Part 1

Your research in perspective

To alleviate poverty and become food-secure we need to transform rural life and improve the productivity of agriculture. The smallholders who are the backbone of agriculture deserve our attention and support. National governments, professionals and outside agencies must all work together to achieve this common goal. Agricultural professionals need to become active change agents. As a scientist or an agriculturalist you need to focus on 'problem solving' and remember that both social and scientific skills are required to navigate and manage rural change. Everyone's life or research journey will be different, but we need to all work together to improve the lives of our rural areas and make agriculture Africa's engine for growth.

This part of the book focuses on many issues with which you will have to deal or confront throughout your career. You will have to work as a team member in a department, programme, or project. This involves cooperation, sharing ideas, openness, transparency, and honesty. You will be a link in the chain that binds the team together. Be sensitive to the needs of others, especially the small-scale farmers – they deserve to be taken seriously, given feedback and all our professional assistance.

Researchers should see themselves as elements in a change process rather than the bringers of answers. The importance of recognising and using farmer's local knowledge is emphasised. You are encouraged to pursue research which responds to demands from the farmers and involves them in solving their problems. The views of the various authors are based on years of experience of what has worked and what failed. However, the ideas they present are all the subject of debate, and others with similar experience may choose different points to emphasise. As a student you should become familiar with these discussions, work out their relevance to your situation and think about the extent to which your experience confirms or modifies them.

Bharati K. Patel

1.1 Research? What, why and how?

Tony Greenfield

- Why do you want to do research? Have you chosen a research project? Do you feel strongly about an outstanding problem or will your study be guided by your professor or research organisation?
- Research is about solution of problems but they must be problems that attract funds, a supervisor and collaborators
- Will your project fit into a wider strategy? Will it make a valid contribution to the big picture?
- Your abilities will yield surprises, results and benefits that nobody predicted. You can be creative
- Write clearly and honestly. Avoid deceit and obfuscation

'We have three principal means: observation of nature, reflection, and experiment. Observation gathers the facts, reflection combines them, and experiment verifies the results of the combination. It is essential that the observation of nature be assiduous, the reflection be profound, and that experimentation be exact. Rarely does one see these abilities in combination. And so, creative geniuses are not common.'

Denis Diderot (1753)

On the Interpretation of Nature

Introduction

You are stuck. You are a graduate on the ground floor and you have been there for several years. There's a hard ceiling to your career and you can't climb the staircase to the floor above without showing a ticket to pass. What is that ticket? It is, at least, a portfolio of published papers. Better, it is a research degree, a master's or a doctorate. Your work experience has sparked many worthy ideas that you know you could develop with well-supported research. So, how do you start?

Even if research doesn't immediately attract you, you realise that a higher degree is essential for any promotion. You may be working in a government department or in some non-governmental organisation or in a company that does not have a research mandate, yet you know that an MSc or a PhD will enable you to climb the staircase to higher management, greater responsibility, and wider opportunities. Research must be part of this process, for it is through doing research that you will learn to learn, to observe, and to marshal new knowledge to the greatest effect.

Or: You are about to graduate. Your head is bursting with knowledge and ideas. The world, you hope, is waiting for you to make it a better place. How will you do this? There must be a job just right for you. Farm management? Well, you'd have to start as a junior and work your way up. How long would that take? Supplier of materials such as fertilizers, pesticides, seeds, machinery? That might be quite interesting, even exciting: travelling about in a company car as a representative and discussing the needs of your customers, the farmers. Or even politics? Could you persuade governments, local, national or international, to direct their resources to where, in your opinion, they are most needed?

But: 'You've done well,' your professor says. 'You might consider staying here and doing research.' Research? Now here's a chance to use your knowledge and ideas to make the world a better place, to improve the quality of the lives of fellow humans, to give them the security of good food supplies, to protect and improve the environment. At the same time you will gain a qualification that may assure you of an interesting and well-paid(?) career; you will publish reports of your work, present them at international conferences; you'll feel good. You might pursue your theoretical studies in Europe and do your field studies in Africa where the farmers' problems exist. If your work is in a university, you will mix with researchers in other sciences, in engineering, in economics and in business. You could teach, become a professor. You might even create a new product or process that will lead you to commercial as well as academic success.

'Show me the lab,' you say. 'I'll put on my white coat and start to work.'

But wait. What will you do? Who will pay you? Who will pay for your research? Will you be paid at all? Perhaps, but not a lot. Are you sure you have the skills for research and understand the procedures?

You will need a grant: money to live on, funds for materials and equipment, travel, conference fees. So you must persuade somebody that what you propose to do is worthy of their investment. So here's a skill that you might not have contemplated: how to write a research proposal.

To me, research is an art aided by skills of enquiry, experimental design, data collection, measurement and analysis, by interpretation, and by presentation. A further skill, that you can learn and develop, is creativity or invention. These are a few of the many skills and methods of research that you should know and understand.

So this book is for you, for graduate students, whether MSc or PhD, at universities throughout Africa if you want to work in agriculture, in natural resources, in rural development or the environment, with people whose livelihoods depend on the land. It is for your supervisors too: those who are appointed to guide you through your first major research project.

Research is a big subject and it would not be possible to write a single volume about it in any depth. This book is intended to be a general reference on all aspects of research methods and should be used as notes for guidance. Its content is intended to be fairly simple and easily intelligible by most readers. There are references to more substantive texts and to websites, and plenty of additional information on the CD.

The many viewpoints and components of research methods demanded that several contributors would be needed. Fortunately, there are enough qualified people in universities, research organisations and consultancy, who volunteered eagerly to write one or more chapters each. The editors asked them to write in a light style that you could read easily so that you can pick up the general themes. We have tried to make it a book not only of general guidance but also of relevance to the reality of current research and agriculture in Africa and to hopes for the future of this continent.

If there are parts that you don't understand, or that could be expressed more clearly, or if there are important omissions, please write to the editors or the publishers. Everything can be improved, especially the first edition of a book, and your opinions will help us.

These notes for your guidance have been divided into five main parts, with several chapters in each. Look through the contents list and see how the topics have been grouped. You may feel that some of the chapters are not for you. For example, do you know how to design a survey? Of course you do! You have often been asked to answer survey questions so you know what questions should be asked. But there is much more to a survey than that. How do you choose your target population and then a sample size? How do you ensure that you get a good response? How do you code the questionnaire for analysis? How do you analyse and interpret results. Read **Chapter 3.6** and learn. How do you attract financial, material and intellectual support? There are chapters to help you with these. You will run into difficulties. You will find problems of management, of resources, of people. There's a chapter telling you who can help. I suggest you read it before you meet those problems. There are also chapters on planning your work, about keeping documents, about examining your research process and keeping it on course.

Glance quickly at the chapter on data analysis and you may think 'I can leave that until much later, when I have some data to analyse.' Scientific method is about observing the world and collecting information so that you can understand the world better. The way in which you do this must surely depend on how you will process the information when you have collected it. The data you collect will depend on how you will analyse the data. Analysis is an essential feature of research and you will make easier progress with your research the more you understand analysis. To some people it is hard and daunting. They would prefer to ignore it. To other people it is a challenge. Whichever is your viewpoint, make it a challenge and face it now. Honestly, the more you understand about how you will analyse and interpret data, the better will be your planning and management of the way you collect it. The design of a good experiment depends on how the data from the experiment will be analysed.

How do you communicate your results so that other people will notice and act on your advice? Whatever research you do, you must present your results: in a thesis or dissertation, in reports and published papers, and in stand-up talks to live audiences. There are many books about presentation and some are recommended.

Your problem within a strategy

Your first problem is to find a problem; the solution of problems is what research is about. You must also find a problem that is of interest to other people: those who might provide your funds and those who might support you, supervise you and collaborate with you. Does that restrict you too much? You have already chosen to work in agriculture, natural resources, the environment and rural development so you have defined the domain in which to find a research problem. Thousands of research problems have already been identified. These have led to research projects that have yielded results: published papers, dissertations and theses, books and, most important, changes in the way things are done out there on the land and in the lives of real people.

So, are there any problems left for you?

The more we know, the more we know we don't know

The more problems we solve the more problems we find that need to be solved. There is no shortage of problems, there never will be, even if you narrow your search down to problems of farmers. The finding and expression of problems and their translation into research proposals are discussed at length in **Chapter 2.3**. But that chapter starts with 'You have decided on the area you want to research'. Have you? There are strategies at work and you would do well to consider them because it is within these strategies that research projects are created, are inter-related and are funded. If you can identify a problem for your research that fits into an existing strategy, then you will have a good chance of approval by colleagues, by assessors of your ideas, by grant-funding panels. The strategy is the big picture. Your project is just a part of it. But if you can understand how a strategy is constructed you will be well equipped to challenge it with such questions as: 'Has it been motivated by political and economic considerations rather than the needs of the farmer?' and to ensure that your research project makes a valid contribution.

Strategy is about answering two questions:

1 How will things be done in the future?
2 What changes and investments must be made to achieve that future?

Answers will be found by following nine concurrent steps (while you read this, think about the farmer and his problems and think about the research that you might do to solve his problems).

1 Understand how well the current products and practices meet current needs so that you can measure the gap in performance and identify the constraints against closing the gap.
   - Specify the needs:
     - eradicate hunger, reduce poverty and safeguard the environment
     - larger harvests through higher yields
     - better nutrition through improved food quality
     - empower people to build their own capacities, self-confidence and self-reliance
     - develop agriculture where water is very scarce, with poor and degraded soils, and where social infrastructure is weak or non-existent
     - provide subsistence farmers with opportunities to increase their income by pursuing opportunities for commercialisation
   - Identify the constraints:
     - low rainfall
     - inadequate water storage and distribution
     - poor and degraded soils
     - weak or non-existent social infrastructure

2 Determine local trends along four main themes.
   - Changing customer needs (often driven by geopolitical changes such as climate changes, urbanisation, wealth, labour and other resources, irregular markets, and perceptions of what might be)
   - Legislation (genetic modifications, crop type restrictions, land access)
   - Science and technology
     - improved water use through water conservation
     - improved water use and drought tolerance in crop genotypes with plant breeding and biotechnology
     - improved farming machinery, processing, storage, transportation
     - improving social structure, education and health
   - Competition (what products are wholesalers and distributors asking for and at what prices?)

3 Who are the farmer's current and future customers? (Self-sufficiency defines small-scale farmers' prime customer: themselves followed by local markets and cooperative marketing companies. Large-scale farmers must think about wholesalers, packaging companies, supermarkets and exporters).

4 Extrapolate the science, technology, political and social structure, economy, environmental management and consumer trends to create the vision of rural transformation and of how African agriculture will look 3-10 years into the future.

5 Determine what farmers must do to continue to be successful in their future markets (change soil management and irrigation, crop varieties, harvesting, pest control, storage, processing, join co-operative partnerships).

6 Determine what investments may be needed to deliver these changes (investments in the research need to find out how to deliver the changes as well as investments in equipment and materials).

7 Convince farmers themselves that the changes are worth the investments and convince other providers of funds (governments, donors, marketing companies) that their support is needed and will, somehow, pay dividends.

8 Promote partnerships and sponsor projects that bring results of research to rural communities, farmers and their families.

9 Translate the investment plans into implementation plans.

A strategy that has room for you may already exist within the university department or in some research institution. With good fortune, enthusiasm and guidance, you will find or be directed to a problem that will occupy you for 2-3 years: the time you need to complete your post-graduate research.

But .... Your head is bursting with knowledge and ideas. The world, you hope, is waiting for you to make it a better place. 'If the strategy is already defined, if my problem is but a small part of that strategy, if my proposal for research must be written so as to earn the approval of my supervisors and my fund granters and has to be so tightly defined as to guarantee a satisfactory conclusion within 3 years, where', you might ask, 'is there any opportunity for my originality?'

Don't worry. You have been encouraged to do research because you have already shown a potential, if not already proved ability, for problem-solving. Your supervisors know that you can:

- Assimilate, analyse and evaluate complex information
- Identify key issues and principles
- Think critically
- Learn from mistakes
- Challenge established assumptions
- Avoid prejudices
- Take a broad view
- Think conceptually and creatively.

These are abilities that you already possess – abilities that will ensure that, no matter how tightly defined, your research project will yield surprises, results and benefits that nobody predicted.

Creativity

'Creativity is what cannot wait, cannot stop, cannot back step: faster or slower, it always goes ahead: through, alongside, above, regardless of crises or systems.'

Jose Rodrigues Migues

There are many ways to solve a research problem. A formal procedure will often yield a solution, provided you keep an open mind and look for the unexpected.

If you look at the most outstanding of creative leaps in the history of science you will see that they were all founded on an irrationality of thought. Well known examples are: Watt's invention of the separate condenser for the steam engine as he strolled in the country; Poincare's theory of Fuchsian functions as he boarded a bus; Kekule's discovery of the benzene ring as he dozed by the fireside. So, be prepared to note any odd thought you might have at an unexpected time in an unexpected place. And don't discard unexpected results.

'If you do not expect the unexpected, you will not find it; for it is hard to be sought out, and difficult.'

Heraclitus of Ephesus

in Khan (1979)

'Just because something doesn't do what you planned it to do doesn't mean it's useless.'

Thomas Alva Edison

You don't have to wait for that magical moment or a bang on the head to spark an original idea. There are some well-established methods of intellectual discovery that you can apply to your problem:

- **Analogy.** Look for similarity between your problem and one for which you know the solution. Electrical circuits are perceived as water flowing through tanks, pipes, pumps and valves;

brain function is studied by comparison with computers. The more remote your analogy is from your problem, the more creative will be your solution

- **By parts.** Break the problem into a series of sub-problems which you hope will be more amenable to solution
- **By random guesses.** Edison used it extensively and brain-storming is a modern version
- **Generalise.** If a specific problem is baffling, write a general version of it; an algebraic model leads to simplified solutions compared with tackling complicated arithmetic head-on
- **Add.** A difficult problem may be resolved by adding an auxiliary sub-problem
- **Subtract.** Drop some of the complicating features of the original problem; this is a trick used in simulation to make it more tractable
- **Particularise.** Look for a special case with a narrower set of conditions, such as tackling a two-dimensional example of a three-dimensional problem
- **Stretch or contract.** Some problems are more tractable if their scale or the range of variables is altered
- **Invert.** Look at the problem from the opposite viewpoint; instead of 'When will this train arrive at Nairobi?' ask 'When will Nairobi arrive at this train?'
- **Restructure.** In clinical studies we do not ask if a treatment will cure a disease, but if an inert treatment will fail to cure the disease
- **The method of Pappus.** Assume the problem is solved and calculate backwards
- **The method of Tertullus.** Assume a solution is impossible and try to prove why.

Check each of these approaches, asking yourself how you might bring it to bear on your problem. Then, if you need any more stimulation, read: *The Art of Scientific Investigation* a book by W I B Beveridge published in 1950 but still, half a century later, stimulating to read; G Polya's *How to Solve It* offers practical recipes; and Arthur Koestler's *The Act of Creation* for a discussion of the working of the mind.

My personal approach to solving a problem that has defeated me at my desk:

- Go for a long and lonely walk in the country or
- Drowse in a hot bath................Inspiration comes.

Ethics of research

'Creativity is great but plagiarism is faster.'

Anon

If you are researching into some aspect of the environment, or into the development of genetically altered viruses for the control of crop pests or in some area of medicine, either human or animal, you will almost certainly have thought about ethical aspects of your intentions. But if your research is in some other area such as sociology, education, water storage and distribution or poor and degraded soils, you may think that there are no ethical questions for you to consider. You would be wrong to think that. Fraud is an obvious ethical matter but surprisingly so are experimental design, planning, management and execution; and so is publication.

If you know yourself to be thoroughly honest, you must be confident that you will never be deliberately unethical. Unfortunately, no matter how good a person you are and how well intentioned, there is the possibility, indeed it is very likely, that you will be inadvertently unethical, insomuch as you infringe the accepted code of research behaviour. Anybody who embarks on research is at risk of such inadvertent unethical behaviour. Avoidance demands good advice at all stages. Where will you find that advice?

Ethics, in its widest sense, is the set of principles of good human behaviour.

Most professional organisations have their own codes of conduct that are largely about the ethical standards that are expected of members. I have distilled the following points from several professional codes:

- It is unethical to conduct research which is badly planned or poorly executed
- Research must conform to generally accepted scientific principles based on adequately performed experimentation and on a thorough knowledge of the scientific literature
- Every research project should be preceded by careful assessment of predictable risks in comparison with foreseeable benefits
- In publication of the results of research preserve the accuracy of the results. Inaccurate and incomplete reports of experiments should not be accepted for publication
- The results of publicly funded research must be available to the public. In some countries this requirement is law and extends to raw data, not just reports and papers. Failure to publish results may be illegal as well as unethical
- The research proposal should always contain a statement of the ethical considerations involved
- Special caution must be exercised in the conduct of research that may affect the environment
- Within your chosen field, you must have an appropriate knowledge and understanding of relevant legislation, regulations and standards and comply with such requirements
- Have regard to basic human rights and avoid any actions that adversely affect such rights
- Accept responsibility for the social consequences of your work
- Seek to avoid being put in a position where you might become privy to or party to activities or information concerning activities that would conflict with your responsibilities
- Never cast doubt on the professional competence of another without good cause
- Do not lay claim to any level of competence that you do not possess
- Any professional opinion shall be objective and reliable
- You must not allow any misleading summary of data to be issued
- Views or opinions based on general knowledge or belief should be clearly distinguished from views or opinions derived from the statistical analysis being reported. It is worth remembering that:

'Precise conclusions cannot be drawn from inadequate data.'

Pearson and Hartley (1966)
Biometrika Tables for Statisticians

Plagiarism

'Plagiarise,
Let no one else's work evade your eyes,
Remember why the good Lord made your eyes,
So don't shade your eyes,
But Plagiarise, Plagiarise, Plagiarise...
Only be sure always to call it please, "research".'

Tom Lehrer, American satirist

- Plagiarism is the **theft** of ideas and text from other people's work
- You will be a plagiarist if you steal ideas or text from other people's work and present it as if it is your own
- You will also be a plagiarist if you present the work of other people as your own even if they give or sell the work to you.

Research demands that you use all relevant knowledge that you can find. But much knowledge belongs to somebody else. There is universal understanding that you may use whatever information has been published, **so long as you attribute the ownership to the original author**. Writers of many books and articles published in the 18th and 19th century ignored that understanding but, through the 20th century, proper referencing became normal and expected practice. But there is still bad practice and it is getting worse. Basically you are encouraged to use other people's work; we do not want you to reinvent the wheel – just reference the ideas, words or examples you take from elsewhere.

You will ensure that nobody can accuse you of plagiarism if you include, with your submitted work, a statement that all unreferenced work is yours. You will also ensure that nobody can accuse you of plagiarism if you reference all work, including quotations, and be totally clear in the text which material is from the referenced work and which is from you. Give credit where it is due but be sure that you are credited for your own work. Refer to **Chapter 2.2** for a guide to referencing.

A difficulty with references is that too many destroy the flow of writing and will bore the reader. So, there is no need to reference the origins of common knowledge, such as process flow charts, differential calculus or for example Student's t-test (W S Gossett, *Biometrika*, 1908).

Some examples of plagiarism

Stealing from a colleague

Sometimes two or more students share a project; one will be more assiduous than the other and finishes the report on time. The second, in a panic, borrows her colleague's report and copy chunks of text from it, handing it in to her examiner with a sigh of relief. But a good examiner will recognise this and may even detect, from the writing style, which student is the originator and which is the plagiarist. The plagiarist will fail and the college may expel the student and her career will be finished.

If you start to write early, you will avoid the panic of late submission and the temptation to plagiarise.

Collusion

Collusion can be as bad as copying. If you and another student work together, but you then present the work as if it is only yours, then you have stolen credit. The lecturer who sets the work for students to share should clearly state what is expected of each individual student. If s/he doesn't, ask.

Stealing from published papers and books

It is so easy now, working at your computer, to copy from existing publications and paste into your own text. You alter a few words here and there, and pass off the descriptions of research methods, results and discussions as your own. 'Look at this,' you tell your friends and your family. 'Listen to me,' you say to the scientific conference. 'Publish this,' you ask the academic journal. You'll be caught. Even if you are not caught, you will live the lie until you die.

Quoting without citation

This is the most common form of plagiarism. Some students claim that it is in their culture to copy original text from a well-known publication, without citation. They may even assert that it would be discourteous to change the quotation in any way. But, without citation and without indicating that the text is copied and implying it is the student's own work, **it is theft of ideas and writing**. This misleads readers into belief that the work is entirely the student's own.

Buying it

A new form of plagiarism arrived with the personal computer and with the internet. There are many essay-writing, even thesis-writing services on the web. Don't kid yourself that you can pay and get away with it. Your university is well aware of these services and will catch you if you have used them.

Stopping it

There are two steps in stopping plagiarism by students: deterrence and detection.

Deterrence

Department heads should tell all new students about plagiarism, defining it clearly, with examples. They should tell all students about the penalties that detected plagiarism will incur.

You can protect your own work by deterring others. You can 'publish' early and simply by giving a draft to your supervisor or by storing it on your university's research archive. If these services don't exist, ask for them to be provided.

Detection

An experienced supervisor for a specific subject should be able to detect plagiarism in any work submitted by students. But there is also help. Programs exist on internet to help detect plagiarism. You can enter short phrases, enclosed in quotes, into Google and other browsers to check for matches. If you are suspicious about a single essay, cutting and pasting a section in to the Google search bar usually provides interesting results.

There are also programs that can help with this. These programs will search a library of documents for any text that matches any of your text. The most widely used program is Turnitin and it is recommended by JISC[1]. If you visit http://www.jiscpas.ac.uk/turnitinuk.php you will find the full services including some training videos. For large scale testing, your University can subscribe to a plagiarism detection service. Turnitin checks submitted documents against a vast database of billions of pages of both current and archived material, which includes previously submitted student papers. Archived material includes internet sources, books, newspapers and journals from both academic and professional sources. It will return a submitted paper as a customised originality report.

Plagiarism has been with us since writing began but it is increasing. Universities are concerned but so are honest students who want to protect their own work. You must be wary, especially when lending work to other students. Modern technology has brought new ways to plagiarise but it has also brought new ways to protect against plagiarism and new ways to detect it.

Fraud

While much unethical science is inadvertent, caused mainly by poor management, there is a long history of scientific fraud reaching back several centuries. Charles Babbage, who was Lucasian Professor of Mathematics at Cambridge University (a chair held by many great scientists including Isaac Newton and Stephen Hawking), published a book in 1830 entitled *The Decline of Science in England*.

One chapter in his book was about scientific fraud under which he described four methods of fraud: Hoaxing, Forging, Trimming, and Cooking. To these I would add Obfuscation. For the first four, I cannot do better than quote him directly.

Hoaxing

'In the year 1788, M Gioeni, a knight of Malta, published an account of a new family of Testacea of which he described, with great minuteness, one species. It consisted of two rounded triangular valves, united by the body of the animal to a smaller valve in front. He gave figures of the animal, and of its parts; described its structure, its mode of advancing along the sand, the

1 The JISC is the Joint Information Systems Committee that was created by the higher and further education councils of the four countries of the United Kingdom.

figure of the track it left, and estimated the velocity of its course at about two-thirds of an inch per minute. … no such animal exists.'

There have been many more hoaxes since Babbage's day, including the saga of the Piltdown man.

Forging

'Forging differs from hoaxing, inasmuch as in the latter the deceit is intended to last for a time, and then be discovered, to the ridicule of those who have credited it; whereas the forger is one who, wishing to acquire a reputation for science, records observations which he has never made. … The observations of the second comet of 1784, which was only seen by the Chevalier d'Angos, were long suspected to be a forgery and were at length proved to be so by the calculations and reasoning of Encke. The pretended observations did not accord amongst each other in giving any possible orbit.'

Statistical methods now exist to discover forged data. Examples may be found in industrial research and in clinical trials, as well as agricultural research. If you are tempted to forge your data, be warned. A good examiner will detect your forgery and you will be humiliated.

There can be great pressure on students to complete a research project within the time specified by the university rules or before their grant expires. Under such pressure the student may be tempted to forge data which they have never observed. Or, if they have made some measurements that don't properly meet their expectations – they may be tempted to cook the results. Cooking is described below by Babbage.

Trimming

'Trimming consists in clipping off little bits here and there from those observations which differ most in excess from the mean, and in sticking them on to those which are too small … the average given by the observations of the trimmer is the same, whether they are trimmed or untrimmed. His object is to gain a reputation for extreme accuracy in making observations …. He has more sense or less adventure than the cook.'

Cooking

'This is an art of various forms, the object of which is to give to ordinary observations the appearance and character of those of the highest degree of accuracy.

'One of its numerous processes is to make multitudes of observations, and out of these to select those only which agree, or very nearly agree. If a hundred observations are made, the cook must be very unlucky if he cannot pick out fifteen or twenty which will do for serving up.

'Another approved receipt, when the observations to be used will not come within the limit of accuracy, is to calculate them by two different formulae. The difference in the constants, employed in those formulae has sometimes a most happy effect in promoting unanimity amongst discordant measures. If still greater accuracy is required, three or more formulae can be used.

'It sometimes happens that the constant quantities in formulae given by the highest authorities, although they differ amongst themselves, yet they will not suit the materials. This is precisely the point in which the skill of the artist is shown; and an accomplished cook will carry himself triumphantly through it, provided happily some mean value of such constants will fit his observations. He will discuss the relative merits of formulae … and with admirable candour assigning their proper share of applause to Bessel, to Gauss, and to Laplace, he will take that mean value of the constant used by three such philosophers which will make his own observations accord to a miracle.'

Obfuscation

Obfuscation means 'to make something obscure'. It is a deliberate act which is intended to convey the impression of erudition, of being learned, of great scholarship. Hence it is fraudulent. There is a style of academic writing, increasingly common in recent years, i.e., long-winded with long paragraphs, long sentences, long words, passive statements and tortuous structures (see Part 3). It is intended to deceive and it does so easily because the reader, even an examiner, is tempted to skim such verbosity and subsequently fears to confess he or she has not understood every word.

It is a trick that is apparent today in many academic papers and theses but it was not uncommon a hundred years ago:

'The researches of many commentators have already thrown much darkness on this subject, and it is probable that, if they continue, we shall soon know nothing at all about it.'

Mark Twain (1899)

… or even 400 years ago:

'The ill and unfit choice of words wonderfully obstructs the understanding.'

Francis Bacon (1620)
(in Novum Organum)

Perhaps some people can't help writing obscurely but if a post-graduate research student does so we should be suspicious.

'People who write obscurely are either unskilled in writing or up to mischief.'

Peter Medawar (1984)

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1.2

Research: a path through the maze[1]

Tony Greenfield and Tom Bourner

- There are many paths through the research maze. Some paths will pose more difficulties than others, present more limitations, and take you down fruitless side tracks; others will present greater insight and surprises
- Every path should have four parts to it: review; theory building; theory testing; and reflection
- A review will identify a gap in the literature and a problem that is worth solving
- Theory building is the most personal and creative part of research
- Theory testing is a challenge to your theory, using all available information including your experimental results and their analysis
- Reflection: You must reflect on how your research findings relate to current thinking in the field of your research topic and identify further questions and new avenues to explore

'Life is a maze in which we take the wrong turning before we have learned to walk.'

Cyril Connolly (1944)
The Unquiet Grave

Introduction

Research may seem, at first sight, like a mysterious world full of very clever people, remote from the rest of us, talking in strange languages about weird subjects, chalking obscure symbols and diagrams on blackboards, writing unintelligible papers for academic journals: an unreal world like a nightmarish fairground full of wonders and coloured lights but also strewn with hazards and pitfalls. Certainly it will seem like a box of tricks, even a disorganised mix of activities, a maze in which you could easily lose your way.

In this chapter, we offer a different view of research that we hope will encourage and guide you along a fascinating and adventurous path of exploration. Yes, research is a maze but there are many paths through it and, by example, we shall take you along those paths.

Research is about solving problems: overcoming the obstacles between the first statement of a problem and its solution.

We can start with a problem that might face you during your post-graduate studies. When you have decided on the topic for your research you may be encouraged to visit a research establishment, an agricultural college or a university in South Africa or Tanzania for the theoretical aspects of your research. The plan might be to return home to run some field trials and then to visit southern Africa, again, for support in the analysis of your results. Your immediate problem is: how should you travel to South Africa from, say, Nairobi? What is the most economical and enjoyable way, following a route that is within your means and takes you through some interesting places? How would you go about it? Well, you would probably start by opening an atlas. You would mark a possible route, putting

1 This chapter is adapted from a chapter by Tom Bourner, with his permission, in the book *Research Methods for Postgraduates*, Second Edition, Arnold (2002).

rings round the names of places that you would like to visit: Lake Tanganyika, Lake Rukwa, Zambia, the Victoria Falls, Okavango Delta, Botswana and on to Johannesburg. Or you might consider travelling through eastern Tanzania to Dar es Salaam, Lake Malawi, Mozambique and Zimbabwe. There are a number of possible routes from Nairobi to Johannesburg; there may be several possible ways to solve any problem. You could find out from friends and relatives what they know about travel options. You could go to the bus stop and make enquiries of people returning along those routes. You could go to the library and read some travel books to learn about modes of travel in each of the countries through which you might pass. The Lonely Planet series can offer plenty of advice. Is hitchhiking safe? Would it take too long? What are local buses like, where is it possible to use trains? How frequent are the ferries? How much would they cost? What sort of accommodation would you expect? Do people in the villages offer accommodation and food to travellers? Are there hostels or cheap hotels? Perhaps you would carry a small tent and sleep in the open. Local weather patterns, local laws and safety might influence you. You might plan three or four possible routes, write down the details of each and a list of pros and cons. You might even devise a scoring system to help you to decide which route to follow. Later, when you have reached your destination and are still marvelling at the differences between Nairobi and Johannesburg, and some similarities, as well as all the wonderful adventures you have had on the way, you will probably reflect on the process: the extent to which your journey met your original aspirations, what your first-hand experience has told you about travelling cheaply across Africa, and what you have learned from your experience.

Now if you take off your traveller's spectacles and put on instead a pair of researcher's spectacles you will observe some similarities between that process of planning a long journey and the process of research. First, you did a literature review (atlas, travel books, bus and rail time tables, tourist leaflets) to get an overview of the field. Second, you developed a theory of which of the available routes would be to your requirements (your short list). Third, you tested the theory by inspecting and scoring those on your short list. The testing continued by making your journey, by doing your fieldwork. Finally, you reflected on the experience and your results. Stated formally, the process contains four parts:

Part 1 Reviewing the field
Part 2 Theory building
Part 3 Theory testing
Part 4 Reflecting and integrating

Perhaps this sequence seems familiar. Perhaps you recognise it from other significant decisions you have made in your life: choosing an undergraduate course, buying a new suit, finding a vacation job.

With some decisions, it's not possible to go through all the stages. For example, when you choose a job the final test of your theory that you have chosen the right job is by doing the job. Unfortunately, this is possible only after you've committed yourself to the job. Perhaps that's why so many unsatisfactory job decisions are made. The literature on labour turnover often refers to the period immediately following recruitment as the 'induction crisis' when job expectations are tested by the job realities.

The four stages are four parts of the path through the research maze. But this is no ordinary maze in which there is a unique path to follow. Side turnings in an ordinary maze will take you to dead ends. Some side turnings in the research maze will also have dead ends but others will reach the goal, a solution to the problem. But will it be the best solution? Another path through the maze might have been better. There are usually several ways to solve a problem, to do research. Some ways will pose more difficulties than others, present more limitations, take you down fruitless side tracks.

Once you recognise that you are already familiar with each of the major parts of the research process through your experience of making the larger decisions of your life you will have a valuable resource to draw on. Reflection on those experiences will also give you an indication of the possible pitfalls.

That four-part process can help you to put what you are doing into a broader picture when you start to get bogged down in the detail of research. It can also be useful in designing your research project.

Let us examine the parts of the process in more detail.

Part 1 Reviewing the field

Many research projects arise from a study of current thinking in a field. The research project follows from identifying a gap in the literature. Most other research projects arise from awareness of a problem that is worth solving. In either case, a good start is an overview of current thinking in the field. In case you are impatient with this part of the process and want to start immediately with fieldwork, here are some reasons for spending time and effort on a review of the field. It would help you to:

- Identify gaps in current knowledge
- Avoid reinventing the wheel (at the very least this will save time and it can stop you from making the same mistakes as others)
- Carry on from where others have already reached (reviewing the field allows you to build on the platform of existing knowledge and ideas)
- Identify other people working in the same and related fields (they provide you with a researcher network, which is a valuable resource indeed)
- Increase your breadth of knowledge of the area in which your subject is located
- Identify the seminal works in your area
- Provide the intellectual context for your own work, (this will enable you to position your project in terms of related work)
- Identify opposing view
- Put your own work in perspective
- Provide evidence that you can access the previous significant work in an area
- Discover transferable information and ideas (information and insights that may be relevant to your own project)
- Discover transferable research methods (research methods that could be relevant to your own project).

Part 2 Theory building

Theory building can be the most personal and creative part of the research process. Some people find it the most exciting and challenging part of the whole business.

In some cases, data collection precedes theory building and, in other cases, it follows it. Have you ever bought a second hand bicycle? If so, you may have identified some possibles before narrowing down to a few probables. You collected data and then formed a theory about which of the bicycles would best meet your needs. In that situation, theory building followed data collection. The process of developing a theory by inspecting individual cases has a special name: **induction**.

Our journey from Nairobi to Johannesburg is another illustration of induction. If each time you are sent the times and prices of a train journey from one city to the next in a faraway country you notice that it is more expensive than you can afford, you may develop the theory that all the train journeys in that country are too expensive for you. Acting on that theory, you may ask the travel agent to stop sending details of train journeys in that country and you ask for details about buses instead. That is the process of induction at work again: forming a theory from information about specific instances. Induction is a type of generalisation.

The other side of the coin from induction is **deduction** that involves reaching conclusions about specific instances from general principles. Here is an example of deduction: 'I can't afford to stay in a Lagos hotel so don't bother to send me the details of hotels in Lagos'. In this example 'I can't afford to stay in a Lagos hotel' – is the generalisation and deduction leads you to the conclusion about any specific Lagos hotel, i.e., that you can't afford it.

Induction is a thought process that takes you from the specific to the general. Deduction is a thought process that takes you from the general to the specific.

We have seen how a theory can emerge from the data. However, theory can also emerge from armchair theorising, introspection, deduction following a review of the literature, personal experience, a fortuitous remark, a brainstorm, an apt metaphor, or pure inspiration. Creativity has a role to play in all aspects of the research process, but especially in the theory-building part.

We said earlier that data collection can precede theory building and that it can follow it. In the case of induction, data collection comes first. When data collection follows theory building then it is usually for the purpose of testing the theory. That is the part of the research process to which we turn next.

Part 3 Theory testing

'Experience has shown each one of us it is very easy to deceive ourselves, to believe something which later experience shows us is not so.'

C. Rogers (1955)

When we were planning our long journey, we wanted to check whether those attractive routes that we marked in our atlas would really meet our needs. Likewise, when we are doing research we will want to check if the theory (or theories) that we have formulated fulfil our hopes and expectations.

The sort of theory testing we do will depend on our ambitions and claims for our theory. If we want to claim that our theory applies generally, e.g., 'All hotel rooms in Lagos are more expensive than all hotel rooms in Dakar' then we may want to use statistical methods (known as inferential statistics) which have been developed to enable us to make claims about whole populations from information about a sample from a population.

But if your claims are only about the accuracy of your theory in the context of a particular situation, e.g., 'The route that suits me best is via Zambia and Botswana' then theory testing may involve checking your conclusions (theory) from other perspectives. You may have gathered a lot of information about a particular route (bus and train fares, hostel prices, sights to see) but you might find people who have already visited some of the places on the route. They could tell you from their own experiences what to expect. In research in the social sciences, the term **triangulation** is used to describe the process of checking if different data sources and different methods allow you to reach the same conclusions.

Testing theory can take many forms. At one extreme, you may simply invite the readers of a research report to test the conclusions against *their* own experiences. The test is: does the reader say 'Aha! I can now make sense of my own experience in a new and convincing way'? But if the reader is unlikely to have first-hand experience for testing the researcher's theory, or if the claims being made involve a high level of generality, then the theory testing stage will be more formal and elaborate. At some level, however, theory testing is likely to be part of any research process.

Part 4 Reflection and integration

'Knowledge doesn't exist in a vacuum, and your knowledge only has value in relation to other people's.'

A.D. Jankowitz (1991)

Reflection and integration is the last stage of the research journey. There may be many things on which you want to reflect: what you have learned about the process of research; what you could have done differently; what you have learned about yourself. But there is one matter for reflection that is a crucial part of the research process itself. It will affect how your research is judged and the impact of your research. You must reflect on how your research findings relate to current thinking in the field of your research topic.

Your reflection on how your research results relate to current thinking will include your assessment of where your research fits into the field of knowledge. It will contain your assessment of your contribution to the field. In this part of the research process you are likely to return to your review of current thinking that you made at the outset and reassess it in the light of your results. It's as if the current thinking in your field of study is a partially complete jig-saw puzzle and you are detecting where your own new piece of the jig-saw fits in.

Relating the outcomes of your research to current thinking in the field may simply involve showing how it adds to what is already known in the field. This would be the case when you have filled a gap in the literature or found a solution to a particular problem in the field. It may involve seeking connections with current thinking. It may involve challenging some parts of the map of the current thinking in the field, so that you will be proposing some reconstruction of that map. It may involve testing the consistency of your research findings with current thinking. It may involve asking 'What if?' questions of your research findings.

Any of these ways of relating your research findings to current thinking in the field may present further questions and new avenues to explore. Successful research usually answers some questions but also raises new ones. It enables researchers to ask questions that would not have been asked before the research. New questions can be an important outcome of research. It is small wonder therefore that the final chapter of most research reports has a section containing suggestions for further research.

A good practical question to ask yourself is: 'What are the implications of my research results for our understanding in this area?' The implications can take many forms. Here are a few:

- You may have filled a gap in the literature
- You may have produced a possible solution to an identified problem in the field
- Your results may challenge accepted ideas in the field (some earlier statements in the literature may seem less plausible in the light of your findings)
- Some earlier statements in the literature may seem more plausible in the light of your findings
- Your work may help to clarify and specify the precise areas in which existing ideas apply and where they do not apply (it may help you to identify domains of application of those ideas)
- Your results may suggest a synthesis of existing ideas
- You may have provided a new perspective on existing ideas in the field
- Your work may suggest new methods for researching your topic
- Your results may suggest new ideas, perhaps some new lines of investigation in the field
- You may have generated new questions in the field
- There may be implications for further research.

Most of all, this last stage in the research process is about seeking to integrate the fruits of your own research with current thinking in the field.

Summary and conclusions

It is sometimes difficult to keep in mind the whole research journey when all of your attention is focused on crossing some particularly difficult ground. Our purpose in this chapter is to help you to keep the whole research process in perspective when you are engaged in a particular research activity. We have done this by giving you an overview map on which the whole journey is plotted in outline. We hope this will help you to plan your research journey.

We have related the process of research to the way that you find information needed for the larger decisions in your life. You already have much experience to draw upon in planning and doing your research.

We have suggested a four-part research process: 1. Reviewing the field, 2. Building theory, 3. Testing theory, 4. Reflecting and integrating.

There is considerable diversity of approaches to research in different fields but this four-part framework is sufficiently broad to encompass most research in the sciences, the agricultural and environmental sciences and the humanities. Much of the literature on research focuses on different parts of the process. For example, in the social sciences it usually focuses on theory-building, whereas in agricultural sciences it may focus on theory-testing.

Your four parts may not follow this sequence strictly. For example, after you have reviewed the literature you may want to monitor developments in current thinking while you are collecting and analysing data. You may engage in some parts of the research process more than once. For example, you may find that data you collect for theory building enables you to test statements found in the literature. Or data collected to test a theory may suggest a new theory so that it becomes an element of theory building.

You may not want to spend the same amount of time and energy on each of the four parts of the process. For example, theory building may be only a token part of your research project if your main contribution lies in testing a theory that you found in the literature. On the other hand, you may direct most of your effort towards theory building, so that theory testing may be little more than establishing the plausibility of your theory in the light of the data you've collected.

The four parts will be present in almost all research projects, at least conceptually. If one of the four parts seems to be missing from your own research project, you should discuss it with other researchers and, if you are registered for a research degree, with your supervisor. If you intend to omit one of the parts from your own research project, you must be able to state clearly why this part has no role.

Resource material and references

Greenfield, T. 2002. *Research Methods for Postgraduates*. Second edition. Arnold, London, UK. 384 pp.

Jankowitz, A.D. 1991. *Business Research for Students*. Chapman and Hall, London, UK.

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1.3 Project development and grant proposals

Paul Woomer and Bharati K. Patel

- **All projects require similar elements but some donors will have specific formats to follow**
- **Highlight the expected impact of the project on beneficiaries**
- **Clearly indicate how you will communicate your results**
- **Keep it simple, clear and easy for a non-specialist to follow**
- **Remember to always acknowledge donors when publishing**

'Developing capacity has been a fundamental component of international development assistance since the Marshall Plan. The huge success of that far-sighted programme, however, inadvertently generated an overly simplistic and optimistic view of what worked: simply transfer capital and know-how to other countries, the thinking went, and swift economic growth will follow. As we have learnt over the past few decades, this view ignored – or at least underestimated – the importance of local knowledge, institutions and social capital in the process of economic development'.

Mark Malloch Brown, Asdministrator, UNDP

This chapter deals with how a project is developed and prepared for funding. A project has many facets and provides a framework for research and development. It usually involves other persons, which implies partnerships and interactions with colleagues, peers, students or clients. A project is normally only a part of a larger agenda. Everyone involved in a project is important and has a role to play and it is essential that everyone is committed to the project and shares a common vision. Throughout your research career you will be involved with projects and will be a part of a team and you need to learn to function effectively with others.

The development of relevant research begins with the earliest stages of research planning. Well designed research consists of a continuity of elements that start with clearly stated and substantiated objectives that in turn lead to key research questions and counterpart working hypotheses. Properly stated hypotheses identify treatment contrasts and necessary measurements which are in turn translated into experimental design and procedures. Too many proposals become truncated at this point by merely indicating statistical procedures and an intention to publish future findings. They fail to elaborate upon the immediate and end-clients of the research. Which additional research products are anticipated, how these products will be delivered and what impacts may be expected from that delivery. Including the latter elements into a research proposal distinguishes that research as 'demand-driven' and 'impact-oriented' and indicates that you are aware that you must find new ways to formalise and popularise your research accomplishments so that they are relevant to your stakeholders.

Research Grant Proposals[1]

The proposal format is generalised and stresses continuity between proposal components. Remember that some donors require very specific formats while others prefer to evaluate a proposal, in part, by its very composition. The key elements of proposals can be seen in Figure 1.

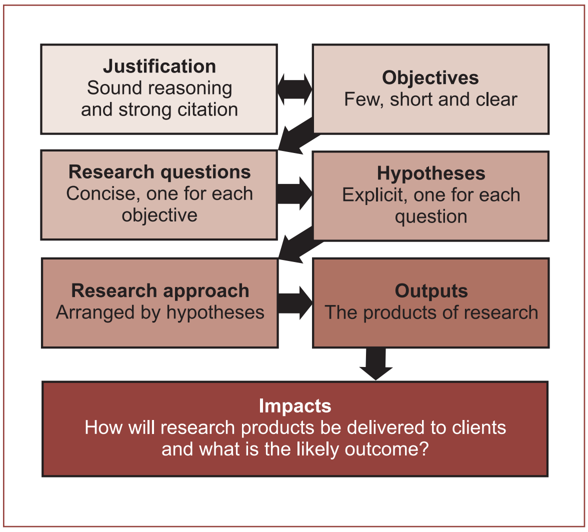

Figure 1. The confluence of proposal elements leads to research outputs and anticipated impacts

Proposal format

An acceptable proposal is not determined by its length. It is more likely to be successful if it clearly specifies:

- why the research is important
- what will be tested
- how it will be tested
- what measurements will be made
- how data will be compiled and analysed
- who is likely to benefit from the research
- when it will be completed
- how beneficiaries will receive the information and what funds are required.

What follows is to some extent a general guideline that has proven effective in the past but is subject to modification depending on your preferences and grantsmanship style. Donors expect potential grantees to be computer literate and to prepare their proposals with word processing and graphics software. The overall appearance of a proposal is indicative to donors of an applicant's ability to later publish their research findings. Incorrectly spelled words, inconsistent heading and sub-heading structure, poorly constructed tables and improperly cited references are liabilities to an otherwise strong proposal. Additional information on proposal formats and on research proposals is available in **Chapter 2.3** and from the Appendices, in particular Stapleton *et al.* (1995) and those by Woomer and by Adipala Ekwamu.

Title page consisting of proposal title, principal investigator, co-operating investigators, complete contact details of principal investigator, proposal duration, funds requested, and a brief scientific summary (1 page). The summary should not be more than half a page, start with a one-sentence description of an agricultural or natural resource problem, how you plan to approach the problem, the time required to do so and the funds that are requested.

Introduction, justification and literature review. A clear statement of the problem and a state-of-the-art review of the research topic are necessary to convince donors that the proposed research is original and meaningful. This is the best place to introduce any conceptual or mathematical models upon which your proposed research is based. Any reference citations you include must be of the latest published work in the field. This is an area where access to

1 Over the past several years, we have had the opportunity to familiarise ourselves with grantsmanship in a variety ways including having several research grants awarded by different donors, by assisting other scientists to develop research proposals and by acting as technical reviewers for the donor community and by being responsible for selecting grantees and managing grant projects.

computer-based bibliographic software is often extremely important because claims that a certain topic remains poorly understood must be substantiated through strong and current citation. In most cases, 2-3 pages of tightly worded introduction are sufficient, followed by a one-page justification and a comprehensive yet concise literature review (3-8 pages). Where appropriate, it helps to include either original or properly cited conceptual diagrams and syntheses tables in the literature review.

Objectives. State a general and a few more specific objectives of the proposed research. These objectives must be well worded (and short). The objectives will lead to the working hypotheses of your proposal (0.5 page).

Hypotheses. The statement of a clear general, global hypothesis and a few specific (working) hypotheses is essential to a strong scientific proposal. What do you intend to prove or disprove? State these very carefully because this sets the standard by which the success of your research progress will eventually be judged. Many donors prefer research proposals that are hypothesis-based and most reviewers pay particular attention to the clarity of stated working hypotheses. You must avoid tautological[2] statements and those that containing jargon in your hypotheses. Social scientists often prefer to pose 'Research Questions' rather than hypotheses and this can be acceptable but it is more useful to present hypotheses and then pose research questions to address them. You should be able to state your hypotheses in half a page.

Research approach. This section is similar to 'Materials and Methods' except that special effort must be placed upon showing how the approach you are proposing is suitable to test your previously stated hypotheses. You need not go into exact methodological detail but all proposed research methods must be cited in this section usually within 2-4 pages. This section can be sub-divided into:

a **General research approach and site characteristics.** Where will the research take place Why there? What are the main phases in the research – for example, survey of farmers, laboratory analyses, field experiment. How will these be linked?
b **How will each hypothesis be tested?**
c **Study design.** This sub-section should specify an exact study design. For experiments, describe key treatment contrasts, experimental units and their layour. For surveys identify study units, populations and sampling schemes. Whenever possible, include a diagram to illustrate the design.
d **Measurements.** Which measurements need be taken to prove your hypotheses, how often will you take them?
e **Analysis of results.** How will the data mentioned in the above section be analysed? Describe the approaches and models and show how these will test the hypotheses and meet the objectives.

Research outputs and impacts. What do you anticipate the key accomplishments of this research topic to be and how will these be popularised? Include such activities as scholarly publications, popular publications, student degrees, seminars and agricultural field days or community report-back (0.5-1 page). Research outputs are often well expressed as research products. What are these products, who are their likely beneficiaries, how might these be disseminated and what are their likely impacts on immediate clients and society as a whole?

2 A tautology is a statement of the obvious rather than a proposition that needs testing.

Remember that applied science exists to offer society solutions to its concerns! (1-2 pages, often presented as a numbered list of complete statements).

Time frame and logistics. What will be done when? How will different components of the research project interact and complement one another? The time frame is best displayed as a table or figure. The logistics indicates to whom the funds will be dispersed and how equipment will be purchased and acquired. Many donors require specific details on how funds will be administered within a given organisation, including whether or not Principal Investigators serve as signatories and if funds intended for hard currency purchases are first converted into local currency upon release (1 page).

Budget and budget notes. This is a simple table with which most scientists are certainly familiar. What funds are required for general budget items by year? These should be sub-totalled by year and item in US$ or the hard currency specified by donor, e.g., £ Sterling or Euros, and also, if you choose in local currency. Typical items include Equipment, Supplies, Technical Support, Travel (local and international), Student stipends, Communication, Office supplies and Miscellaneous. Details of these items should be included as footnotes (1 page) or in more detail if required by the donor.

Literature cited or references. Place these in the format of an international journal within your discipline but do not abbreviate journal titles (1-3 pages sufficient). Be aware that many technical reviewers will evaluate your literature by conducting a literature key word search using bibliographic software and will compare the recovered references to those listed in your Literature Cited. Also be sure that you include some of the more recent literature.

Funding Level. Well written research proposals in the area of agricultural resource management that seek between US$15,000 to US$30,000 per year for 3 years are frequently funded. Feel free to ask for less ($45,000) but be reluctant to ask for more ($90,000) especially if the grant is your first proposal to a particular donor. This should be sufficient to keep a research team very busy and to partially re-equip a laboratory as well.

Time frame. Whenever possible the completion of a research proposal should be a fairly rapid process. Very few donors will consider funding a single research project for longer than 3 years and many prefer a 2-year duration. This time frame allows donors to assess research progress and then encourage successful grantees to submit an extension study. You could thus construct the project proposal in phases and apply only for phase 1 in the first instance. It will be important that the first phase does include some measurable results with some impact. Also, remember donor's funding cycles and try to fit within them. In general, donors begin to exhaust their funds by mid-year but it is never too early to submit something for the following year. Many donors have well established technical review procedures that require several weeks or months to complete. Whenever possible, ask the donor when is the best time of year to submit your proposal (and then do it!). Sometimes life is full of surprises and a donor may offer seed money on the spot to test the feasibility of a research proposal, especially one that is near the cutting-edge of current thinking on a topic. Do not hesitate to accept these funds at this point even though the offered funds are less than you have requested. Offers of seed money may signal that the donor is very interested in your proposal and wants to see how successfully you can initiate it.

Continuity between proposal elements. The key to a successful grant proposal is continuity between proposal sections. The objectives must be few and clearly stated and in turn lead to well worded working hypotheses. These hypotheses must be stated in such a way that the experimental design and important measurements are obvious to the reader. If more than one experiment is being proposed within a single grant proposal, these different experiments must be easily distinguishable from one another (sometimes a donor may be interested in funding only part of the proposal). When writing your grant, you must be prepared to anticipate different experimental outcomes and identify the potential significance of these research outcomes upon outputs and impacts within the proposal itself, rather than later when experimentation is completed. **Keep-It-Simple-Scientist**; remember that often a donor may not be a specialist in your field of science but is generally interested in the impacts of many areas of science on sustainable agricultural development, food security, environmental awareness or curriculum development.

Avoid proposal drift. Sometimes people's thinking and ideas change or further develop during the proposal writing process. This must not be considered undesirable because it is a fundamental part of the learning process. Adapt all parts of your proposal to reflect the changes. One all-too-common example of ‘proposal drift’ is to add an unexplained experiment or set of treatments when the proposal reaches the Experimental Design section without returning to the Introduction, Objectives and Hypotheses sections to reinforce the necessity of that experiment. Beware: sometimes research activities are included seemingly as an afterthought. One sure way to not be funded is to confuse the donor representative who reads your proposal!

Emphasise the role of students. One of the advantages of university-based research is the potential to involve students within research programmes. The enthusiasm, commitment and cost effectiveness of graduate students in conducting research is well known to donors, and some donor programmes require student involvement. In this regard, proposal authors are encouraged to identify their candidate students and specific research topics within a proposal. At the same time, investigators must not give the impression that they are imposing tightly prescribed research programmes but rather have opportunity for creative input. What is more, authors must be careful not to appear as delegators of responsibility to co-operators and students, but rather they must provide scientific leadership and maintain their own responsibilities to the project as a whole (Patel and Woomer, 2000).

Tables, figures and conceptual diagrams. Proposals should include tables, figures and conceptual diagrams. These tools demonstrate an ability to compile and synthesise diverse sources of information and to prepare publication-quality material. **Conceptual diagrams** are best designed as graphic presentations of working hypotheses that identify likely mechanisms and how they might be elucidated. In many cases, quality graphics greatly reduce the need for lengthy text explanations when ‘one picture is worth a thousand words’.

Additional documentation. The submitted proposal should be accompanied by a short covering letter, letters of institutional support, and a brief description of the investigators' qualifications. When possible, the covering letter should identify the title of the proposal and the specific donor programme to which the proposal is submitted. You must indicate your willingness to provide additional information to the donor in the future but the letter must not go into detailed explanation of the proposal's intention or methods. **Letters of institutional support** from a high-ranking member of the Principal Investigator's organisation are usually a prerequisite for processing an applicant's proposal. The letter of institutional support should mention the proposal by title and Principal Investigator by name and express commitment to accommodate the project. It is not usually necessary to include a full resume of all investigators with a proposal, but each investigator should prepare a 1 or 2-page profile of their qualification with emphasis on their educational and professional backgrounds, publications and previous experience in grant administration. You must not overwhelm a donor with enclosures or attachments accompanying a proposal because these could distract from the strengths of the proposal itself.

Know your donors. While it is not possible for most scientists to know every donor representative personally or to be assured that an individual proposal will appear attractive to a donor organisation, it is possible to target a proposal to a given donor. Many donor organisations maintain home pages on the Internet that describe their aims and programmes. Some post their Instructions to Authors and Application Forms over the Internet as well. You can gain an insight by examining the Acknowledgements sections of recent publications because the donor organisation and its specific programme that funded an investigation are usually identified there. Most donors 'specialise' in areas of food security, natural resource management, privatisation/liberalisation, forestry, environmental conservation and in specific commodities or agroecological zones and it is important to learn which topics are funded by which organisation. Such knowledge is gained through experience, as there is no single source and donor priorities change with time.

Emphasise substance, not superficial structure. Be aware that many donors rely on experienced technical reviewers to evaluate incoming proposals and that these reviewers are expected to comment on the feasibility, relevance and potential impacts of the proposed research. Some proposals highlight the structure (administrative mechanisms) through which a project is managed, rather than scientific substance and these proposals tend to be negatively reviewed. Avoid establishing 'management committees' for a project, the Principal Investigator should assume responsibility for completion of activities once the project is awarded. Also, be careful not to reflect top-down administrative and client attitudes in work plan diagrams, but instead emphasise interactions between research partners and stakeholders. Highlight the quality of your research experience rather than the size of your parent organisation. The proposal should reflect your stature as a developing scientist, not your ambitions to become a technocrat. Also, you must remember that donor representatives are by necessity generalists and that grant submitters will usually possess much greater knowledge of their individual subject area. Take care to explain the scientific approach and key measurements in understandable terms, and to rely upon the references you cite to represent extremely technical details. **Avoid disciplinary jargon and excessive abbreviation as this will be interpreted as an inability to communicate with the wider scientific and development community.**

Proposal refinement. If you submit a first version as a 'finished' proposal you are well advised to not consider this the end of your effort, but rather an important stage toward reaching a desired opportunity. The proposal award process may be viewed as a series of interactions between donors and applicants with many important steps required subsequent to submission (Figure 2). A donor's call for submission is met by applicants and then acknowledged by donors who will often request additional documentation. A request for additional documentation should be regarded as a sign of interest by the donor that you should satisfy in a timely manner.

Proposals are often sent by donors for technical review. This may require several weeks or a few months. Reviewers' comments are then returned to donors and forwarded to applicants. These comments almost always require moderate to major proposal revision and you are well advised to accept and respond to reviews in a constructive manner, but not necessarily to comply with every one of the reviewer's suggestions. In some cases, proposal refinement occurs through several review/revision steps and you should not become discouraged unless it becomes clear that irreconcilable differences in scientific viewpoint exist between yourself and the reviewers. Even then, a proposal could be rescued by preparing a letter to the donor that documents and describes the merits and potential weaknesses of each perspective.

Ultimately, your proposal will be either accepted or rejected (Figure 2). If rejected, you should be told the reasons for this decision, and you should be aware that proposals rejected by one donor based upon their present criteria and priorities may be more acceptable to another donor. If accepted, you will be notified in a letter that is often accompanied by a contract that must be signed and returned to the donor before funds are released. If the donor's acceptance letter requires acknowledgement and requests banking details, you must reply as immediately as possible.

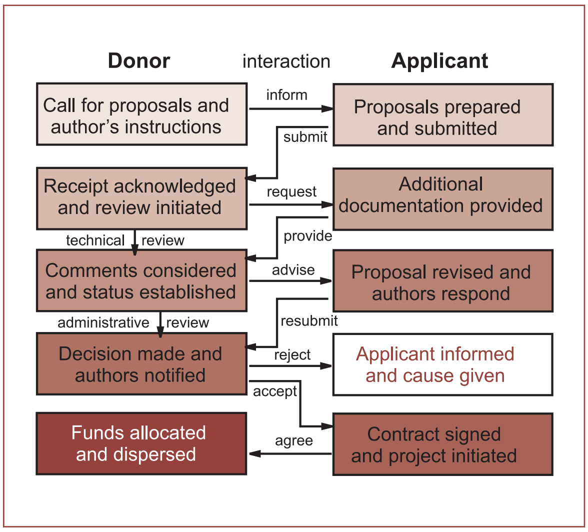

Figure 2. Interactions between the donor and applicants in the proposal submission, evaluation and award process

Project Management Tools

Most agencies and organisations use a project design approach based on some version of a **logical framework matrix (LFM)** and a **work breakdown structure (WBS)** of project activities. The LFM and WBS facilitate not only project design but also progress reporting and evaluation. The LFM is a one or two-page overview of a project which summarizes its design information. The WBS is a one-page graphical presentation of the project which links the goal, purpose and outputs to specific project activities.

It can assist in obtaining funding if your proposal includes a preliminary LFM and WBS but it is especially useful to develop this for managing the project and to provide a consistent system for evaluating and reporting on your project.

Logical Framework Matrix (LFM)

Begin by preparing the LFM as shown in Table 1. The LFM will be useful throughout the life of the project. Initially it helps to clarify the components for the research proposal. As you are implementing the project you can keep referring to see how you are measuring up and how it needs to be adapted to meet changing circumstances. It should not be considered fixed but any deviation from the original, needs to have a rationale. You can provide evaluators with your LFM against which they can assess the project's performance.

Vertical axis of LFM

Goal refers to the broad programme or sector goal to which the project is expected to contribute. It represents a development objective.

The **purpose** is the immediate objective that describes the intended impact of the project on the direct beneficiaries, but is beyond the direct control of the project team since it relies on how the beneficiaries will make use of the project outputs. A project should only have one immediate objective or purpose.

Outputs are the specific kinds of results that can be expected from good management of the project inputs and activities. The project team should be held accountable for the production of the outputs.

Table 1. Logical Framework Matrix for Project Design			
Narrative Summary	**Objectively verifiable indicators**	**Means of verification**	**Critical assumptions** (beyond the control of the project team)
Goals The reason for the project, the desired end toward which the efforts are directed (e.g., to raise farm yields)	Conditions which will indicate that the Goal has been achieved (e.g., higher yields in farmers fields)	The way that Goal achievement can be objectively verified (e.g., output sale records; demand for seed; government yield statistics)	Assumptions which must be met if Purpose is to result in achievement of the Goals (e.g., effective seed access systems exist)
Project Purpose The anticipated benefit if the project is completed successfully and the outputs are actually utilized (e.g., improved varieties released by NARS)	The signs which will indicate that the Purpose is achieved (e.g., NARS release at least three varieties)	The way that Purpose achievement can be objectively verified (e.g., official varietal release documents)	Assumptions which must be met if Outputs are to result in achievement of the Purpose (e.g., NARS skilled and funded to effectively test and release varieties)
Outputs The specific kind of results that are expected from good management of the project inputs (e.g., improved elite lines)	The tangible form in which the Outputs can be observed (e.g., breeder's advanced germplasm collection)	The way these Outputs can be objectively verified (e.g., yield trial results)	Assumptions which must be met if Inputs are to result in achievement of the Outputs (e.g., useful genetic variation exists)
Inputs Resources for activities necessary to produce the outputs (e.g., basic germplasm)	The tangible form in which the Inputs can be observed (e.g., 1000 new accessions used)	The way these Inputs can be objectively verified (e.g., field books and plantings)	Assumptions which must be met if Inputs are to be attained (e.g., importation of exotic germplasm is allowed by national authorities)

Inputs are the resources (funds, personnel and goods) that are needed for the production of the outputs.
Activities are not listed in the LFM since they are provided in the work breakdown structure.

Horizontal axis of LFM

Indicators are parameters, preferably those that can be quantified, which verify the achievement of the goal, purpose and outputs. Indicators provide a basis for monitoring and evaluation, they should define attainment in terms of target group (for whom), type of output (what), quantity (how much), quality (how good), time (by when) and location (where).

The **means of verification** should specify both the instrument for measuring the indicator and the sources of information necessary to use the indicators (e.g., questionnaires and structured interviews, the results of which are found in Ministry statistical reports, project technical and financial progress reports).

Critical assumptions are the events or conditions over which the project team have little control but which must be assumed to exist if the inputs are to be applied, the outputs delivered, and the objectives achieved. These external factors determine the risks of the project. They clarify and set the limits of responsibility for the project management. Projects may be unsuccessful because:

- Unreasonable assumptions were made during the design phase
- Reasonable assumptions do not hold up
- Inputs are poorly managed.

The identification and clear expression of the **assumptions** are therefore extremely important in the evaluation process.

Work breakdown structure (WBS)

After completing the logical framework matrix, the next task is to prepare the WBS.

The WBS is a graphical diagram which groups project activities around specific outputs. The outputs of the WBS provide the link to the LFM Table.

Activities identified in the WBS serve as the basis for:

- Project monitoring
- Preparing both technical and financial progress reports to the donor
- Providing the framework for mid-term and/or end-of-project evaluations.

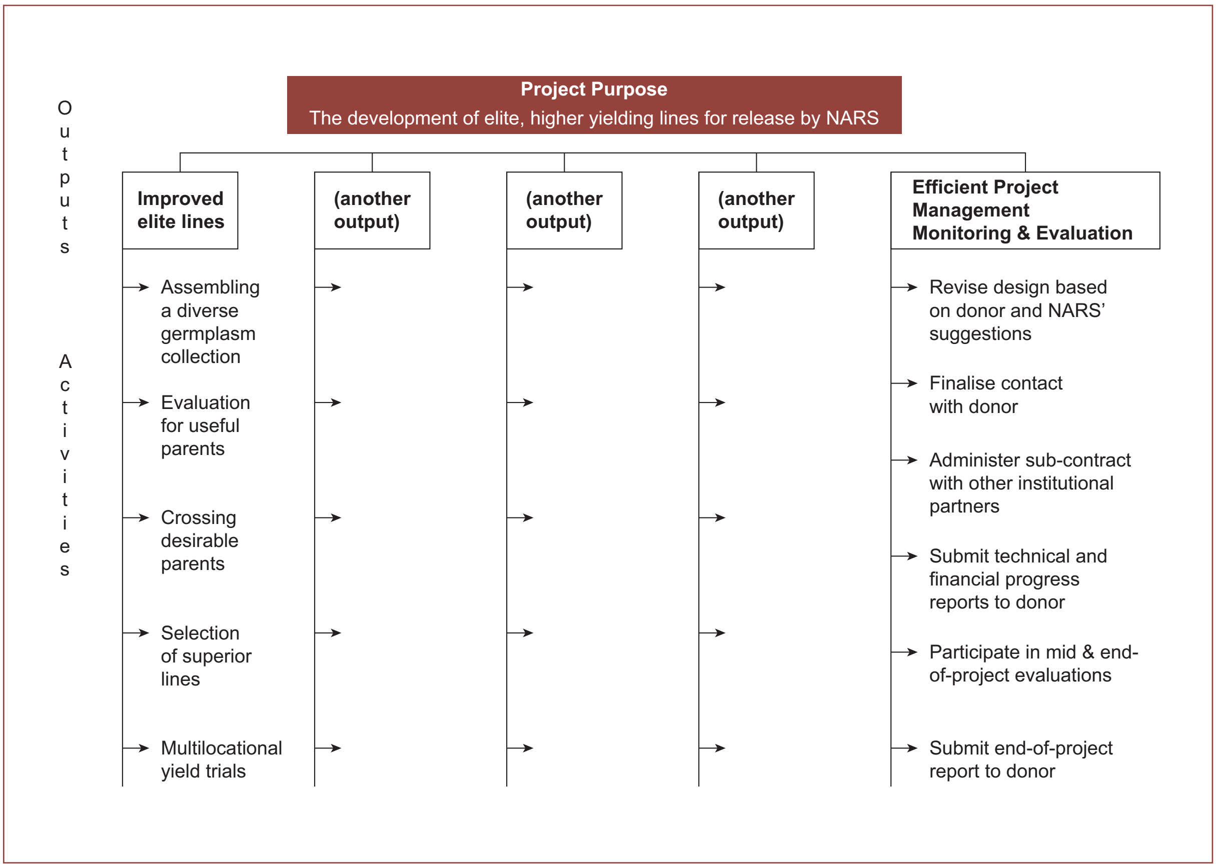

Figure 3. Example of a work breakdown structure linking project activities to project outputs

Diagnostic indicators of proposal and project viability

There are several indicators of the viability of a given proposal or project that are independent of scientific approach and technical details, but are related to the philosophy and openness of proposal preparation and project management. Healthy approaches include true collaboration in research, writing, internal review of a proposal prior to its submission, circulation and open discussion of reviewer's comments and careful selection and preparation of references.

Similarly, there are several indicators of successful project management including scheduling of regular project meetings, assumption of research responsibilities by the Principal Investigator rather than operating through top-down delegation, and the clear assignment of tasks and funds to co-operators, including those from outside the Principal Investigator's organisation. The attitudes of the Principal Investigator and senior investigators are easily ascertained by reviewers and donor representatives from the proposal contents and short visits to their offices and laboratories.

As a student, your inclusion within a university-based proposal is usually an asset, but only if you are truly integrated into the research team. You should be provided with a copy of the complete proposal so that you may be in a position to better understand your role within a larger context. You should be aware of the funds available to you and be expected to account for these funds as part of your training. Project resources, particularly vehicles and computers must not be treated as personal property by the Principal Investigator and senior investigators, but should be made available to help all members of the team to complete their work. You must be assigned desk and laboratory work space so that you can work efficiently and be easily accessible to other team members. Your stipend must be sufficient to meet your living needs and must be paid in a timely fashion, otherwise it will be difficult for you to devote your full efforts to your thesis and project responsibilities. The opportunity to creatively contribute to a project and your treatment as a developing professional must both be reflected within any proposal with which you are involved, and again, these considerations are very easily detected by reviewers and donors.

The entire research team must strive for project accomplishments that reflect a healthy and productive research environment, particularly if the senior investigators seek further funds and a lasting relationship with their donors. The Principal Investigator must meet all project deadlines and goals and must not conveniently ignore, or attempt to redefine those goals at the end of a project. Late technical reporting and lax financial accounting reflect poorly upon a project and its investigators. Projects that lead to publication in leading journals will always be regarded in a favourable light that is not achieved by those that simply produce technical reports with limited circulation. Such other opportunities for research products as pilot products and pioneering technologies must not be overlooked. Senior investigators are better positioned to lead productive research teams when they assume direct research and writing responsibilities rather than operate exclusively through delegation and they must not demand co-authorship as a 'courtesy'. Project accomplishments and the manner in which they are obtained present an entry point for further donor relations and future project funding.

Indicators of healthy and weak approaches to proposal preparation and project management and outputs are shown in Table 2. If you find yourself working in a weak research environment you should reconsider your position. If you are in agreement with the principles described in the healthy research environment you should take care that your intentions are clearly reflected in the proposals, project reports and research products of your team.

Grantee ethics

As a proposal writer you must be fully aware of the ethics surrounding proposal writing and research (see Booth *et al.*, 1995). All scientific ethics apply to grantsmanship, including the requirement to accurately cite and fully acknowledge the ideas and contribution of others, and not to misrepresent or obscure contradictory evidence.

The following must be kept in mind throughout the proposal preparation and research process:

1 It is ethical to submit the same or similar proposals to more than one donor at the same time, but unethical to accept funds from more than one donor for a single or similar research

Table 2. Indicators of impacts on MSc programmes through grants by the FORUM	
Indicator of positive impact	**Indicator of no or negative impact**
Proposal preparation	
Proposal is jointly prepared by principal investigator (PI), other investigators and, possibly, candidates for MSc scholarships	Proposal is prepared by PI in isolation, no inputs from other investigators, candidate students are not identified in the proposal
Proposal is internally reviewed by other FORUM grantees before submission	Proposal is sent to FORUM without the knowledge or comments of other local grantees
Reviewers' comments are circulated and revisions made by the project team	PI responds to reviewers' comments in isolation does not circulate reviews and revised proposal to others
Project activities and administration	
Regular project meetings held and attended by all investigators and students	Project meetings seldom held, PI assumes complete authority through delegation
PI pursues individual research interest as well as supervising students	PI delegates all research responsibilities to students or other investigators
Co-operating investigators assigned research and supervision responsibilities	Outside co-operation exists in name only to meet requirements in proposal guidelines
Co-operating investigators and students assigned research budgets	PI withholds budgetary information, preparing the financial statement in isolation
Student relations	
FORUM students group organised and meets regularly to discuss shared concerns	FORUM students discouraged or prevented from organising
Students provided with complete proposal and assigned some financial responsibilities	Proposal or sections of it withheld from students and other investigators
Students assigned designated desk and laboratory work space	Students lack designated work areas due to vaguely worded 'policies'
Students with ready access to project or student computer room established	Computers locked away from students for use by computers PI or other investigators and students require special permission for their access
Students regularly travel to field in project vehicle, vehicle available to other FORUM projects	Students must travel by public means, PIs use vehicle as personal transportation
Students work solely on research and thesis preparation, stipend sufficient for student's needs	Students distracted from thesis by outside employment
Project outputs	
Students submit thesis within 2 years then assist PI in preparing renewal	Students leave campus after conducting field work, completing thesis elsewhere
Project findings results in publication and completed MSc thesis	Research results only appear in submission of MSc thesis
PI serves as an active co-author in the preparation of scientific papers	PI's name appears as co-author as a courtesy claiming time not available for writing
Thesis and papers contain numerous, current citations from leading, peer-reviewed journals	Thesis dominated by grey, in-country literature or unpublished sources

project. When one donor funds a research project, notify other donors who have been sent similar proposals that you no longer require funding for that particular research project, thank them for their consideration and mention that you look forward to sending additional proposals to them in the future.

2 Grant contracts are legal documents and as the grantee you should feel legally and ethically bound to complete these contracts to the best of your abilities. Always comply with the contractual schedule for technical reports and financial statements in a timely manner. Remember that in these days of competitive research, entitlements and endowments are few and far between. Donor organisations have long institutional memories, and donor agencies willing to fund a particular topic in a particular area are not limitless. Do not feel trapped by your grant. Experience suggests that donor representatives are usually sympathetic to difficulties encountered and changing circumstances, so remember to keep channels of communication between yourself and donor representatives open.

3 Avoid double reporting. Often different research projects are complementary to one another and may constitute components of an overall research question. Some donors encourage or readily accept 'piggy-backing', but others shy away from such arrangements. In general, donors do not approve of combining different funding sources into a general pool that does not distinguish the research activities that arise from each funding source. Double reporting results when investigators report all their research activities to all funding agencies, regardless of which agency actually funded each individual study. Remember that the members of the donor community are often in close communication with one another and will become extremely disappointed in you if you double-reports your research accomplishments.

4 Different donors have specific acknowledgement conditions with which you must familiarise yourself and comply. Some donors require that funding be acknowledged in all publications arising from your research. In general, always acknowledge donor assistance unless explicitly forbidden. Some acknowledgement conditions extend to specific wording. For example, one donor organisation discourages grantees from stating 'This research is supported by DONOR X' preferring 'this research was conducted through the financial assistance of DONOR X'.

If you fully acknowledge sources, cite contrary findings, recognise the limitations of your own findings, assert claims only as strongly as warranted and then strive for publication in the leading, peer-reviewed scientific journals, you will not only avoid moral dilemma but also accrue scientific credibility!

Hints on Grant Applications

Table 3. Hints on Grant Applications

Applicants should	Applicants should not
• Inform themselves of donor programme objectives and author's instructions • Respond to requests for additional information promptly • Respond to reviewer's comments in a constructive, interactive manner • Revise and resubmit proposal in a timely manner	• Submit proposals without fellow cooperator's knowledge • Send frequent, unsolicited enquiries about proposal progress • Respond to reviewer's comments in a dismissive or defensive manner • Present superficial changes as major revisions

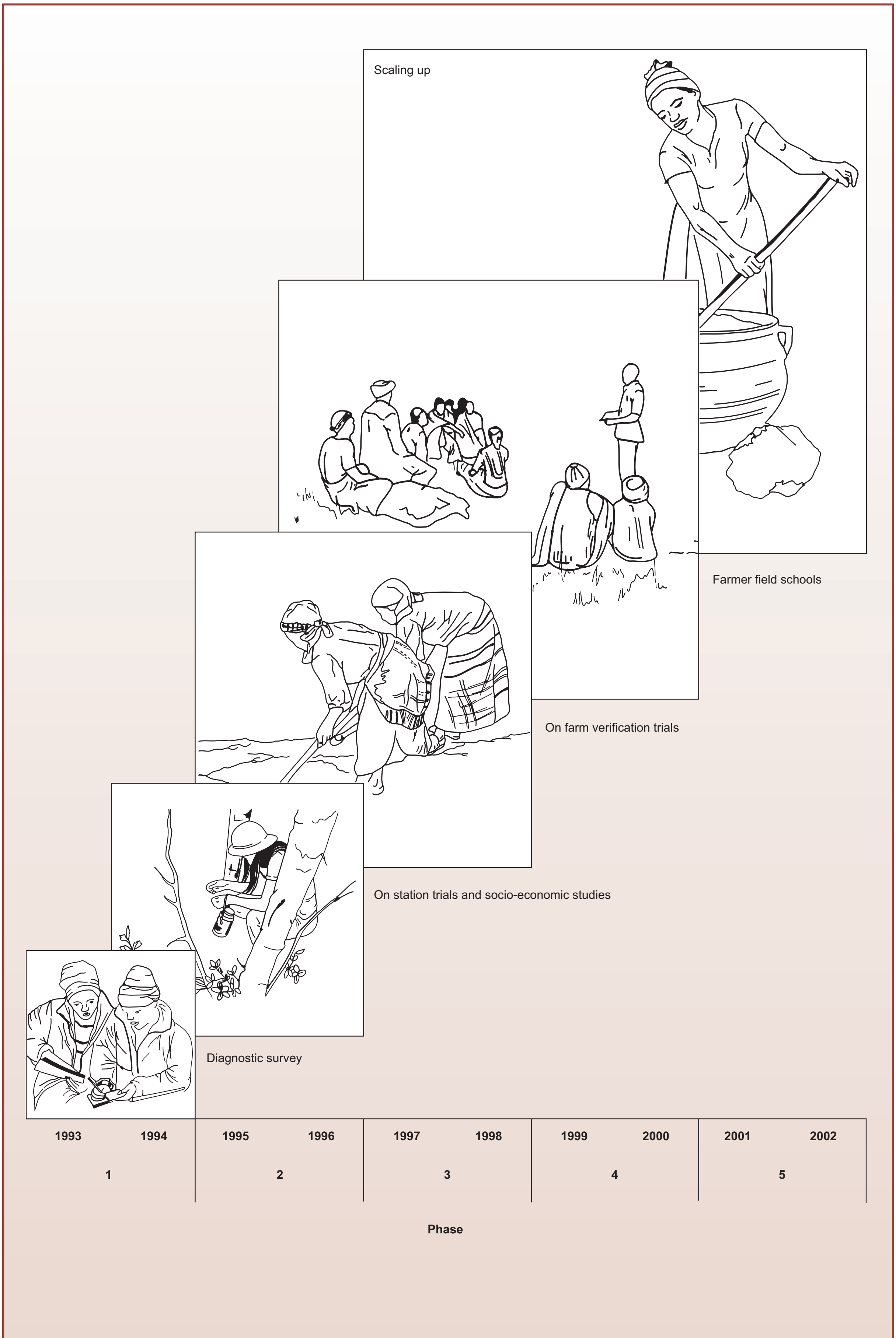

Figure 4. Phases of the Cowpea Project

Examples of Successful Research Projects with Students

The Cowpea Improvement Project at Makerere University, 1993-2003

In 1992, a Needs Assessment by the National Agricultural Research Organisation (NARO-Uganda) and Makerere University researchers identified cowpea (Vigna unguiculata) as a key legume crop supporting livelihood of about 30% of the Ugandan population. Strikingly, no research was being done on cowpea. A multi-disciplinary team was subsequently formed to develop a research agenda for this important crop of the semi-arid regions of Uganda. The starting point was clearly to conduct a baseline study (survey) to:

- Establish the status of the crop (its importance in relation to other crops)
- Gather production statistics
- Identify and categorise the available germplasm
- Identify production constraints (social and biological)
- Establish the competitiveness of this crop vis-a-vis other crops grown by the farmers

A proposal was submitted to the Rockefeller Foundation's Forum on Agricultural Resource Husbandry Programme, which agreed to support it. A multi-disciplinary team that included from the University, NARO, and the Extension Service participated with seven MSc students from four disciplines. The key issue that emerged was the low yields (<200 kg/ha). Technologies were developed to address some of the causes: pests, diseases, weeds, a narrow germplasm base (7 cultivars/varieties), and poor agronomic practices and a more detailed analysis of market competitiveness, and underlying marketing issues was carried out. In Phase III, the promising technologies developed were then tested in farmers' fields but were managed by the research students. These trials resulted in a basket of options that farmers could potentially use to improve the productivity of their cowpeas. They targeted different farmer groups and market demands. The final phase involved refinement and dissemination of the IPM options developed. A farmer field school approach was used involving 6 farmer groups (each group consisting of 20-30 farmers). The farmers conducted season-long evaluations of the different options. Pre-tests were conducted to establish baseline knowledge and background of the participating farmers and at the end of the second year, post-tests were done to establish the acquisition of knowledge and changes in practices. Based on this Phase, strategies for scaling up were developed in partnership with farmer groups and district extension officials. After 10 years of study three improved varieties were finally identified and recommended to the National Variety Release Committee and the Makerere University Cowpea Improvement Project, using graduate students, has joined up with a number of partners to support widespread dissemination and adoption.

10 years of phased studies led to the development of technologies that are now being adopted nationally. It has also strengthened linkages and partnerships and produced 22 graduate students that are highly practical and more responsive to society's needs. In addition to its participatory work with farmers the project has produced 46 scientific publications (30 Journal Articles and 16 Proceedings publications) and a wide range of extension brochures.

The Smallholder Soyabean Research and Development Programme, University of Zimbabwe, 1996-2006 Sheunesu Mpepereki

Food insecurity among smallholder farmers in rural Zimbabwe due to declining soil fertility and expensive mineral fertilisers led University of Zimbabwe soil scientists to explore soyabean biological nitrogen fixation as a low-cost, sustainable soil fertility improvement technology. Soyabean is a legume that produces nutritious grain with up to 40% protein, 20% oil, 30% carbohydates, vitamins, minerals salts and 10% fibre.

Soyabean production by smallholder farmers was almost non-existent prior to 1996. This was due to a number of factors including: the lack of varieties and technologies appropriate for small-scale farmers, low-input production and lack of access to rhizobium inoculants and the very limited information on soyabean production, processing and consumption that was available in rural areas.

Earlier soyabean promotion efforts targeted at smallholder farmers failed because they did not work closely with the farmers. A major soyabean promotion program was launched[3] as a result of some preliminary research on promiscuous soyabean which held promise to assist farmers who could not readily access commercial rhizobium inoculants. From the beginning this initiative was participatory and involved the rural households, graduate student research students and senior university scientists together with various private and public sector agencies. A stakeholders' workshop was held at the University of Zimbabwe in 1996 and this established the 'Soyabean Promotion Task Force (SPTF)' made up of representatives from key stakeholder institutions, with the University of Zimbabwe as the implementing institution responsible for mobilizing funds from donors and carrying out the research and extension in close collaboration with Ministry of Agriculture Research and Extension Branches. The Task Force met 2 or 3 times per year to chart policy and direction. The Farmers Unions mobilized volunteer farmers for the pilot phase and for participation in the on-farm research activities.

Strategies for soyabean promotion

Inputs that included seed, fertiliser, lime and rhizobium inoculants were provided to an initial group of 55 volunteer farmers each planting four varieties on 0.4 ha. This initial phase tested the performance of the technologies under smallholder cropping conditions across agro-ecological regions II and III whose climatic conditions favoured soyabean production. Detailed replicated experiments were set up to collect data on agronomic and symbiotic performance of two promiscuous and two specific soyabean varieties while farmers tested the same technologies in simple with/without trial experiments. After the harvest, farmers were trained in the home processing and utilisation of soyabean grain. When farmers experienced difficulties in selling the small surpluses generated in the first year, the SPTF intervened to identify appropriate markets for the produce.

Main promotion phase

Once the multiple benefits of soyabean were demonstrated, small holder farmers rapidly adopted the crop for cash, food and soil-improvement. Using soil fertility as the entry point, small holder farmers were introduced to soyabean biological nitrogen fixation technologies as a strategy to provide 'cheap' nitrogen fertilizer. Training was provided to both farmers and extension workers in the correct use of rhizobial inoculants and agronomic practices such as correct use of basal fertilizers, lime and planting densities and dates.

The SPTF found itself at the centre of efforts to respond to the demand for soyabean technologies by farmers. The Taskforce built strong farmer groups which were later consolidated into a National Soyabean Commodity Association. Training, extension and provision of technical management back-up were the main promotion activities. In addition to scientific research and evaluation of soyabean technologies by local farmers and scientists, training sessions were organised on home processing and utilisation of soyabeans as food.

3 by the University of Zimbabwe led by Professor Sheunesu Mpepereki and Dr Fred Makonese

Right from the pilot phase, farmers were linked to viable markets through agreements with major processors and input suppliers who were partners in the SPTF. The smallholder soyabean success story is one of an integrated approach combining research, demonstrations, training and provision of input/output marketing that fuelled a near exponential adoption of soyabean technologies. It is a programme that is both interdisciplinary and multi-agency in scope clearly rooted in a participatory approach.

Research

The research team made up of scientists and graduate students from the university and national research institutes included soil scientists, agronomists, economists, social scientists, food scientists and graduate students. It was linked to private, NGO and public sector participants through the SPTF, drawing membership from all stakeholder sectors. The University of Zimbabwe scientists, sponsored through RUFORUM and other agencies, co-ordinated the research and development agenda drawn up in full collaboration with farmers and partners from the public, private and NGO sectors. A key element in developing the partnerships was the need for mutual benefit: the university was able to enrol and train scientists and provide a rewarding environment for its staff; private companies expected to have an expanded market for their products (fertilisers, chemicals); processors expected larger volumes of local soyabeans and less imports and savings on foreign currency and government agencies were helped to fulfil their mandates. Farmers expected to improve their incomes and diversify their farm enterprises. Success was dependent on full regular consultation and sharing of roles with proactive co-ordination.

Research themes were articulated at field meetings and workshops and included agronomic issues, performance of promiscuous varieties, screening germplasm, residual soil fertility benefits, need to inoculate, soyabean pests and diseases, soyabean grain and stover use as livestock feeds and marketing and socio-economic issues. While scientists wrote research grant proposals, private sector partners and farmer unions mobilised inputs and farmer groups through their links with industry and the farming communities. To increase the coverage, university scientists teamed up with NGOs as technical partners where NGOs provided the social dimension in the development work. Regular stakeholder workshops allowed farmers to report on their evaluation of the soyabean crop, students to present research results and private sector partners to educate the rest on market trends, quality parameters and pricing. Load consolidation facilitated by the formation of farmer groups allowed smallholders to enjoy the economies of scale.

Parallel research and extension activities were run in which the extension messages were constantly reviewed and updated in the light of research findings. Detailed replicated experiments were located on a limited number of farms while a large number of simple plus/minus treatment trials were carried out by farmers in the target areas allowing for rapid and widespread evaluation of the soyabean technologies. Extension officers from the public sector in the respective areas were the main link with local farmers. Field discussion days were organised around the various trials by participant farmers and at harvest time, open field days for surrounding communities, local leaders and development agents were held. Information generated by the research fed into the parallel promotion-extension program and was published in local and international journals and made available in handouts and at workshops and field days.

Achievements of the promotion program

From just 55 farmers in the pilot phase (1996), over 100,000 farmers had adopted soyabean technologies by 2002. Production in the sector has risen from 395 tons in the 1996 to 12000 tons in the 2003 with yields improving from less than 0.5 ton/ha to an average of 1.2 ton/ha in 2003 (CSO, 2003). Significant impacts on nutrition and health especially for the chronically malnourished rural poor and the HIV/AIDS-infected have been recorded. The residual soil fertility benefit of soyabean to maize grown in rotation was also demonstrated, further fuelling adoption. Soyabean consumption by both humans and livestock rose significantly among the rural population. The impact on farm incomes has been demonstrated by the number of farm implements (scotch carts, ploughs, cultivators etc), modern building materials, household furniture and inputs (seeds, chemicals and fertilisers) purchased during subsequent marketing seasons. Soyabean marketing has been shown to contribute directly to paying school fees and increasing incomes and home-processed soy milk, bread, cakes, snacks and protein fortified maize meal are now important grocery substitution items for farm families. The major lesson from this highly successful research-outreach initiative has been that investment in building partnerships between and among the various players for mutual benefit is the main key for success!

Promotion of Rural Initiatives and Innovations (PAIIP) in Aguié, Niger
Aissétou Dramé Yayé
(refer to **Appendix 8** for a more comprehensive review of the programme)

Situated in the centre-South part of the Maradi region of Niger, Aguié is densely populated, some 2800 km² with an estimated population of 275 000. Although a poor and fragmented area it has benefited from numerous intervention projects and development programmes through the PDRAA (Rural Development Project of the Aguié Area). These have had only limited success in addressing the economic, social and environmental issues. There has also been very limited empowerment of local people and little ownership of the projects and very few interventions have been sustainable. In response to earlier failures it was determined that a radical change in approach was required. In 2001 the Abdou Moumouni University were invited to work with the rural development agency in Aguié and PAIIP (Promotion of Rural Initiatives and Innovations) was developed.

This project used university students working closely with villagers to help them to translate their issues and problems into researchable topics and to worth with the villagers to carry out the research. The primary objective of PAIIP was to work on a methodology that would allow research and development to harness the initiatives and innovations of rural people. It was first carried out by the University in a pilot study on the rural practices and strategies relating to soil fertility and climate risks in Aguié (Maradi). This was successful and subsequently resulted in a larger project and a partnership protocol between the University Abdou Moumouni (the UAM) at Niamey (Niger), the Catholic University of Louvain (Belgium)and the Project for the Promotion of Rural Initiatives in the Department (area) of Aguié (PPILDA) to establish the Project Initiative Ciblee (PIC).

PIC was established to enable the villagers to contribute to the solution of the multiple constraints with which they are confronted. It determined that innovations would be defined not only as something new, but useful with innovation broadly defined as an initiative which brings, at an initial stage, considerable improvement and could be technical (production), organisational, political, environmental or economic.

- technical innovation: new ways of using natural resources (soil, animals, trees, water) as well as those resources that come from production (harvest, biomass etc.) on the level of family contributions, communal or individual plots.
- socio-organizational innovation: new ways to organise agricultural work or new ways for

the community to function.
- economic innovation: new ways to improve the value of the resources, transportation, storage, distribution, redistribution, with respect to the family or the community, or new commercial strategies.
- institutional innovations: new ways to take decisions 'on behalf of' or 'by' villagers, to assume responsibility, to legitimize, to regulate to the advantage of the community the inter-group relations around resources and common property and to produce new norms at village and inter-village levels. These would influence the laws and rules which govern the relationships between individuals e.g. new fencing rules which regulate the access to the ground or its exclusion, rules of water usage for irrigation purposes etc. (PDRAA, 2001).

The program also views innovation as a process: it places those who are involved in the innovation, in an integrated cycle of questioning, experimentation, analyses and questioning again with researchers, beneficiaries, officials and facilitators working closely together throughout. Finally, it recognizes innovation as a relative notion because it is contextual. What is new in one place may seem to others old or even obsolete.

All the studies carried out by the students were conducted on the basis of this approach in which the centrality of the village was respected and included the population fully in the debates, deliberations and proposals for solutions. For each program activity a certain number of operational partners were identified and made responsible from all sections (programme staff, villagers, researchers and students). There were a number of projects designed to reinforce the capacities of the rural population in defining, planning and putting in operation, by means of a process of local development and partnership, the technical, economic and social initiatives and innovations, which allow them to reduce their poverty and vulnerability. The beneficiaries formulated the demand (the research idea) which the project team translated into a research theme (proposal with hypotheses) to be carried out by the students and their supervisors. The research subjects focused on vulnerability, gender, inter-village and intra-village institutions, the promotion of initiatives and innovations. The research was undertaken by students from the participating universities under the direction of PIC. The beneficiaries also determined, in consultation with the researchers, which villages, households, research sites etc were used. For all the projects, the same methodology was followed as far as possible allowing for comparisons. Workshops with all participants, seminars and publication of research results highlighted the approach used.

All ideas were discussed with the villagers and the research conducted by consensus. There were periodic progress reports made by the students to the villagers and to PIC and their research leaders with the final report of results made in a workshop made by the students and their supervisors. These interactions not only helped to broaden access to the information generated but also helped to validate the results, to sensitise the local administrative authorities and to stimulate debate on directions for further research and project initiatives. The students and researchers then produced publications of their research including both peer reviewed publications and locally available pamphlets. In addition to the empowerment of the community, their active engagement in the projects and visible results in terms of improving livelihoods, this approach encouraged
- local experiments with new ways of collective decision making
- innovations with a high level of uptake
- the emergence of local associations and organizations, especially of women.
- student respect for local communities
- awareness among students, researchers and officials that the top-down approach is very limited

The approach resulted in optimal improvement of local potential, real participation by local people in their development, the acceptance of change and real empowerment. It was a real school of cooperation and democracy and a means to reinforce a feeling of common destiny. It introduced the need for reform to both research and development to government agencies and universities. The most interesting results were obtained by the combined efforts of all actors. The production of a methodological guide which emphasized approach rather than prescribed actions was especially useful to guide students to meet both the community and academic needs. The research conducted in the context of PIC proved useful for the development of results with and for the rural people. The working methods based on the PAIIP approach have introduced profound changes both at the level of the villagers and with the researchers. The PAIIP approach necessitated a process of reflection and questioning which is good in itself. The approach inspired the prime actors and the results showed the value of investing time and effort in working together. The question of knowing what to change and why to change inspired the prime actors who saw the need for change.

The change in attitude necessary for the success of the new approach (real initiative, transparency, responsibility and engagement) needs time and effort from all actors.

The PAIIP approach was drafted and put in place without any procedure manual which prescribes what should be done, how, when, by whom and why. These reference documents hold the actors 'prisoner' in their capacity for reflection and innovation. Within PAIIP, the absence of pre-established procedure manuals required people to take charge and reflect carefully on the particular rural situation in which s/he was placed.

'The success or failure of the many community projects and farmers' associations…depend on the availability of profitable technology for small-scale farmers… Will African political leaders make the hard choices required to build strong national agricultural science bases…?' Will our researchers develop the technologies and institutions to transform our agriculture?

Carl Eicher (2003)

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1.4 Approaches to impact-oriented agricultural research

Paul L. Woomer

- You need patience, vision and teamwork to bring about change
- Rural farmers need your help
- You need help from farmers
- If possible work through local farmer organisations
- There are many successful participatory scaling up projects
- Be a life long learner – learn from others
- Do not let your research vision be narrowed by disciplinary bias

'Providing insightful answers to difficult questions in ways that are useful to society is the principle responsibility of the scientific community.'

W.C. Booth *et al.* (1995)

'Documenting good ideas and potentially useful solutions through carefully conducted experimentation and case studies, in a manner that disentangles them from research fads and personal opinions, is the means to achieve these answers.'

Carl Sagan (1996)

Introduction

There is a renaissance in African agriculture. Many farmers in sub-Saharan Africa are moving from subsistence, cereal-based farming to market-oriented and mixed-enterprise agriculture. Threatened households find new uses for available resources that lead first to greater self-sufficiency and then to local and more distant markets. Farmers are diversifying into new enterprises such as confined livestock and poultry keeping and market gardening. They are forming community self-help and conservation groups and independent marketing associations and they are joining out-grower schemes. Several international, national and non-governmental research and development organisations are helping. A decades-long commitment to increasing human resources in agriculture adds force to the changes. Stephen Carr (1997) identified five components for attaining rural transformation that provide guidelines on where your research could make an impact:

- Access to suitable improved germplasm
- Access to inputs
- Closely linked crop and livestock enterprises
- Road and communication infrastructure
- Information and market access.

What skills are required?

Professionally trained young Africans are keen to contribute to this rural transformation and to apply their knowledge. This is not easy. You will need patience, vision and teamwork: skills that may not be taught to undergraduates. You need patience because progress is always too slow for the eager. Agendas are inflexible, administrators are bureaucratic, donors are cautious, colleagues are preoccupied, sites are remote and farmers are conservative. A project rarely has impact within 2 or 3 years.

Teambuilding and teamwork are essential because successful research and development projects demand a spectrum of skills. The need for particular skills changes over time as the focus of efforts shifts from applied research to its adaptation and dissemination. Each team must be flexible and its members must be willing to move both forward and aside, depending on project needs and achievements. Honest criticism is essential to appraise team performance, and team members must remain open to the suggestions of others, even when they point to shortcomings and mistakes of individuals. As a team member you must be proud of the team's achievement as well as you own contributions; you must also learn to trust the instincts and abilities of others.

Two types of small households that need help

The poorest farmers suffer from food insecurity, and research efforts should focus on improving their food production and storage systems (Figure 1). When food supplies are exhausted from season to season, any improvement must be achieved within one season. The poorest households lack land, labour and the capacity to invest in farm inputs, so you should be realistic about the candidate technologies you explore. You can help the poorest farmers by examining their management practices, discovering changes that will bring them the greatest improvements, and advising them on how to make more efficient use of their resources. You will find many practical limitations such as nutrient or moisture supply, pests and diseases, weed competition or crop genetic constraints, so a wide range of agricultural disciplines and perspectives are needed within a research team. Food insecurity also affects household nutrition, so you may be able to improve diets with advice on the productivity and diversity of the home garden. Households on very small holdings in peri-urban settings cannot be expected to achieve food self-sufficiency; they are more likely to benefit from research that promotes market-oriented gardening than increasing food production.

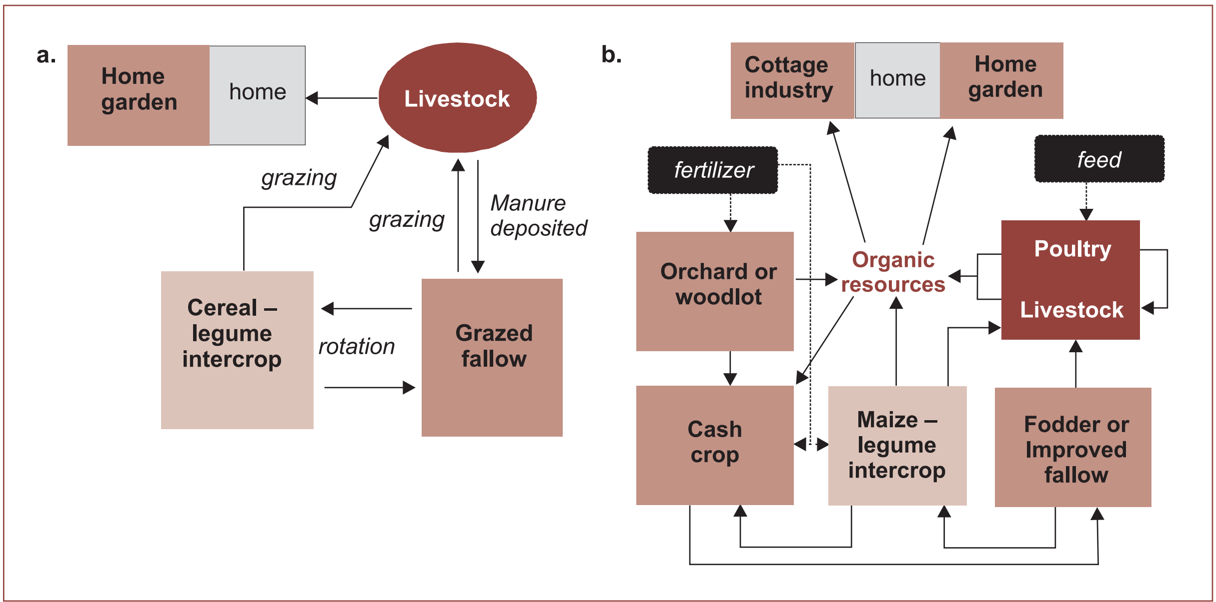

Figure 1. Major organic resource flows within: a. subsistence, cereal-based farming, and b. mixed enterprise, market-oriented agriculture. Note that resource flows within subsistence farming are more passive in nature and that more uses of organic resources emerge as farm operations diversify

Food-secure households offer a more diverse pallet of research and development opportunities. Management systems which economise on inputs and labour, or that substitute one for the other, offer special opportunities for research. Food-secure farmers are market-oriented, more open to changes and place more value on their time (Figure 1).

Working with farmers

Establishing a healthy, productive working relationship with farmers is an essential component of applied and adaptive research. Farmers' involvement in the research process may vary with different types of investigations. In researcher-designed and -managed off-station studies, farmers simply provide the research field and are consulted about local growing conditions. In researcher-designed, farmer-managed studies, the farmers' actions determine the experimental outcomes. In farmer designed-and-managed studies, as a researcher you can play a facilitating role in assisting farmers to better interpret results, and by treating farmers' impressions as sources of data. Regardless of the division of duties between you and the farmers, it is extremely important that both parties understand their rights and responsibilities (Table 1).

Table 1. Guidelines for successful collaboration between farmers belonging to self-help groups and researchers conducting on-farm studies

While doing research you should • Involve cooperating groups and farmers in an earlier stage of research planning • Rely upon simplified experimental designs and relatively few treatments and explain which treatments are intended as candidate improved technologies • Establish a clear timetable and division of responsibility for field operations, data collection and record keeping • Interpret their research findings into terms understandable by client farmers, particularly their costs and returns • Be prepared to modestly compensate collaborators for their efforts and harvest removal • Encourage farmers to conduct their own satellite experiments adjacent to the field trials.	**You should not** • Perform unplanned on-farm field operations without the knowledge and consent of collaborators • Fail to keep appointments or rearrange schedules without consulting collaborators • Ignore collaborators' impressions of different management practices, particularly unrealistic reliance upon additional labour, land or expenses • Exclude acknowledgement of community groups and key individuals in your publications.
Collaborating farmers should • Make their own observations concerning field trials and express them at group meetings and to research partners • Organise local field days that demonstrate the tested technologies to their communities • Make a genuine effort to understand the scientific basis for treatment selection and sampling procedures so that promising results can become adapted into farm practice.	**Collaborating farmers should not** • Falsify data collection records, disguise experimental failures, or exaggerate claims for compensation • Remove crop harvests without the knowledge and agreement of research partners • Expect researchers to engage in lengthy social interactions during intensive field campaigns.

You must not dominate the research process, and should take time to explain your intentions and approaches to farmers. Establishing regular consultation and firm timetables, and relying upon simple experimental designs with understandable treatment combinations are important means to this end (Box 1). Hiring family members to assist in routine measurements is one possible reward mechanism and you could offer a small compensation for the use of the land. Don't intrude too much and keep your social interactions with farmers to a respectful minimum.

Box 1. On-farm miscommunication

- Patty's MSc research involved large field experiments on three farms. She would arrive at irregular intervals, deride farmers for lateness of field operations, refuse to consider claims for compensation and argue with fellow students and technicians during data collection. During her defense, she acknowledged the assistanceby 'the farmers' without referring to them by name. Three yearslater she received a PhD scholarship and sought to work in the same general locations but experienced difficulty in securing collaborating farmers!
- Bill and his team of field technicians were experts in installing on-farm trials, completing as many as 10 per day. They would arrive, mark the plot boundaries, apply pre-packaged inputs, plant the seeds, label the plots, thank the farmer, Cornelius, and be gone in a matter of minutes. Cornelius established an independent satellite experiment by carefully marking the plots in string and planting along a marked 10-m line, just as the researchers did. But there was no improvement in crop performance because nobody had bothered to explain which inputs were being examined and why!
- A team of researchers scouting for new field sites chanced across a farmer burning brush next to a slightly chlorotic stand of groundnuts. They observed satisfactory root nodulation and concluded that the groundnut suffered calcium deficiency. They carefully demonstrated how to apply wood ash to the groundnut pegs and then recommended that the farmer do the same. He replied 'Why should I waste this wood ash on my neighbour's groundnuts?' Because no obvious boundary existed, the researchers had assumed a contiguous landholding!

Advantages of working through local farmers' organisations

Projects designed to achieve agricultural impacts almost always involve a stage of on-farm research. It is common to select collaborators from a list of farmers obtained from local authorities. Where possible, work with self-help groups. Self-help groups are formed as a means to access information and to assess new technologies. Groups of neighbouring farmers share common concerns and it is reasonable that they organise themselves for collective action. They share information, learn new technologies and pool resources to acquire inputs or to market surpluses. Farmers who belong to self-help groups are often enthusiastic and capable collaborators. Among the advantages of working with local groups is that it is easier to assemble farmers to explain the goals of a research project and to identify collaborators. Training in experiment installation, measurement and record keeping can be organised more easily through the officers of a local self-help group, whose keenest members can be recruited as trainers. Identifying one farmer as a local coordinator tends to invoke less rivalry when all of the collaborators belong to the same self-help group, especially when the appointment is made in a participatory manner. It is easier to establish experimental schedules and to adjust them when working with groups of farmers. During experiments, peer pressure among group members will ensure that tasks are performed correctly and on time, such pressure does not exist among independently recruited farmers. Similarly, the rights and responsibilities of collaborating farmers are more easily established and enforced. Farmers within groups will tend to voice their opinions more openly and to be bolder in challenging your actions and highlighting your misconceptions. Local self-help groups are in a better position than you are to organise farmer field days to promote research findings. They often have important contacts among neighbouring groups and local authorities that will ensure these events are well attended. An example of a very successful self-help group in rural Kenya, the St. Mark's Women's Group, is presented in Box 2.

Box 2. St. Mark's Women's Group, Amagoro, Teso, Kenya

Teso lies to the south of Mount Elgon in Western Kenya. It has infertile sandy soil and until recently was primarily used for grazing. The conversion to sedentary agriculture resulted from increased population and establishment of land titles but was accelerated by an epidemic of East Coast fever, a viral disorder that decimated the local cattle population. The St. Mark's Women's Group was started by 30 church members in 1998 as an outgrowth of a prayer group. Its original goals were poverty alleviation and improved child nutrition. The group has five elected officials; a Chairperson, Vice-chairperson, Secretary, Vice-secretary and Treasurer who are elected for 3-year terms. The membership in 2003 was 52 and the group is locally recognised as an effective and equitable community-based organisation, partly because of its widely attended field days and its successful efforts in processing and marketing traditional crops.

The group's primary collaborator is the Sustainable Agriculture Centre for Research Extension and Development in Africa (SACRED-Africa) that initiated a local outreach project in partnership with St. Mark's and other local organisations in Teso in 1999. Relying upon participatory methods for problem identification and a simple adaptive research process, progress was made in the areas of composting, soil fertility management, tree seedling establishment, integrated pest management, crop diversity, marketing farm surpluses and gender roles in agriculture. The St. Mark's group also serves as one of seven co-operators in the Best-Bet Network, a group that evaluates alternative land management recommendations side-by-side on 140 farms in Western Kenya. Exposure to different maize-legume intercropping technologies has demonstrated to members how to raise yields from less than 2700 kg/ ha to over 4200 kg/ha, increasing net returns by US$200 per crop. In the process, members developed new skills in recordkeeping and fertilizer use, increasing their experimental successes from 70-87% within a single year.

After 5 years of operations, several impacts from the group are evident. Their rapid bulking and broad distribution of cassava resistant to the mosaic virus promoted food security within the group and among neighbouring farmers. When most other cassava in their district was failing, this group had established over 240 ha of cassava throughout the area. The adoption of a maize-lablab relay fallow has demonstrated that sustainable field cropping can be achieved on the worst of N-deficient sands. Traditional green vegetables and small grains that were previously considered a home gardening activity now have established markets. But the benefits from the group's activities extend beyond technical adoption because its members now view agriculture in a more holistic and positive manner.

Members are able to diagnose new problems as they arise and to better apply past lessons to emerging situations. The underlying mechanisms for the degradation of agricultural resources are now better understood, as are the relationships between various conservation measures. As Jenipher Etiang, the group's Chairperson, stated 'We discovered that we had many resources at our disposal that we were not using well and the relationship between the problems that we were having and our present and past actions. It was a turning point in our lives.' The group is frequently visited by members of other organisations from Kenya and neighbouring countries, by officers from the local Ministry of Agriculture and by local politicians who attend field days to make modest donations. Members assist one another with medical and funeral expenses and through small loans because they know their neighbours can now generate income from farming. Even domestic lives have improved, as is evident from Jenifer's comment 'Women no longer bother husbands for money to buy salt, sugar or tea leaves and this has improved our family relationships.'

How to navigate the research and development continuum

Along the research and development continuum (Figure 2), 'upstream' theory and basic research is translated into potentially useful technologies that are then applied under field conditions. Next, these candidate technologies undergo 'downstream' adjustments based upon the needs of potential users and their site-specific conditions become captured into products that are tested under a wider range of conditions, and are then offered to communities as a possible solution to common problems. This process requires several years at best, and while relatively few candidate technologies are likely to become widely adopted by society, actions and choices taken by scientists as they escort research products along the continuum can greatly affect the fate of their innovations.

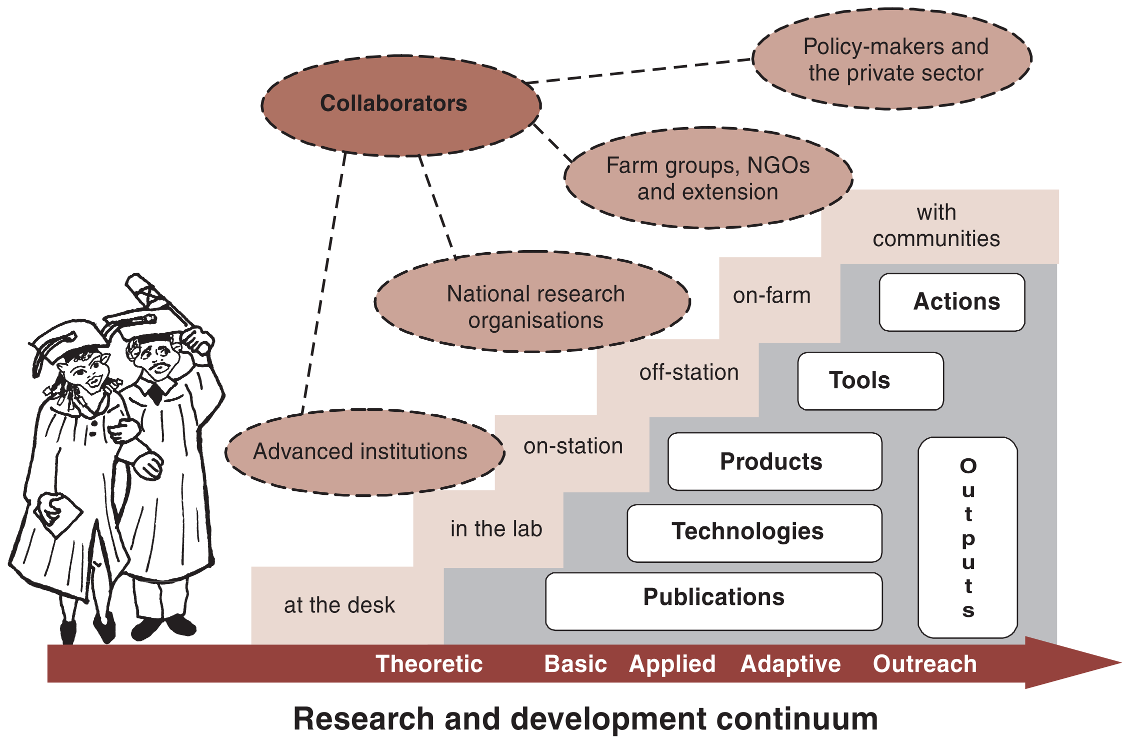

Figure 2. Research intended to achieve impacts through collective action is conducted in a series of settings and with changing sets of cooperators, leading to a sequence of more widely distributed research products

While the process appears straightforward, navigating the research and development continuum requires teamwork, vision and persistence. Innovators must select the appropriate setting and collaborators, both of which change as their innovations undergo testing and become refined. Theoretical and basic research leading to new ideas, is performed at the scientist's desk and in the laboratory, and is best facilitated through collaboration with leading scientists from advanced institutions. On-station studies translate these ideas into candidate technologies, with emphasis on better understanding of the underlying mechanisms that govern their effects.

When studies are moved away from the research station, different collaborators are needed with expertise in packaging technologies and examining their cost-effectiveness. If these technical packages offer promise, they can be scaled up. You must remember that farmers will innovate and adapt your technology while trying it out. Accept this – they know the reality of their situation better than you. If you choose your research setting and collaborators wisely as you escort your innovations or your contribution to an innovation, 'downstream' you are much more likely to achieve impacts than someone who does not. Make sure that you have solid well tested technologies to pass on.

The case of staggered intercropping (MBILI) in Western Kenya presents an interesting example of movement along the research and development continuum. The farmers' main enterprise, maize-bean intercropping, was performing poorly, primarily because of inadequate nutrient supply to the maize and a severe pest-and-disease syndrome on the beans. Researchers had examined a wide range of solutions over many years, including mineral nutrient replenishment, short-term improved fallows, green manure and cover cropping, breeding for stress, pest and disease tolerance and detailed integrated pest management (IPM) strategies but none of these interventions were reaching farmers, partly because they overestimated farmers' land, labour and ability to invest. A simpler solution was required, one that involved reconfiguration of farmer-available resources.

By simply staggering the 75-cm maize rows into alternating 50-cm and 100-cm rows (Figure 3), and orienting the rows in an East-West direction when possible, substantial improvement was achieved. This adjustment allowed for the inclusion of additional, higher-value legumes such as groundnut and green gram into the intercropping system, crops the farmers already knew but only grew as occasional monocrops. These legumes fixed more symbiotic nitrogen, resulting in strong residual benefits to maize, and, when grown as a maize-legume intercrop rotation (maize-groundnut, maize-green gram, maize-bean), greatly reduced the incidence of legume pests and diseases.

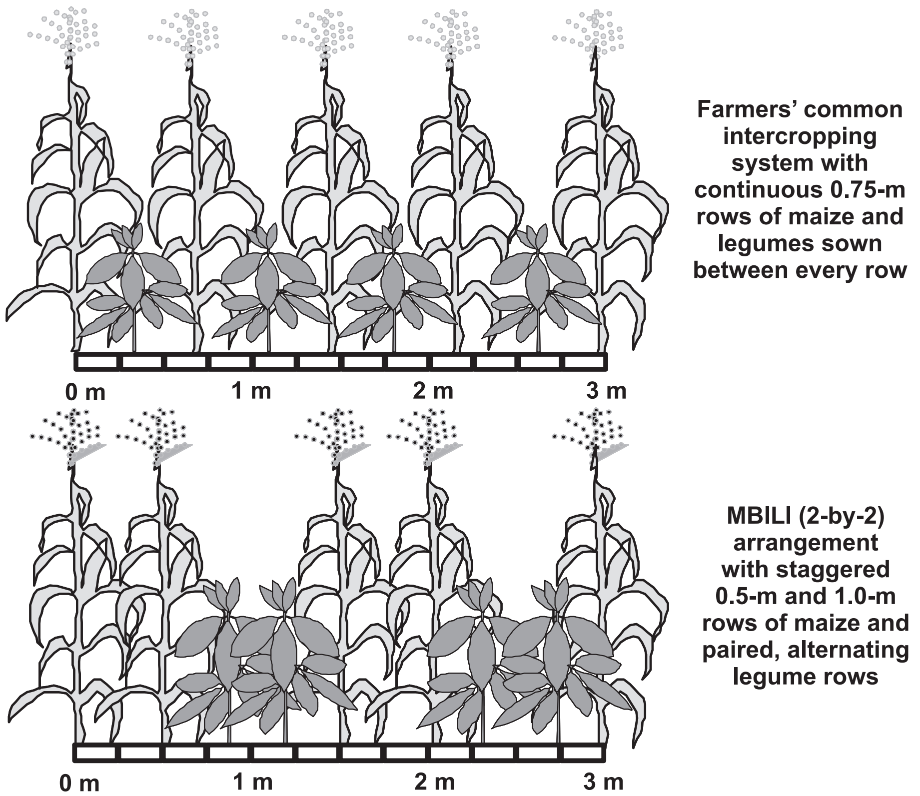

Figure 3. The MBILI staggered maize-legume intercropping system that improves maize and legume production and provides better market opportunites in Western Kenya

This MBILI intercropping adjustment was first proposed for Western Kenya by a university scientist in 1999 based upon an understanding of current farmers' problems and the volumes of literature on intercropping, relay and strip-cropping. MBILI was field tested at a farmer field school later that year, and then expanded to eight farms in 2000. In 2001, it was tested on 32 additional farms by a local NGO and featured at several agricultural shows and farmers field days. In 2002, it was included as one of eight candidate intercropping technologies for testing on 140 farms over 2 years by a research network, where it emerged as the most cost-effective management system. In 2003, MBILI was featured in a regional farming magazine and formal collaboration was established with officers from the Ministry of Agriculture, allowing the practice to be further promoted by extension agents. Only 5 years after its inception, many of the poorest farmers in Western Kenya credit MBILI for their escape from hunger, while better resource-endowed farmers rely upon it to produce greater crop surpluses for market. The progress of MBILI along the research and development continuum serves as an example of how rapidly a new technology can reach its intended clients when different partners within the agricultural community all play their respective roles, and when that technology matches farmers' needs and resources (see Box 3).

Box 3. Two perspectives on MBILI's benefits

Agronomic A baseline study of 107 farms in Western Kenya revealed intercrop yields of 1197 kg maize and 192 kg beans/ha, offering a net return of US$72/ha. Introduction of the MBILI intercropping package, involving row adjustment, substitution of groundnuts for beans and modest fertilizer application (31 kg N and 20 kg P/ha) resulted in 2431 kg maize and 360 kg groundnut/ha. The MBILI package required additional investment of US$63/ha, but increased returns by US$183.

Personal 'I am a housewife with 6 children. I plant MBILI on my farm and I have found the system very paying. When I used to plant maize and groundnuts using conventional methods I could get 5 bags (250 kg) of maize and 1 bag (33 kg) of groundnuts from 0.2 hectares of my land. Under MBILI planting, I got 12 bags (600 kg) of maize and three bags (100 kg) of groundnuts which was a record yield for me. The rows in MBILI receive enough sunlight and it reduces wastage of land...'

Purity Nalianya, Chililila Woman's Group, Bungoma, Western Kenya

From project outputs to farm impacts

Dissemination and outreach strategies are at the other end of the research and development continuum. From the social perspective, science exists to provide useful solutions to human difficulties, a goal that requires that the research community be linked to the public. In developing nations science is largely confined to academia, and society has yet to recognise a substantial improvement through investments in research. Donor investment in applied research is usually linked to such pressing social concerns as food security or public health, and important scientific findings are expected to become translated into flexible tools for development. Thus, dissemination and community outreach (Figure 4) are natural conclusions of a successful project.

Within the context of agricultural research, the progression from on-station to off-station and to on-farm research proceeds in a stepwise manner. You must understand the mechanisms, ranges and suitability of a new technology, so that you can then identify opportunities, options and potential impacts (Figure 4). Many farmers consider all technologies tested on farm to be 'recommended', so you must make it clear to farmers that you are refining or testing a technology and that it is not a recommendation. As research becomes more participatory and demand-driven, dissemination moves further 'upstream', a phenomenon that requires you as a researcher to be more responsible and conservative about the technologies you might propose as candidate solutions to farmers' problems. The risk of miscommunication is reduced as farmers increasingly recognise their roles as full partners in adaptive research.

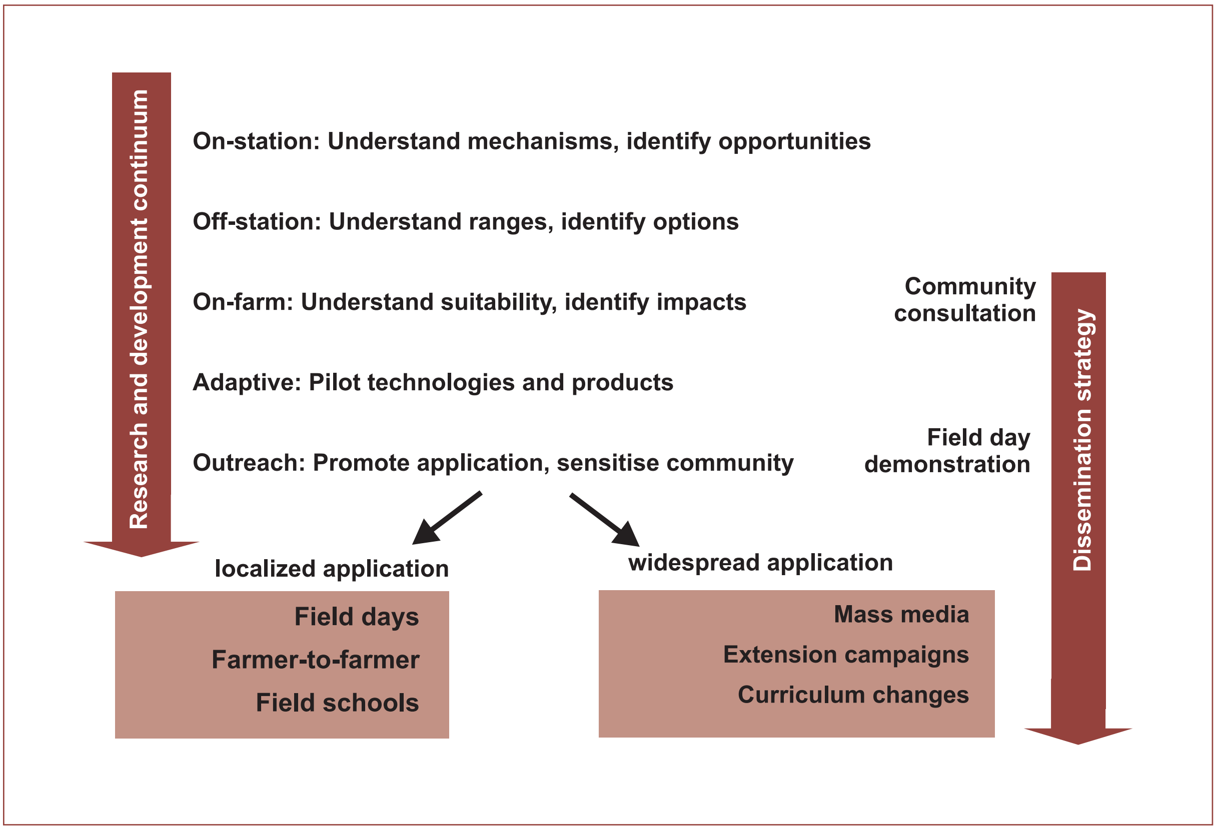

Figure 4. As the research and development continuum proceeds downstream, it interacts with different possible dissemination and community outreach strategies. Innovators are encouraged to escort technologies beyond their experimental stages in order to achieve greater impacts from their research

One useful approach to on-farm adaptive research is to test current recommendations and various 'best bet' technologies side-by-side across a range of cropping conditions, because many competing 'recommendations' are developed in relative isolation from one another. For example, the effects of applying composts are seldom tested against mineral fertilizers, or fallow systems are compared to one another but not to direct soil amelioration. You should welcome the opportunity to test your candidate solution alongside others. The fusion of alternative management practices represents an exciting avenue of research, particularly in partnership with farmers empowered to combine and manage different recommendations as they see fit. If you treat farmers' planning and reactions as useful information if will be an important step in realising fuller partnership with them during your adaptive research.

During project planning you should devote funds to the promotion of your findings. This can be done through farmers' field days, or the facilitation of adjacent farmer-to-farmer training, particularly through local extension agents and nearby self-help groups. Widespread application is effected through mass media campaigns, exhibits in regional or national agricultural shows, designing extension campaigns, and inducing curriculum changes within public school systems. It is generally difficult to plan and budget beyond localised outreach at the onset of a research project but you should try to liaise with senior extensionists, educators and journalists in order to popularise your findings to wider audiences. Table 2 identifies different outreach options, indicative costs and likely beneficiaries.

Table 2. Returns to US$1000 investment in various dissemination options		
Option	**Audience**	**Unit cost (US$)**
Field day attended by	100 participants	10.00
	500 participants	2.00
	1000 participants	1.00
Printed media prepared and distributed	2000 copies	0.50
later each copy read by nine more farmers	20000 readers	0.05
Video documentary prepared and broadcast	50000 viewers	0.02
Video documentary taped and distributed	100 recipients	10.00
later seen by 99 additional viewers	10000 viewers	0.10
Field school initiated with	25 members	40.00
Initiated with	50 members	20.00
and each member trains 9 farmers	500 trainees	2.00

Pitfalls you should avoid

Intense disciplinarity

Agricultural science is not a single discipline, but rather the sum of numerous sub-disciplines. These pursuits include agronomy, animal husbandry and nutrition, crop improvement, economics, food science, horticulture, pest and disease management, post-harvest handling, rural sociology, soil science and many other fields. Modern society is complex, and this is especially true within science. Indeed, most of the greatest scientific discoveries result from several years, or even decades, of intense, highly specialised, often obsessive study. But this model for scientific achievement is less applicable within the more-applied disciplines such as agriculture. Agricultural science still involves discovery, but within an iterative, problem-solving context. Support for agricultural science is society's insurance against malnutrition and famine. Most of agricultural science starts not with theory, but in the field, where plant production is failing. This situation is especially true in Africa, where the continent's capacity to feed its people is failing.

Even at the undergraduate level, young agriculturalists are expected to declare an area of specialisation. Graduate candidates specialise further, often leading to detailed knowledge within a sub-sub-discipline, and little else. This situation is most severe in universities where graduate studies do not include coursework. Do not let your research vision be narrowed by disciplinary blinkers.

I recall a farm visit in the Central Kenyan Highlands accompanied by a noted virologist. This farm was extremely diversified, and included a number of different vegetables intended for Nairobi markets. After discussing crops and markets with the host farmer, and touring the fields, the virologist confided that she did not enjoy the visit because the crops were all healthy and none displayed symptoms of viral disorders. At the time I sympathised, and promised to better direct future field visits, but afterwards I recognised a perverse logic. The absence of pest and disease is not random, or the result of good fortune, but rather nested into farm practices and the farmer's skills and experience. Even a famous virologist should be prepared to learn something from a farm where viral disorders are controlled. This analogy may be extended to soil fertility specialists and the lack of nutrient deficiency symptoms, economists and strong markets, entomologists and harmful insects, agroforesters and trees and all other agricultural specialists. It is naïve to assume that farm productivity is necessarily restricted by factors related to your chosen sub-discipline, and this becomes more so as you specialise further. When agricultural scientists behave like the blind men attempting to describe an elephant, then they are practicing precise, and most likely inaccurate, disciplinarity.

Survey-mania

Too many talented scientists focus upon describing problems that are already known, rather than exploring possible solutions. As a field researcher you should conduct your own ‘participatory, diagnostic survey’ at an early phase of every investigation. Concise survey instruments consisting of less than 20 short questions that are based upon important research questions are a useful first step. Many farmers grow weary and wary of answering questions about family members, land tenure, income and education, so your survey should be short and conform to the task at hand.

Over-delegation

Delegation is a responsibility in a research setting, it entails the optimal use of available time, funds and staff to ensure scientific quality and meet project goals and it requires that delegated tasks be closely supervised. Responsible delegation breeds scientific teamwork and mutual satisfaction, irresponsible delegation leads to division and inferior science. For example, I once visited an agricultural research station and noted a large, vigourous stand of an indigenous legume that was being examined elsewhere as a candidate for land restoration efforts. Some controversy surrounded the nodulation of this legume, so I asked a station scientist if I might borrow a shovel and conduct an impromptu investigation. He agreed to help, and consulted the Chief Technician. After about one hour, a stranger arrived to deliver my ‘bag of soil’. When I asked where the soil came from, he could not say. Evidently, the Chief Technician consulted the Laboratory Technician who informed the Field Technician who instructed the Field Labourer who put some soil in a bag for reasons not understood. Obviously, my intentions were mistaken in the process. This ‘tradition’ of over-delegation, where scientists and senior technicians avoid ‘unnecessary’ field labour and where important tasks are performed by unqualified casual workers, poses a serious hazard to quality research.

Compulsive home-area focus

Many young agricultural scientists in Africa feel compelled to conduct studies in their home areas. Clearly, advantage exists for these studies. They have an intuitive understanding of production constraints, are able to communicate with the poorest farmers in the most local dialects and have ready access to field sites. During field visits, workers are often able to economise on accommodation. Moreover, working within your home area fulfils a social obligation to return the benefits of education to your family and immediate community. All of these factors offer clear advantages in terms of research position and motivation.

> **Box 4. Where will your work have impact?**
> Mary receives an advanced degree in plant pathology overseas, finds employment in an African public university and returns home intent upon ‘proving’ herself. She has specialised in bacterial diseases of a crop that is not widely gown in her home area, but nonetheless she bases her research project upon it. After several years, she has produced a research publication but failed to impact upon farmers lives. Next she employs her skills within an interdisciplinary team active in another agroecological zone where the crop is very important and within one year is assisting farmers to better understand their production problems and improve their yields. Where, and with whom should she have initiated her research?

But a suite of disadvantages also exists. Your home area may be remote, and may suffer from similar constraints to a closer more easily accessible location. You may not have the expertise to address the constraint that exists in your home area. Furthermore, social obligations can become confounded with research strategies in a compromising manner. Sometimes it is appropriate to work in your home areas and other times it would be better to work elsewhere. Your choice should be to devote yourself to good science in the place where your work can have most impact (Box 4).

Conclusion

Well-trained scientists practice credible research within their immediate sub-discipline almost by instinct.

As practicing agriculturalists in Africa, given the continent's persistent problems of under-and malnutrition, resource degradation and rural stagnation, identifying important questions requires that we look no farther than into the lands, crops and practices of the poorest farmers, particularly into their main food production enterprises. Escorting communities from failing subsistence farming to mixed, market-oriented agriculture is a major responsibility of the agricultural research community, and if you cannot identify your particular role within this key transformation perhaps you should rethink your longer-term research interests. Let us not merely identify the farmers' problems, but work together to solve them. Let us not be dazzled by proliferating agendas and research fads, but rather focus upon the basic needs of the poor and their abilities to secure better lives. Let us not work as individuals on those problems that comfortably address our disciplinary bias, but work together with other specialists and generalists to ensure that food security and better rural livelihoods result from our combined efforts. This process requires patience, vision and teamwork, and its completion is not likely to be repaid in riches, but rather rewarded through personal satisfaction and social wellbeing.

Resource material and references

Appendix 2. Innovation, Problem Solving and Operational Research Strategies. Paul L. Woomer.

Appendix 3. Designing Research Around Client Needs. Paul L. Woomer.

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