how much supplementation is required. Strategic analysis of this type can be assisted by SimSAGS, which models the effects of climatic and spatial variation on livestock systems.

The user can specify a wide range of inputs, such as land type and area, rainfall, and livestock management, and then run the simulation for a given number of years. The model simulates animal population dynamics from vegetation biomass dynamics, which is driven by soil type and daily rainfall data. Spatial heterogeneity is represented by a chosen number and size of cells in a grid. For each cell, soil, vegetation and altitude can be specified, and water points can be located. The strengths of the model lie in its adaptability to a wide range of conditions and its applicability to real world scenarios.

Ways of 'tracking' *temporal* environmental fluctuations could be of value in limiting drought-induced mortality and increasing output. A range of tracking policies, designed to tackle climatic variation, were simulated. These compared annual sales, designed to limit stocking rate, pre-emptive sales triggered by insufficient rainfall, and variable sales and stocking-rate regimes determined by the current season's rainfall. Although the flexible strategies reduced mortality losses (compared with fixed stocking), they did not increase average annual sales. The main reasons for this are that major losses of stock are associated less with one-year than with two-year droughts, which are difficult to track, and that de-stocking can be really effective only if the productive potential of the herd can be re-established more rapidly than is possible from depleted herd resources. Policies designed to track climatic variation had minimal advantage in terms of sales and yet had about twice the inter-annual variability, with zero sales in nearly one year in four. For subsistence pastoralists, maintaining the maximum number of breeding stock, and hoping that most of them will survive, may be as close as 'opportunistic' management can get to dealing with drought.

[10] Illius, A.W., Derry, J.F. and I.J.Gordon (1998), 'Evaluation of strategies for tracking climatic variation in semi-arid grazing systems', *Agricultural Systems,* 57/3: 381-398; Illius, A.W., Derry, J.F. and Godron, I.J. (2000), 'Evaluation of strategies for tracking climatic variation in semi-arid grazing systems', *Agricultural Systems,* 63: 73-74.

Spatial heterogeneity also plays a vital role. Livestock populations exploit such variation in resource abundance and are dependent on 'key resource' areas during the dry season. Field measurements show that browse is the main component of forage in the dry season (20-70%), when grass is very scarce; that it is more important to goats than to cattle, which depend more on stover and are less adaptable; that cattle and goats compete little as they use different species. Modelling results show that long-term mean animal abundance is very largely determined by the quantity of key resources (including supplements, if any) available during the dry season, when mortality limits animal numbers, and scarcely at all by resources available in the wet season. On the other hand, wet season resources, which are far more abundant (non-key), are not coupled to animal numbers. Thus, if animals are maintained on supplementary food during the dry season, their numbers do not reflect the supply of range resources, and animal performance does not reflect any impact of grazing on the range.

Further work is needed on developing a self-sustaining institutional framework that would allow livestock keepers to buffer droughts by renting grazing rights elsewhere (agistment) or selling animals without reducing future productivity, for example through co-operative storage and marketing.

One of the technical limitations identified by modelling work is that of drought prediction: if livestock keepers knew in advance how severe a drought was going to be and for how long it would last, then decisions about whether to sell some animals in advance of the drought would be much less of a gamble. In general, *methods of reducing uncertainty* are the key to stabilising economic activity.

Modelling is a useful tool but it needs to be supported and challenged by field studies. How do animals use what is, in reality, a range of resources varying in nutritive properties and accessibility, and what impact does this have on survival and production? Key resources need to be husbanded, where livestock production is a priority, and not encroached upon by other users. What are the technical and institutional requirements for increasing the productivity of these resources? The theory that key resources (including all dry-season feeds and supplements) are fundamental to livestock population dynamics needs to be validated in other places and conditions.

The model is being extended to a wider range of users and made more user-friendly, a Help service is being provided, and dissemination effected. In future work economic variables (price variations) and analysis will need to be incorporated. From a climate change perspective it is essential to run the model with scenarios of increased rainfall variability in order to support a search for appropriate policy responses in pastoral areas.

3.4 Reducing vulnerability in small-scale fishing livelihoods

Line FMS – 1: Sustainable livelihood strategies from fluctuating fisheries resources and under conditions of environmental change (R7336, R7042, R8118; **R8475, R4778J**)[11]

This Line developed from studies (R7336) of the implications of fluctuations in fish stocks, as a consequence of climatic variability or other factors, which had the aim of identifying appropriate management regimes and development policies. Working in Malawi (Lake Malawi) and Indonesia (west Java), methods for assessing and modelling specific fluctuations, based on suitable databases, were developed. This work exposed the inadequacies of central regulation that ignored local knowledge and livelihood realities, and of conventional co-management policies based on equilibrial assumptions, in the light of the non-equilibrial behaviour of fish populations. Over-specialisation of fisherfolk driven by technical support intended to increase fishing incomes is an inappropriate strategy. Such policies need review.

The appropriate strategy is to recognise that small-scale fishers have a range of coping and adaptive strategies, at individual, household and community levels. They adapt flexibly and autonomously, by means of constant mobility between grounds, and by diversifying their livelihoods into non-fishing activities. Policies should not undermine these strategies. Many productive systems may be resilient to change, provided that human responses that maintain the integrity of the integrated social-ecological systems are not impeded, and flexibility is maintained. Rather than trying to enhance the productivity of one component of the system – e.g., fish stocks – a broader model of maintaining ecosystem function is needed, especially where climate is variable. In temporal context, monitoring of environmental variables and trends needs linking with adaptive management (R7042, R8118).

The scoping project R4778J and its successor R8475[12] show that poor fishers' vulnerability stems not only from a poverty of fixed assets and low incomes (temporary houses, shifting settlements, exposure to production failures when boats or equipment may be sold), but also from economic and social marginalisation (no land rights, poor access to education or health services, political exclusion). A global data set is used in order to compile a composite national index of vulnerability among fishing communities. This index is a function of exposure to risk, sensitivity, and adaptive capacity. The study shows the priority deserved by Africa which has a large proportion of the world's poor fishers, both oceanic and inland.

Reducing vulnerability may be more important to fishers than the risk of resource degradation. To increase the effectiveness of capture fishing as a pathway out of poverty, recognition should be given, not only to a need for diversification, but also to social and political marginalisation, which are barriers to the achievement of fishers' rights. The research contributed to the Sustainable Fisherfolks' Livelihoods Programme (SFLP) of FAO, which aims to strengthen fishing rights, the capacity of fishers' organisations, co-management, support for livelihood diversification, access

[11] See Allison, E.H., Adger, W.N., Badjeck, M-C., Brown, K., Conway, D., Dulvy, N.K., Halls, A., Perry, A. and Reynolds, J.D. (November, 2005), 'Effects of climate change on the sustainability of capture and enhancement fisheries important to the poor: analysis of the vulnerability and adaptability of fisherfolk living in poverty. Summary Report (Project No. R4778J)', Fisheries Management Science Programme, DFID.

[12] Both projects reported in 2005

to health services, and empowerment of marginalised groups including women. Attention to these issues will motivate private investment and increase government revenues.

A key knowledge gap is in understanding how fishers perceive fluctuations and the risk of degradation in relation to other risks they face ('double exposure' to climate change and globalisation), which include the extraction by dams and industry of 'environmental flows' in rivers on which they depend, as well as long-term changes in sea levels and temperature. A suite of research priorities (identified in R 4778J) targets the parameterisation of the three components of vulnerability – risk exposure, sensitivity, and adaptive capacity, and the challenge of analysing vulnerability across different scales. Since the natural conditions, local livelihoods, and policy environments vary from place to place, and not all fish populations fluctuate to the same degree, research is needed on a larger number of fishery systems (both inland and oceanic).

3.5 Optimising tree-planting and agro-forestry decisions

Line FRP-1: Tree species for farm planting and ecological restoration; a compendium for application across a range of conditions (**R7588).** *AnnexE.*

Research by FRP and its pre-RNRRS antecedents from the 1960s to the early 1990s provided both observational and experimental investigations into genotype x environment interactions for a number of tropical tree species. Climate-site-species performance matches have potential value for adapting forestry practice under conditions of climate change. Decision support systems based on this work will allow regions, countries, provinces, districts and individual farms to select appropriate species for planting given projected climate change. R7588 applies this approach to Mesoamerica, providing a compendium (in Spanish) of all available trees for on-farm planting, widening the options and potential livelihood benefits from the restricted choice of often exotic species that are presently used. The innovative, demand-led approach is capable of application in other regions, where it again offers added value to earlier work.

Line FRP-2: Sustainable agroforestry decisions, adapted to local conditions and species, developed through modelling (FLORES) to maximise water use efficiency and productivity (R5651; **R6348, R7315**, R7635)

The diversity of experimental results in agroforestry reflect a great range of local conditions, making it difficult to recommend reliable agroforestry solutions to farmers. Alley cropping is not a universal panacea. Among other model applications to the forest-agriculture interface, Forest Land Oriented Resource Envisioning System (FLORES) attempts to record local decisions and their determinants in formal simulations, to find alternatives in land and labour allocations and other livelihood decisions, and thereby to better inform policy makers (R6348). The modular modelling approach strengthens predictive insight into optimal tree-crop and management combinations using multiple parameters for extension services and in-country researchers. The biophysical model, when adequately developed, will be

complemented with socio-economic modules to bring it closer to farmers' own multiple objectives and operational circumstances.

FLORES has been promoted through workshops and manuals in Zimbabwe (R7315).

Models have already been used to extrapolate research results to new soil or climate conditions. Agroforestry modelling has been applied elsewhere to the effects of climate change on productivity, the impact of agroforestry on local climates and carbon sequestration, the effect of economic incentives on land use decisions, the impact of climate change (in Senegal), yield probabilities under variable conditions including rainfall, and identifying areas where agroforestry combinations are precluded by climate or other conditions. Given reliable climate change scenarios the model can strengthen adaptive capacity at the level of service provision and economic policy. The work is integrated with CIFOR's Adaptive Co-Management programme.

3.6 Integrated land and water management in catchments

Line FRP-3: FLOWS Project Cluster on upper catchment management for optimising water conservation and use under a range of rainfall conditions and land-uses (ZF0167, **R7937**; **ZF0173,** R7991, R8171, R8174, ZF0176). *Annex F.*

The FRP designed the FLOWS (Forestry and Low Flows) Cluster of related projects in order to make use of improved instrumentation, better mathematical modelling and powerful geographic information systems to produce more reliable predictions of the impact of vegetation (including forests) and land use on dry season stream flows. There are four key projects in the group, which focus on the following areas:

- Instrumentation and quantification of the effects of cloud forest on dry season flows downstream (Costa Rica, R7991).
- Water policy, catchment management and poverty alleviation, extending the findings of the CAMP (Catchment Management and Poverty Alleviation) project in South Africa to research sites in catchments in Tanzania and Grenada (R7937).
- Strategies for sustainable catchment management in Himachal Pradesh and Uttar Pradesh (India, R8171).
- Payment for environmental services (Costa Rica, R8174).

Of these, only R7937 had reported at time of writing.

The FLOWS projects have generated important findings with policy implications, including the need to reverse the popular assumption that more tree-planting attracts rainfall or facilitates the recharge of groundwater in dry climates. On this finding, rethinking of several major environmental projects around the world is now necessary. The ten major findings are summarised as follows (FRP/DFID, *From the mountain to the tap: how land use and water management can work for the rural poor,* released 29 July, 2005):

1. In arid or semi-arid catchments, there is no scientific evidence to support the view that forests increase or stabilise water flow.

2. Modelling based on "green water" (evaporation, as opposed to "blue water" or streamflow) data is an efficient and usable means of predicting the impact of land-use change on water flow.
3. Soil degradation can cause localised flooding during rainy periods, and reduced dry season flows.
4. Uncertainty surrounding hydrological processes within and beneath the soil makes it difficult to quantify the amount of water provided by a specific land manager upstream to a specific water user downstream.
5. Integrated land and water resources management can only be achieved if governance is holistic and evidence-based.
6. Water alone cannot pull people out of poverty
7. Market mechanisms linking land management and watershed services do not tend to address rural poverty.
8. Small-scale irrigated agriculture is unlikely to reach the majority of the rural poor.
9. What rural people want and what policy makers think they want are not necessarily the same.
10. Pro-poor benefits [of water programmes] should not be an afterthought.

Strategies to adapt specifically to climate change will include changes in land-use involving altered cropping patterns and areas under forest and irrigation. These alterations will have both biophysical and socioeconomic impacts. Water flows and water resources will be changed together with production values and job opportunities associated with the different land uses. The Exploratory Climate Land Assessment and Impact Management (EXCLAIM) dissemination tool has been produced for use with the FLOWS cluster, for visualising these different impacts under a range of past climate scenarios. The tool has been applied to demonstrate the impacts of catchment land use and interventions in a range of countries including India, South Africa and Costa Rica, showing the necessity for integrated land and water management. Where appropriate socio-economic data are available, it can also demonstrate how spatial changes in land use impact on job opportunities and economic production values.

As an example of its application, EXCLAIM has been used to model the impacts on surface and groundwater flows of changes in forest and irrigated areas, soil and rainwater conservation, and tank rehabilitation, in the Mustoor catchment, Kolar District of Karnataka, India (FAWPIO-India Second Interim Report, November, 2005). It demonstrates the impact of land use and water management on the outflow of 'blue' water under different rainfall conditions. The tool may therefore be used to define and demonstrate such interactions under a range of climate change scenarios.

Payments for environmental services (PES) are financed by the Government of Costa Rica through a national forestry finance fund which acts as an intermediary selling carbon sequestration and watershed protection services to domestic and international buyers. The science is provided by a research team (R8174). The significance of PES in a context of climate change is that in principle they offer a means of achieving integrated land and water management goals through market mechanisms. There are many provisos on their successful operation, but experimental projects are justified, if possible in a variety of ecological and institutional environments. (See section 6.2 below.)

4. Research Area: New approaches to local institutional development and rural service provision

Summary of Chapter 4
This chapter highlights RNRRS work on facilitating institutions at the local level, which aims to develop poor peoples' social capital in ways that can exert effective demand on service providers. These include the 'dialectic approach' to self-help group formation, improving access to information and knowledge, and using credit as a lever to move poor peoples' production systems to higher productivity.

Introduction

In pushing natural resources management towards more productive, achievable and sustainable strategies, human and social capital at local level are critical determinants along with service providers. This partnership has failed to achieve its full potential for many reasons, including: weak demand for services; inadequate resources, knowledge or proven technologies on the part of service providers; and local peoples' perceptions of top-down, non-participatory methods and recommendations inappropriate to their needs and resources or to local conditions. Strengthening local ownership, autonomy and capacities *viz a viz* either governance institutions or development interventions will create demand for service provision and raise expectations of its quality. A virtuous circle is achievable, linking productivity and sustainability with local practice on the one hand, and self-improving service provision on the other, a circle which will be demand-driven. In the context of climate change and variability, the process will strengthen management capacity at all levels. Promoting this partnership can therefore form a coherent part of a policy strategy for adaptation.

Without specifying climate change adaptation in their purpose statements, three NRSP projects or groups of projects have confronted this capacity enhancement - service provision equation across a range of agro-ecological conditions.

4.1 Facilitating local institutional development through new approaches

Line NRSP-3(a***)***: *A 'dialectic approach' to local institutional development* NRSP-3(a) (R7583, R7830, **R7839**); *Annex G.*

Climate change will add a new dimension of risk to poor peoples' livelihoods even in high potential areas, especially if hydrological regimes on which irrigation systems depend are adversely affected. Asset poverty (landlessness, weakly defended rights to water or other natural resources, few animals, poor housing, a lack of working capital) increases vulnerability to risk. An absence of empowerment (in relation to political, social or economic structures at local level) closes off adaptive options. Thus the benefits of many interventions, either technical or organisational, have been captured by the not-so-poor or better-off.

Many adaptation interventions are at the pilot stage and a long way from mass replication, which will require

- large numbers of communities to organise themselves to respond quickly, effectively and efficiently to changing situations and new ideas,
- a diversity of institutionalised interfaces and partnerships between local actors and governments, scientific organisations, NGOs and external actors,
- exchange of accumulated learning and information accessible at local level, and
- cost-effective facilitation, operational organisations, and appropriate adaptive models.

A facilitated *dialectic approach* to forming community-based institutional infrastructure (Self-Help Groups, SHGs) was developed and tested in high potential irrigated areas in India (R7839).[13] The essential feature of this approach is that the locus of control (together with many costs) is moved from external to local actors. It involves:

- self-evaluation by communities,
- reference to external experience and information,
- review of available resources, capacities and opportunities,
- challenging assumptions held by various stakeholders, and
- re-iterative critique of positions and arguments.

The approach values *unspectacular entry* into villages, use of *local volunteers,* and *incremental, non-deterministic facilitation,* with *avoidance of distorting incentives.*

The aim is to catalyse the search for practicable strategies, rather than promote solutions. Other agents must therefore also be involved, and the approach works best where facilitators have no conflicting or competing interests (for example, by working for government). On operation it is necessary to prevent deviation from the declared aim, for example by allowing the less poor to crowd out the poor from benefits. Attitudinal orientation is important for the facilitator, in particular in not seeking or enlarging personal authority.

[13] The 'dialectic approach' is a rough-cut and evolving concept that resulted from a painful and slow syncretic process beginning c.1995, and catalysed primarily by willing cooperation and intellectual inputs of communities in scores of villages in the Indian states of Andhra Pradesh, Bihar, Karnataka, Tamil Nadu, and Uttar Pradesh. Funding, inputs and support from the following sources have led to its development and articulation: a) Shriram Group of Companies (Chennai, India), which supported the Shriram Rural Development Project (1995-2004), and is now part of a joint venture with Cirrus Management Services Pvt. Ltd. to develop and expand its reach across India; b) DFID through programmes in which M.S.Ashok was involved, particularly R7839; c) The World Bank through its *Swashakti* programme, where Sunil Choudhary (a member of the R7839 team) developed valuable ideas, practices and techniques; d) Cirrus Management Services Pvt. Ltd., an organisation of rural development professionals that provided internal funding, motive power and an incubator against indifference and hostility, and is now developing the concept in collaboration with Shriram Group; e) M.S.Ashok, who developed and articulated the concept since 1995, and first used the label 'dialectic approach' in 2004, at the R7839 workshop, Delhi (footnote supplied by M.S.Ashok).

The approach is not claimed to be a 'magic bullet', but project experience shows that micro-organisations are capable of fast and significant change, and can respond quickly to new programmes, ideas or service providers. Post-project experience indicates that the dialectic approach, combined with other strands including professionally managed information networks and independent oversight, can lead to scaling-up at unit costs low enough to attract private capital. In the 17 months to March, 2006, under a private sector programme, 1,079 SHGs (13,471 households) have formed in 320 villages in six states, and with reported savings worth £60,000 and rotating internal loans worth £105,000. A parallel credit service established in May, 2005, issued loans to 285 SHGs worth £40,000. A marketing service has recently been added and discussions have begun to set up basic health services, with education and rights awareness on the agenda. It is established now that SHGs can be initiated within short time-frames and at low cost, simply through facilitation. Although it is well-known that credit is an important need, it is not by itself sufficient. Something more significant than credit provision is happening. Secondary and tertiary organisations and networks previously tested in R7839 are now being re-tested on larger scales. As local institutional networks develop, the external facilitator becomes progressively redundant. Participation of the entire community is possible, with the inclusion of poor people, fulfilling active or leadership roles. New services with very low entry costs can now be added to the institutional infrastructure.

Business plans and models for large-scale, for-profit, poverty focused micro-credit delivery, and for other kinds of farm input delivery and services, which should form (in time) a response by the private sector to these opportunities, are being pilot tested in Southern, Mid-Eastern, Central and Western India.

R7839 was linked to a concurrent project on participatory technology development in irrigation agriculture (R7830): including a mechanism for controlling irrigation water, adjustments to the timing of transplanting and sowing, aquaculture on low-lying rice land, zero tillage and deep ploughing. Existing SHGs under the aegis of an NGO were enabled, through the formation of water gate or Outlet Management Groups, to gain access to water management downstream from the control of Water Users' Associations which are dominated by local elites. This improved the efficiency of water use, and helped to test the new or improved technologies, by reversing the role of researchers to that of service providers to newly empowered farmers, rather than merely promoting technologies that the scientists considered relevant.

More work is desirable in the following areas:

- institutional adaptive capacity and interaction between science and local people
- learning from the autonomous growth process lessons that may be applicable elsewhere (e.g., dryland agro-ecological zones; continental Africa)
- increasing private sector involvement in service provision through self-help groups.

Empowering institutions at the local level will strengthen social capital (especially among the poor), which, in the event of negative impacts of climate change, may open adaptive options either in the natural resource sector or through diversification. The difference inherent in this approach is that facilitation relies on community effort and

is directed strictly to building institutional infrastructure without prejudging specific solutions.

4.2 An information approach to rural service provision

Line NRSP-3(b): Information approach to rural service provision for enhanced productivity by poor farmers through Integrated Crop Management (ICM: R7600, **R 8083**)

The purpose of this project (continuing at time of writing) is to enable organisations in Bangladesh that provide agricultural extension and related services to poor rural people, to better target their own services and also to facilitate their clients' access to services of other providers. The ICM database (from R7600) is being piloted in three communities, knowledge and information systems analysed, made more accessible to extension systems and promoted. In encouraging extension agents and farmers to populate the database has the aim of developing an interactive information tool for which both the supply and demand sides have a sense of ownership. Information interventions designed by Target Institutions (TIs) responsible for service provision will be implemented in two locations. The TIs will enhance their capacity, with that of rural service providers, to respond to demand for ICM technologies by redeveloping their procedures to build on strengthened capacity at local level. This strengthening at both levels is critical to improved management of NR and should include a capacity to respond to variability or change.

4.3 A micro-credit approach to rural service provision

Line NRSP-3(c) (HP, East Africa, Suite 2): Micro-credit approach to rural service provision for enhanced productivity by poor farmers through Integrated Crop Management (ICM: **R7962**)

The project (continuing at time of writing) targets beneficiaries who were identified in earlier studies in SW Kenya to be of intermediate ranking in the scale of poor to very poor: "intermediate and innovative poor farmers, who will be the main target groups for credit provision and so enabled to make productivity-enhancing changes to their farming systems". Soil phosphorus deficiency and a lack of improved crop varieties are regarded as key constraints to the productivity of the system. Credit provision will facilitate access to fertilizer in order to implement ICM technologies, enhancing their capacity to make sound management decisions.

A community-based micro-credit scheme will be enabled by two decision support systems - for assessing credit viability and appropriate soil fertility management strategies, whilst an improved basket of crops will be made available to enable farmers to improve economic returns and enhance the soil resource base. Extension services will benefit from decision-support tools; input suppliers will benefit from increased demand, stimulated both by greater availability of credit and increased returns from use of purchased inputs, and an ICM strategy will be adopted by target institutions (CBOs, extension systems, credit providers). Local institutional capacity (Village committees) will be enhanced, having potential value for managing variability.

To take these approaches forward, on the terms of the original purposes of the projects, and additional to communication, dissemination and promotion of recommendations, the findings need to be tested and extended to additional areas on the basis of impact and monitoring studies. There will be a diversity of pathways towards achieving a satisfactory partnership between local people and service providers, a partnership that can drive growth. In a context of adapting to climate change, new research is needed urgently on the linkages between institutional development, capacity at local and other levels to adapt to variability, and sustainable natural resource management.

5. Research Area: strengthening poor peoples' participation in NR management, governance, and policy

Summary of Chapter 5
This chapter highlights RNRRS work on improving poor peoples' participation in governance and policy, based on work in Ghana and Uganda (policy process between local and district levels; local governance through byelaws), on managing floodplain fish-farm systems under multiple use, on participatory institutions for coastal resources, and on stabilising aquaculture at a sustainable level. In these diverse ways, greater participation achieves enhanced management capacity for poor people which is the best insurance against risk.

5.1 Strengthening social capital for improved NR policies and governance

Line NRSP-5: Achieving democratic, evidence-based and participatory policy process, and strengthening the capacity of poor people to manage natural resources sustainably (R7957, **R8258**, **R7856**)

This Line includes work in Ghana and Uganda.

The first addresses the concern that under conditions of rapid change on the forest-agriculture interface, the benefits of current decentralization policies may not necessarily improve the livelihoods of the poor. Although democratization is a necessary condition for sharing the benefits of change with the poor, governance of natural resources is strongly influenced by social and political factors and by grand narratives of environmental mismanagement which lack a strong evidence base. The scoping study (R7957) analyses the situation in Brong-Ahafo, Ghana and proposes a new project (R8258, in progress at time of writing) which uses research to improve the quality of information, strengthen networking (e.g., farmers' groups), and articulate needs through Unit Committees and Districts. It aims to facilitate dialogue between the public and the policy makers to create policy frameworks which are transparent and evidence-based, and responsive to local interests.

Misplaced, ineffective or non-participatory environmental policies worsen poverty and vulnerability to climate change as well as being bad for the environment. New strategies are needed for delivering participatory management to the poor and ensuring that decisions about access to natural resources are made by accountable bodies on the basis of sound information within the decentralisation process. Distinctions are made between formal and informal institutions in this process, and between narrative and evidence-based decision making.

In the second (R7856) in Western Uganda, social capital was analysed in detail. During in-depth interaction with the research team, the 'participatory policy process action research framework' concentrated on key elements: (a) facilitating community planning of desired future conditions; (b) participatory policy analysis; (c) linking bottom-up processes to higher level policy processes through dialogue and learning events, and (d) supporting policy action in the form of byelaws on soil conservation, tree planting, controlled animal grazing, drinking of alcohol, wetland management and bush burning (which were implemented with different levels of success in pilot communities).

The purpose of this project was to strengthen social capital, to improve the effectiveness of local institutions and policies and to support the integration of participatory approaches to policy decision-making, in an area where land degradation is perceived to be serious. The experience suggested a five "ins" model: (1) strengthening local *institutions*; (2) providing *information*; (3) linking byelaws to NR management *innovations*; (4) finding and promoting *incentives*; and (5) building a network of *influence*, as effective mechanisms that research and development organisations can use to promote policy action at local level for sustainable management. With the decentralisation process in Uganda, there are significant opportunities to translate research results into policies that can help to accelerate wider-scale adoption of NR technologies.

It may be inferred from both projects that a research focus on democratic and evidence-based decision making and policy in natural resource management is potentially valuable where climate change threatens to accentuate instabilities in natural resource management. Strengthened social capital is an insurance against inequitable or unsustainable management, which worsens the impact of variability. There is scope for taking this work forward under different conditions of political ecology and agro-ecology.

5.2 Management of floodplain fish-rice farming systems

Line NRSP-1: Promoting integrated floodplain management (IFM) based on rice and fisheries in Bangladesh (R6756, **R7562**, R7868, R8103, R8195, R8306)

Complex interrelationships between competing production systems on floodplains (wet and dry season rice with opportunistic fishing in permanent or seasonal *beels*) have been mapped, quantified and inventoried at two sites using GIS (R6756), and impacts of exploitation and livelihood strategies understood. Participatory needs assessment and information transfer requirements from TIs have been assessed. Work was carried out on participatory action plan development (PAPD, R7562), chiefly in relation to common pool resources, to strengthen social capacity.[14] Seven wealth groups were used as a framework to provide a better understanding of poverty linkages and strategies. Use of the Flood-Plain Fisheries (FPF) Model, with existing data, have shown how it is possible to maximise joint benefits from multiple resources (R7868). Among seven new or improved management strategies considered, a key emerging issue for fish productivity is minimising water losses under late dry season rice. It is however possible to improve output and incomes substantially with low-cost adaptive management. Adaptive testing of these management options is being undertaken in two projects (continuing at time of writing):

- in riverine islands (R8103) - 'action research supporting poor women and men to build representative institutions, to gain greater policy influence, and to enable them to secure greater benefit from development planning and improved access' and
- in floodplains (R8306) – 'community participation in integrated sustainable management of terrestrial and aquatic floodplain resources.'

[14] RNRRS work on CPRs is the subject of another Synthesis Study.

Promotion of these findings to target institutions, policy makers and intermediaries is also being undertaken (R8195), on the basis of an extensive study of institutions and participation in Bangladesh.

Floodplains are vulnerable to extreme hydrological events, and the climate change scenarios are uncertain. Integrating and optimising local floodplain management would appear to be a pre-requisite for managing variability, and a temporal dimension needs to be written into the models, as well as promotion and continuing engagement with policy processes, and extension to more localities. This institutional capacity building will complement the experience gained at community level. Evidence of the effectiveness of PAPD was found in a Programme Development Study (PD131) in 2004.

The possibility of negative climate change, most probable here in the form of increased or decreased flooding and variability, puts a premium on optimising natural resource management through integrating the demands of fishing and crop production for access to land and water, productivity and benefits.

5.3 Institutional mechanisms for coastal management

Line NRSP-2 (LWI, Caribbean Suite 1): Developing livelihood strategies and institutional mechanisms for integrated coastal zone management will enhance preparedness in the event of climate change impacts adding to pressures on the ecosystem (R7408, R7559, R8134, R8317)

Reconciling ecosystem conservation with sustainable livelihoods in the coastal zones of small Caribbean countries and islands calls for approaches to planning and regulation that can successfully meet the needs of poor people, and involve them in participatory partnerships with government institutions. Productivity, pollution and unequal access are barriers to the efficient use of coastal waters and Marine Protected Areas are not necessarily the best solution.

Trade-off analysis has been put forward as a tool for decision makers (R7408). New technologies and livelihood options have been proposed and experimented, in a project whose purpose was to test and develop strategies for managing the use of coral reef resources sustainably, by generating economic benefits, strengthening community participation and maintaining ecosystem integrity (R7559). Co-management arrangements between local people and government hold promise, and guidelines to assist in their formation have been prepared, and tested with action research at six different projects and study sites (R8134).

A current project is developing new decision support tools and communications strategies, and testing both in the field (R8317, still in progress). The purpose of this project is that poor people in coastal communities will benefit from (a) improved resource management, towards sustainability and maintenance of critical stocks, (b) improved technologies, and (c) increased opportunities to participate in policy and management processes and institutions, in particular in the vicinity of Marine Protected Areas. The decision support tools are planning methods, institutional design, and partnership and co-management agreements. These are to be validated and

promoted. Integrating pro-poor strategies and tools into the policies, programmes and operations of a wide range of institutions will help create a policy environment that is more favourable to civil society, and establish meaningful partnerships between states and civil society.

Innovative strategies and a 'seat at the table' for poor stakeholders in co-management will strengthen human and social capital in the region. Climate change and variability are not yet on the agenda, but if implemented, these measures will build capacity for managing adaptation at both institutional and individual levels.

5.4 Reconciling coastal aquaculture with carrying capacity

Line AFG-2 Achieving sustainable aquaculture in coastal ecosystems based on carrying capacity criteria (R6011, **R8094**).

Coastal regions of South and East Asia are densely populated and urbanised, and so are affected by land scarcity, deforestation and pollution. Carrying capacity is the environmental capacity to absorb wastes from a profitable level of aquaculture production. Over-production leads to loss of water quality and yield failure. On the other hand, the costs of maintaining water quality on-farm, or the loss of land for dispersing waste (especially mangroves) off-farm, may threaten economic viability.

The TROPECA project aimed to develop simple models of carrying capacity suitable for use by farmers or policy makers as management tools (R8094), and a set of practical guidelines. This work was supported by case studies in Bangladesh and Vietnam. The models of capacity and adaptive management approaches when developed and tested will enhance natural resource management capabilities of users. Policy guidelines will enhance the institutional capacity to plan and manage aquaculture resources.

Under climate change, coastal ecosystems may be subject to changes in the long term that threaten poor peoples' livelihoods. Improving ecosystem health in the longer term therefore represents an adaptive goal. Aquaculture that is badly managed or over capacity is more likely to be vulnerable to ecosystem change. Strategies accessible to farmers will improve their resilience. Taking this work forward in a climate change context calls, therefore, for the incorporation of change scenarios into the models and guidelines.

6. Research Areas: Building resilience in poor peoples' livelihoods through intra- and inter-sectoral diversification and management capacity

Summary of Chapter 6
This chapter highlights RNRRS work on supporting livelihood diversification in uncertain environments, including crop-livestock integration, payments for environmental services, the promotion of on-farm aquaculture, supporting livelihoods in semi-arid areas to diversify off-farm, and peri-urban diversification. Diversification both within and beyond the natural resource sector should receive recognition and support as a strategy for countering risk.

Introduction

Livelihood construction and management are keys to individuals' or families' capacity to accumulate wealth or survive shock. Innovative technologies, modes of sustainable resource management, new or strengthened institutions, participatory policy making, income diversification and other strategies promoted through research are judged by beneficiaries on their impact on livelihood improvement and sustainability - in the present context, under conditions of increased climate variability. It is important to recognise that livelihood strategies are multi-dimensional (especially where variability is routine), dynamic and complex, embedded in social relations, and do not necessarily prioritise the natural resource sector. An example taken from outside the RNRRS portfolios, is annexed to illustrate these features (Annex H).

6.1 Strategies for integrating livestock production with farming

Line LPP-1: Increasing or enhancing the technical options and economic benefits available to smallholders integrating livestock with crop production (R 4338, R5732, R6153, R6536, R6619, **R7955, R6781**)

Crop-livestock integration is widely promoted in policies targeted on small farms in areas with increasing population densities and land scarcities. The traditional response has been to research into productivity-enhancing technical options for poor farmers. In East Africa, for example: digestible, bird-resistant sorghum residues (Ethiopia, R4338); the use of tree fodder (Kenya, R5732); optimal use of sown Napier grass (Kenya, R6153); baling maize stover (Tanzania, R6619) and protecting maize from weeds, pests and disease (Kenya, R7955).

Animals produce income and may be sold to raise capital which can be re-invested on or off the farm, or to finance consumption, cushioning the impact of grain shortages. If uptake and benefits are widespread, and targeted on poor farmers, they will enhance their capacity to manage their natural resource-based livelihoods, including the effects of exogenous variability. Rainfall variability that adversely affects crop production may not necessarily have the same impact on fodder supply, and vice-versa. Moreover animals hold their value during short-term rainfall fluctuations. Small ruminants and fowls are accessible to poor people. Crop-livestock integration may (in the right circumstances) permit a more flexible response to variability.

The earlier projects supported the technical advancement of intensive, small-scale, integrated farming, though subject always to economic incentives, effective promotion and uptake. Social determinants of farm production were not usually considered, a rare exception being a study of women's dairying activities in Tanzania (R6536). More recently, research in Mali, Ethiopia and Zimbabwe has focused on policy issues, and confronted the complexity of pathways of change, social differentiation and institutional mediation (R6781). Findings include the following:

- technological change occurs in a broader livelihood context than that of crops or livestock alone;
- there are multiple pathways of change that can co-exist and interact;
- change may be either incremental or abrupt, calling for different policy responses;
- changes are affected by a variety of institutions at all levels and degrees of formality; and
- different policies can either interact or conflict, with sometimes unexpected consequences.

Long-term profiles of intensifying production systems (30-60 years) in certain parts of Africa have demonstrated significant achievements along integrative pathways.[15] Livelihood diversification beyond farming and livestock production has also been integral to these achievements. But the future trajectories of farming systems undergoing intensification will be critical. Increased variability will add stresses to these systems. Participatory policy formation will strengthen local management capacity (see below, LPP-3), and appropriate policies can provide incentives for sustainable NR management.

6.2 Income generation through carbon sequestration

Line FRP-4: Sustainable community forest management with incentives to provide carbon sequestration services (R6320, **R7274**, R7374, ZF0167; ZF0202)

The principles of compensation mechanisms as a part of integrated land and water management – in particular in relation to water rights (R7937) - and that of payments for environmental services (PES, R8174) have been mentioned in Section 5.2 above. A form of PES that is currently receiving much attention in a global climate change context is the growing market in carbon sequestration services, which at least in principle can be introduced in poor countries (R6320, **R7274**, R7374, ZF0167; ZF0202). Promotion, through financial incentives, for planting and managing forests or trees on a sustainable basis recognises the sequestration potential of very large global areas of dry forest inhabited by farmers with private access rights to land. For example, a project is operational in 20 communities in Mexico, under the aegis of a regional facilitating agency (R7274). Related projects address the demand for information about how to activate such projects under the Kyoto Clean Development Mechanism (ZF0167), and the need for training (Uganda, ZF0202). In this fast developing field, evaluation of early project experience, extension of trial projects to other communities and areas, and the necessary feasibility studies, deserve priority.

[15] R6051 (NRSP); R7072 (NRPRI); R7221 (ESCOR).

From a global perspective carbon trading is regarded as a mitigation strategy. At local level, however, sequestration schemes offering financial or other incentives to small farmers in poor countries may impact positively on livelihoods. For them, participation is an adaptive strategy reducing the risk to livelihoods brought about by variable rainfall and its effects on crop yields. The impact on poverty depends on ensuring that benefits are not appropriated by larger landholders able to meet minimum holding thresholds and enjoying registered title (as found by R8174), on competition with other potentially more profitable land-uses, and also on sustainable financial arrangements that will actually deliver the rewards to beneficiaries rather than to government revenues.

6.3 Enriching farming systems with aquaculture

Line AFG-1 Enhanced promotion of aquaculture on riverine, floodplain and small basin sites as a means of diversifying and enriching farming systems (R4681, R6721, **R6380Cb,** R7064)

Diversification is a risk-spreading strategy, and increased household incomes from fish can strengthen livelihood portfolios or improve nutrition. It is a reasonable proposition that aquaculture under the right conditions can enhance capacity to manage change and variability, whether in humid, sub-humid or semi-arid agro-ecological zones. However, in Africa aquaculture projects have a poor record. Analyses carried out in Kenya and Zambia (R6721) show that failures (ever since colonial times) have resulted from a variety of causes including: poor design for local conditions, failure to resolve rights to and benefits from common pool resources, poor extension support, poor management, unprofitable markets, and marginalising women or poor people. The policy and practice implications of these findings suggest that implementation rather than aquaculture *per se* has been at fault; if better designed, promoted and managed, and integrated into the social and farming system, it still has a future in rural development.

In Asia, aquaculture is combined with irrigated rice production, and there is scope for expanding output both in small farmer-managed irrigation (R6380Cb) and in engineered water systems (R7064). In order to promote aquaculture in small-scale rice farming systems, technical, social and economic constraints will need to be overcome. R6380Cb tested five management options graded in order of intensity, with a fish yield range of 10s kg/ha to 500 kg/ha. A range of wealth groups were included in farmer-participatory workshops and trials, which appear to have enhanced capacity at both farmer and community levels based on a strengthened knowledge base and an ability to choose among options according to a farmer's circumstances.

These projects suggest that in the past, aquaculture promoters underestimated the complexity of the farming systems in which it was to be inserted. The way forward is through flexible and multiple options appropriate in a variety of natural, social and economic conditions, backed by analysis and technical data that integrates local with scientific knowledge and concurrently enhances local capacity. Aquaculture is not risk-free, as water regimes are susceptible to climatic variability. With regard to climate change, the proposition is that variability is less likely to affect both sectors at once and that farmer-fishers whose livelihoods are thus diversified have an enhanced capacity to manage it.

Line NRSP-4 (HP, India, Suite 1): Practice and policy changes for promoting aquaculture, as an income enhancing and risk-spreading strategy, in rainfed farming systems in eastern India (R6759, **R8100**)

Where ponds abound in rainfed agricultural areas there are opportunities to promote and improve aquaculture for enhancing food security and incomes of poor (in this case tribal) people. Participatory, group-based and low-input methods were used to develop new germplasm/species/techniques (R6759) in conjunction with development agencies in the eastern plateau of India. It was intended to introduce new varieties to the market place by capacity building within poor farming communities.

Using participatory, group-based and low-input methods, a range of new species and management modes (breeding hatchlings, production of fry, fingerlings, table sized fish), adapted to seasonal availability of water, achieved a 57% uptake of aquaculture during the project period (4 years) in >200 villages. Asset enhancement effects on livelihoods include strengthening of social capital through groups, networks, group financing, and better access to government funds. The research also provided a better understanding of the institutional constraints blocking aquaculture uptake in this region.

An inclusive process was developed for transacting the necessary technical and institutional changes for marginalised people to embark on aquaculture as a means to improve their food supply and earn income (R8100). Embodied in this process is a strategy for bringing through the voices of poor people, referred to as *facilitated advocacy*. An eight-step strategy was developed for transacting technical and institutional change, engaging local people with policy and planning. Through strengthened self-help groups, better access to information, and new links with planners and policy makers, better service provision for aquaculture was achieved.

The work is being taken forward through partner institutions. The consensus-building method is relevant to policy areas beyond aquaculture, particularly where social divides act as barriers between stakeholders. Local capacity to manage variability and climate change may be expected to be enhanced through strengthened social and human capital. However the systemic interactions between aquaculture and agriculture, the basis for using a diversification strategy, were not investigated in this project. (As a project on the empowerment of marginalised people in securing better service provision and policy support, this work has a close affinity with Chapter 4 above.)

6.4 Enabling NR-based livelihoods in semi-arid areas

Line NRSP-7. Enabling of NR-based livelihoods in semi-arid areas (R7304, R7537, R7545, R7805, R8192, R6051 & R7093); *Annex H.*

A defining characteristic of primary production in semi-arid production systems (SAPS) is variability in time (between and within seasons) and space (often at relatively small scales), largely as a result of rainfall variability. Deriving any degree of livelihood from such an environment necessitates frequent adjustment to

environmentally induced variability. A frequent observation of NR users in the drylands is the flexibilities of their natural resource management systems that can employ for example a range of crop planting responses, weeding intensities, and livestock feeding options. Critically for development policy, the inhabitants of drylands also exploit a range of options outside the natural resource sector, which are themselves subject to variable outcomes.

A generic finding of research in this Line and elsewhere is that investment in dryland NR management is risky and this influences engagement patterns. An important corollary of this noted in Zimbabwe (R7304) is that the most successful households are considered those least dependent on the environment. Though successful NR use, replete with productivity enhancing investments, can and does occur in the SAPS, it does so more often than not on the back of successful non-farm income streams (R7304, R7545 & R7805). Whilst investment may move in both directions, diversification *per se* does not necessarily lead to farm investment. Pro-active, successful development of non-farm activities may lead to farm investment, but re-active 'survival' diversification (as widely practiced by the poor), less frequently generates positive and enduring returns to their NR management.

An analysis of natural resource asset management in semi-arid production systems, as carried out by one of the earliest projects in this Line (R6051), highlights the sheer diversity of their forms and means of deployment. Bringing in the whole suite of livelihood assets and related activities in order to determine the most effective poverty alleviating entry point, as a related R7304 output attempted through modelling,[16] the sobering finding is that single interventions are unlikely to have a substantial effect.

The logic of not putting all one's eggs in one proverbial basket is clearly felt in SAPS. However, having to distribute only a few eggs between a limited number of baskets highlights the dilemma of 'jack-of-all-trades, master of none'. Additionally, the eggs (and baskets) tend to be re-arranged as opportunities and constraints shift. Research needs to understand how livelihoods unfold and how assets are used in dynamic environmental and personal scenarios. Thus as R7537 revealed, making predictions of technology demand on the basis of information given by current users is not helpful. Though improvisation is a critical skill for all dryland NR managers, a poverty of options may nevertheless prevent many from making the best strategic use of their assets.

Which way forward? If effective NR management is dependent on some buffering capacity provided by non-farm incomes, then a strong case can be made for focussing on increasing this income share for the poor whilst keeping their NR options open. Research questions include: the organisational basis of the NR and non-NR sectors within the household; whether extension is promoting NR uses that accommodate the non-NR options of the poor; the covariance of risk among different assets; the policy options that complement those aimed at stimulating non-farm opportunities for the poor (e.g. paying farmers to leave fields in fallow). There are several justifications for making this area a research priority: there is mounting evidence that income diversification is increasingly the norm in rural livelihoods (not only in SAPS); efforts

[16] Campbell, B.M., Jeffrey, S., Kozanayi, W., Luckert, M., Mutamba, M. & Zindi, C., 2002 Household Livelihoods in Semi-Arid Regions: Options and Constraints, P.121. Bogor, Indonesia: CIFOR.

to attain universal education should increase human capacities to work outside the NR sector; and finally, combinations of non-NR elements in livelihoods could serve to offset risks from climate change.

In SAPS attempts to control the effects of environmental variability on natural resource production through technological solutions have met with limited success. Research in this Line indicates that the best way forward is to support the management of natural resource assets in relation to their wider livelihood context. Climate change is likely to extend the applicability of this direction. Taking this work forward will require enabling primary beneficiaries to articulate their natural resource needs in relation to their wider opportunities. To respond to such needs, service providers will need to look beyond the NR sector. Offering clients a choice of asset technologies from which they can choose is suggested in several projects in this Line (R7304, R7537).

6.5 Lessons from diversification in Peri-Urban Systems

Line NRSP-13 Diversification strategies adapted to market and environmental risk in peri-urban systems (R7867, R8084, India; R7854, R8090. Ghana)

The adaptive capacity of individuals and groups may be expected to vary temporally and spatially not only because the experience of climate change will differ, but also in response to available adaptation options. The relative roles of farm and non-farm elements is increasingly emphasised in livelihoods research. Resilient rural livelihoods often appear to be based on the interdependence of farm and non-farm assets (see Line NRSP-7). However, the way resilient livelihoods are established depends *a priori* in part on the location and qualities of the farm and non-farm assets employed and critically, their accessibility.

Though distant farm and non-farm opportunities can be and are incorporated into resilient livelihoods through mobility, the importance of natural capital tends to shift along the urban-rural continuum. Since climate change predominantly affects natural resources (albeit with downstream impacts on other sectors), its impact on non-farm livelihood elements may be expected to vary along the same continuum. Research and policies to strengthen adaptive capacity to climate change need take account of this increased engagement with the non-farm sector. As O'Brien & Leichenko (2000)[17] have pointed out, vulnerability often emanates from two principal directions, climate change and the market, which combine to create a condition they call 'double exposure'. It should not be assumed that diversification into the non-farm sector will better insure livelihoods against climatic risk, since it may engender increased vulnerability to the market.

In the peri-urban interface, increasing access to non-farm activities is enmeshed with declining farm opportunities as the city spreads. Livelihoods are constructed within this dynamic setting according to specific local opportunities and obstacles, contacts and personal motivation. How the poor can benefit from this situation—and there is evidence that some do—relates to a host of factors. Research from India (around the twin cities of Hubli-Dharwad, R7867 & R8084) and Ghana (around Kumasi, R7854

[17] O'Brien, K.L. and Leichenko, R.M., 2000, "Double exposure: assessing the impacts of climate change within the context of economic globalization" *Global Environmental Change* **10**: 221-232.

& R8090) highlights the following key features of non-farm opportunities that help increase the adaptive capacity of the poor:

- Regularity of non-farm work is highly desired to provide income security, but when it is not available throughout the year, seasonal work is vital in other activities.
- Non-farm activities that come to fruition quickly are preferred over those that have a longer gestation period.
- Prior individual or traditional experience in certain types of work was considered a qualification for choosing certain livelihood options (including that of remaining in farming). In Kumasi, a programmatic upshot was that a capacity to develop new skills to adapt to the job market is best supported through allowing people to discover new options themselves.
- Spatial convenience of non-farm activities is particularly important for women, in order to facilitate their domestic chores and in some cases, respect cultural restrictions.
- Reasons for changing activity careers among the poor/poorest often relate to changing family circumstances (e.g. marriage, death, divorce).

Implications for DFID's future research and development policy

7.1 Defining a mandate: adaptation within development

A body of knowledge has been identified in the RNRRS portfolios that is relevant to climate change adaptation (Chapters 2 – 6; Output 1). How should this be positioned within DFID's development through poverty reduction mandate?

Adaptation means change. Poor people have responded to change in the past as a matter of necessity, and borne many of the costs of transacting it. The addition of climate change and the resulting variability to the challenges they already face intensifies this burden. The adoption by the international community of the Millennium Development Goals, in accepting a rights-based approach to poverty, adds urgency to developing appropriate adaptive strategies for responding to climate change. Such are the numbers of people likely to be affected by climate change scenarios that adaptive failure on a large scale will block the achievement of the MDGs, especially in Africa. Yet variability and long-term change result from other elements of the poverty equation than climate alone. 'Double exposure' to the effects of globalisation *and* climate change complicates analysis, response, capacity building and policy.

It follows (though perhaps a truism) that the best form of adaptation to climate change is development:

> "A two-fold link can be seen between climate change and development. One, the impacts of climate change can severely hamper development efforts in key sectors, e.g. increased threat of natural disasters and growing water stress will have to [be] factored into other sectoral development plans. Second, development policies and programmes will themselves influence the ability to adapt to climate change, e.g. policies for forest conservation and sustainable energy will, if correctly targeted and implemented, enhance the resilience of communities and thereby reduce the vulnerability of their livelihoods to climate change" (IIED, *Climate Change and Sustainable Development, 4.2, South Asia,* p 11; *India,* p 10).

Conversely, it can be argued that adaptation is a paradigm of development,[18] an apt interpretation in the contemporary setting of political (e.g., democratisation, decentralisation), economic (e.g., market liberalisation, subsidy removal), social/demographic/medical (e.g., urbanisation, HIV/AIDS) and environmental change.

It is essential therefore to define the focus of adaptation research, which aims to respond to the actual, impending, or probable impact of climate change within the broader context of poverty reduction. It is desirable (though not always practicable) to retain a distinction between variability in climate parameters and that originating from other sources, especially markets and economic policies, for the simple reason that

[18] Schipper, Emma Lisa Freya (2004), *Exploring adaptation to climate change: a development perspective.* PhD thesis, School of Development Studies, University of East Anglia.

short-term remedial action for the latter is within the reach of policy makers whereas for the former it is not.

From the standpoint of the present study it is necessary to emphasise another distinction between two popular uses of the word 'adaptation'. The first, and by far the most common usage in the climate change literature and debate, concerns policy and planning responses on the part of governments and the public sector.[19] The individual appears as a recipient of education and advice, and as an agent of mitigation (via reduced carbon emissions, changed lifestyle, conservation practices, etc.), led always by guidelines, policies or regulations set by the appropriate authorities. The second usage is concerned with autonomous adaptations to increased risk of livelihood damage or other costs of climate change, assisted by research-development products such as technologies, new participatory institutions or enhanced opportunities. These responses are contextualised in local knowledge, political economy, and poverty. This usage reflects the orientation of most (though not all) RNRRS research. The present study, therefore, positions adaptation in relation to development, focusing on autonomous action.

7.2 What approach for DFID?

There are only two practical approaches to formulating development research policy (Output 2) in response to an expectation of climate change. The first is an issue-led approach that seeks to compile an action agenda either by selecting priorities from a global list of issues organised by sector or region on the basis of expert consultations,[20] or by constructing an integrated science agenda around a priority issue, such as the policy and institutional frameworks required to ensure that climate change does not add to the burden of poverty.[21] Priority issues are linked to vulnerability, adaptation, and improving the linkages between climate change research, mainstream development and disaster relief.

The alternative is a 'value-added approach' that aims to build on previous research and development investments in fields relevant to climate change by formulating a new strategy reflecting available institutional strengths and comparative advantage. DFID's RNRRS is such an institution. Climate change research is not taking place in a vacuum. Issues of impact and adaptation have been anticipated in some earlier work. However a fresh impetus and renewed focus are needed in relation to new, or newly urgent, research questions. This focus is defined, for the purposes of the present study, as that of strengthening the adaptive capacity of poor people who use natural resources in their livelihoods, through research, development interventions and policy (Chapter 1). By sharpening this focus, knowledge gaps can be identified that are capable of being closed from the platform provided by previous work.

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[19] See, for example, Tomkins, Emma L., Nicholson-Cole, S. A., Hurlston, L., Boyd, E., Brooks Hodge, G., Clarke, J., Gray, G., Trotz,N., and Varlack,L. (2005). *Surviving climate change in small islands – a guidebook.* Tyndall Centre, <www.tyndall.ac.uk>

[20] See: IIED (2005), *Climate change and development. Consultation on key researchable issues*. London: International Institute for Environment and Development.

[21] See: IDS (2005), *Linking Climate Adaptation: IDS Bulletin, 11/08/2005*. Brighton: Institute for Development Studies at the University of Sussex.

The two approaches are complementary. Within over-arching global agendas, actors must define their own achievable pathways. For a donor working within existing frameworks of country and institutional commitments, alternative or competing research agendas, and long-term strategies or priorities, a 'value-added approach' is pragmatic and offers benefits: scientific continuity and a platform for framing new questions, returns on previous investments, and optimal utilisation of research capacity (either in partner countries or the UK). Such an approach does not mean 'more of the same', not least because climate change adaptation was not targeted in the original research. The need for further evolution in response to new challenges is fundamentally important.

The ideal of adding value should be applied also to the capacities of poor people and their institutions. Much is known about indigenous resources of knowledge, skills, community organisation and risk management. (Less attention has been paid to indigenous environmental management institutions.) Earlier practice in development (agriculture, forestry, livestock, fisheries) followed a diagnostic-prescriptive model that paid scant regard to indigenous capabilities, and sought to regulate or transform production systems according to externally perceived models. The weaknesses of these approaches have been exposed and new models of development are being espoused. Nowhere was the diagnostic-prescriptive model less adequate than in understanding and supporting responses to risk and uncertainty where ecosystems (and their management) may not return to equilibrium after disturbance, but follow unexpected trajectories. There is a need for caution in seeking to transform production and livelihood systems on predetermined lines under such circumstances.

Climate change scenarios suggest that new levels of variability may soon impact on poor people in many tropical and sub-tropical agro-ecological regions. Unfortunately for policy makers, the scenarios are a long way from complete agreement at national or local levels, the levels at which development interventions take place and policies are formulated. This uncertainty fully justifies an emphasis on the management of *variability* (more or worse extreme events, Chapter 1) as the key research target. There are 'living laboratories' where adaptive resources have already been tested, notably the Sahel which saw a reduction of one-third in average annual rainfall between the 1960s and the 1990s, with an attendant increase in the frequency of major agricultural droughts.

On the other hand, living with variability has another face: exceptionally good years or seasons are interposed with bad or average ones, and they offer opportunities for accumulating surplus value, strengthening livelihoods and preparing for the bad times. Opportunistic response, as every poor person knows, is a form of enablement that can impact positively on livelihoods. It can be facilitated by technical, institutional or policy measures. It holds the key to effective insurance systems at the local level.

DFID's comparative advantage (Output 3b), therefore, is defined first as its RNRRS portfolios of multi-disciplinary, research-based knowledge, a knowledge platform to which value may be added through an evolving strategy on climate change adaptation through research groups in international partner institutions and the UK. Second, the strategic benefits of DFID's international coverage must be capitalised in moving forward. Unlike local partners DFID has the advantage of being able to compare differences in regional experiences in promoting adaptive capacity and is thus in a

position to extract and diffuse generic lessons of best practice. The NRSP's Production Systems Characterisation Study[22] is a key asset for enabling such comparison and streamlining DFID's potential bridging role between its worldwide set of regional partners.

In order to help formulate DFID's policy, and building on the findings of the value-added approach, two strategic options for research policy are set out in the following sections.

7.3 A research strategy – Option (A)

Option (A) for DFID, in formulating its research strategy for climate change adaptation research, is to adopt a broad-based approach encompassing the range of five Research Areas (though not necessarily every Research Line), taking them forward through dialogue with research partners and building on new research priorities defined essentially through identifying unanswered questions in respect of each Line. The five thematic Research Areas described in Chapters 2 – 6 are summarised below as elements of a strategy (Output 3b).

- *Innovative technologies to support enhanced NRM under variable conditions* (Chapter 2). These are located principally in: crop varietal development; the promotion of seed priming; and the control of migrant pests. What distinguishes the capacity of a technology to contribute to this goal is its contribution to reducing risk, in addition to the normal developmental goal of enhancing productivity on a sustainable basis. Priorities for new work include advancing to new varieties and agro-ecological zones and targeting new pests or diseases. Adjoining these is a need for expanded work on livelihood dimensions - not merely on impact but on embedding the technologies in social, economic and political change.
- *Using analysis and modelling to support decisions on asset management under variable conditions* (Chapter 3). These approaches include: locally applicable climatological analysis and weather forecasting; modelling optimal rainwater harvesting strategies for users; modelling alternative options for livestock keepers; optimising the decisions of small-scale oceanic or lacustrine fishers; modelling agro-forestry decisions to maximise water use efficiency; optimising species selection and management in on-farm tree-planting; and modelling integrated management of land and water in river catchments. Such tools have the potential to reduce the risks borne by small producers in bad times and assist opportunistic responses in the good. The capacity of these approaches to respond to the needs of poor people is uneven, but a general priority for continuing work is to develop user-friendly, relevant and situational applications.
- *Facilitating local institutional development (social capital) and creating demand for more effective rural service provision* (Chapter 4). A 'dialectic approach' to rural institutional development, and information-based and micro-credit approaches to rural service provision, have been developed and tested. Pathways for modest accumulation, and forms of insurance against risk,

[22] Taylor, J., Tang, M., Beddows, C., Quin, F.M. and Stocking, M. (2003), *The charactarisation of six natural resources production systems.*DFID/NRSP.

can be facilitated through these channels, and possibilities for private sector participation in service provision have been pointed up. An important need is for clarity of purpose – building social capital – in new approaches to familiar recipes (such as self-help groups and credit). The key to success will be a capacity for self-multiplication. Successful up-scaling is already claimed for the first approach but is yet to be demonstrated in the others.

- *Strengthened poor peoples' participation in natural resource management, governance, and policy* (Chapter 5). This goal is approached through Research Lines on: participatory local governance and evidence-based policy making; integrated local floodplain management; institutions for participatory coastal management; and model-based advice on managing coastal aquaculture sustainably. Enhanced institutional competence at the local level, besides offering equity, accountability and sustainability benefits, provides an essential form of preparedness against uncertainty. Each has its own agenda for further work, but the problem of re-engaging poor rural people in the management of their own natural resources requires a great deal more attention.
- *Enhancing resilience in poor peoples' livelihoods through inter and intra-sectoral diversification* (Chapter 6). The many dimensions of diversification taken up in Research Lines include: integrating livestock with crop production; generating additional income from carbon sequestration through market mechanisms; enriching farming systems through investments in aquaculture; enabling multi-dimensional and flexible livelihood strategies in semi-arid areas; and learning lessons from experience gained in peri-urban areas. In future there is a need to strengthen integrated approaches in research on the natural resources and non-natural resource sectors. Specifying pathways of autonomous adaptation through the many options and constraints affecting individual or family circumstances is not for the researcher, but finding ways of facilitating sustainable diversification, where natural resources are becoming scarce or degraded or more risky presents a research challenge. The removal of barriers, setting in place of enabling policies, and increasing the range of appropriate technical or economic options are priorities for future work.

Specific suggestions for taking the Lines forward are given in Chapters 2 - 6, but the review has illuminated some more generic knowledge gaps that will now be summarised.

7.4 Knowledge gaps

Some generic gaps that deserve attention in a climate change adaptation strategy (whether or not Option A is favoured) are as follows:

- Uptake of new technologies has tended to be measured by *over-simplified indicators*. Data collected before and after the promotion of a new technology or management system, for example, do not necessarily measure either impact on livelihood systems or adaptive capacity to climate change. Also, there has been no mechanism for monitoring continuing uptake beyond the lifetime of a project. A more sophisticated methodology for assessing adaptive capacity

over the medium to longer term is needed as a guide to future research investment. Research itself will need to be adaptive.

- The local *political economies* that form the context in which new technologies are developed or introduced have not received enough attention, perhaps because most research groups were primarily interested in the biophysical aspects of natural resource management. 'Success stories' of adaptive change should be studied in depth with regard to key issues, for example incentives and barriers that affect livelihood change, engagement of the research process with policy formation, democratisation, and the potential replication of action research approaches including their capacity for autonomous multiplication after intervention is withdrawn.
- Few projects have addressed the challenge of how poor people can *optimise the use of new knowledge* within complex livelihood systems that are beset with competing demands on scarce resources; for example, modelling approaches tend to leave out social variables in order to simplify operation. Strategies recommended by research must pass into a personalised realm of decision making that is highly variable. Environmental risk adds an extra dimension to this complexity and ways are needed of engaging with it in order to ensure that benefits of research are realised by intended beneficiaries.
- *Economic drivers* of change – incentives and constraints - have been underused in models and decision advice. This goes beyond the observation that new technologies or strategies are not adopted unless profitable. In the present context, price fluctuations and inflation that are caused by interactions between environmental and economic variables need to be understood in specific regions, as they frame poor peoples' responses to livelihood options.
- Complex institutional issues are too easily oversimplified in research and policy debates (for example, reducing resource tenure to a matter of land titling). The facilitation of *institutional development*, governance and management has only recently become a priority in natural resources research, and much work remains to be done in this area. 'Power-cognizant narratives'[23] that can inform understanding of how poor people respond to, or are constrained by, risk need to be taken seriously in case studies and action-research.
- The trade-off between *diversification and risky specialisation* needs more attention in action and research intended to facilitate robust livelihoods that are capable of withstanding climate change**.** So too do the best ways of managing a diminishing or degrading natural resources sector in multi-sectoral livelihoods. Both these needs call for a broader systems framework than has been applied in most natural resources research.
- *Territoriality* (the exploitation of assets in different places) and *personal mobility* (between such places) confer, among other benefits, the spreading of risk (see Annex H). Invariably, a climate crisis (such as drought in semi-arid areas) brings about a sharp increase in both. Attempts to control these important forms of response (for example, by registering private titles to land,

[23] Omamo, S W and Farrington, J (2004), 'Policy research and African agriculture: time for a dose of reality?' *Natural Resource Perspectives,* 90. London: Overseas Development Institute.

denying the secondary rights to fuelwood, grazing, or non-timber forest products, or by placing restrictions on migration) may be counter-productive if not futile. A hidden assumption that poor people should be self-sufficient in their homelands, ideally on freehold farms, while for those better endowed the world is their oyster, is overdue for critique and replacement. A right to mobility may be a precondition for achieving the MDGs, and climate change adds to the urgency of this issue.

- A longer timeframe is needed to respond appropriately to *cumulative ecosystem change* than to manage variability in the weather, which resource users already do, if sometimes sub-optimally. Long-term trends are under way in (for example) sea surface temperatures, frequency of coastal flooding events, lowering of water tables in semi-arid areas, or the reconfiguration of growing seasons, that on crossing critical thresholds, may lead to the collapse and reorganisation of dependent production systems. Building awareness of longer term risks associated with cumulative ecosystem change is difficult, partly because of scientific uncertainty. Several projects reviewed in this study contain implicit warnings of such eventualities, but they remain for the most part too far in the future to command the attention of local people or their policy makers. In the meantime, improving capacity to manage variability will enhance levels of preparedness.

This list is not exclusive. However it suggests the breadth of scope required to take climate change adaptation research forward, either under Option (A) or, as will now be argued, towards an alternative Option (B).

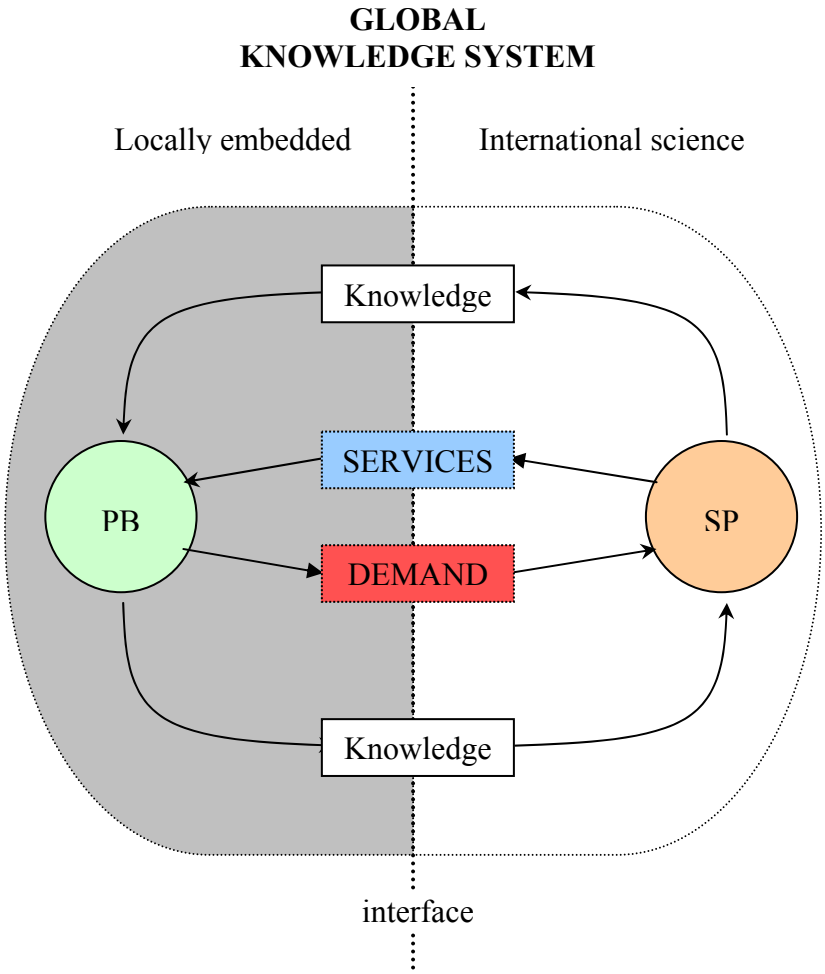
7.5 How is demand articulated for knowledge and services?

A recurring theme in many Research Lines is the question of addressing demand for knowledge and services (see especially Chapter 4). As a motor of development research, the concept of demand setting the agenda chimes with historical currents towards greater emphasis on indigenous knowledge in formulating development processes as well as the wider ethos of participation. The notion of demand for knowledge and services however raises fundamental questions about how, on one side, such demand can be articulated, and on the other, how it can be received and acted upon. This section will briefly outline these issues in order to generate reflection on how DFID can best rise to the challenge of enabling positive adaptation in the face of the uncertainties posed by climate change.

Considering first the articulation of demand, it is important to examine the sources of information that intended primary beneficiaries draw on as they constantly adjust and adapt their livelihoods to the host of changes they face. As globalisation alters the information landscape in unprecedented ways, it is pertinent to verify where and how people find their points of reference for adaptation. Although the complexities of local political economies warn against generalisation, it is difficult to deny the primacy of individualised channels. The diffusion of new seed varieties, for example, frequently works through social networks dependent on face-to-face interaction. Known individuals broker the unfamiliar - they have the advantage over unknown people or impersonal media of being questionable, observable, more trustworthy and easier to relate to. Mobility, experience, experimentation and serendipity may all change the

realm of known possibilities. As numerous examples from the RNRRS portfolios illustrate, many people, given voice, are able to articulate the factors that impinge on their ability to change. On the other hand, a lack of exposure to possibilities beyond the boundaries of their information encounters, or institutional barriers, may curtail uptake of promising adaptive possibilities (see Section 7.2 above).

Turning to the question of responding to demand, a sea-change has occurred. The older one-way traffic model of the development agent promoting research products to beneficiaries is being replaced by one in which the development agent is succeeded by a service provider who receives and meets demands from the beneficiaries. The change requires a new research architecture which can ensure that intended beneficiaries have access to appropriate conduits for articulating their demands (e.g. SHGs and networks). Initiating demand-led research is not a shortcut to appropriate development but requires critical reflection on how to facilitate conduits of demand and tailor them to meet the different realities of primary beneficiaries. In an operating environment where DFID itself is unlikely to be the primary receptor of demand, it is imperative that regional partners have the capacity to mediate demand in line with DFID's principled interests. DFID will also need to insure that it transmits insights from its inter-regional perspective to its regional partners. Appropriate responses to such demand also need attention where there are alternative or complementary institutions on the ground.



The model that appears above shows in very simple terms an interface between the knowledges of primary beneficiaries (PBs) and of service providers (SPs). Demand-led service provision is positioned as a bridge between the two systems, and is facilitated in an ideal, power-equal way by a circular flow of knowledge, in which the local fertilises the scientific, and research creates more options to feed local demand. In terms of the research mandate of DFID, with its over-arching, inter-continental comparative advantage, the architecture of both demand expression and service provision at the interface is critical for delivery.

7.6 A research strategy – Option (B)

Option (B) offers a focused alternative to Option (A). The 26 Research Lines offer an impracticably wide range of possibilities for a focused research strategy. In this alternative option, focus is sought first, through *prioritising demand* (as explained in the previous section) and second, through making *process-enabling* central.

The concept of demand, as argued above, is adopted as a strong unifying principle around which adaptation research can be organised. Such research must be demand-led if its impacts and benefits are to be sustainable; a strategic vision 'promoting a transition from supply-led programming to the establishment of sustainable systems for service delivery'.[24] In Chapter 1 a case was made for supporting poor peoples' autonomous adaptation as distinct from strengthening the adaptive capacity of planning and governance institutions. This strategy is the reverse of a demand placed by external actors for compliance with adaptation policy directives and incentives.[25] The purpose of building adaptive capacity at the primary beneficiaries' level can be understood as one of facilitating demand for and access to adaptive resources, and supporting the development of these resources and their uptake with research investments.

In the Introduction to Chapter 2 a distinction was made between two approaches exemplified in the five Research Areas - those of *finding solutions* and *enabling process.* Traditional technology transfer models of development aimed for solutions to expertly diagnosed constraints, with a bias towards increasing productivity. More demand-responsive and participatory modes are now in use (Chapters 2 and 3), and there continues to be a need for new and tested technical or strategic options with which to confront environmental uncertainty.

In practical terms a difference remains between technological development and formal modelling approaches on the one hand, and on the other, approaches whose problematic is the equitable engagement of poor people in the development process through enabling their voices to be heard within a supportive and responsive institutional setting. The first has been often tried and has led to some disappointments. The second is less tried but has the virtue of transferring ownership of the adaptive response to climate change into the hands of its beneficiaries.[26] There

[24] DFID (2005), *Post-conflict agricultural rehabilitation: linking social protection, livelihood promotion and humanitarianism,* London, Overseas Development Institute

[25] It should be emphasised that the present study is on adaptation to climate change, not its mitigation.

[26] It is not intended to introduce a rigid typology of research and it is recognised that some modelling approaches, for example, may in practice resemble the second rather than the first type. But the principle is believed to be a valid one.

is enough experience in the RNRRS portfolios to justify a greater effort in *enabling process* towards an enhanced capacity to manage variability (Chapters 4, 5 and 6). This works through a systems approach to institution building, knowledge management, or livelihood diversification support, as suggested in the following examples:

- In Eastern India, self-help groups extended in 17 months to over 13,000 households in six states, strengthening social capital and evidently meeting a widespread latent demand for institutions supportive of the poor; while on irrigation schemes, new Water Outlet Groups extended control to previously excluded farmers, improved the efficiency of water use, and helped to test new or improved technologies (R7839 and R7830, Research Line NRSP-3(a), Chapter 4.1).
- In Eastern India, participatory, group-based and low-input methods were used to achieve a 57% uptake of aquaculture during 4 years in >200 villages in rainfed areas. Asset enhancement effects on livelihoods include strengthening of social capital through groups, networks, group financing, and better access to government funds. Embodied in this process is a strategy for bringing through the voices of poor people, referred to as *facilitated advocacy*, engaging local people with policy and planning (R8100, Research Line NRSP-4, Chapter 6.3).
- In Ghana, research has been used to facilitate better knowledge for the governance of natural resources by district planners, through a database compiled by villagers themselves, and to strengthen farmers' groups to better articulate their needs. In Uganda, village people have been engaged in policy process through the involvement of local institutions in making and enforcing byelaws governing the use of natural resources. Although it is too soon to evaluate their impact, these projects have opened new doors in participatory governance (R8258, R7856, Research Line NRSP-5, Chapter 5.1).
- In semi-arid Africa, where income diversification is a time-honoured strategy for managing risk, and policy has tended to be unsupportive, there is abundant evidence of resilience based on available knowledge, access to labour markets, and opportunistic commercial skills, even against considerable odds. Unlocking these potentials of human and social capital is essential as the productivity of natural resources is severely constrained (R7304, Research Line NRSP-7, Chapter 6.4).[27]

A process-enabling approach does not obviate a need for technological research and models, but the linkages need to be defined. First, a need for new technologies still exists. Process-enabled adaptation needs new or improved risk-minimising technological options. However in the present context, DFID may need to consider the respective roles and needs of technology development within and outside the CGIAR system, to which it has a major commitment.[28]

[27] See Anderson, J (and 18 others, 2003), *Chance, change and choice in Africa's drylands. A new perspective on policy priorities?* Bogor, Indonesia: CIFOR.

[28] It is not known to what extent CGIAR research may take on board the challenges of climate change in future. If it does not address adaptation, there may be a stronger justification to pursue this focus within the Climate Change Theme of DFID-CRD.

Second, the comparatively large number of formal modelling approaches (Chapters 3 and 4) in which this review has found present or potential relevance to climate change adaptation signals a major commitment on the part of RNRRS to such methods. They have been in use for long enough now to justify questions about the capacity of asset management modelling to meet demand from small-scale resource users, and the likely costs of reaching this target through additional research. Potential relevance is demonstrable using a scientific rationale, but as is recognised in most of the literature seen, there remains a jump to be made to engage successfully with local knowledge, which has absorbed much energy, and invites the cynic to ask what value is added to such knowledge by modelling. There is also a linked question about ownership. Of those described, only one model appears to have been decisively transferred to a southern partner. Models were sometimes developed in the first instance to meet a need for advice for policy makers, rather than local resource users. There is unevenness amongst those included in this study in terms of the distance travelled towards practical applications at the level of the farm, herd or household. From the present perspective, there is a strategic need to review and refocus modelling work, building on the experience of the more successful projects.

Option (B) offers a more focused but also more challenging research strategy for DFID. It will also provide a clear identity for climate change adaptation research in relation to DFID's other programmes.

7.7 Linking with other research and development policy

In developing research on adaptation to climate change as a contribution to development policy, it is important to avoid fragmentation. The RNRRS knowledge on climate change adaptation, as summarised here, is not only relevant to DFID's Climate Change research theme but also to three programmes included in the new agriculture research strategy: Getting Agricultural Research Into Use; Sustainable Agriculture in Africa and Other Rain-fed Regions; and possibly that proposed with the UK Science Research Councils. It may also be relevant to risk-screening in policy development work under National Adaptation Plans of Action to climate change. This will need a process of consultation, participation and oversight to ensure that adaptation receives enough emphasis within the broader development agenda.

DFID intends to devolve more research commissioning to the regions. A regional focus is appropriate for research on adaptation to climate change, since climate change will take regionally specific forms and adaptation research needs to be tailored to them. The thematic Research Areas set out in Chapters 2 - 6 offer a framework for deciding on regional priorities and how research should relate to national and regional institutions. Partnerships and collaboration with international research organisations as well as governments will evolve within this regional framework. The legacy of the RNRRS is a significant resource in the public domain which can help take adaptation research forward in the global context of international climate change initiatives. DFID will need scientific capacity in its regional offices if it is to realise this potential.

Much of the work of RNRRS is location- and time-specific. Effective links between scales are needed if such research is to contribute to issues that are being treated at higher levels of generality, such as global adaptation to climate change or the advocacy of agriculture as a development priority. It will also be necessary to ensure

that local research findings are fed into higher-level policy initiatives such as the development of poverty reduction strategy papers, and linked to the achievement of the Millenium Development Goals 1 and 9.

7.8 Conclusion

The RNRRS, amongst its 1,617 projects, has substantive and diverse findings to offer in the domain of climate change adaptation, which provide a platform for a research strategy to enhance the adaptive capacities of poor people in managing variability. This is notwithstanding the fact that little of the work explicitly addressed climate change. Output 1 is this body of knowledge, which identifies 105 projects in 26 Research Lines, organised in five Research Areas (Chapters 2 – 6). RNRRS work has added to scientific understanding of some key parameters and developed a range of technologies, models, decision support tools, and management options for specific situations. Opportunities for taking the Research Lines forward are identified.

Outputs 2 and 3 identify the implications for DFID's future research and development policy, and the knowledge gaps that need to be filled in its further development. The strategy is set out in terms of a demand-led model (Chapter 7). First a mandate for adaptation research is defined within development. The chosen approach, that of adding value to finished work, is held in tension with a need to evolve to meet new scientific challenges. A broad-based strategy (Option A) is set out in terms of the five Research Areas. Specific and generic knowledge gaps are identified as a guide to potential future research. The concept of 'demand-led' climate change adaptation research is examined and conceptualised in a simple model linking primary beneficiaries, service providers and DFID. A more focused strategy (Option B) is developed around process-enabling research, which defines certain strategic questions facing DFID. Finally, relevant issues concerning linking with other research and development are identified.

Communication (Output 4) is reported in Annex J.

The RNRRS evolved historically from a range of antecedents. Under DFID's poverty reduction focus, and influenced to a greater or lesser extent by a prioritisation of a Sustainable Livelihoods Approach, it has expanded in scope from strictly technical towards more holistic perspectives of development. Different projects have made predictably uneven progress towards placing rapidly evolving natural science, modelling, systems and other tools at the disposal of poor people and their livelihoods. This effort is particularly relevant to the purpose of the present study, as managing variability well or badly has dramatic implications for livelihoods.

If demand is accepted as the central principle of a research strategy on climate change adaptation for poor people, issues of knowledge management, communication, local institutions and articulation arise on the demand side of the equation, and those of service provision, participatory planning, democratic governance and (most relevant in the present context) responsive research and facilitation on the supply side. Such orientations call for some role reversals compared with traditional ways of doing things. This conclusion, which has been driven by the specific challenge of climate change adaptation, may very well apply to development as a whole, supporting the view that adaptation is a paradigm of development. Be this as it may, adaptation

research has its own agenda, as suggested here, and should focus initially on variability management within the general goal of poverty reduction. The RNRRS legacy, with its rich bank of site-specific knowledge on natural resources management, provides a foundation for this endeavour.