T869 Climate Change: from science to lived experience

Module 3: Interdisciplinary methodologies for investigation into the 'lived experiences' of climate change

TEXTBOOK

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1 Aims, objectives, learning outcomes and how to study this module[1]

The concept and analysis of 'lived experience' is complex. This is due firstly to the holistic nature of experiential knowledge which rides roughshod over established frameworks for analysing phenomena, for example frameworks provided by academic disciplines. Secondly, it is also due to the many material and social influences on lived experience. Finally, lived experience does not represent a fixed body of knowledge – it evolves over time[2]. Therefore, we need to think carefully about how we investigate and capture the complexity and intricacies of 'lived experiences' in any reliable way, particularly in relation to climate change. You may want to do this simply because you want to gain a sounder understanding of how 'lived experiences' are shaped by climate change. Alternatively, you may want to explore questions around the issue because you want to develop a dissertation project related to particular aspects of the story. Finally, you may want to carry out a rigorous investigation in a non-academic context, for example in relation to your work, and the approach taken in this module will hopefully be equally useful for that purpose.

The generic aim of Module 3 is to make you think about, and provide guidance for using research tools which will allow you to develop a research question and project around the broad subject of 'lived experiences' of climate change. You may already be familiar with dominant methodological tools of your own disciplines (for example, the 'objective' quantitative data for natural scientists, and qualitative 'subjective' data for many social scientists, to put it crudely). This module aims to cross over such crude distinctions and extend knowledge boundaries which allow you to take an interdisciplinary approach, whilst at the same time acknowledging the value of methodologies that have shaped your own discipline. Another generic aim of the module is for you to think about an interdisciplinary approach to research methods, and the methodological issues that arise out of this.

The specific objectives of the module are to:

a) Introduce you to recent arguments and discourse (Box 1.1) on research methods that will enable greater insights into key methodological approaches of your discipline.

b) Explore the disciplinary assumptions and philosophical arguments underlying both natural and social science methodologies as well as approaches to 'mixed' methodologies.

c) Develop tools which allow you to reflect critically on research methods and methodological approaches for your dissertation or other investigation which you might undertake; and

d) Develop critical and analytical research skills.

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[1] There are two other modules in this series. Module 1 is *Introduction to climate change in the context of sustainable* development. Module 2 is *The lived experience of climate change*. A *Water case* study is also provided as an extended text. These other modules and the Water case study might be referred to from time to time in this e-textbook and corresponding e-workbook.

[2] For an elaboration of the concept of lived experience see Module 2: *The lived experience of climate change.*

Box 1.1: Discourse

As the term 'discourse' is often fairly loosely used in lay vocabulary these days, I thought I might quickly clarify some relevant theoretical points underpinning its meaning, even if very simply. The term was given a more particular and precise meaning in the works of the French philosopher and social theorist, Michel Foucault (1926-1984) who argued that our communication (spoken, written, visual) is mediated through the knowledge and power – or discourse -- of various social institutions (such as family, political systems, markets, religion) and individual capacity and ability to act. Thus how we communicate and interpret events is shaped by the historical, political, economic 'discourse' we are living in at the time. In turn, this also mediates and limits our own understanding of the world and the 'truth' and 'knowledge' we seek.

Debates on 'discourse' and a 'discourse' analysis have generated much interest over the decades and have become critical foci of several subject disciplines, for example, anthropology, cultural studies, sociology, women's studies and psychology. In this, a big challenge has been has been around the topic of research. This includes questions of what has been investigated, how this investigation has been influenced by disciplinary discourses and underlying assumptions and what this has meant for subject 'truth' and 'knowledge'.

Take for instance the argument that anthropological and ethnographical studies set in the colonial era were bounded within a colonial discourse of power, domination and racism. Thus for instance, some anthropological studies which set out to 'represent' the tribal 'other' to the world during the colonial era, were in fact based on much untruth, fallacious 'knowledge' and misrepresentation. One such study is that of the Bhagia Hill tribe in India (Elwin, 1939) where Elwin photographed bare-breasted Bhagia women. A follow-up study (Srivastava 1971) found that Elwin had contrived the photograph, as the 'desirable' social situation for the purposes of producing a 'reputable' ethnographic study of tribals, by paying the women's husbands who forced them to go bare-breasted. Srivastava also found that none of the women actually dress in this fashion and, in contrast, going bare-breasted was considered immoral.

Whilst it could be argued that Srivasta simply checked and found Elwin's research to be deceitful and "bad", there is also an important point that Elwin's interpretation and communication was shaped within the historical, political, economic 'discourse' of his time. This bordered and limited his (and consequently his reader's) 'truth' and 'knowledge' of tribal societies. It is therefore important to question the questions to which we seek answers - how, why, or whether we should ask them at all - within the context of dominant discourses of the time to make for "better" research.

Learning outcomes

Learning outcomes/objectives concern what you should know, understand and be able to do on completion of a module. They are important indicators of your learning development. We recommend that you use them as a checklist of your progress as you work through the module. On completion of Module 3, you should be able to:

a) *Demonstrate your knowledge and understanding of*

(i) Interdisciplinary research methods

(ii) The underlying assumptions and philosophical arguments that direct research methodologies.

b) *Be able to:*

(iii) Develop and critique interdisciplinary research approaches for dissertations or other investigations requiring primary data, while seeking complementarities to those defined by your own disciplines.

(iv) Locate and use your preferred methodology within an interdisciplinary framework.

(v) Apply interdisciplinary methods and analysis to given case studies of lived experiences of climate change.

c) *Apply the following key skills*

(vi) Understand and engage critically with the theoretical arguments regarding research methodologies.

(vii) Assess the dominant methodologies and boundaries within your own discipline and explore how these can be extended through crossing disciplinary boundaries.

(viii) Develop a research proposal using your chosen methodological approach.

How to study this module

As with other teaching modules in this series, *Interdisciplinary methodologies for investigation into the 'lived experiences' of climate change* consists of a 'textbook' comprising a central narrative about the subject, a 'workbook' containing a series of activities for you to perform, and a detailed case study on water and climate change. The 'textbook' follows on in this document. It is like a conventional book, although being in a virtual learning environment it may refer to a range of media and not just the printed word. Once you have read through the textbook carefully you should be able to meet the 'knowledge and understanding' learning outcomes/objectives above.

The 'workbook' is contained in a separate document, and again it may refer to a range of media. The 'workbook' helps you reach a more extensive and deeper, critical understanding of the subject matter. It does this in two complementary ways, by providing: you with:

- Further reading and audiovisual links, and asking you to search yourself for additional sources.
- Opportunities to develop through practice the 'be able to' skills (which we call cognitive or thinking skills in relation to the subject) and the 'key skills' (skills which are transferable across a range of subjects) above.

Thus, although, with one possible exception[3], the choice is ultimately yours, we recommend that you do not neglect the workbook and its activities. Your sense of overall satisfaction with the module is likely to be greater if you engage with them. Also, although the textbook may refer directly to the water case study, the purpose of this case study is for you to apply critically the principles and concepts of the module to a real-world challenge associated with climate change. One or more of the workbook activities will help you do this and therefore the workbook is the main point of reference for the water case study.

How in practice might you combine the three main resources at your disposal in this module – the textbook, workbook and water case study? You should choose the method which best suits your own learning style. One way is to go to workbook activities at the points that they are indicated in the textbook. Another way is to read the whole of the narrative in the rest of this textbook (and the water case study), without worrying too much about remembering the detail. Then, having completed your reading, work through the activities in the workbook systematically, analysing sections of the narrative and water case study again more closely as appropriate.

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[3] The exception concerns any workbook activities which might be deemed compulsory by your accrediting institution. The obvious example concerns workbook activities which are designed for group work. If the key skill of transboundary competence or similar formulation is part of the learning outcomes of the accrediting institution, satisfactory participation in activities that deliver that learning outcome is likely to be a requirement.

Structure of the module

Textbook

1 The module starts by clarifying concepts and discussing the importance of reflecting on research methods and interdisciplinary methodological approaches as a first step towards rigorous investigation into the lived experience of climate change. You will begin to grasp that it is often not the question, but how you ask it that leads to more comprehensive answers.

2 It will demonstrate how each natural and social science discipline has its own leaning towards particular research methods. Whilst this is valid and not to be undermined, an inability to move beyond these can skew results and limit knowledge and understanding. An example is the ‘versus’ in a natural science versus social science methods, whereas the two can be complementary and contribute towards a holistic understanding. Please note that whilst the textbook separates the discussion on natural and social science methodologies for teaching purposes, there is an embedded recognition that these are overlapping, integral methodologies, points which I will qualify further in Chapters 3 and 4 in particular.

3 You will be introduced to methodological discourses and how the pathway towards interdisciplinary approaches has developed, especially since the 1960s. The textbook then ends with a worked example of an interdisciplinary approach.

‘Workbook’

1 Activities take a problem-solving approach which further demonstrates the underlying assumptions of various methodologies and how these can be addressed by crossing disciplinary boundaries in order to expand knowledge on the issue under investigation.

2 The activities explore how data, particularly as used in your own analysis and dissertations, can be tested and validated in novel ways when reliance on “traditional” ways is not necessarily sufficient. In doing so you will also critique and question whether it is possible to reconcile discipline-based methodologies.

3 To end, and because lived experience by definition concerns human beings and their lives, you will reflect, and provide some evaluation on doing research ethically. You will also reflect on some of the challenges to be faced in developing a multi-disciplinary research approach.

2 Clarifying concepts: research, research methods and research methodologies

2.1 Processes and concepts of research

Prior to discussion on how we can explore the intricacies of ‘lived experience’ of climate change, I will seek to clarify the relation between research, research methods and research methodologies. Firstly, it seems that as human beings, we are constantly asking questions, constantly inquisitive in our thirst for ‘knowledge’[4] and the unknown. When does this thirst become ‘research’ in the academic sense? Indeed many academics and post-graduate students spend years doing academic research at much personal cost, often feeling isolated and socially outcast in their quest. At the risk of appearing arrogant, research is about that thirst and inquisitiveness for which the researcher is willing to take on these personal costs.

We undertake research for several, often intermingled reasons including investigation of phenomena to identify new variables, hypotheses and research questions and to explore any gaps in knowledge. Through this, we attempt to describe, document, find patterns and characteristics that offer explanations and understanding of particular phenomena with perhaps an underlying aim to predict future events from our findings. What also makes academic research different to other types of ‘fact-finding’ is that it is a process of developing systematic approaches, asking the right questions, seeking a convincing analysis of the answers, all in the hope that this leads to a better understanding of the issue and makes an original contribution to the existing human ‘knowledge’. Academic research is therefore also about hard graft, discipline and dedication!

There are several stages that embed the research process (See Figure2.1). These are not neatly compartmentalised although they may appear so in the diagram below. In fact, the research process continuously builds on what you are learning and repeatedly challenges your initial ideas and plans as you gather new knowledge and understanding. Research is therefore a reflective and iterative process which has the capacity to generate new ideas at any of the stages identified in Figure 2.1 below.

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[4] The concept of ‘knowledge’ will be further explored in Chapter 6. It also forms a foundation of Module 2 *The lived experience of climate change.*

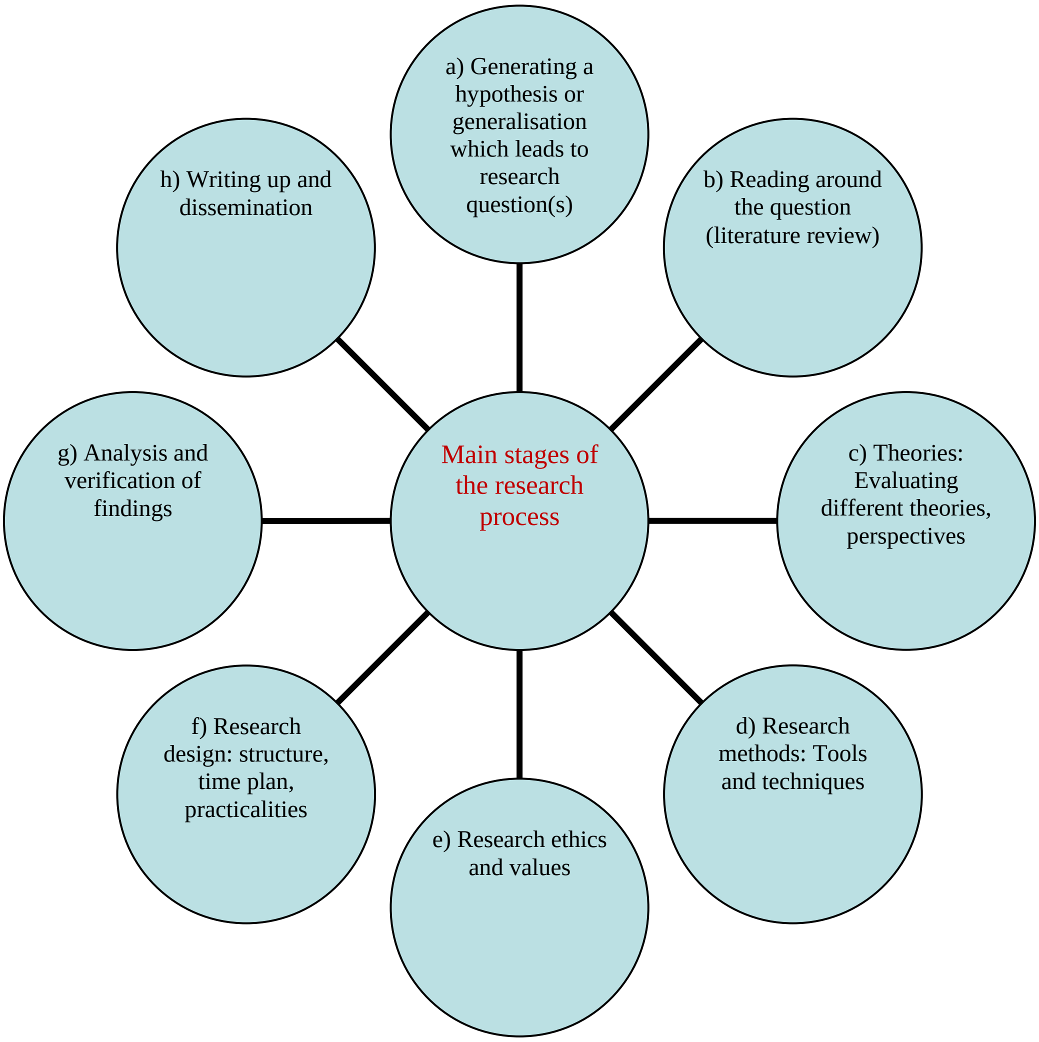

Figure 2.1 Main stages of the overlapping, continuous processes of research

A first, important, and often the most difficult, stage is generating a research question which is usually led by your personal interest, and the level of study (under- or post-graduate) or independent project in which you are involved. I will return to the problematic of generating research questions in Chapter 3 later when I consider the underlying assumptions that researchers make in formulating questions about what is worth exploring. For now, suffice it to know that in generating research questions, we are actively concerned with formulating a hypothesis or seeking generalisations depending upon the nature of the enquiry.

A hypothesis is usually associated with natural science subjects that require discernable facts and observations, perhaps in a laboratory experiment or observations in chosen sites/fields. A hypothesis is about deduction and attempts to evaluate and validate particular theories. It tests theories through what is known as “inductive reasoning” involving production of data sets, identifying patterns and any regularities (and irregularities) from systematic observations, recordings and field notes. Inductive reasoning allows theory to be tested and retested until there is some level of predictability from the particular to the more general.

For example, take malaria. This continues to be a huge health risk for individuals in Africa and a drain on global development budgets. It is therefore paramount that the global community attempts to find ways forward. One area of supposition/theory that is gaining weight on the topic is that malaria is exacerbated by anthropogenic climate change. To test this, Hay et al (2002) for instance, chose four high altitude sites in East Africa which have reported increases in malaria incidences over a period of time. The study used a number of measurements and data-sets on various variables including temperature, rainfall and vapour pressure during and outside of the peak months suitable for *P. falciparum* transmission (a parasite that causes malaria in humans). They then made theoretical inferences from the patterns/regularities that emerged from the data and concluded that there was little significance between anthropogenic climate change and malaria resurgence. In fact Hay et al saw the hypothetical link as too simplistic.

In this example, the relationship between two main variables (climate change and malaria) has not been proved, making this is a null hypothesis. However, the question of what causes malaria resurgence remains important so there is a need to generate alternative explanations and hypotheses. But just a note of caution – whilst we have rejected the hypothesis from our study and reasoning, there is always a chance that we have done this in error during data compilation or interpretation. We therefore have to seek an alternative hypothesis where the effect of one variable on the other cannot be proved as by chance alone. An alternative independent variable that explains the increase in malaria incidences in East African regions, for example, might simply be that people have stopped using mosquito nets!

Some research, particularly in social sciences whose ‘laboratory’ is the whole of society, looks to generalisations rather than defined hypotheses. Generalisations also involve issues of inference where you move from the particular to the more general. This process involves reasoning where general principles are drawn from facts that often appear unrelated, by shifting detail, abstracting common properties and formulating a general principle or theory. An example of generalisation which is with us in our everyday life is evident in maps and map-making where we aim to make a small-scale map from real life, hugely varied large-scale data and somehow standardise the reading of it. In another example, some years back I looked at causes and explanations for women’s poverty in Mumbai slums (Abbott, 1993). My ‘laboratory’ was thus based in the human context of slum livelihoods, and whilst I came to some conclusions, they were specific to the set-up in Mumbai and the textile industry that surrounded the area. Does this mean that the conclusions that arose from this specific locality and specific context cannot be applied to situations of women’s poverty elsewhere? As with hypothesis building, this move from the particular to the general also requires several considerations, for instance, issues of sampling, representation, verification and ethical values (to be further discussed in later text). Both hypothesis and generalisation building are thus rigorous processes.

For those who wish to engage with the issues of hypothesis and generalisations more deeply than I have addressed in this chapter, I suggest you now turn to Activity 1 (Thinking further about hypothesis and generalisation) in the workbook.

Once an idea that needs exploring has been generated, it becomes important to consider how it can be operationalised which means how we link theoretical and conceptual language to that of practical research. A first and prime consideration in this is to identify the research methods that will best fit the investigative framework. Research methods are the tools and techniques we adopt to enable us to investigate systematically, organise and analyse our findings. Whilst these tools and techniques will allow us to generate data and interpret results (hopefully effectively), research is not simply a technical exercise. In fact as soon as you start formulating an idea and think about research method choices, you begin to engage in a debate that involves much wider issues. For instance, you carry out a literature search (literature review) to explore existing subject knowledge, see what others have said about particular and related topics, in order to weigh up the context and methods by which knowledge was derived. Thus, you begin to develop a critique of both the subject knowledge as well as the way it was derived, in turn entering inevitably into an engagement with the philosophy of research processes. This is the recognition that all research is ultimately rooted in societal and individual assumptions about the world, how it should be perceived and best interpreted. There are of course no definitive answers and arguably we, as individuals will offer differing interpretations based on assumptions arising from societies in which we live about how best to understand the world. The philosophy of research is therefore a hugely contentious area, which I will revisit in detail in chapters below.

This type of philosophy-led engagement into research processes leads us into yet another wider area known as ‘research methodologies’, the scope of which is very large and continuously expanding! Here, discussion on ‘research methods’ is an important facet of ‘research methodologies’, but only one of them. Whilst, as I point out in the above paragraph, methods are merely the tools and techniques for systematically generating, organising and analysing data within the chosen methodological approach, methodology concerns the overall epistemological (See Box 2.1) approach and covers the whole research process. The philosophical discourse on research methodologies is built around several other facets and centres on a challenge of the choice, logic, utilisation, analysis of research tools and techniques that dominate particular disciplines as discussed in the section that follows. Thus, starting from the very embryonic stage of shaping the research question, the whole of the research process at every stage is tightly bounded by theory and practice, ultimately defined by both researcher and disciplinary assumptions. Methodologies are thus closely related to and characterised by underlying ideological (Box 2.2), epistemological and ontological (Box 2.3) assumptions that shape our disciplinary knowledge, and indeed our understanding of what “knowledge” itself is[5] (See Figure 2.2). It is not surprising that, since the 1960s, led largely by a challenge from social and political scientists and feminists, a research methodologies discourse has developed into a fully fledged philosophical critique of all stages of the research processes, so much so that it has become a subject in itself. I will detail this in Chapter 3.

Box 2.1: Epistemology is based on the Greek term epistêmê signifying ‘knowledge’. Epistemology is thus the study of ‘knowledge’ and the philosophical questions that relate to our understanding of it. Amongst several other questions, epistemology queries the conditions under which we seek and create knowledge; what makes ‘knowledge’ acceptable; how it is derived; how it is interpreted and how it is acknowledged and classified and disseminated as ‘knowledge’. A main epistemological question is: “Through what processes do we come to knowledge of something?”

Box 2.2: Ideology is a system of ideas which are used to justify and form the basis of social and political order. Karl Marx (1818-1883), the famous German philosopher and political scientist, was very interested in how dominant ideologies are produced. He argued that it is in the interest of those who hold power in society to relay only partial truths so as to legitimise their privilege. Those in power thus filter messages that make us believe that our place in society is defined by the ‘natural’ order of things, when it is in fact defined by power. Marx thus showed how class relationships of production (the bourgeoisie and the proletariat) were presented in 19th century society as something natural, when in reality these relationships spelt privilege for some and toil for the others. Another example where relationships are presented as ‘the natural order’ can be found in the Indian caste system where ‘upper’ castes exercise considerable power over the ‘lower’ castes through presenting subjugation as a legitimate, God-created natural order. A main ideological question is: *“What are the underlying power mechanisms that filter messages in society?”*

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5 As Stephen Hawkins, the famous theoretical physicist has said, “The greatest enemy of knowledge is not ignorance, it is the illusion of knowledge”.

Box 2.3: Ontology is closely (and abstractly) associated with metaphysics and the notions of the underlying reality of things. Whereas epistemology questions how we come to knowledge, ontology is concerned with the conditions under which things exist. For examples, if human interpretation is that trees are beautiful, would they still be beautiful if humans did not exist? Or are trees only beautiful because humans have language and communication to express this characteristic? Another contemporary example refers to everyday germs. These require a laboratory microscope for us to see them and grasp what they are. When human knowledge was limited to the visible world before microscopes were invented, did that mean there were no germs? A main ontological question is: *"What set of specific assumptions are we making about the basic nature of reality and what exists?"*

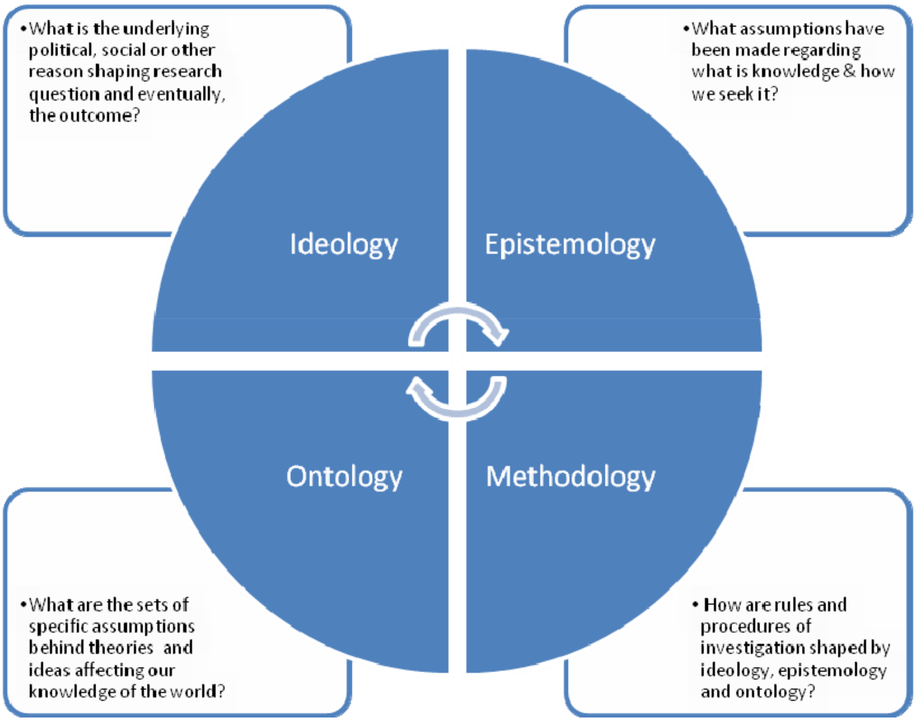

Figure 2.2 Methodologies and underlying areas of assumption

2.2 'Standpoint' in research processes

To end this chapter, note that any research involving human beings and societal interaction cannot generate definitive answers. If it did so, where would all the politicians, academics, librarians and information highways be? From the very start, the type of research questions we select for our attention, the exact nature of the issue, and how we go about investigating and interpreting this, depends on our own understanding of the world in which we live. In turn this is defined by multiple, overlapping factors including our place in society and where we feel we belong. For instance, race, caste, class, gender and the power relations these involve can shape the mental position from which we view the world as individuals and/or members of various groups to which we belong. In social science terminology, this positioning is known as 'standpoint', which is basically our ontological understanding of reality based on our place in society. Thus the underlying argument is that mental positioning is socially constructed, defined and shaped through status and power we hold within our overlapping primary (family, kinship) and secondary (work and leisure peer groups, community groups) societal relationships. Within this, it is important to understand the notions of power, equality and inequality which heavily influence our mental positioning and standpoint. These inequalities, based on power relationships between and within different social groups, are social constructs which define the way we see things. A 'classic' and evident example is the artificially created racial divide in apartheid South Africa which gave Black and White South African different power, perceptions and standpoints in the same country.

A strong philosophical argument underlying research methodologies discourse is that all research processes, theory and practice are influenced by researcher standpoint, and it is imperative to realise this in order to carry out rigorous research. Arguably, this statement could be more readily accepted by social science whilst ‘natural’ science might be sceptical about how standpoint affects their empirical work on examining what happens physically, for example, predicted temperature rise, predicted sea level rise, and predicted increased climate variability shown by a climate model. An argument would be that whilst natural scientists may construe their research as devoid of values, maybe even ethically neutral, their processes of conducting research are not simply about ‘craft’ and technique. If that was the case, knowledge arising from the natural sciences would be very narrow. Predictions and how these are interpreted depend on the resources we have, on the knowledge base we have and who is allowed to do this prediction. If natural science was so neutral why, for instance, is there so much disagreement on causes and explanations of climate change? As feminist scientists argue, in order to discover scientific ‘truth’, all scientists draw on socially constructed tools and technology, choosing the validity of data sets and results and errors. Also natural scientists too are creatures of society and societal beliefs. Their judgments are bounded by assumptions that are influenced by individual beliefs and the social context within which they are shaped. Think, for instance, of the religious (Christian) context in which Darwin developed his evolutionary theory. The issue of values and standpoint and how this underpins all research is further discussed in Chapter 6 which returns to the questions of reality and the search for scientific ‘truth’.

In summary, this chapter has clarified some of the main concepts that underlie Module 3, research, research methods and research methodologies, and suggested how individual standpoints shape research processes. For those who wish to engage with these concepts more deeply, I suggest you now turn to Activity 2 and Activity 3 in the Module 3 workbook.

3 Dominant research methods in natural science

As noted in Chapter 1 (under Structure of the textbook), the next two chapters separate the discussion on natural and social science methodologies for teaching purposes only. As the discussion progresses, you will note that the methodologies are not as polarised as they first appear in this separation, and in fact complement each other.

3.1 Meaning of natural science

The term "natural science" is used to classify those fields of knowledge that deal with objects and processes in the biophysical world. For example, on a very large scale we can say that the biophysical world is our entire solar system within the Milky Way galaxy. Alternatively, at a smaller scale it is a number of things including the atmosphere that surrounds our planet, the geological formation of oil bearing rocks beneath the sea bed, a colony of mountain gorillas, or even the inside of a wasps nest or termite mound. The scale of the biophysical world can thus vary enormously.

Natural science is commonly divided into two areas. These include, firstly, (i) life (or biological) sciences, including plant biology (botany) and animal biology (zoology) which together cover the biological processes; and secondly, (ii) physical sciences such as astronomy, chemistry, earth science, and physics, which cover the physical and chemical laws underlying the universe.

Often, when a natural scientist is trying to prove a hypothesis or to model natural phenomena, they will need to borrow tools from the "formal sciences". These include computer science, logic, mathematics and statistics. For example, a natural scientist may want to predict climate change scenarios and need to use aspects of mathematics and computer modelling to build up the model. Alternatively a plant ecologist may use a statistical test to prove that there is, or is not, a difference between the rates of seed germination sown in different types of composts. As you can see from Figure 3.1 below, natural science and the formal science areas can overlap and complement each other.

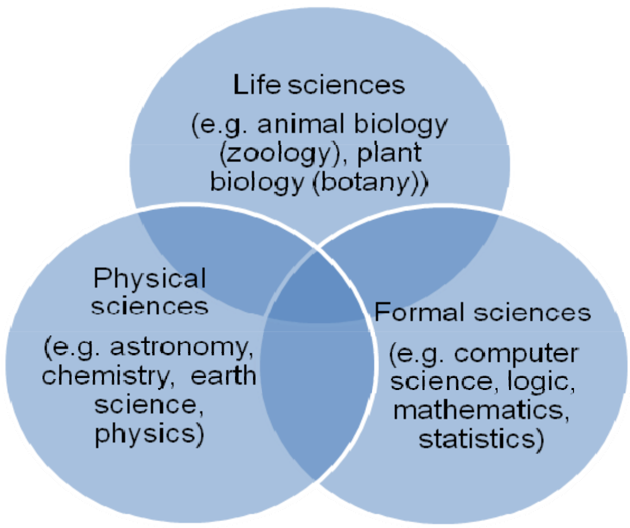

Figure 3.1 Examples of overlapping science disciplinary categories

As stated at the start of this module, the separate focus on natural science and on social science is for learning purposes and convenience sake only. In real life the biophysical world does not operate in isolation and there are several ways in which the biophysical and social influence the shape of each. For instance, people live in the biophysical world, and manipulate and manage its resources for their own use and benefit. In turn this creates cultural, living landscapes in hot and cold, wet and dry areas of the world.

A most apparent link between the biophysical world and people is the example of agriculture. Climate, soil and water resources are manipulated by communities in different ways around the world, to produce food, for local consumption or distribution and export. Agriculture is an area of study that therefore bridges both aspects of the natural and social sciences. Hopefully, points such as this will enable you to appreciate the benefits of an interdisciplinary approach to studying science which is what this module builds towards. We will be discussing interdisciplinary approaches further in Chapters 6 and 7 towards the end of this module.

To summarise this section we can say that although there is an increasing awareness that the ‘natural’ is influenced by human (anthropogenic) activity, ‘natural science’ focuses on the study of the biophysical, non-human aspects of the earth and the universe around us and is therefore distinguishable from the formal and social sciences.

3.2 Fundamental principles of natural science research

There are two important things to understand about research in the natural sciences. Firstly (i) the natural sciences use a “naturalistic approach” to studying the biophysical world, and secondly (ii) the natural sciences use the ““scientific method” to study nature and explain the biophysical world. Below we describe popular natural science research methods. I recommend that you read the information in Boxes 3.1 and 3.2 to make sure that you fully understand these two concepts, particularly if your background is predominantly that of social science.

Box 3.1: A “naturalistic approach” in science is one which is based on a process of asking questions to gain knowledge about the natural world.

Questions include: “*How can we seek reliable knowledge about the natural world? What practical methods can we use to measure the natural world? How do we test and interpret the new knowledge with reference to natural causes and events?*” Such a ‘naturalistic approach’ underpins all modern natural sciences today.

Box 3.2: “Scientific method.” Natural science investigation is based on the “scientific method”, the fundamentals of which were set many years ago and remain similar today to Bertrand Russell’s 1931 (p57) description of different stages:

(i) The first stage he calls “observation of the significant facts”. In natural science this is when you observe or experience a natural phenomenon, and you ask yourself questions such as: *Why did that do that? How does that work? What effect does that have? What are the processes that makes that happen?* Alternatively you might see a problem in the natural environment, e.g. pollution, and think “*How can I solve that problem?*”

(ii) Secondly “arriving at a hypothesis”. In other words you propose an explanation to try and answer your question. You construct a hypothesis which, if true would account for the natural phenomenon.

(iii) Thirdly “deduce from this hypothesis consequences which can be tested by observation”. You set up a prediction, and outcome, that you think will happen.

(iv) Fourthly you design and undertake observations or experiments to prove or disprove the hypothesis. Russell writes that “if the consequences are verified, the hypothesis is provisionally accepted”.

(v) Finally, the experimental methodology and results are written up and publicly disclosed for other scientists to read and replicate. Russell observes that the provisional acceptance of the hypothesis “will usually require modification later on as the result of the discovery of new facts”.

It is important to note that underlying the formal processes of investigation into the natural sciences, a “scientific method” also has a number of important characteristics and assumptions which are outlined below and discussed more fully in later chapters as we proceed through this module.

Firstly, (i) “scientific method” is based on *empirical* facts. That is, it is based on direct observation of the natural world to see whether the hypothesis agrees with the facts. Secondly, (ii) the method is *systematic*, i.e., all aspects of the test observations or experiment are carefully planned in advance, and carried out in a rigorous manner, with checks that nothing is done casually. The test observations or experiments are conducted with careful measurement in a very controlled environment. Thirdly, (iii) the process involves *replication,* i.e. measurements are replicated and compared to a blank or control test in order to confirm a trustworthy result, i.e. not one that has arisen by chance. Not only is replication built into the design of the test, but the actual methods used must also be clearly written up and presented so that other scientists interested in the subject can replicate the work in another place, at a later date. Finally (iv) the method enables *verification* of the work and hence adds to knowledge. Without this, the study cannot be seen as valid.

A critical underlying assumption of “scientific method” is that it is objective. The gist of this is that natural scientists attempt to remove their own beliefs, bias, preferences, and wishes from the scientific research. The outcome of the test or experiments is therefore real “value free” results. However, please note that this assumption has been seriously challenged by both social and natural scientists who ask whether any enquiry, including that of natural sciences can be value free. (See for instance, the argument in Section 2.2. and Section 4.2). I shall return to this discussion on underlying assumptions in natural sciences in greater detail at the end of this chapter.

However, for the moment, note that in essence a naturalistic approach, using the stages and characteristics of the “scientific method”, is the principal approach used in all modern science. “Scientific method” attempts to be a structured, objective process of investigation that seeks to explain natural events by making hypotheses and testable predictions about the physical environment. Careful, systematic and rigorous observations and/or experimentation under controlled conditions are established. The observations or experiments involve practical, hands-on methods to collect repeatable, reliable, trustworthy data about the natural world. This enables either the provisional acceptance or rejection of the initial hypothesis. In addition subsequent analysis can verify that data with reference to previous research findings. A very simple example is that of water or H_2O – a formula that can be repeated and tested in any laboratory set in any context. Having given you a glimpse into the basic tenets of natural sciences and “scientific method”, I will now introduce you to some popular natural science research methods.

3.3 Frequently used natural science research methods

There are of course several ways of testing hypotheses and conducting natural science research which those of you who are natural scientists will have no doubt come across in your undergraduate study. Due to lack of space, I will however focus on three dominant ones which are experimentation, observation and survey methods.

3.3.1 Experimentation

An experiment is usually run to test a new research question or hypothesis and can be used to investigate a range of subjects. For example this approach is useful in animal biology to test the success of a new vaccine against disease in cattle or sheep. Testing new research questions is also part of astronomy, such as with NASA’s Galileo space investigation of the planet Jupiter and its moons between 1995 and 2003. Scientists were particularly interested to discover the likelihood of a saltwater ocean beneath the surface of Jupiter’s ice crusted moon Europa. (You might like to do your own internet search on this exciting experiment).

A research question, to which many people throughout the world in April 2010 wanted a rapid answer, was "*What levels of atmospheric volcanic ash are safe for aircraft to fly through?*" Permissible levels of atmospheric ash were exceeded in April 2010 during the eruption of Mt Eyjafjallajoekull in Iceland. Due to the enormous volume of ash and the prevailing winds at higher altitudes the ash clouds were blown south and east across northern Europe. As a consequence thousands of air flights across Europe and other parts of the world were grounded and passengers were stranded far from home. Earth scientists were quickly involved in a series of experiments monitoring the movement of the ash clouds using satellite imagery. Others such as physicists and engineers on the ground conducted experiments on aircraft engines in laboratory research centres. After two weeks this research was complemented by aeroplanes with experimental monitoring equipment flying through the ash clouds at altitude. These tests eventually allowed scientists to revise the permissible ash limits which enabled flights to resume.

Experiments may also be used to support or disprove ideas and theories. For example, in the United Kingdom there is a contentious debate about the transmission of Mycobacterium bovis (M. bovis), the cause of bovine tuberculoisis (bTB), between cattle and the badger (*Meles meles*). Tuberculosis is also transmitted to people through infected milk, so therefore there is a need to control TB infection in cattle herds. In the past both observational and experimental evidence indicated transmission of M. bovis from badgers to cattle. The use of simple epidemiological (disease transmission) models also predicted that reducing badger density by culling should reduce both badger-badger and badger-cattle transmission (Jenkins et al 2008 p1). To try and prove this hypothesis, Randomised Badger Culling Trials (RCBT) started in 1998, in selected 100 km^2 areas of South West England and Wales. Donnelly et al (2006 p843) demonstrated that, after five years of proactive badger culling, bovine tuberculosis was actually reduced inside the cull area. However, subsequent analysis, noted by Jenkins et al (2008 p457), demonstrated that these trials also showed an increase of bovine tuberculosis in the neighbouring areas outside the cull areas, probably linked to disrupted badgers' social and territorial organisation.

However, post cull monitoring has continued to investigate whether the benefits within the culled areas could be sustained. Jenkins et al (2010 p1) writes "Our findings show that the reductions in cattle TB incidence achieved by repeated badger culling were not sustained in the long term after culling ended". The figures reported show that post cull, the number of infected herds inside cull areas was on average 37.6% lower than the number of infected herds in non-cull areas. However, this benefit diminished over time after the culling ended, by 14.3% every six months and by months 43–48 after the final cull, there was no remaining beneficial effect (Jenkins et al 2010 p 2–4). In addition this latest paper also demonstrates that badger culling is unlikely to be a cost-effective way of helping control cattle TB in Britain, because "the costs of conducting culls is substantially more than the overall benefits accrued" Jenkins et al (2010 p 6).

As I have indicated above, experiments are conducted following the "scientific method", and good experiments therefore exhibit the stages and characteristics of that method identified in Box 3.2. Thus even from the start, during a laboratory experiment a researcher operates in a highly controlled environment. This is to maintain rigour and to be sure that the results are trustworthy and reliable. This rigour is required because an experiment is used to search for cause and effect relationships in nature. The experiment must be designed so that changes in one item cause something else to vary in a predictable manner. These changing items are called variables.

A variable is a characteristic or condition that can be measured using practical hands-on equipment which can show how it changes in value. For example weight, volume and temperature all make good variables. They can be measured and will produce clear, objective, value free results, which a good experiment should have. By contrast characteristics such as colour change are not good variables to measure. This is because every scientist will see colour differently hence error and subjectivity is introduced into the experiment and results.

In an experiment there are usually three types of variable, i.e. independent, dependent and control. Let us imagine we have a water tap and we intend to find out how much water flows through the tap at different openings:

(i) Independent variable: This is the variable that stands alone. It is not changed by the other variables that you are trying to measure. This is the variable that you will consciously manipulate to observe if it produces any change or effect in the others. Ideally there should only be one independent variable in an experiment. In our water tap experiment the independent variable is the tap opening (closed, half open and fully open).

(ii) Dependent variable: In an experiment you will monitor the dependent variable to see how it reacts to changes made in the independent variable. There may be more that one dependent variable. In the water tap experiment the dependent variable is the amount of water flowing measured in litres per minute.

(iii) Control variable: You also need to establish a control test against which change can be measured. Control variables are characteristics or conditions that you want to remain constant. They need to be observed and monitored for change as well. In the water tap experiment the control variables are the water pressure and the tap itself. Different water pressures can result in different amounts of water flow and different taps with varying pipe diameters could also affect the flow rate. Therefore you need to keep these constant at all times.

An important stage in the process of experimentation is that the finished results are clearly reported so that its procedures can be repeated and verified by another person. The experimental procedures must be immaculately described and the evidence for cause and effect clearly explained, with reference to previous research where appropriate. Evaluation and reflection on what you have done is very important in experimentation.

In summary, in this chapter I have introduced you to the notion of experiments as an important investigative method for natural sciences, and suggested the characteristics and processes of experiments. I now invite you to turn to Activity 4 in the Module 3 workbook to give you an in-depth insight into “real-life” experimentation. This Activity sets two tasks: (i) to study an experiment carried out in Morocco, and (ii) to conduct a simple experiment yourself.

Finally, please note that the experiments described in Activity 4 in the workbook are relatively straightforward because there are no real ethical issues involved in using the selected plants and the experimental methods used. This is not to say that plant experimentation is always controversy free. One very important area where ethical issues arise is with genetic modification of plants. For example, is this carried out to produce more and cheaper food for the hungry masses, or is it to produce ‘designer’ crops (e.g. tearless onions, perfectly shaped vine tomatoes) for richer countries? We will be further looking at ethical issues and moral dilemmas of research in Chapter 5.

3.3.2 Observation and description

Another way that natural scientists collect data and information is by observation and description. Observation allows natural scientists to do a number of things.

(i) Observation helps scientists to formulate ideas and questions about how something works or behaves.

Observation within the natural sciences is usually classified under the rubric of field studies. i.e., non-experimental approaches used in the field or in real-life settings. In this case the researcher very carefully observes and records some phenomenon or behaviour in its natural setting, probably over a long period of time. The observer attempts to be objective and does not interfere with the phenomenon or subjects (such as an individual animal or a group of animals). For instance, Dr Diane Fossey, a primatologist, studied mountain gorillas (Gorilla beringei beringei) in the Virunga Volcano area which straddles the Rwandan, Ugandan and Congo borders. This work undertaken over a span of nearly thirty years enabled her to record the life of mountain gorillas in detail. Her work is clearly described in her book "Gorillas in the Mist" (Fossey 1983) which was also made into a film with the same name in 1988.

In fact the history of observations in science goes back much further. For example, in the observations of the eruption of Mount Vesuvius in 79AD, a letter written by Pliny the Younger to his friend Tacitus gives a detailed account of the preceding earth tremors, the nature of the eruption and the ash plumes (Walsh 2006). Pliny the Younger describes how he and his mother watched the eruption from the safety of Misenum across the Gulf of Naples. Meanwhile his uncle Pliny the Elder had set off across the bay to investigate the eruption and rescue people by boat. The letter describes Pliny the Elder's final hours and his death at Stabiae, probably from toxic gas and dust clouds. Figure 3.2 shows the Gulf of Naples in 79AD and the eruption of Mount Vesuvius. The black cloud shows the extent of the distribution of ash.

Figure 3.2 Gulf of Naples 79 AD showing extent of ash cloud (Source: absoluteastronomy.com)

We must note here that observations lead to a description of behaviour or process but do not offer an explanation. Nevertheless, observation can build up a wealth of understanding about how plants interact with their environment. For example, the Peak District National Park which is located in Central England also has a long tradition of lead mining which dates back to the historic early Roman conquest of Britain. By the end of the seventeenth century most of the ore producing veins accessible from the ground surface were either worked out or flooded by ground water. Alongside the introduction of new technology to drain the mines, searches were initiated to look for new ore bodies.

Lead is toxic to most living things, and whilst the miners had not measured this cause and effect directly using experiments in a laboratory, they knew from generations of observations that poorly performing crops, and dying trees and plants could be related to lead ore close to the surface. They would also know from observation that “leadwort” or spring sandwort (Minuarta verna, Figure 3.3) was one of very few plants that would grow on the lead mine spoil heaps, i.e. it was tolerant of high levels of lead in the soil. Putting this observational evidence together enabled the 17th century miners to isolate potential new areas for closer examination with exploratory diggings. The leadwort plant is a good example of an indicator species used for bio-prospecting. Its presence indicates where soil lead levels are potentially higher when compared to background soil levels in the surrounding area, therefore offering a basic ore prospecting field study method.

Figure 3.3: Leadwort at Mouldrigde mine, Long Dale National Nature Reserve, Derbyshire, UK. (Source: H Moore)

Other plant species and species communities have also been used in this way. Another more recent example comes from the 1950’s, when the United States Geological Survey, which is a federal society for science about the earth, was rapidly prospecting for new uranium deposits within the Colorado Plateau in central North America. It was known from experimental laboratory research that some uranium ore bodies contain higher concentrations of the element selenium than the surrounding host rock in which they are found. Therefore plants that concentrated this element could act as indicator species for likely uranium ore locations. Various species of Astragalus (A. pattersoni , A. preussi, A. thompsonae) were used as selenium indicator plants and, by observing and mapping the distribution of these plants, potential prospecting areas could be identified.

Whilst botanical prospecting can be regarded as a relatively crude and rapid description technique, it has provided much local knowledge and served many generations of prospectors and miners. Therefore, natural scientists are not averse to using this as a preliminary method before more detailed surveys are applied to potential target areas which saves them time and money. (We will discuss surveys and survey techniques in detail later in Section 3.3.3 that follows.)

(ii) Observation allows us to use animals and plants as indicators of climate change.

This is very much evident in phenology which is the study of recurring natural phenomena. For example we can study the annual cycles of plants and animals and how they respond to seasonal changes in their environment. One particular insect, the butterfly, is an excellent indicator of the effects of climate change. For instance, in 2010 while I am writing, the majority of UK butterflies are at the edge of their natural European distribution and generally this limit is due to a change in temperature instead of other direct causes such as the availability of plants upon which their caterpillars feed or the availability of habitats they prefer. Therefore, using “scientific method” terminology we can hypothesise that butterfly species should spread further north in the UK if the climate becomes warmer.

To support this hypothesis, current and historical distributions of butterflies can simply be compared through measurements. The UK has a very large historical archive of butterfly observations and recordings made over the last 200 years. In particular, the UK Butterfly Monitoring Scheme (UKMBS) was set up in 1976 to provide detailed information of the changing abundance of butterflies. This scheme has a network of approximately 1,700 monitoring sites in England, Scotland, Wales and Northern Ireland. Observers make weekly visits and record the butterflies observed. Some of these sites are like the green and lush National Nature Reserve at Lathkill Dale in the Peak District National Park, whilst others are derelict power stations or new business parks. All these types of site can be important for butterflies and their records are important to provide an overall picture for butterfly conservation.

As global temperatures rise and we see alterations in precipitation there is also discussion that the natural cycle of seasons is changing, for example the start of spring and autumn in the UK. For instance, the dormouse in Southern Britain is hibernating 5½ weeks less than was the case 20 years ago, possibly linked to higher temperatures in spring and autumn. Similarly evidence of migrating birds such as swallows arriving back in Britain earlier year on year, or the first daffodils blooming are seen as indicators of climate change. This sort of observational and recording research is not just the preserve of natural science researchers as they simply could not do it alone! Therefore, natural scientists will seek public help in order to broaden their observations. They also take advantage of internet technology where a major benefit to research is that thousands of personal observations from the public can be collated to give indicators of climate change on a national scale.

Thus in the UK in autumn 2000, the Woodland Trust, a registered charity, and the Centre for Ecology and Hydrology (part of the British government's Natural Environment Research Council – NERC) came together to found the UK Phenology Network. The network aims to promote and coordinate phenological observation and recording of different natural phenomena on a national scale. An outcome of this network is 'The Natures Calendar' survey www.naturescalender.org.uk which allows the general public to record and view results of seasonal events that show the impact of climate change. In 2010, 240,000 people were registered on the site and regularly supply information. This is augmented by other data sent to the Network via coordinated surveys promoted on television, such as the BBC Spring Watch and Autumn Watch series. In this way the science base and observations are extended hugely as ordinary people are involved in collecting information on plants and animals including flowers, fungi, grasses, shrubs tree, amphibians, insects and birds. All the species selected for observation and recording are considered potential indicators of climate change and the mass data will enable a fuller picture of this very pressing phenomenon and the lived experience of it for the public.

You will be interested to know that such (nature's) calendars have also been long established in other European countries and places around the world. See, for example the Netherlands calendar through the website http://www.natuurkalender.nl/. Also, the United States National Phenology Network has an overview of networks around the world: http://www.usanpn.org/

It is not easy to control public observations in the way "scientific method" requires. However, to develop a systematic approach, the UK Phenology Network asks each contributing person to observe and record only one single phenomenon, for example, the date of the first leaf unfurling for a particular tree, the appearance of the first bluebell flower in spring, or the first signs of leaf colour change or blackberries turning ripe in autumn. Alternatively if they are interested in animal observations they can record the first observation of frog spawn in a pond in spring or the last time they see a swift before the autumn migration. The site gives advice on making observations and provides printable recording sheets and identification guides. This is to make sure data are collected consistently and to try and eliminate subjectivity. Observations are submitted on line and all data analysed by natural scientists. The network then produces a number of interactive maps and reports so that people can see patterns and trends they have helped to record.

You yourself might be interested in observing birds, insect or animal behaviour in your own neighbourhood and start keeping records. If you are, why not carry out an internet or other community-based search into any organised studies you can take part in a similar way. If so, please turn to Activity 5 in the workbook for further guidance.

Climate change not only extends the range and distribution of indigenous species such as butterflies, but also increases the potential survival of invasive alien species. Invasive alien species are non-native species "whose introduction does, or is likely to, cause economic or environmental harm, or harm to human health" (US National Invasive Species Council accessed at www.invasivespecies.gov, March 2012). An example is that of the Pacific Oyster (Crassostrea gigas) which was introduced into the North Sea for economic aquaculture in 1964. However, as water temperatures have changed, Pacific Oysters are extending their range, reproducing in the North Sea and displacing native oyster species in the Wadden Sea.

Further, in such observation and recording schemes, the recorded data are incorporated into a large online national data base to provide indicators of change year on year, and hence monitor the response of the natural world to climate change. However, the anecdotal nature of this evidence is often one reason why climate change sceptics are not convinced that climate change is actually happening or is indeed a significant problem. Thus it is argued therefore that without the controlled conditions of the laboratory, conclusions about cause-and-effect relationships cannot be drawn and that characteristics can only be described, not explained!

(iii) Observation allows us to infer processes

Often an experienced researcher can infer a process from field observations. For example, a soil scientist investigating the drainage of a particular soil type in a field situation will initially dig a large hole 1.5 m long by 1m wide by 1m deep called a soil pit. This will allow her/him to place a tape measure vertically down the side of the pit (Figure 3.4) and make a systematic description of the soil profile with depth. The investigator can then note down various soil profile characteristics onto a specific recording sheet or enter them directly into a handheld computer or data storage device.

Soil depth is easily measured using the tape measure whilst soil colour is most conveniently measured by comparison with a Soil Munsell Colour chart. This chart is specifically produced for soils and contains 322 different standard colour chips, systematically arranged on cards (Figure 3.5). The researcher will take a small sample of soil and carefully compare the soil colour to colours on the cards. The matching soil colour is noted. This description is made for the predominant colour of the soil matrix and for any small patches or mottles of different colours.

Figure 3.4: Soil pit with mottles dug to a depth of 1.2m (Source: H. Moore)

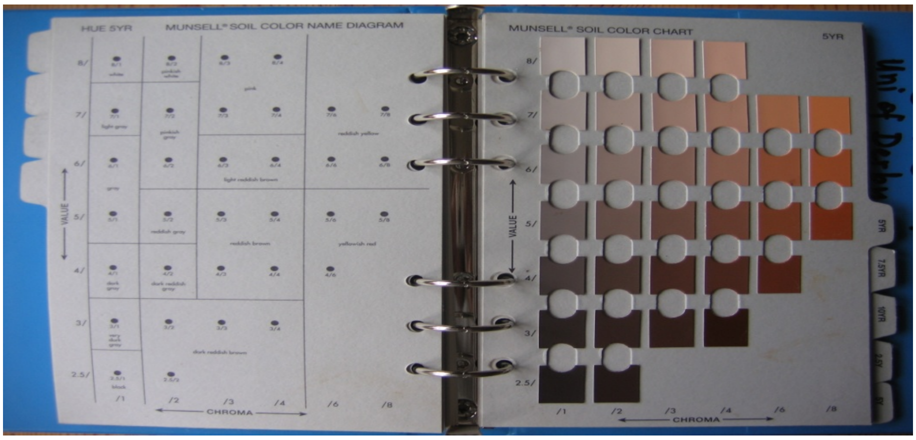

Figure 3.5: A page from the soil munsell colour chart (Source: H. Moore)

To an experienced eye it is the combination and changes in soil colours with depth that infer soil drainage processes. In lowland Europe the predominant colour of a well-drained soil is a brown or reddish brown colour. The soils are well oxygenated with large pores allowing rapid water drainage and easy air movement down into the soil with depth. In such a well aerated soil, the oxidised state of iron dominates, called Ferric iron, hence the red colouration. This is just like a red rust patch appearing on the side of a car. On the other hand a poorly drained soil has predominantly grey and blue colours. This is because the iron in the soil has been chemically reduced to its Ferrous form and is a grey colour (Brady and Weil,1996 p217). The juxtaposition of red and grey patches of colour or mottles particularly around the edge of soil beds, or down root channels indicates alternating oxidation and chemical reduction conditions as a water table moves up and down the soil profile (Figure 3.5). If a soil profile has these mottles within 30cm of the soil surface we can infer the soil drainage process is poor and the soil remains waterlogged for long periods of the year. If on the other hand mottles are not present or occur below 80cm we can infer that the soil is well drained (McRae 1988).

In this case, detailed soil observations and description allow an attempt to infer processes operating in the soil. Of course there are some obvious weaknesses. Firstly the technique is highly subjective. It depends on the comparison of field soil colours against a colour chart. The colour a surveyor chooses may vary from observer to observer and can introduce bias. The technique also depends on the moisture status of the soil. If you ever had the opportunity to make a sand castle on the beach, or water your garden or fields, you will know that a moist soil has a darker colour than dry soil. For this reason the determination of soil colour is made rapidly on a freshly exposed soil profile, before the area dries out on exposure to the atmosphere.

In summary we can say that observation, and the way that this is carried out is done in a number of ways by natural scientists. Observations enable scientists to formulate ideas and investigate the workings and patterns of certain phenomenon through which we can infer processes.

3.3.3 Survey

Sometimes within field studies the process of observation and description needs to be formalised into a structured survey. This makes the collection of data more rigorous and can be important if we want to quantify the characteristics of an animal's behaviour or a physical landscape phenomenon to enable some form of statistical analysis.

We acknowledged at the start of Chapter 3 that a naturalistic approach and "scientific method" is about gaining knowledge by asking questions. The form of the questions asked in experimentation is "how, why or what if", and as we discussed, this research strategy requires rigorous control over the research environment. For surveys, the questions we ask are "who, what, where, how many or how much". In contrast to experiments, surveys are usually conducted outdoors, which gives rise to less control over the research environment, for example when studying wild animals.

The word "survey" means to collect information about something, with an aim to understanding its condition, quantity, or quality. Survey is a term that is used in both the natural and social sciences, but with a different focus. In natural science surveying is essentially about collecting data to enable the description, classification, analysis and mapping of natural phenomena. For example a topographic survey, a soil survey, a vegetation survey, or a contaminated land survey. In social science a survey refers to the collection of data about people and their opinions, for example a government census or an opinion poll during a general election, often enabling in this instance social classification. This chapter will focus on the nature and usefulness of natural science surveys.

Before we begin our study of the usefulness of surveys we need to spend a short while reviewing the overall nature of surveys. There are several factors to be considered before any field survey is undertaken. For instance, in doing surveys you may need to ask the following:

1) What is the purpose of the study? Is it an overview, a quick look, reconnaissance survey; a very detailed one-off survey; a semi-detailed survey; a baseline for long-term monitoring? There must be a clear purpose, and if you are working as a consultant, a clear definition of what the client wants.

2) What is the scale of the survey? Is it covering large areas of terrain or ocean? Or smaller discrete areas? For example, is this survey investigating the whole of the North Sea or maybe one particular valley, or pond, which needs closer investigation. The detail of investigation is left up to the surveyor.

3) What is the overall terrain type? Are you surveying forest or grassland, dense tropical rainforest or open savannah? For example, in Figure 3.6 the size of the quadrat (the taped square) is approximately 2m x 2m and is an appropriate size for studying heathland vegetation. However, this is far too small to study the forest in the rear of the picture, where the vegetation structure would need a larger quadrat (20m x 20m) to incorporate a representative sample of trees. If we were studying a dense grass sward a 50cm x 50cm, quadrat would be sufficient.

Figure 3.6: Quadrant to study heathland, but not the forest (Source: T Rice)

4) What are the major constraints on surveying? Money, resources, labour? A major constraint for some surveys, for instance, is that they may have to take place within a certain time frame, for example, those monitoring bird or animal migration. Alternatively with vegetation, it is usually better to survey during the flowering period to help with plant identification. In some areas of West Africa, for example, the rainy season precludes survey operations due to poor road conditions or flooding which affects accessibility. Figure 3.7 shows the location of the vegetation monitoring area on the salt marshes within Chichester Harbour in West Sussex (UK). Obviously when the tide comes in they are submerged!

Figure 3.7: Plant growth monitoring in the salt marshes Chichester Harbour, UK (Source: F J Moore)

(5) What is the extent of the task? This depends on any existing previous knowledge of the area. If a desk study shows that previous surveying and mapping has been undertaken in an area, this can help narrow the extent of the task ahead. If there have been no previous surveys then the task will be greater. Technology allows us to use aerial photographs and satellite imagery to create base maps which can provide helpful background information.

(6) What specific characteristics are to be surveyed? How will these characteristics be measured, recorded, stored? Does this involve a one-off survey or several revisits to the same area? Are field samples collected as well as field observations, for example, when collecting water and sediment samples from a stream?

(7) How do you maintain consistency of data collection between different surveyors? This is always a difficult issue. If you are the sole surveyor you need to ensure consistency in your observations and recordings. When working in a team the quality and consistency of data collection can be a headache. The issue can be addressed by thorough training of all survey team members. Another way to try and achieve consistency is to use a standard field data collection sheet as illustrated in Figure 3.8. This data sheet was designed by a colleague to record vegetation and soils data at Gibraltar Point in Lincolnshire, UK. Data were collected through quadrat analysis based at intervals along a transect running from the foreshore back into the sand dunes. The further inland, the older the dune, the more complex the vegetation types and the more developed the soil profiles. This survey was to try and establish changes in vegetation and soils with dune succession.

If these considerations are well thought through then we can make sure that surveys are conducted to give a rigorous and accurate description of the physical world. Any environment can be surveyed, but the complexity of interrelationships between its constituent parts -- soils, plants, animals and climate -- sometimes means a survey needs to narrow its focus and record only those characteristics of particular interest. This creates a potentially more systematic and rigorous methodology for collecting data, which can usefully increase knowledge in at least two ways:

(i) Firstly, it can enable some form of statistical analysis to answer a question or accept a hypothesis. Field data is collected in a highly structured and rigorous manner.

(ii) Secondly, data can be collected, classified and disseminated into maps. This survey information is either collected in the field first hand, or remotely via satellite technology or telemetry. This process will probably involve the use of Geographic Information Systems (GIS) to collate and query the data, looking for patterns in space and time. This is an important mapping tool which can aid, for example, land resource management decisions or conservation strategies.

To demonstrate the usefulness of surveys I am going to present two case studies related to (i) and (ii) above.

GIBRALTAR POINT SAND DUNE SURVEY FIELD PROFORMA	Date: Names:
Distance along transect:	Sample number:

50 x 50cm Quadrat

MARRAM GRASS *Ammophila arenaria*	
Number of stems	
Abundance % Cover (Scale = 0-100%)	
Abundance (Scale = DAFOR)	

DAFOR SCALE
D - dominant
A - abundant
F - frequent,
O - occasional
R - rare

LIST OF OTHER SPECIES PRESENT & ABUNDANCE

Species	Abundance

Record% cover of species on scale 0 – 100%

SURFACE SOIL PROPERTIES	
Depth of Litter (cm)	
Depth of Surface Horizon (cm)	
Munsell Colour of Surface Horizon	
Ph of Surface Horizon	
Calcium Carbonate Content (description and %)	

DESCRIPTION / SKETCH OF SAMPLE LOCATION
Include notes on: Physical description of site characteristics; Evidence of erosion, damage & disturbance; Evidence of habitat management etc.

Figure 3.8: A sample field data collection sheet. (Source: T Rice)

Case study 1: Does organic farming improves soil condition and fertility?

Often the natural environment is so large and complex we need to be able to collect information from a representative sample of a wider population. If collected in a careful manner, field data samples can be statistically tested. This will help support whether there are statistically significant differences between groups of natural phenomena, or, alternatively, to identify if there are statistically significant relationships between various phenomena. This case study outlines how a field survey was conducted and the data statistically analysed in order to demonstrate that organic farming improves soil condition and fertility.

There is much debate about the benefits of organic farming both for the environment and regarding our own health. According to the UK Government Department for Environment Food and Rural Affairs (DEFRA), the main components of an organic farming system are “the avoidance of artificial fertilisers and pesticides and the use of crop rotations and other forms of husbandry to maintain soil fertility and control weeds, pests and diseases” (http://archive.defra.gov.uk/foodfarm/growing/organic/systems/method.htm -- accessed March 2012 but note that this link may become extinct as DEFRA updates its webpage).

To attain “organic status”, and become eligible for organic certification, land must be managed organically for at least two years. During this two year conversion period the land manager will decide which fields to convert to organic production (it may not be all the land on a single farm) and will stop the use of artificial fertilisers and pesticides on these areas. In addition there will be a switch to crop rotations. This means that instead of a cereal crop, like winter wheat, being grown on the same land year after year, the land is planted with a grass/ clover ley-crop[6] for maybe two years to build up the soil’s fertility. These activities, together with the use of green manures, livestock manures and composts should create long term soil fertility. A related important question therefore is, “How can we demonstrate that these organic farming techniques are beneficial for soil fertility?”

To study this, a research student Tracey, decided to look for evidence of the build-up of long term soil fertility on two organic farms in East Leicestershire, UK. One farm had been organically farmed for seven years and the other for twenty years. From reading around the subject Tracey knew that certain biological, chemical and physical soil characteristics could be used to indicate soil fertility. Amongst these were the number of earthworms / volume of soil, the nutrient content as indicated by NPK (nitrogen, phosphorous and potassium), the dry bulk density (g/cm^3) and the percentage organic content of the topsoil and subsoil. Following the “scientific method”, hypotheses were generated which predicted that soil which had been farmed organically for twenty years would have (i) a higher number of earthworms per volume of soil, (ii) a higher value of NPK, (iii) a lower dry bulk density and (iv) higher percentage organic matter in the top soil and sub soil.

Having set up the hypotheses a structured survey was carried out. The two organic farms were near each other, to ensure they were on the same natural soil type, had similar positions in the landscape and were exposed to the same microclimate – i.e. they had the same control variables. Both fields chosen for the detailed survey also had a similar planting history in order to hold as many variables constant as possible whilst the survey focused on those soil characteristics of interest.

Before the field survey began, a sampling strategy was designed. Sampling was important because the two fields could not be completely dug over and surveyed in detail. This would be impractical and would destroy the crop! Therefore a grid of sampling points was set up in the field to enable a systematic collection of data, spatially distributed across the two fields. Soil earthworm counts were made by digging out a known volume of soil and counting the worms, which was later converted into the number of worms / m3. Samples were collected for later laboratory work to calculate NPK, dry bulk density and percentage organic matter. Data were collated for each soil characteristic on each field, about 16 samples in each.

In order to test the different hypotheses, a statistical test of difference was used. The two-tailed Mann Whitney U test is a non-parametric test for assessing whether two independent samples of observations have equally large values. It was used to test if there was a significant difference between the soil characteristics on the two farms. For the nutrient levels, dry bulk density and percentage organic matter there was a statistical difference between the samples from the two farms.

Although this is a fairly simple piece of research, the results go some way to prove that organic farming is good for soil condition and the environment. Extending the discussion

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[6] Ley farming is an agricultural system where land is left fallow for a number of years to recuperate chemical and physical qualities for subsistence and cash crops. Ley crops usually refer to fodder-based, often perennial, crops grown in between rotation of main cropping.

we can postulate that organic agriculture helps to counteract climate change by restoring soil organic matter content that may have been lost. Thus, organic agriculture helps bind the soil particles, reducing erosion and improving its physical structure. Organic soils also have better water-holding capacity, which explains why organic production is much more resistant to climate extremes such as droughts and floods. The incorporation of organic matter into a soil also helps carbon sequestration, the process of removing carbon from the atmosphere and depositing it in a soil reservoir. In this way monitoring soil organic matter build-up can estimate how much carbon is sequestered per hectare of organic soils each year and therefore the emissions of carbon dioxide (CO_2) that have been saved..

Case Study 2: Using surveys to map a resource

Field surveys are useful because they provide accurate information about the physical world which can help us to utilise, plan and manage our natural resources. For example, a survey of geological strata in semi-arid environments can locate an underground aquifer, which may be utilised to provide fresh clean water for local people. In other areas of the world the accurate mapping of geological fault lines helps building and construction planning in known earthquake zones. In the UK accurate mapping of a brown field site (a previous industrial site) can identify the nature and level of any potentially toxic contaminants and hence aid the design of a remediation strategy and re-create clean and safe land for redevelopment. On a small island like Great Britain, land needs to be recycled!!

An advance in surveying in recent years is the incorporation of the Geographic Information System (GIS) and the Global Positioning System (GPS) into the natural scientist's research toolkit. A GIS is a system that allows the capture, storage, analysis and presentation of data based on the spatial location of a phenomenon. This data is usually collected using the GPS which is a space-based navigation system that provides reliable location and time information, anywhere on or near the Earth, when and where there is an unobstructed line of sight to four or more GPS satellites. When it is input into a GIS system, GPS data can be mapped as individual point data or manipulated into data layers to analyse spatial patterns of several phenomena. The case study I am going to outline is a wildlife survey of harbour seals using GPS telemetry (tagging) technology.

Harbour seals in the central and eastern English Channel between Devon and Kent are a rarity (Chesworth et al 2010). Consequently the presence of a small population in the Solent waters, between the northern Isle of Wight and the coasts of Hampshire and West Sussex, UK, made them an important population to study. Although there had been the occasional observation and reported sightings in the creeks and mudflats since the late 1970's, precise numbers, age classes, sex ratios and foraging and breeding habits were unknown (ibid, 2010). To undertake a systematic survey using the latest technology, the Solent seal tagging project was initiated in 2008. The use of seal tagging devices was part of a larger survey which involved other field observation techniques such as boat and shore-based counts, photographic seal identification, and a public sighting scheme similar to those discussed in Chapter 4 below. The online recording form for public sightings was hosted at the Hampshire (UK) and Isle of Wight Wildlife Trust website (www.hwt.org.uk).

Just like the tagging device worn by prisoners on probation, similar devices can be attached to animals to track their movements. It was hoped to monitor their movement around the Solent, but also indicate if there was any contact between this seal population and those to the east in Kent or south in France (Chesworth et al 2010). The tagging devices used in this study were designed by the Sea Mammal Research Unit (SMRU) at St Andrews, Scotland, UK (http://tinyurl.com/375k8ef). Called Fastloc™ receivers they were designed so that wave wash, submersion in water and poor antenna orientation did not prevent the GPS receiver from maintaining a signal lock on the satellites. The receivers could then obtain the data required for a GPS location within a fraction of a second. They were programmed to record a location fix every 30 minutes using a minimum of five satellites for a high degree of accuracy and transmit it back to a receiving station (Chesworth et al 2010). As well as location, the receivers also recorded “haul-out” behaviour using a wet/dry sensor. A haul-out (when the seal hauls itself out of the water onto a mud or sand bank) began when the sensor was continuously dry for 10 minutes, and ended when it was continuously wet for 40 seconds. Detailed dive data were also obtained using a pressure sensor. The data gathered was relayed to a ground station at SMRU using a mobile phone system. The tags operated on the Vodaphone network and data stored on the tag were phoned through every 6 hours.

Figure 3.9: A telemetry tracker attached to a seal back. (Source: E Rowsell)

Tags were attached onto a subset of five seals from the total population of approximately 20 seals (Figure 3.9). The subset included four adult males and one juvenile female. The tags were designed with a battery life of 6 months and would fall off during the seals’ annual moult in July/August (Chesworth et al 2010). If they fell of on the mud banks before this time, their transmitted position enabled them to be recovered.

The advantage of this kind of survey is that it can gather and transmit data on seal behaviour when the animal is out of visual sight. In addition the very high resolution data can be captured day and night over periods of months. The method is able to collect a variety of data on location, and dive characteristics such as depth and duration, and haul out data (e.g. when the seals were out of the water on sandbanks). Although the method has a high initial cost (each receiver costs £3000) it is cost effective, collecting continuous data for months.

The disadvantage is that the technique requires catching and anaesthetising the animals, which can cause them distress. It also involves a licensed specialist with a high degree of skill and experience. There are also ethical considerations about the seals’ welfare. However, the seals were only administered a mild anaesthetic and after 20 minutes, during which the tag was attached and blood samples taken, the seals were fully alert again and returned to the water. This example shows that only a sub-sample of the population was tagged, because it was impractical and expensive to catch them all.

Once received at SMRU the data were processed and uploaded to their website for download (password protected). Data were available in Google Earth files for quick visualisation and as an Access database for in-depth analysis (Chesworth et al 2010). Location data from the tagged seals were mapped. The map below (Figure 3.10) shows the routes made by three different seals over three different days in May 2009 (ibid 2010). You can see that two of the seals (the red and yellow plots) travelled along the coast and crossed over the Solent to the shores of the Isle of Wight. The third seal represented by the green line stayed within the creeks of Langstone and Chichester Harbours and does not venture into the open sea. Without the tagging technology this behaviour would not be possible to observe and record.

Figure 3.10: GPS tracking of three individual seals over a three day period in May 2010 (Source: Google Earth Images)

The two main haul-out sites were mud banks in Langstone and Chichester harbours. The seals used both, confirming a single Solent wide population. The team was able to identify 15 regular foraging grounds. Some seals foraged as far as the Isle of Wight but most forage journeys were short with seals resting each day. The widest ranging seal swam to Shoreham on a two day round trip of 100 miles, sleeping at sea and diving to depths of 60m. Forage dives averaged 10m in depth and usually lasted 3–4 minutes, although some seals were recorded diving to 60m and holding their breath for up to 25 minutes (Chesworth et al 2010).

I am sure that you can appreciate the importance of this type of monitoring survey. From this research scientists were able to collect exact and reliable data about the seals' resting and feeding behaviour. This knowledge and the maps that were produced could then be considered in any proposed coastal management and development plans. Without this kind of survey and knowledge it would be impossible to protect the seal haul-outs and underwater foraging sites. If you would like to read more about this work, access Chesworth et al 2010 on http://www.conservancy.co.uk/page/Seals/375/.

This sub-section has reviewed the main types and purposes of survey techniques. Although not undertaken in a laboratory, the scientific method is still adhered, to provide rigour and collect objective and truthful data. The next sub-section considers modelling and natural science.

3.3.4 Modelling

Before you begin reading this, please note that modelling, particularly in relation to climatic systems, is dealt with in much detail in Module 1, Chapter 2. This sub-section, however, may be useful to you if you are not from a scientific background.

A model can perhaps be best described as a simulation of some aspect(s) of the real world, and in that sense, it is a simplification. This simulation, or modelling, depends on what you want to find out. Some models, e.g. those associated with climate change are analytical, i.e. this is what is happening to the world's climate. Many are "what if" models, such as those asking what will happen to sea levels if global temperature rises by 4°C? Natural scientists may use models because: (i) the object under investigation is too large to examine in the real world; or (ii) the processes which created it operate over a very long time period; or (iii) experimentation might actually cause harm or destroy the natural phenomenon.

To get around these issues natural scientists have developed three different kinds of models which help to simplify the real world and help our understanding. These are either (i) a physical model (ii) a conceptual model or (iii) computer simulation as considered below.

Physical models

A classic example of a physical model is the investigation of air flow (the flow field) around a model aircraft in a wind tunnel. A wind tunnel is basically an enclosed passage through which air is driven, usually by a fan. During the tests a scale model is supported within this tunnel, in a carefully controlled air stream. This produces a flow of air around the aircraft model, which duplicates that of the full-scale aircraft. The aerodynamic characteristics of the aircraft model and its flow field are directly measured by test instrumentation. This provides accurate, reliable, repeatable and verifiable data, i.e. all those characteristics needed within the scientific methodology. Today wind tunnel experimentation is an absolutely necessary procedure before any aircraft is deemed safe to fly.

Another example of a scale model is the use of soil erosion plots. I have already discussed this in the sub-section above. However, if you wish to explore a further detailed example concerning land degradation, you will find one in Activity 6 in the workbook, but don't turn to this Activity until you have studied 'computer models in natural science' below.

Conceptual models

These models are usually simple diagrams, for example a circle and arrow diagram, which helps us understand an idea or concept. An example is shown in Figure 3.11 below, where model (a) represents the circulation of nutrients from the environment to living organisms and back to the environment.

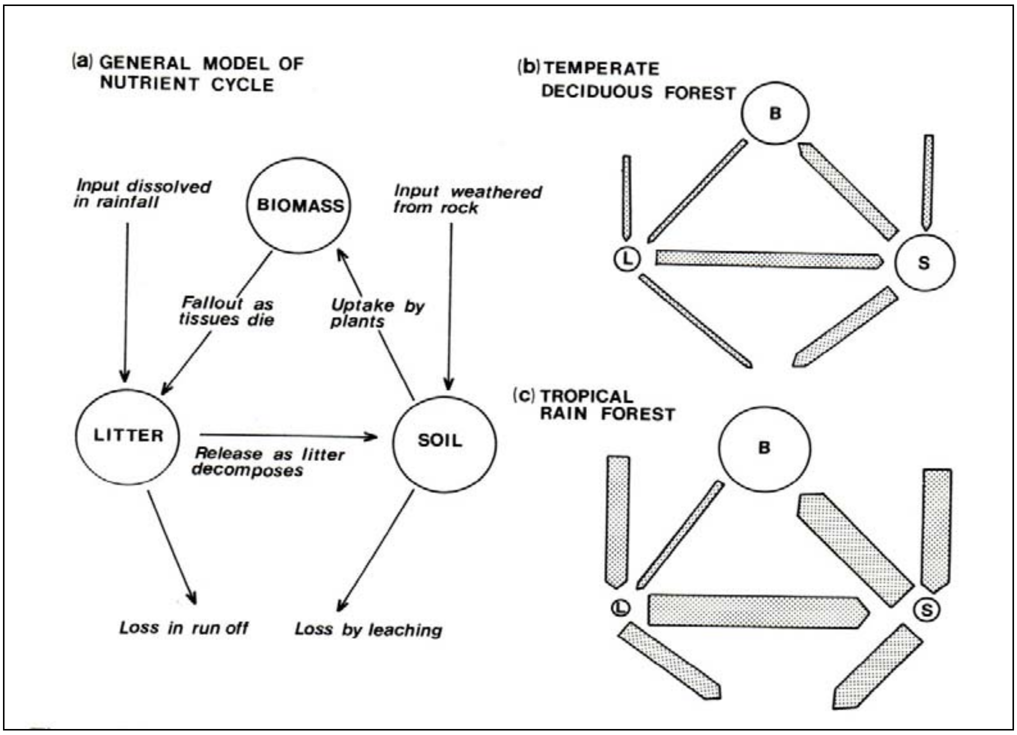

Figure 3.11: Model of nutrient circulation, input and loss in an ecosystem. (Source: O'Hare 1988 p101 and 140, (after Gersmehl, 1976).

In model (a) nutrients are stored in three areas that are represented by the circles. Nutrients are either in the living biomass (i.e. in vegetation and animals), or the soil, or in the litter layer (i.e. in the dead organic matter lying on the soil surface). The size of the circles represents the relative amounts of nutrients stored in the biomass, litter and the soil. Nutrients move in a cyclical way between these three areas via three pathways represented by the central arrows of the uptake pathway, the fall out pathway and the release or decay pathway (O'Hare 1988 p101). The size of the arrows indicates the volume and speed at which the nutrients are transported from one storage area to another via these pathways. The model also considers alternative inputs, for example, from rock weathering and rainfall, together with losses via run-off and leaching.

The advantage of this type of conceptual model is its flexibility. It can be modified very simply for a whole range of ecosystems (O'Hare 1988 p140). For example in Figure 3.11(b), the model has been modified to represent a temperate deciduous forest. This indicates that most nutrients in a temperate forest are stored in the soil and the biomass, while little is stored in the litter layer. There are also relatively fast uptake and decay pathways and a slower fall out pathway. Model (c) in Figure 3.11 represents a tropical rain forest, where most of the nutrients are locked up in the vegetation (biomass). The large arrows tell us that nutrients are circulated very quickly through the decay and uptake pathways, together with large inputs from rainfall and weathering of rocks.

In general conceptual models in natural science[7] are useful diagrams that simplify reality and help us to summarise and understand processes and relationships. However, they do not involve real data and they have limited capacity as a predictive research tool. This is the domain of the computer model.

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7 In social sciences, models are thought of rather differently as representations of systems which also offer possibilities of what might be elsewhere, for example, the Soviet Model or the Grameen Bank Model (discussed in sub-section 4.2.3).

Computer models in natural science

This area of study uses computers to 'model' naturally occurring phenomena. By modelling we mean a simulation of the physical world and more importantly to predict different scenarios by changing parameters (Box 3.3) in the model itself. The use of computer modelling has enabled both simple and complicated simulations of the real world, quite rapidly, and at a number of scales, both globally and locally. This section will use two different case studies to look at i) weather and climate change modelling ii) contaminated land modelling. In addition we will discuss the reliability and trust we can place on these models' predictions.

Box 3.3. Defining "parameter"

The term "parameter" can hold varied meanings for specific disciplines including mathematics, computing, science, politics which space does not allow us to explore here. It was also used in Module 1 of this series, in relation to climate models (chapter 2). Generally, however, it is associated with boundaries, limits and measurement (sometimes quantifiable through averages, means and variables). In fact, we are all used to parameters in our everyday social action whether we are actively aware of these or not. For example, we come across political parameters where we can only voice our dissent within particular boundaries and social frameworks such as whether you live in a democratic or an autocratic state. We have parameters on who we can have social relations with, for example, incest is strictly "off limits" in most societies. We have parameters defining details of our work day, breakdown of work hours and even the pages we write on with set fonts, sizes of sheets. We have physical parameters such as temperature which restrict our habitation and some arbitrary parameters such as family height, weight, colour which also compare our social parameter sand so on.

Before we begin looking at more complicated model examples in the workbook, I want to examine in this section a very simple example of a computer simulation. This is not strictly a natural science example but it will give you a simple overview. The example is the process of a designer helping you to plan a kitchen. The first step is to measure physically the dimensions of the kitchen using a tape measure. This real data is put into a computer model and an outline of the room is drawn to scale on the screen. At the second step the designer begins to change the features of the room, and place cupboards, cooker, sink and other furniture and fittings in the room. By selecting these different features (or parameters) a predicted 2D plan is built up. At the third step these separate 2D parameters are linked together and the model switches to a 3D screen which predicts how the whole room will look from different angles. You now have a predicted simulation of the new kitchen. The model's flexibility enables you change and move the features (or parameters) of the kitchen around, and predict a whole range of design scenarios. If each item of furniture is linked to a pricing spreadsheet (yet another level of parameters) you can adjust the layout and predict the best design within a certain budget range. Of course our initial trust in the model only arises from the reliability and trust we place in the designer and their experience. The ultimate trust will come when the kitchen is complete and we are happy with the outcome.

Like the kitchen model, natural scientists use computers to build up larger models, with more complex parameters, to predict outcomes. Weather forecasting is an obvious example of computer modelling. Just as the designer measured the room to predict the final kitchen design, meteorologists need to measure current weather conditions to make a weather forecast.

If you wish to engage with the issue of models further, please now turn to Activity 6 in the Workbook which discusses weather prediction models and how computer modelling was used to design a football stadium for a derelict site. Also, 'models' are developed to enable us to check our own 'carbon footprints', and you should turn to Activity 7 in the workbook as a practical engagement with such 'models'.

3.4 Underlying assumptions in natural science: positivist rationale and neutrality

In the previous sections of chapter 3 you have read about the various research methods in natural sciences. I hope that, as you have read, you have begun to appreciate a number of certain underlying assumptions within this type of research. This section intends to explore these underlying assumptions and extend the debate around two particular research approaches, empiricism and positivism. But before I enter into a further explanation of these assumptions, I would like to take a slight detour into a 'thumbnail' history of natural sciences to show how these assumptions are a legacy of the past, particularly a legacy set within a Euro-centric discourse.

3.4.1 'Natural science' historical legacy

The natural sciences have been shaped throughout history by several grand world cultures. However, in order to discuss the foundation of 'objectivity' and 'truth' of natural sciences, I turn to Europe where the foundations of this discourse were laid in the Middle Ages (475– 1550 AD) when the church controlled all scientific and philosophical ideas about the natural world. Church doctrine established "undeniable 'truths" about the natural world based on the interpretation of the Bible and the Aristotelian system based upon the view of the world which was expressed principally by Aristotle and other ancient Greek philosophers. The system developed accepted ''truths' about biology, physics and astronomy, which the church embodied into its established doctrine.

For example, Claudius Galen (131–201AD) put forward the theory that general health and temperament of the human body was a result of a balance of four principle body liquids or "humours", namely, blood, phlegm, black bile (melancholia) and yellow bile (cholera). Any illness could be explained as an imbalance between these four liquids and their manipulation could give effective cure. In order to redress the imbalance a physician would either remove "excess" blood (plethora) from the patient give them an emetic to induce vomiting, or a diuretic to induce urination. Blood letting in medicine continued as a routine practice well into the 19^{th} century in Europe (Figure 3.12).

Figure 3.12: Ancient Greek vase showing a physician bleeding a patient (Source: Wikimedia Commons)

Another idea, adopted as an undeniable 'truth' in the Middle Ages, had been established by the philosopher Empedocles of Acragas in Sicily (c 492BC – 432BC). He asserted that all matter consisted of four elements: earth, air, fire and water (See Figure 3.13). This theory was later embellished by Aristotle who added a fifth element, aether, which was neither hot, cold, wet nor dry and was the matter that filled the heavens. The planets and stars were described as located in the aether, where everything was permanent, regular, and unchanging except in terms of changing place in a circular fashion.

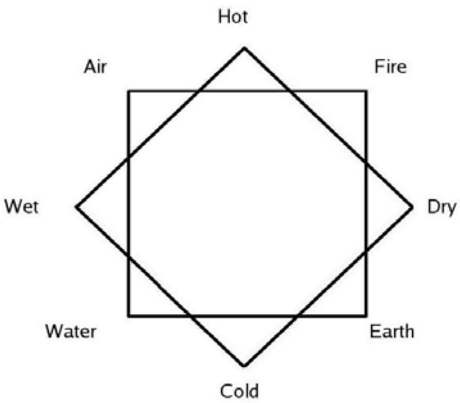

Figure 3.13: The four elements (Source: wikimedia commons)

Central to the church's doctrine was also the "undeniable 'truth'" that the earth was the centre of the universe. That is, the earth was a static, central planet around which the sun, other planets and distant stars revolved. Although these basic ideas were already incorporated into the Aristotelian system, it was the Egyptian mathematician, geographer and astronomer Claudius Ptolemy (c100–170 AD) who fully developed the Ptolemic geocentric model (Figure 3.14) which lasted for 1400 years. Two common observations, later disproved, were cited in support of this model: firstly (i) that the stars, sun, and planets appeared to revolve around the Earth each day; and (ii) the perception that, as the Earth is solid and stable, it is stationary[8].

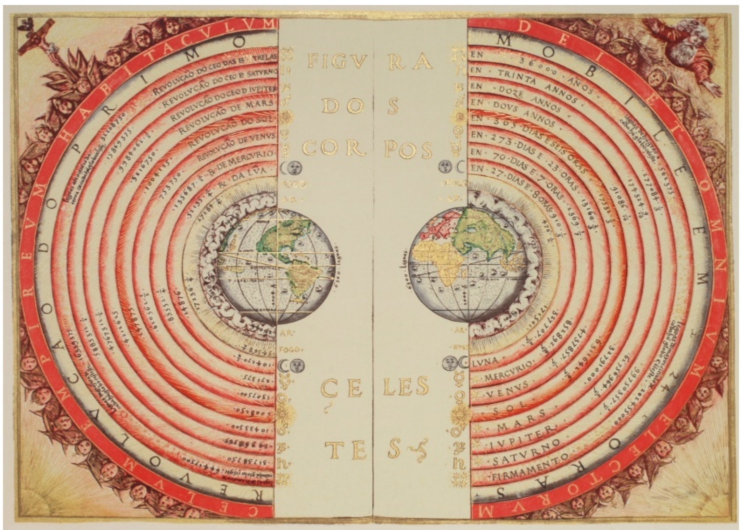

Figure 3.14: The Ptolemaic geocentric system as illustrated Bartolomeu Velho, a Portuguese cosmographer and cartographer in 1568 (Bibliothèque Nationale, Paris via wikimedia commons)

The 'scientific revolution' (circa1550–1700), however, brought new ideas in physics, astronomy and human anatomy which began to challenge and undermine the church's "unconditional truths" and the Aristotelian systems view of the natural world. Two publications in particular were seen as the tipping point for the start of the revolution:

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8 Amazingly polls carried out by Gallup in the 1990s found that 16% of Germans, 18% of United States citizens and 19% of Britons thought that the sun revolved around the earth!! **http://www.gallup.com/poll/3742/new-poll-gauges-americans-general-knowledge-levels.aspx**.

Nicolaus Copernicus's *De revolutionibus orbium coelestium (On the Revolutions of the Heavenly Spheres)* and Andreas Vesalius's *De humani corporis fabrica (On the Fabric of the Human body)*. We will consider both of these briefly to analyse their contribution to the scientific knowledge of the day and how they led to other scientists pushing forward 'knowledge' of the natural world.

Nicolaus Copernicus (1473–1543) was a Polish astronomer and mathematician interested in predictive geometrical astronomy. Between 1506 and 1530 he developed a heliocentric model of the universe and in 1543 (just before his death) he published *De revolutionibus orbium coelestium*. This book presented a shift from the geocentric model and explained how the earth is a planet that revolves around the sun, once a year, and turns on its axis, once a day. Although Copernicus placed the sun at the centre of the planetary system, he did not place it at the absolute centre of the universe. In a nutshell, this model for the first time demonstrated that the observed movement of planets and stars could be explained without the earth being stationary at the centre. The model appeared contrary to common sense, to contradict the Bible and fundamentally questioned the church.

However, Copernicus was a former church cleric in Poland, the nephew of a Polish bishop and a man of faith, held in high regard by the Vatican in Rome. He dedicated his book to Pope Paul III and in his foreword he explained that he hoped that his system might increase the accuracy of predictive astronomy and help the church to develop a more accurate calendar. The book also included a preface later attributed to Osiander, a Lutheran theologian and mathematician. Osiander had been entrusted to proof read the manuscript but it is thought that he also secretly included a preface, supposedly written by Copernicus, who suggested that the heliocentric model was only a mathematical tool which simplified and aided calculations but did not insist that the Earth was not the centre of the Universe. Largely on the strength of this preface and its interests in advancing scientific knowledge, the Catholic Church at first accepted the model. However by 1610 the church had changed its view and the booked was deemed heretical and in 1616 was placed on the *Index Librorum Prohibitorum*, the list of books forbidden as dangerous to the faith or morals of Catholics.

Despite this prohibition, the theory had already been published and there were copies of the book circulating in the scientific community. During the 17th century, three further discoveries eventually led to the complete acceptance of Copernicus's heliocentric model:

- Firstly the invention of the telescope allowed the Italian physicist and mathematician Galileo (1564–1642) to observe the skies as never before. He observed various natural phenomena which supported Copernicus' model. Firstly he discovered the four large moons of Jupiter, providing evidence that the solar system contained bodies that did not orbit Earth. Secondly he observed the phases of Venus, exactly like the phases of the moon, which provided evidence that Venus orbited the sun not the earth. Thirdly he was the first person to observe the sun through a telescope. Over a series of weeks he saw sunspots moving across the Sun's surface and realised that it was rotating (Figure 3.15). Galileo was arrested for his heretical theories supporting the sun as the centre of the solar system and was sentenced to house arrest for the last eight years of his life.
- Secondly Johannes Kepler a German astronomer and mathematician (1571–1630) made detailed observations of the orbit of Mars from which he elaborated and expanded Copernicus' model and introduced the idea that the orbits of the planets were elliptical rather than circular. He published this work between 1609 and 1621.

- Thirdly In 1687 the English physicist Issac Newton (1643–1727) proposed universal gravity and his inverse-square law of gravitational forces. This states that two bodies attract each other with a force that depends on their masses and separation. This attraction was used to explain Kepler's elliptical planetary orbits.

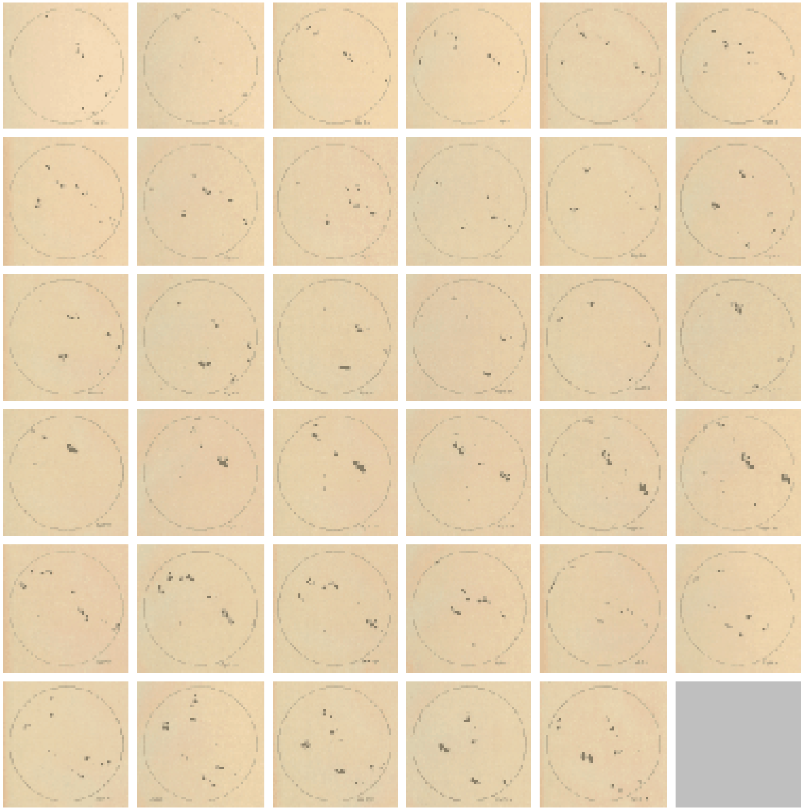

Figure 3.15: Galileo's drawings of sun spots, summer months of 1612. (Source: wikimedia)

We can see from the events above that advances in physics and astronomy have been made by a series of scientists being able to publish and communicate their ideas to each other. Similarly Andreas Vesalius's publication of *De humani corporis fabrica (On the Fabric of the Human body)* had a parallel impact in the field of biology and human anatomy.

As we saw previously in the ancient world of medicine, the Greek Claudius Galen (131–201AD) was responsible for the theory of the four humours, which persisted into the Middle Ages. However, Galen was also a physician to five emperors and had responsibility for the treatment of wounded gladiators. This gave him the opportunity to observe human anatomy and undertake surgery, particularly brain and eye operations. He performed vivisections and post mortems on animals including Barbary Apes (but never humans) and his recorded observations provided the basis of medical teachings throughout the Middle Ages. In particular, with the use of experiment and observations he showed that the arteries were full of blood not air, as previously believed. He also believed (incorrectly) that blood was continuously being made by the liver and used up by the body.

Andreas Vesalius (1514–1564) was a Belgian physician and anatomist who obtained his medical degree from the University of Padua in Italy. After graduation he took on the Chair of Surgery and Anatomy at the University. As a student Vesalius would have learnt about anatomy and surgery from the classic texts and watch barber-surgeons dissect animals. In this teaching environment there were no attempts to check Galen's theories about, for example, arterial blood flow, as these were seen as the undeniable 'truths'. Vesalius dissatisfied with this approach started to make hands-on dissections of animals a direct teaching tool. He made, and also commissioned artists to make, meticulous drawings of dissected bodies, from which his students should learn. In 1539 a Paduan judge made executed criminals' bodies available for dissection, despite human dissection being against the law. In 1541 Vesalius realised, probably whilst translating Galens work from Greek into Latin, that all of Galen's observations on human anatomy were actually based on observations of dissected Barbary Apes, and had assumed similarities to human anatomy. This did not go down very well with other anatomical scientists of the day!

By overthrowing Galen traditions and making his own thorough detailed observations Vesalius made a lasting contribution to scientific knowledge. He proved that the skeleton was the framework of the human body and that the mandible is one bone, whereas Galen thought it was two. Also he showed that men and women have the same number of ribs, and that the human sternum has three parts whereas Galen had assumed seven like the apes.

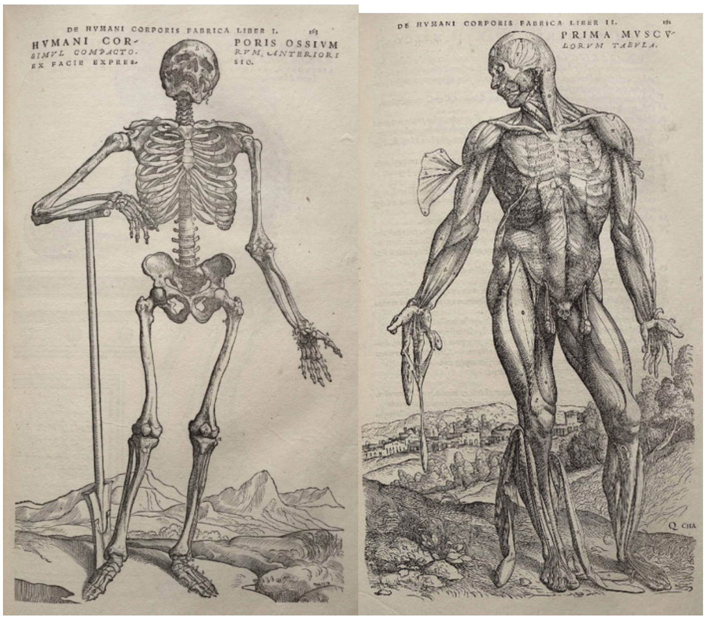

Figure 3.16: Vesalius' drawings on the human body (Source: wikipedia commons)

Vesalius' diagrams show detailed muscle formations for the human body (Figure 3.16 above) and his work on the heart described four chambers, and proved the importance of the mitral valve to explain blood flow. However, he was conscious of the religious beliefs at the time and, not wanting to whip up a storm, he did not refute the heart as the centre of the soul. Vesalius also described the anatomy of the brain and believed that nerves do not originate from the heart, as was the Aristotelian belief, but that nerves stemmed from the brain.

The foundation of Vesalius's work was taken forward by an English physician William Harvey (1578–1657) in the early 1600s. He developed an understanding of blood circulation and showed that circulation was dependent on the heart. He performed a series of experiments on animals including eels and other fish, and by tying their veins, he was able to show, that when the veins were tied, the heart remained empty and when the arteries were tied the heart filled with blood. When he published this *work De Motu Cordis* ("On the Motion of the Heart and Blood") in 1628 in Frankfurt, he ran head-on into conflict with the Galen-accepted view of the liver as the origin of venous blood.

Just as advances were made in astronomy with the invention of the telescope, so advances were made in medicine with the invention of the microscope. In 1595, the microscope was developed by a Dutch lens maker Zacharias Jansenn. He ground two glass eye lenses and experimented with them in a tube and achieved a magnification of x20-x30. In 1665 Robert Hooke (1635–1703) an English natural philosopher and architect published a book Micrographia which collated his microscope observations made between 1663 and 1664. Later In 1674 another Dutchman, Anton van

Leeuwenhoek, began to make microscopes that could magnify an object up to 200 times. He examined blood and he was the first person to see bacteria allegedly after looking at scrapings from his teeth!

As you can gauge from the above discussion, the scientific revolution was not based on one single event but a whole series of discoveries. From this we can see that science has advanced knowledge by using direct observation and experimentation to learn. This also encouraged the development of a scientific approach to study which eventually became the ""scientific method" (see Box 3.2 above). With all these rapid and important discoveries being made there was an imperative for discussion and dissemination of ideas and developments. This gave rise to the model of the "invisible college". Today we exchange scientific knowledge through academic journal publications. However in seventeenth century Europe this exchange was facilitated through an "invisible college" i.e. a network of intellectuals that exchanged ideas. For example, the network of astronomers, including Kepler, Rheticus, and Brahe, passed information and ideas to one another. Another example of knowledge exchange networks came when Padua University invited William Harvey to observe first hand the work of Vesalius's revolutionary teaching methods. In England in 1654 such an "invisible college" consisted of a group of scientists including Robert Boyle, John Wilkins, John Wallis, John Evelyn, Robert Hooke, Christopher Wren and William Petty. They met to acquire knowledge through experimental investigation and in 1660 this group formalised themselves into the prestigious Royal Society (UK).

The Royal Society of London for the "Improvement of Natural Knowledge", also known as the Royal Society was founded in November 1660 and granted a Royal Charter by King Charles II in 1663. The founders used it as a vehicle for research and discussion and its motto became 'Nullius in verba' ('Take nobody's word for it'). This expressed the members' wish to remain independent and to verify all statements through experimentation. Society members (Fellows) met weekly to observe experiments and discuss scientific topics. In 1662 the Society was permitted by Royal Charter to publish two books, John Evelyn's *Sylva* and *Micrographia* by Robert Hooke. This was followed in 1665 by the publication of the Philosophical Transactions of the Royal Society which was the first journal devoted to scientific research and has remained in continuous print to this day.

Initially housed at Gresham College in London, the Society began to develop a library and a museum of interesting natural science specimens. It has seen become a highly prestigious institution where Fellows are elected solely on the merit of their scientific work and the Royal Society continues to cream off the very best and has a world-wide reputation. Today the Royal Society is a scientific advisor to the British government receiving a parliamentary grant-in-aid. The Society acts as the UK's Academy of Sciences, and funds research fellowships and scientific start-up companies.

I hope that this slight detour into the historical sketch of science helps you understand the origins of the scientific legacy we have today. We can see from the examples that there is a legacy of presenting science as the "truth" and science as "objective" within which science has advanced knowledge by using direct observation and experimentation. This methodological approach, known as the "scientific method" has become entrenched in the scientific pursuit of knowledge and it is still the one we rely on today. Until recently, when the public has often been asked to take a more inclusive role (for example in data recording of natural species), European science by and large continues its historical legacy of being led by an academic, dominant elite of educated people, often through patronage, and in the case of the UK, royal patronage..

3.4.2 Scientific method and underlying assumptions

It is important to recognise that all disciplines have certain underlying philosophies which give shape to their fundamental character, and expectations of research processes. For natural sciences this is the "scientific method" which is determined by two key elements, that is (i) the critical role of empirical evidence, and (ii) the significance of "laws" of physics, chemistry and other science subjects. Thus a critical requirement and a basic assumption of "scientific method" is that all hypotheses and theories must be tested systematically against observations of the natural world and framed within the laws of pure sciences. Hence any claim to scientific knowledge has to be verified through observations, measurements, experiments, data collection. In fact, this is the only valid evidence, and anything that is intuitive or instinctive requires "objective" verification through rigorous empirical testing – a notion that is sometimes challenged by others, particularly many social scientists as you will note in Section 4.3. Pure empiricists (as they are often known), thus hold that science should only be concerned with the natural world and "facts", and that all hypotheses and theories must be tested against observations of the natural world, measured or observed by an objective researcher in order to justify new "truths".

The term that captures this type of thinking is known as empiricism and forms the epistemological basis of "scientific method". By empiricism I refer to a philosophical position that places emphasis on experience, particularly the experience acquired from specific aspects of scientific knowledge created through experimental events[9]. As empiricism involves experience, and thus some manner of sensory awareness, there are several forms of empiricism depending on the nature of the inquiry and its subject affiliation. For instance, experience and sensory awareness may mean something else for a psychologist compared to that of a physicist. (I do not intend to digress into this.) However, it is important to note that whatever the definition of experience and whatever the subject, empiricism nevertheless considers observation and evidence as fundamental to the establishment of "truths". Thus for instance, we moved from one historical "truth" – that the Earth is flat – to a modern one that the earth is round supported by observations from satellite images and other natural "facts" such as movement of the sun/moon. Unless therefore, we observe some other spectacular "truth", for the moment we are pretty much stuck with a (more-or-less) round earth!

Another fundamental characteristic of the "scientific method" is that it is framed within established, general laws. Natural scientists endeavour to create theoretical explanations based on causal relationships determined by these laws which are in fact universal, that is, wherever tried and tested, the result will be the same. Examples include the theory of gravity, behaviour of hot and cold air and so on. To defend laws and theories as "knowledge", scientific method turns to 'positivism'. Positivist evolution is associated with an early 1830s French philosopher Auguste Comte. Comte challenged notions of speculation and utopian ideas of a pre-revolutionary France in what he termed a "negative philosophy". Instead he argued for a positivist view based on the real world of given circumstances and material objects. Thus positivism focuses on "positive" facts and actual, rather than imaginary, observable phenomena. In doing so, the approach avoids metaphysical questions (such as those related to being and self) and theological questions (about God) that dominated the era, and could not be measured scientifically.

A positivist rationale thus embraces careful measurement and objective data collection to create general laws to predict and explain nature. To obtain objective data, interference from the researcher's personal or political values, which may mar "truths" and knowledge, need to be kept in check. Positivist knowledge thus requires propositions or hypotheses and laws and theories to be tested and verified, hence it provides the foundation of "scientific method". In fact, pure positivists are so sure about the methodology they argue that "scientific method" is not only the true essence of natural

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9 The experience I refer to here is based on that acquired through verified, objective scientific knowledge. As discussed in Module 2, this differs to that of lived experience which concerns the knowledge we gain over time through our encounters with the world around us. Lived experience is a subjective knowledge, therefore, which can be quite difficult to articulate because it is tacit – within ourselves -- and does not lend itself to codification.

sciences, but all knowledge. This includes knowledge within social sciences which can also rely on “scientific methodology” as this can be applied universally.

There are several contemporary versions of positivism, with two historically influential ones being (i) logical positivism and (ii) critical rationalism. The roots of logical positivism are in the 1920s Vienna positivists who argued that theories are only meaningful if they could be tested and verified – and this included theories beyond the realm of natural science, for instance, social science theories. Thus they turned to logic to make “scientific method” more rigorous for verifying theoretical “truth” or falsity of empirical statements. For them, verifying or falsifying requires propositions to be justified against reality, without resorting to experiential analysis or synthetic statements whose ‘truth’ needs to be established by empirically tested hypotheses. Logical positivism attracted some important names amongst whom are early logicians such as Ernst Mach and Ludwig Wiggenstein and later Bertrand Russell. Whilst logical positivism contributed significantly to the philosophical debates of logic, language and mathematics in their day, this “totalising” approach has since been discredited as over-simplistic.

A challenge to logical positivism came from the critical rationalism of Karl Popper, also a philosopher, in the1930s. Critical rationalism, as the name implies, is about reflecting on claims to knowledge in a critical and rational manner. To do this, we can only accept a claim that can be proved and/or through reason and experience. Popper argued that empirical evidence cannot be confirmed in advance of the event and thus it is possible that we may come across inconsistencies. Therefore, if the claim is based on empirical findings, it can be tested in order to falsify it. He argued that in testing a theory or other scientific claims, scientists are in fact not looking for evidence, but counter-evidence to see whether or not the empirical evidence is refutable or false. Contemporary critical rationalism elaborates Popper’s arguments to several areas of thinking and action around particular problems, fundamentally to replace justification methods with critical rationalism.

The underlying assumptions of natural science are thus partially built in the fundamentals of a “scientific” methodology and partially on a positivist philosophical rationale. The goal of inquiry is to explain and predict. Most positivists would also say that the ultimate goal is to develop the law of general understanding, by discovering necessary and sufficient conditions for any phenomenon (creating a perfect model of it). If the law is known, we can manipulate the conditions to produce the predicted result. In this, the essential premises of scientific inquiry are (i) inductive and deductive reasoning; (ii) value free and objective research; and (iii) validity and reliability which are considered below.

Inductive and deductive reasoning

Natural sciences focus on using these two types of reasoning: (i) an inductive reasoning where theoretical propositions about the truth are generated from observations or measurements by looking for patterns and regularities, which means that the research comes before the theory, and (ii) a deductive reasoning where experiments are undertaken to test the validity of a theory to see whether it can be verified or falsified, which means that the theory comes before the research. Inductive reasoning on climate change, for example, would examine or produce data on climate variability and then construct a theory which explains the data. In contrast, a deductive analysis would first construct a theory about climate variability and than test the theory by generating appropriate data.

Value-free and Objective

The notion of objectivity, devoid of moral and political values is central to empirical or positivist approaches in natural science. The idea is that the research processes are rigorously designed and controlled to measure empirical evidence and discover laws.

Therefore the researcher is expected to simply observe, record and analyse empirical findings neutrally. A question to ask, however, is whether knowledge can ever be obtained in such an objective and neutral way? Every scientist has personal opinions, things in which they personally believe or disbelieve, and their own favourite topics and interests which influence how they approach and see the world, and the questions they ask. Their underlying standpoint may be a legacy of how they, or their mentors, learnt their scientific methodologies, possibly with the laboratory leader expecting them to blindly follow his/her ideas and philosophies and not question the truth, rather like Vesalius's experience discussed previously. Ethics (to be discussed in further detail in Chapter 5) also enters into a consideration of value free objective research for example when doctors have a strong personal moral belief and will not research on human embryos.

Researches also operate in a cultural environment with holds certain beliefs and doctrines to be true. Historically we saw how the religious absolute "truths" dominated scientific thinking and processes in the Middle Ages. More recently, for example, biologists have looked for truth and evidence of racial supremacy within their own cultural environment. Fortunately this theme has now faded from popularity. Other examples include the work undertaken by scientists working for the tobacco companies in the US who have sought to discredit the scientific link between smoking and cancer, and those scientists who have questioned the link between anthropogenic carbon dioxide emissions and climate change. Because large multinational corporations have funded much of this research, it has focused on finding a negative link rather than a positive one. Therefore, however hard scientists seek objectivity, many factors including human values impact on how hypotheses, research design and questions are formulated and analysed.

Validity and reliability

All good science also aims to be valid and reliable. In natural science, valid research is that which accepts an empirical or positivist approach as discussed above, accepts the entire experimental concept and establishes whether the results meet all of the requirements of the "scientific method". We should note that there are two aspects of validity to consider, internal and external validity.

Internal validity dictates how an experiment or survey is designed. We have seen in the research methods Section 3.3.1 that experiments and observations require internal rigour in order to produce valid results. There must be an ordered and careful approach to collect valid data. Meanwhile external validity is concerned about how you process the results and ask questions of them to discover causal relationships. These relationships are easier to prove if there is some form of control built into the experiment, for example the use of statistics including randomised samples or locations to determine significance and difference. However, we must remember that these are exactly what the term says, significant, not evidence of an "absolute truth". Also correlation does not prove a relationship because there may always be some other reason, not yet measured or observed, which has contributed to the results.

Reliability refers to repeatability, comparison and consistency of a result. Golledge and Stimson (1997 p13) identify three types of reliability, namely: (i) quixotic reliability, where a single method of observation continuously yields an unvarying result; (ii) diachronic reliability, which is the stability of an observation through time; and (iii) synchronic reliability referring to the similarity of observations within the same time period. Reliability is reinforced by other researchers being able to conduct exactly the same experiment or survey observation, under the same controls and obtain the same results. The use of instruments for measuring, for example, a stop watch, is also seen as a robust way to collect accurate and reliable data. In natural science, following a deductive approach, we can say that the more repeatable and consistent a finding, the more weight it adds to a hypothesis and eventually it may become a scientific law or truth and add to our collective knowledge. In terms of climate change models, these are tested against past climate data to check for validity and reliability.

Having discussed the basic assumptions and fundamentals of scientific inquiry, let me finish by claiming that today our scientific endeavours and research are still a quest to establish "truths". We have had large jumps in truth stretching from historical times to recent years yet we do not know everything about our world and strive to understand it on all levels. Thomas Kuhn, a physicist who wrote many learned works on the history of science from the 1950/60s onwards characterised these large jumps in knowledge and truth as paradigm shifts or revolutionary science. This is science which somehow challenges its previous basic theories and assumptions. Science history is full of examples of how and when this has occurred, including Charles Darwin's theory of natural selection and Wegener's Plate tectonics theory for large-scale geological events. Paradigm shifts are a result of challenge to the established view of reality and "truths", and arguably, science today continues that challenge.

4 Dominant research methods in social science

4.1 Meaning of 'social science'

'Social science', as the name implies, is the study of the 'social' or society. The 'science' aspect of social sciences refers to academic study which is carried out systematically and analytically to produce some generalisation with similar rigour and testing of validity as is applied to natural sciences discussed above. Do note, however, that historically, there has been a debate on whether social science is indeed a 'true' science because it concerns systematic observations rather than the exacting results you may obtain from a laboratory analysis (which will be detailed in section 4.3 below).

Essentially society revolves around the relationship an individual has with others at both a micro- and macro-level within their immediate and wider surroundings. Social science very much concerns power relationships between people and groups of people and what defines these, both apparent to the observer and those that are unseen or unmentioned but ever-present (like the proverbial elephant in the room), shaping both the individual's and societal behaviour. Those who study such relationships are known as social scientists.

Societal power relationships arise from all kinds of specific contexts and therefore 'social sciences' is a very broad term encompassing several disciplines, including sociology, anthropology, geography, history, political sciences, economics (to name some). Social sciences are not simply about theory but are also applied, for instance in social work, psychology, language analysis and linguistics, educational action research and international development. Activity 8 in the workbook asks you to explore further the broad application of social science research.

There are at least three very famous names who have contributed significantly to the social sciences and who remain highly influential to this day, with many social scientists falling in one 'camp' or the other. These are Emile Durkheim (France, 1858 -1917), Karl Marx (Germany,1818 -1883) and Maximillian (Max) Weber (Germany, 1864 -1920). Out of these, Durkheim is considered the founding father of sociology[10] and of the discourse on what makes 'social facts' from which we can understand societies. For Durkheim, 'social facts' form the core of moral values, behaviour codes and cultural norms of which the individual is not always aware, and which appear external to, but nevertheless influence, him or her. According to Durkheim, an analysis of 'social facts' enables us to understand how the structures and hidden 'laws' that govern a society work and what it expects.

Thus Durkheim attempted to build up 'scientific' data through an analysis of the 'social facts' and identify their correlation to societal structures and 'laws'. In his pioneering work on research methods *Les règles de la méthode sociologique* (*Rules of the sociological method)* (1895), Durkheim attempted to regulate the study of society through two major premises, (i) that a specific 'social' fact' be identified as an object of study, and (ii) that the method used to study this objective was devoid of subjective feelings and reasoning, being as close as possible to the objectivity and positivism (discussed in section 3.4) as that of natural science methods. He used these premises in his influential study *Le suicide* (1897) in which he established several correlations between 'social facts' such as religious values, gender (men and women) and peace and conflict to study suicidal behaviour in a particular society at a given time. By doing so, he took a very private individual affair (that of suicide) and gave it a very public, societal context. Thus Durkheim began the processes of generalisations discussed in chapter 2 of this module!

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10 Sociology (study of society). Note other disciplines that end with an –ology (anthropology, archaeology) also focus on studying societies, whether past or present.

Marx was also concerned about correlations within society but, in the epoch of the early industrial revolutions, he adds the powerful dimension of class to his analysis of society. For Marx, the essence of society lay in a ‘class struggle’[11], located within the powerful ‘bourgeoisie’ who own the means of production and the ‘proletariat’ who sell their labour. He traced class struggle to antiquity arguing that “the history of all hitherto existing society is the history of class struggle” (Opening line of Marx’s Communist manifesto 1848). Thus Marx did not see history, politics, economics and social behaviour as being separate, but as very much intertwined and manifest in societal power relationships as defined by individual class position. Whilst Marxist ideas have historically influenced revolutions, uprising and worker solidarity all over the world and continue to do so today, for social scientists, Marx has offered a colossal, inescapable dimension to the analysis of social values – that based on power, class and underlying ideology (Box 2.2). And, even today, argue as they might, social scientists cannot escape a class analysis in any societal enquiry!

Within the context of a more modern world and the rise of global capitalism Weber, the third name associated with social science, offers further dimensions to societal analysis, including religious and political party affiliations. For example, in his seminal work, *The protestant ethic and the spirit of capitalism*, which is a series of essays compiled between 1904 and 1905, Weber argued that capitalism has grown (since the onset of the industrial revolution) because of the filtering of religious messages of a ‘protestant ethic’ which celebrates hard work as a path to riches and spiritual salvation. This was a completely new angle to that of the overthrow of capitalism through a class struggle analysis.

Weber also analysed the behaviour of nation states and how state mechanisms attempt to legitimise their behaviour, in his analysis of violence in the form of war and conflict. He argued that states present a rational, legal front through complex bureaucracies and employ agents (policemen, soldiers) to give authority to these. In turn, state authority becomes embedded in the culture of a given society. What Weber thus saw was a growing system of classification of people by state bureaucracies, one that included several sub-categories of citizen classes (e.g. aristocrats, upper class, middle class, lower class) defined by their wealth and social stratification and status in society. This is very different from the Marxist two-class analysis and reflected a more ‘modern’ stratification generated by changes in capitalism amongst other things. Whilst there have been several criticisms of Weber’s analysis as being descriptive rather than explanatory (compared with Marxist ideology analysis), nevertheless, Weber has made an important contribution to the study of modern societies and his ideas continue to be used to analyse the global intricacies of capitalism and social stratification even today (for example, with the global division of labour).

To summarise, social science is a systematic study of society that is located in several disciplines and has at its core, an analysis based on variables derived from the historical, political and economic make-up of society.

4.2 Frequently used social science research methods

4.2.1 The research context for social science

Below are two sets of images of research instances. The first, represented by Figures 4.1 and 4.2, is set in the laboratories at the Institut Agronomique et Veterinaire Hassan II in Morocco. The researcher in Figure 4.1 is in a confined, temperature-controlled laboratory where he is carrying out minute observations of locust larvae responses to the ‘Green Muscle’ biological pesticide control of locusts. This is to test the effectiveness of the

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[11] The two classes within Marx’s analysis, the ‘bourgeoisie’ and the ‘proletariat’ each share common interests within their respective groups, but are in conflict with the other. As the ‘bourgeoisie’ want to accumulate as much profit (surplus) as possible using ‘proletariat’ labour, a class struggle is inevitable, with the ‘proletariat’ revolution eventually toppling the ‘bourgeoisie’.

pesticide because recently a few people have expressed concerns about the level of its success (less than 100%). This research is very important as locust swarms can destroy harvests in seconds. Thus data and findings have to be immaculate, compiled over a long period which reflects differing stages of locust fertilisation and growth. The reason for the urgency of this research is that, after some twenty years of reasonably successful control, locust activity in the North of Africa has increased and, according to the Food and Agriculture Organisation (FAO), there is a serious threat that swarms will move rapidly over other parts of Africa and even Asia. It is feared that the movement may even be related to warming climates. For further detail see www.fao.org and http://www.scienceinafrica.co.za/Green_Muscle.htm

Figure 4.1: Laboratory observation (Source: D Abbott)

Figure 4.2: Controlled laboratory conditions (Source: D Abbott)

Now compare the above images with the second set in Figures 4.3, 4.4 and 4.5.

Figure 4.3: Filling lunch boxes (‘tiffins’) for industrial workers, Mumbai (Source: D Abbott)

Figure 4.4: Women's organisation making food to sell, Mumbai (source: D Abbott)

Figure 4.5: Researcher (right) under the banner of the women's organisation, Mumbai, (source: D Abbott)

The two sets of images above quickly point to apparent differences of research between that which is set within a natural science laboratory and that which is set within a social setting of the 'human laboratory'. These include the neat and unclustered set-up of the laboratory-controlled event, and the disordered and clustered setting of the human event depicted in the second set of images. In each, the researcher is required to negotiate their surroundings and the events. For the researcher in Figure 4.1 for instance, this means ensuring the temperature control, making detailed notes and minute data recordings of locust larvae behaviour that stretches over many, perhaps lonely, hours.

For the researcher in Figure 4.5, this means trying to find out relevant information about a particular set-up (here the working of a poor women's organisation) through observation and a degree of participation without any of the paraphernalia that signals laboratory research. For instance, this researcher does not have a white coat and is dressed in clothes of a similar style to those of the women, neither does she carry any pens and notebooks but instead relies on memory of social interactions, direct observations and sense of any underlying currents. She is also interacting with a range of women who will give her differing accounts of the organisation, depending on their individual standpoint and perspective and she will be required to analyse the meanings of these. Although it may not appear so, this too can be a lonely exercise and a strenuous one, but in addition one which requires immaculate recall and recording of 'data' gathered from what most respondents regard as nuisance busybodies who interfere in their work and ask too many silly questions! From both these set-ups, each researcher will be required to produce a rigorous conclusion- the first regarding the workings and success/failures of the 'Green Muscle', and the second, a macro-level generalisation based on a micro-level situation on how women's organisations function and whether the findings can be generally useful to women who live in poverty.

Because society and social situations are so complex, and no human being or event exactly the same, social science cannot make judgments based on any singular research method alone. Most social scientists will therefore borrow a range of methods from varying disciplines, tending to draw on a multi-method approach for both research and 'finding out' as well as the analysis of those findings (as some natural scientists also do, but more so). For instance, 'finding out' can involve observation and participatory techniques based on anthropological methods and surveys, statistical analysis based in mathematics, structured and semi-structured interviewing based on sociology, digging deep into historical records from archaeology and history, along with analysis of drawing, sculpture, arts and music from the arts and media schools. What you choose will, of course, depend on the nature of the enquiry. If you wish to think about this in further detail, please turn to Activity 9 (Choosing social science methods) in the Module 3 work book now.

4.2.2 Similar but different: Social science research methods

There is then a range of methods that social scientists draw on in order to discover and understand the relationship between the layers of reality they wish to explore. I cannot deal with them all here, and neither will I attempt to describe methods or techniques (such as interviewing) that you may have already addressed in one way or another at an undergraduate level in any case. I will instead, firstly attempt to show you how the approaches of social science may differ from those outlined in the natural sciences above (Chapter 3). I will then consider the overarching debate of whether qualitative and/or quantitative data best capture social reality.

4.2.3 Social science experimentation, observation and surveys

In Chapter 3, we looked at experimentation, observations and surveys as methods used to capture data in natural sciences. These methods also are used in social sciences, but differently and arguably geared more towards generating qualitative data, as detailed below. In the disciplinary field (development studies) that I am involved in, a primary concern is poverty alleviation, particularly in developing countries. In the 1970s, the concern over the lives and livelihoods of the very poor and those at the bottom rung of the social and economic ladder was becoming increasingly paramount, particularly for Asian, African and South American countries where it was evident that poverty was intensifying. A very successful intervention strategy that emerged in South Asia during this time was that of micro-credit lending for the poor as a way to enable the poor to develop or retain their livelihood, income-generating strategies. This can only be done effectively if we have enough knowledge about the complexities of the lives of the poor, and this requires a complex social analysis based on both quantitative and qualitative data. However, while the poor have in the past more often than not been left out of, without much say in, their own development, contemporary development studies is very careful to include the 'voices of the poor'. Thus there is much emphasis on the stories of the poor and their lives that can only be generated through qualitative data. In discussing research into micro-credit, I will show how social science too uses experimentation, observations and surveys, albeit in a different manner.

Case Study 3: Real life social science: micro-credit for the poor

The very poor in South Asian countries (India, Bangladesh, Pakistan) often suffer massive discrimination arising out of their caste and religious status, generally occupying the bottom rungs of the social and economic ladder in society. Whilst it may be against the law to discriminate on these grounds, nevertheless, it cannot escape the notice of even the most new arrivals to these countries that those who live in the urban slums, eking out a living on the footpaths of mega cities, or who live on the edges of rural areas in fear of their higher-caste landlords, are very much down-trodden and socially excluded. Millions of people, both men and women, fall into these groups from all the main religions including lower-caste Hindus, Muslims and Christians. They have little choice but to survive their hardship on a daily basis, dodging municipal authorities and the police who shift them off the footpaths where they attempt to trade small goods, begging and borrowing (often at high interest rates) small amounts of capital from unscrupulous moneylenders to purchase goods they can sell that day.

Micro-credit intervention in the 1970s attempted to break the cycle by providing initial capital through 'micro' loans so that the poor could free themselves from moneylenders who were charging extortionate rates which they could ill afford, whilst making violent demands for the return of their money. The poor do not have enough confidence or capacity to turn to other sources, for example banks, to seek initial capital to enable their daily income-generating activities. Here it is necessary to understand that if a woman wishes to sell vegetables on the footpath, she needs initial capital to buy them from a wholesale market; if a young boy wants to polish shoes on the pavement, he will need shoe polish; if a man wants to sell newspapers at a traffic jam, he will have to purchase the newspapers first. The vegetable seller will also require a (costly, bureaucratic) municipal licence which she might or might not have. In all cases, the shoeshine boy, the vegetable vendor and the newspaperman will most likely be also harassed by local 'mafiosi' who will demand their 'cut' in cash or kind (goods, sexual payment) through threats of violence. Therefore the poor need an alternative organisation from where they can borrow tiny amounts on a daily basis without having to offer any collateral, and also an organisation that offers them some protection and empowers them through collective action. 'Grassroots' organisations such as the Grameen (village) Bank (http://www.grameen-info.org) and Self-Employed Women's Association (SEWA http://www.sewa.org) began to do this in the 1970s. However as loans (for which the organisations themselves initially had to turn to mainstream banks) of such small amounts are difficult and costly to administer, certain provisos were placed by the Grameen Banks and similar organisations that they would only lend to borrower groups rather than individuals, and that each group would ensure the money was returned[12].

Micro-credit lending has since become a highly successful practice and many micro-finance organisations have developed all over the world including Africa, Latin America and other Asian countries (China, Vietnam). There is now a growing and voluminous literature on the subject where we require more and more carefully detailed information on the effectiveness of interventions such as micro-credit. Current areas of concern, for instance, are the economics of 'joint liability'- where, when and how is group credit most effective for parity in individual access to funds and higher repayment rates. A very interested party is the banking sector itself who, like the World Bank, commission many social science and economic studies on micro-credit which include the research methods mentioned at the start of this section.

Surveying micro-credit behaviour

As illustrated by Hermes N and Lensink R (2007), there have been several large scale surveys on various facets of joint group liability, starting with Wenner (1995), whose first empirical studies of 25 micro-lending groups in Costa Rica suggest that the repayment performance of groups improves when groups have written (formal) rules stating how members should behave. Zeller (1998) extends this thesis through a study of 146 groups in Madagascar by suggesting that the role of strong social ties and internal rules and regulations is important in achieving higher repayment rates. And, Sharma and

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12 This proviso was initially made by banks in India. In my study of a women's organisation which was built on micro-credit lending, the Bank of Baroda insisted that they would not administer small loans and asked the women to return when they had formed a group of fourteen, which they did not think would happen. But it did, and the group of women also found a common voice and purpose in building a powerful organisation. Ironically, therefore, the banks had helped achieve what both trade unions and political activists had failed to do, i.e. organise the 'unorganisable' millions eking out a living wherever they could (Abbott 1993 p183, 1996, 1997.) Later on in the mid 1970s, the nationalised State Bank of India also officially introduced micro-credit lending and differential rates lending for the poor.

Zeller (1997), based on data of 128 groups from four group lending programmes in Bangladesh, further conclude that when group member are relatives, the repayment problems increase. Using an extensive number of variables and data from 137 groups in Guatemala, they further suggest that social ties within groups lower the group's ability to exercise social pressure for individual loan repayments.

These survey studies on the hugely complex question of human behaviour (in this case regarding joint liability of repayment) have been critiqued using similar questions focussing on analytical rigour as you find with natural sciences. For example, Hermes and Lensink (2007 p4), in looking at the potential weaknesses of these earlier studies, argue that:

> "The empirical studies mentioned above present interesting results on how and why joint liability group lending works. However, they also suffer from a number of potential weaknesses. First, in most papers the link between theory and empirics is rather implicit. Many of the variables used to measure group member behaviour in terms of screening, monitoring and enforcement are only indirectly related to the contents of these concepts from a theoretical perspective. Moreover, in several cases crude, or at least one-dimensional, measures are used to proxy for complex constructs such as social ties. Finally, the empirical analyses may suffer from endogeneity problems…"

There are also, as with the natural sciences, questions of prediction. For instance, Hermes and Lensink (ibid p4) cite Ahlin and Townsend (2007) who work from some well-known theoretical models of joint liability group lending, such as those of:

(i) Stiglitz (1990) and Banerjee et al. (1994) to explain how moral hazard problems of joint liability can be resolved;

(ii) Besley and Coate (1995) to suggest repayment rates can be resolved with limited contract enforcement by using social sanctions;

(iii) Ghatak (1999) to help resolve adverse selection problems.

From this, Ahlin and Townsend attempt to generate theoretical predictions on the repayment behaviour and performance of groups. However, unlike the natural sciences where the 'laboratory' context is neutral, the prediction models for joint liability group lending operate within different sets of economic environments and present varied data regarding repayment performance.

Therefore, Ahlin and Townsend (ibid) are also aware of conflicting predictions regarding cooperation and social cohesion between group members, and the correlation between loan returns and the degree of joint liability in explaining repayment performance. In summary, therefore, social scientists also make extensive use of the sampling and survey research methods for both gathering and analysing data. Through these methods they hope to build prediction models just as natural science does, but as discussed here, the differing economic and social contexts that influence human behaviour can baffle the best of social scientists!

Experimentation for micro-credit behaviour

In spite of being a method critically associated with the natural sciences and being somewhat problematic for the study of human behaviour, social science is not averse to using experimental techniques at times, even for complex social issues such as the joint liability, group, micro-credit lending above. For instance, in also critiquing the surveys referred to in the discussion above, Carpenter and Williams (2010) turn to 'field experiments' to better understand and predict loan repayment performance. In a working paper for The Reserve Bank of Boston, they explain and justify the field experiment thus:

> "Borrowing from the behavioural literature, we develop an experiment to measure individual propensities to monitor one's peers in a social dilemma with incentives similar to group lending. We then test whether the monitoring propensities of women about to enter an actual group lending program in Paraguay predict loan performance six months later.
>
> There are many advantages to our approach. First, instead of relying on a proxy for the cost of monitoring, using an experiment in which monitoring is costed, we directly measure the behavioural propensity of individuals to engage in peer monitoring.
>
> Second, because our participants did not know the exact identity of the people that they chose to monitor in the experiment, our measures of peer monitoring are inherent; that is, these measures could not be conditioned on individual characteristics like being a friend or being a bad credit risk. In this sense our measures are much less likely to be endogenous.
>
> Third, inspired by Karlan (2005), we estimate the effect of peer monitoring on subsequent loan performance. Because we ran the experiment before the groups received their first loan (we collected loan data six months after we measured the behavioural data), simultaneity bias is also less likely to affect our results, and we can be more confident that we are estimating a causal relationship between peer monitoring and repayment rates.
>
> Fourth, since overt default rates tend to be very low in group lending situations, we follow Wydick (1999) and use a broader loan performance measure that indicates whether or not an individual had trouble making payments over the term of the loan. We are confident in the accuracy of this measure, since it is constructed from administrative data and cross-reports from individual interviews.
>
> Fifth, in addition to providing measures of peer monitoring propensities, our protocol also allowed us to gather behavioural measures of time, risk, and social preferences that we can also use to predict repayment problems. Lastly, we collect a large set of controls that include standard demographics and a number of other potential correlates of default (for example, the number of family members in the loan group, an objective measure of default risk, and a measure of nonverbal IQ)" (Carpenter and Williams 2010 p4).

You will note from the above explanation and justification that there is here an attempt to build a rigorous methodology and control in the 'outside lab' similar to that which can also be expected in the 'inside lab' of natural sciences. This includes hidden identities, cross-referencing and checking and attempts to control the context-specific and endogenous nature of the enquiry.

If you wish to think further about experimentation techniques in social science, please turn to Activity 10 in the workbook.

Finally, please note that whilst I focus on micro-credit as a case study, there are many other instances and a large range from which social scientists attempt to devise prediction models based on both experimental and survey information, the largest of which is the census. Drawing from existing knowledge and latest census findings, prediction models will attempt to identify trends and comment on hugely complex social issues such as crime, corruption, unemployment, drug abuse, marriage and co-habitation trends, marital behaviour, consumption behaviour, education and so on. The list is endless, reflecting the multitude of social change and problems we as a society experience. There is little doubt that as with any natural science models, there will be margins for error, but social science prediction models will attempt to minimise them through the use of several variables and careful analysis of proxies.

Nevertheless, social science prediction models are extremely important to policy makers and governments as they give society some idea of dealing with current and future trends. For instance, work, marriage and co-habitation behaviour may give an indication of whether people will have children or not, and what this means for future population growth – knowledge which is crucial in planning for the country's future. A 'classic' example of how the state will intervene in private family life is that of France where, in the face of declining population numbers, the state has entered into proactive intervention to encourage working mothers (at least the middle-class ones) to have children. Thus current French family policy spans a range of measures including realistic income support to families, promoting a work-family balance and encouragement of employers to implement family-friendly policies (Pailhé et al 2008).

To end this sub-section and reflect further on what you have learnt so far about social science research methods, particularly social science prediction methods as discussed above, please now turn to workbook Activity 11 if you wish.

4.2.4 Social science and participatory observations

Social scientists are very much involved with observations and this is usually carried out whatever the methods that are used, but the way this is generally done may be different from observations undertaken for natural science subjects. In similarity with natural science, social scientists also attempt to observe specific events, record data and validate and analyse them. The crucial point of difference is, however, that the events observed are located in a societal context which in turn is shaped by the history, geography, economics, and cultural specifics from local to global scales. Having to work around these contexts makes observation in social science a complex and contentious methodology with many questions surrounding it. These include questions of how to observe, how to validate that observation, researcher bias, ethics and morals of the exercise – which I attempt to detail below.

Firstly, I will say a bit more about 'observations' as a research method in social sciences itself. As I indicated earlier, social science draws from many disciplines, and the preliminary disciplinary home of 'observations' is ethnographic research which is a branch of anthropology. Ethnographic research, in a nutshell, concerns the observations of people (often 'ethnic' groups) in order to understand their everyday lived experiences and how these relate to their view of the world. In order to do this, ethnographers have historically attempted to minimise their role as an 'outsider' by moving into the 'insider' context that they are researching. It is suggested that Malinowski B's (1922) study, "Argonauts of the western Pacific", (cited in Atkinson and Hammersley1998 15:250) in which he carried out and documented everyday life between 1915–16 and 1917–18 lay the foundation for modern ethnography, by developing the notions of fieldwork to discover 'the native's point of view'. Margaret Mead is another name strongly associated with ethnographic fieldwork and observation in her work amongst the people of Samoa documented in her famous book 'Coming of Age in Samoa' (1928) in which she hypothesised whether adolescence was a traumatic event because of cultural upbringing or a biological universal fact[13].

Arguably an ethnographic shift towards participatory observation, allowing a closer insight into the study of a society, can be traced to the scene set by a pioneering ethnographer (even though he may not have known it at the time) Hamilton Cushing, who around 1879 moved in without invitation with the Zuni Indians in Mexico, sketching their ceremonies and getting into serious trouble with the 'natives' as a result. Later ethnographers such as Mead and Evans-Pritchard (famous for his 1940 study of the Nuer, a pastoral tribal group from the Sudan area) began to use 'participatory observation' in their own studies, and firmly established this as a creditable and desired field research

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[13] There have been since of course much questioning of the data collection, fieldwork and recording methods for both Malinoski and Mead (for example, Stocking 1983 and Freeman 1983).

method within their own institutions of top British and United States universities. Their understanding was that the participation method required the researcher to get as close as they could to the community through participating and thereby integrating within the daily lives and events of that group so that they could be less intrusive than an 'outsider' observing events. Participatory research thus meant a lengthy study in the setting which possibly allowed the researcher to establish themselves within the community and gain trust in order to attain information that is both apparent and that which is less so. This includes information on societal expectations, rules, regulations, taboos and so on. The underlying message is that it is only through observing the observable, and getting to grips with the hidden, invisible meanings which participatory observations allow that we can begin to decode social interaction and behaviour. Of course over time, these early ethnographic studies have received much criticism concerning their assumptions about racial differences and how 'the other' is viewed, fallacies and misinterpretations of societal behaviour, and methodological errors.

It is also pertinent to note that at the same time ethnographic notions of fieldwork and participatory observation were being moulded into sociology from the 1920s through a highly influential set of sociologists known collectively as the Chicago School (because they were based in one of the world's oldest -1892 – Sociology Departments at the University of Chicago).

These pioneering sociologists regarded the study of the dynamics of the urban environment as a critical way forward in understanding social relations within the metropolitan areas of the United States (through which planning and policy issues could be addressed). Their approach can be characterised as focussing on the city, with investigation based on qualitative data and a rigorous approach to data analysis. Amongst the many illustrious names associated with the Chicago sociology school are:

- Frederic Clements who theorised on how communities develop;
- Edward Burgess who explored correlations between natural and social systems, formulating theories of land use in cities to which urban geographers still refer;
- William Thomas who laid the department's foundations for rigorous qualitative methodologies in his studies of Polish immigrants;
- Louis Wirth who also researched immigrant communities;
- Herbert Blumer who explored how we relate to a wider community through meaning, language and thought in an interplay he labelled "symbolic interactionism";
- Irving Goffman who reflected on how we present ourselves to society, giving rise to questions of identity.

The contribution that these and other sociologists have made is simply too big to go into here, but if you are interested, you can carry out your own further research. For our purposes, what is important to note is that social science by the 1950s became heavily associated with qualitative data and qualitative methods such as participatory observation which could be carried out in locations related to everyday life, and enable a study of micro-scale interaction as with criminal and deviant behaviour, collective mob behaviour, behaviour of the rich and poor who live side by side in cities and so forth.

Having read this brief history of how social science has taken qualitative data and participatory observation and remoulded it to fit its own purposes of commenting on societal interaction, you may well ask how this can be used to tell the story of people's lived experiences of climate change. If by any chance you did wish to use this method for your thesis or any other project, and have allocated yourself time for a lengthy piece of work, you will need to consider at least three[14] issues: (i) how can I access/ or gain entry

[14] There is, of course, a fourth question of a different order: How will I find the time as a Masters student?

to the groups/communities I wish to observe; (ii) what will my role and research encounter be in that community; (iii) what type of data must be generated to support the research hypothesis and how will I construct a plausible, tested account of what I have encountered for dissemination purposes. All of these questions are different to the ones you might ask for natural science observations in a laboratory. However, let me give you an example to demonstrate how you might begin approach them. In doing so, I will attempt below to lead you into thinking about the first two questions, but will return to the third question in the final Chapter 7 on how to design your dissertation.

There are many ways to gain entry and access to a group or community but each has to be carefully negotiated in the first instance. All communities have some kind of hierarchy, and to negotiate entry you may have to work through these (and there can be many rungs to this ladder!). For instance, when I was carrying out some research in India and needed to obtain information regarding strikes in textile mills from a prominent trade union leader in Mumbai, I had to jump through several hoops where I was 'checked out' by several of his 'henchmen' who did or did not understand my intentions, thinking I was a journalist. A textile workers committee that was very loyal to this particular leader wanted to know 'whose side I was on'; policemen and authoritative figures wanted to know whether I was a security risk or would somehow get in the way and so forth. Eventually after several visits and several questions, I was shown into a makeshift office where I met the leader for half-an-hour during which he mostly evaded my questions! Usually, therefore, there are several 'gatekeepers' you have to pass before you can even think of participation.

One way of gaining entry, particularly when you wish to reach groups that are spread out and not familiar with you, is to seek people who are trusted and have intimate knowledge of each group's lives and livelihoods. For instance, many researchers who work in the field of development will be drawn towards practitioners working with development agencies and non-governmental organisations (NGOs) to help them identify and gain access to groups, maybe even help to collate data. Below, for instance, are (Figures 4.6 and 4.7) images taken at a participatory workshop based at Makerere University, Kampala (Uganda) in 2009. This workshop was about developing ideas on how to access and gather information from groups across North and South of Uganda and other parts of the East African region on their everyday lived experiences of climate change. The groups in question are the very poor, often subsistence, farmers and the workshop participants included practitioners from different NGOs working with them and academics from Makerere University and two UK universities. In this case, the practitioners are working out ways the research can be done and what methods would be used.

Figure 4.6: Development practitioners working in various regions of Uganda at a research workshop, Makrere University, Kampala (Source: D.Abbott).

After initial discussions, the groups came together to present their ideas of ways forward to the rest. At the end of the workshop it was decided that certain regions would be more suitable than others for research purposes, how entry could be gained and what type of research methods would be most suitable to develop for the next stage of the process. The workshop also discussed the roles of the practitioners and academics in carrying out the research.

Figure 4.7: Groups report back (Source: D. Abbott)

In this case, the approach to participation is overt and open. All involved, including the respondents and people who will be interacting with the researchers know about the research and its intentions, particularly as it is hoped that the findings will provide some authoritative information about climate change and poor people’s lived experiences of it, which will enhance practice, planning and understanding. Hopefully, the research process will also enhance the respondents’ own understanding, empowering them to deal with issues in a clearer way. Do note, however, that not all participatory observation is overt, thus raising many ethical questions - an important point with which I deal in Chapter 5.

Social science participatory observation can be a highly rewarding experience, but only if carried out methodically, systematically and ethically. However, I do want to caution against using this lightly, not only because of the time for research and data analysis involved, but because you may find yourself unable to handle situations as they arise. Even the most experienced researchers have to confront the most awkward moments and sometimes have to make the most uneasy compromises. For instance, in my textile mill research based in Mumbai slums, I came across incidences of domestic violence, women’s secret savings, payment for food in return of sex, infant deaths and so on. This required much mental compromise and an extreme command of emotional self-control and guarding of information that was obtained. There was also the issue of how I was viewed as a researcher, and how some people felt threatened in giving me information when they did not understand how it would be used (Abbott 1995).

In summary, observation in social science necessitates participation and researcher engagement within the research context (of the human ‘laboratory’). Whilst there are equal demands of rigorous and careful methodology as in the natural sciences, in social sciences participation is a hugely complex, lengthy affair which cannot be entered into lightly.

4.3 Underlying assumptions of the social sciences

In order to understand what marks out social science research, we can examine two underpinning assumptions, (i) a methodological one which to a significant extent focuses on qualitative data as a primary tool for commenting on societal interaction, and (ii) an ontological one which not only regards research as value laden and anything but objective (in contrast to positivism of natural sciences), but one that actually celebrates subjectivity of research as of value in itself.

4.3.1 Methodological assumption: underpinning qualitative methods

Table 4.1 below, while not claiming to be fully comprehensive, covers the main strengths and weaknesses of quantitative and qualitative methods in the social sciences:

Table 4.1 Quantitative and qualitative methods: Some potential strengths and weakness

Quantitative methods: Potential strengths	**Qualitative methods: Potential strengths**
Data gathering and analysis is precise, dictated by professional and academic guidelines. Rigorous analysis and reliability of data and findings, allowing generalisations from samples to overall (comparable) populations, socio-economic groups etc. Replicability and transferability. Leads to action, possibly through policy 'from above'.	Flexibility and open-ended methods that allow deeper insight into respondent lives and any incidents that may not arise directly from the researcher. More detailed with deeper insights into social interaction and relationships. Deeper insight into sensitive issues; the "voiceless" "missing" persons (such as footpath dwellers, illegal immigrants); and societal practices and ideology. Potentially empowers respondents (as with participatory inquiry) rather than treats them as objects of research. Leads to action, possibly beginning from a 'bottom-up' grassroots level.
Quantitative methods: Potential weakness	**Qualitative methods: Potential weakness**
Aggregated information and rigid categories do not allow or cut down on certain data, for example the details of social interaction and relationships, underestimating information on sensitive issues. Often focuses on mainstream groups and where formal information is available, although studies of marginal groups and alternative information are also possible. Large amounts of information that are difficult to analyse or use meaningfully.	Analysis and collection methods difficult to validate as rigorous. Meanings of categories and definitions are researcher-interpreted rather than commonly understood. Data take a long time to gather and analyse and exercise is costly. Questions of generalisation and, representations not clear. Lack scientific validity and so results may not be taken seriously. Data cannot be tested. Researcher bias, language criteria, ability of enumerators are all unchecked by standardised procedures. Large amounts of information that are difficult to analyse or use meaningfully.

Table 4.1 represents a necessary exercise in understanding the value of these techniques of gathering information. However a note of caution: we should not regard quantitative and qualitative data as compartmentalised, 'either'/'or' techniques embedded within a dichotomous model. There is no doubt that the history of methodological discourse has had its moments when provocative statements have been made as if the respective proponents are engaging in a qualitative 'versus' quantitative 'tennis match'- which is ultimately not very fruitful in conducting inquiry, as can be seen in Figure 4.8 below!

Figure 4.8: A qualitative/quantitative battle: Is there a 'versus' coming in between us? (Source: Google images)

Social science methods have historically not always been dominated by qualitative methods. In fact social science continues to draw on quantitative data and ponder how it can be worked within a convincing interpretation that is essentially located in a positivist, statistical framework (see for instance, Bulmer and Warwick 1993). However, there have been critical inputs that have, particularly since the later part of the 20th century, made qualitative methods dominant.

A marked input into the shift towards qualitative methodology has evolved from gender studies[15,] essentially challenging what are claimed to be the gendered leanings and ideology of rationalist, quantitative methods. Following the 'waves' of western feminist discourses in the 1960s and 70s, publications on the gendered nature of research processes began to appear in the early 1980s. On a personal note, I recall that as a student I had always been worried about getting my methods 'right' and intimidated at the thought of justifying them in any written work. Thus when I came across a small book entitled "Doing feminist research' by Roberts (editor 1981), I was highly excited as it gave a whole new meaning to research, embedding this in the context of societal ideologies and opening up a new philosophical paradigm on research processes (and meanings of reality and knowledge that I discuss later in Chapter 6). What this book suggests is that research is about power and powerlessness. This is reflected in (i) the way we communicate with the respondents to our questions sometimes as objects of research (Roberts ibid p7–29, Oakley 1981), (ii) androcentrism[16] of data analysis (Delphy, 1981), (iii) and what research is done, or not done through lack of institutional support -- thus limiting our knowledge to what these institutional 'gatekeepers' think is important (Spender 1891).

What was new and radical here was the notion that research is not simply about gathering data and analysing it according to set models and formulae and getting the techniques right. Research, it was argued, is much more about the hidden meanings and assumptions behind all stages of the research process (as identified in Section 2.1 Figure 2.1) and reflects our societal beliefs, gendered relationships, questions of equality, inequality and discrimination which are entrenched within the dominant political, economic and ideological contexts of the worlds we live in.

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15 There are of course other leading subjects and disciplines who also questioned the emphasis of quantitative rationality in the 1970s and contributed significantly to qualitative methodologies for social sciences, for example Development Studies, Geography and a post-colonial discourse.

16 Androcentrism is the practice, conscious or otherwise, of placing male human beings or the masculine point of view at the centre of one's view of the world and its culture and history. (From Wikipedia).

In the 1980s, qualitative methods were described as 'soft methods', quantitative methods as 'hard methods'. For feminist social scientists, this terminology encapsulated the main issue: Roberts (1981 p 22) shows the thinking of the time in the following:

> The language in which we make distinctions between qualitative and quantitative data is, as Pauline Bart (1974) writes, not gender-neutral. She has her own solutions (p 1): "We speak of hard data as being better than soft data, hard science better than soft science, hard money better than soft money. In the fifties, one was being criticised for being 'soft on communism'. This is of course a male sexual metaphor, so since discovering this, I have substituted a metaphor based on female sexual experience and refer to wet and dry data.".

The above quote shows how strong the feeling was on the nature of data and power that came across in the language of research processes, though of course with the passing of time we can now find some humour in it! But what has happened is that qualitative methods have become grounded within social science inquiry which continues to deconstruct concepts, definitions, meanings, metaphors and symbolisms and the societal ideological context from which they evolve.

This kind of unyielding conflict between which type of overall method is better for discovering 'truths' based on social science research has somewhat died down, although there are still some dismissive attitudes from time to time. For instance, Berg (2004 p3) cites a Miles and Huberman quote (1994, p90) from Fred Kerlinger, a quantitative researcher that "There is no such thing as qualitative data. Everything is either a 1 or 0", while countering the argument is D.T. Campbell that "All research ultimately has a qualitative grounding" (ibid). However, by and large there is an acceptance that there is value in seeing both methods as complementary rather than opposites. Even some older-day feminists have relented somewhat as is evident in Oakley (2000). Oakley, an ardent campaigner for qualitative methodology in the 1980s, surprised many with her year 2000 seminal work, "Experiments in knowing: gender and method in social science", on the history of the qualitative-quantitative dichotomisation. There, Oakley argued for a reconsideration of experimental methods, and that the dichotomy today "functions chiefly as a gendered ideological representation" (ibid, p3). Oakley had in fact started developing this argument in an earlier paper (Oakley 1998) where she argued that "the history of social and natural science [suggests] that a social and historical understanding of ways of knowing gives us the problem not of gender and methodology, but of the gendering of methodology as itself a social construction." Thus Oakley changes her stance in proceeding to say that she is "in favour of rehabilitating quantitative methods and integrating a range of methods in the task of creating an emancipatory social science."

Whilst we may have moved on from the idea that quantitative and qualitative methodologies are polarised, and that they are in fact complementary[17], social science nevertheless needs still to defend its qualitative leaning. This is because qualitative methods include a whole range of techniques such as observation, experiments and surveys as discussed in Section 4.2. They also use other techniques which might seem at first glance somewhat illusive, such as photographs, video, historical documentation analysis to name but a few. Which technique is used when depends on the question and context under research. For instance, one of my PhD students, Bridget, who was studying banana production in Uganda, used life timelines (Figure 4.9) to break down barriers between herself as a researcher and women small-farmers.

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[17] In fact most social science students nowadays get a grounding in quantitative data analysis and introductions for using computer-led programmes such as SPSS. See. For instance, Rose and Sullivan (1996).

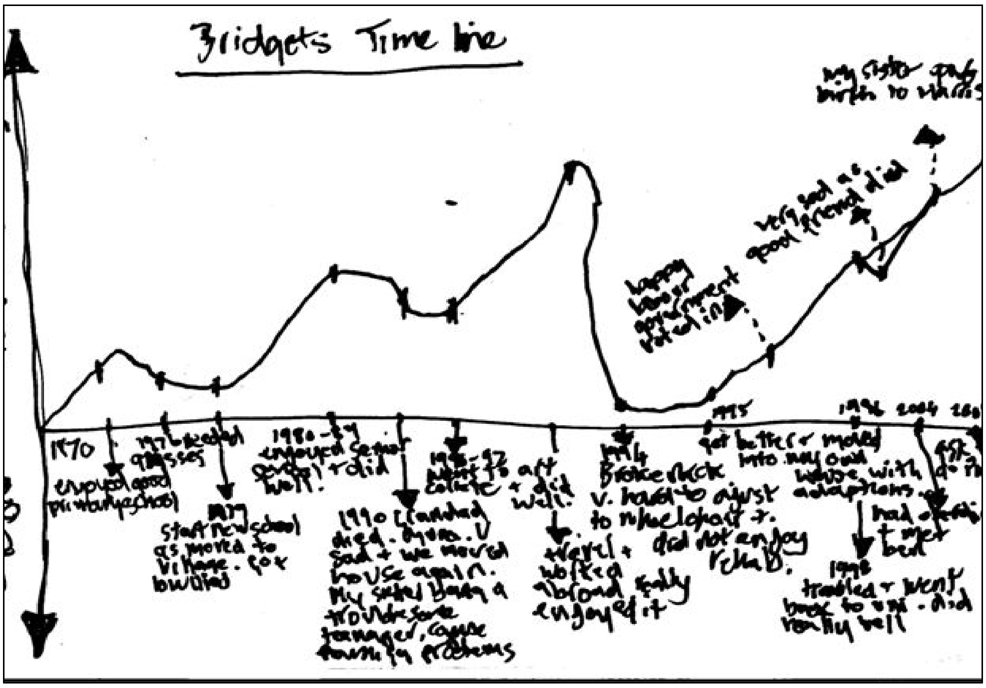

Figure 4.9: Rough field notes of a personal timeline as an example to begin dialogue on shared experiences (Source: B Leadbeater).

Here is an extract from Bridget's field notes concerning the timeline:

> "Being aware of changes in livelihood through time, appreciating the 'life experience' of the farmers consulted for the study was imperative. Hulme (2004) employed 'ranked timelines', where respondents created a timeline and rated defining experiences as 10 to -10 retrospectively -- I felt it could be adapted as a component of the study. After completing a long semi-structured interview nervously, I requested farmer participation in creating personal timelines. In view of breaking down barriers and in an atmosphere of shared experience I represented my life story in a timeline and used it as an example (Figure 4.9 above). Surprisingly, after listening to my blemished life story in which I referenced political, personal and some societal changes, they agreed to draft a timeline defined entirely by their particular momentous events.
>
> The control of revelation was therefore in the hands of the farmers. However, issues of domestic violence, alcoholism, rape and the death of children reoccurred in timelines of the women. Aspects of gender relations, unethical and difficult to broach in an 'interview' situation, were raised by the process of creating the timeline. Feedback after drafting timelines included comments such as 'I did not realise I had done so much in my life'. A number of women declared no one had ever asked about their lives, and that just someone showing an interest in the details of their livelihoods 'made us feel better'. Although distressing to read at times, timelines on the whole, were a rewarding exercise for all participating" (With kind permission from Bridget Leadbeater: Field notes for work in preparation).

Bridget's approach did a number of things: (i) by opening up her life history, it allowed her to participate in the research, but also made it secure for other women to impart with sensitive information about themselves, (ii) it gave women a chance to reflect on important but traumatic events in their lives that they may have not been able to voice in their everyday social interaction; (iii) the process generated some confidence and feelings of empowerment through a recognition of what was happening in the women's lives, who besides being small-farmers are mothers, wives, and daughters with another societal role. In her research, Bridget has of course also used quantitative data, for example that from laboratory experiments on banana tissue culture, statistics on banana production and so on. However, to find out more about the lives of small-farmers who contribute so much to the Ugandan family and culture which surrounds the growing of bananas as staple, it is necessary to engage with qualitative methods, even if they may appear obscure and difficult to analyse. Nevertheless data generated from qualtitative methods, like that of quantitative ones, also require a rigorous analysis as discussed in section 4.4 later.

4.3.2 Ontological assumptions: celebration of the subjective

Throughout Chapter 3, but particularly section 3.3 you were exposed to the idea that underlying all processes of natural science research methodology, is the notion of objectivity and neutrality and that this is to be guarded at all costs. In contrast, contemporary social science mostly argues that there is no such thing as neutrality and objectivity in studying any aspect of society. As I argued in Section 3.4.1 (historical legacy of natural sciences), nothing is free of a social context and existing social knowledge of the time. Most social scientists (sometimes also known as humanist researchers) thus argue that there is a subjective element underlying all research, whether based in broader areas of natural or social sciences, and emphasis on rationality, neutrality and attempts to objectify can be disingenuous. In fact discourses which include ethnography, feminism and development argue that subjectivity is a necessary part of research and has to be recognised explicitly and reflected upon carefully to produce fresh knowledge and give a fuller account of the study in question. In this view, social sciences, rather than spending considerable time and effort in weeding out subjective ‘interference’ in a search for pure objectivity, should in fact celebrate subjectivity, being clearly in contrast to the underpinning ontological assumptions of the natural sciences.

Prior to a further discussion on the value of subjectivity to research, firstly pause with me for a moment and think of why we, as individuals, do research at all. There are, of course, several external motivational factors in this, for example you may have particular principles or personal beliefs that draw you to specific subjects, you may be asked by your institution (which may be a practitioner organisation as well as a university) to take part in a particular project and you dare not refuse for fear of jeopardising your job, or you may wish to gather empirical data in full or partial requirement for a degree. You may also carry out research simply because you come across an opportunity that is too good to miss and appears to be within easy reach. For example, Berg 2004 (p 157) cites the Alders (1985) who carried out a dubious, dangerous piece of research (which may not instantly appeal as a subject) on drug dealers and smugglers because they met “Dave”, a “dodgy” neighbour after renting an apartment on the beach following the end of their graduate studies. It so happened that “Dave” was a member of a smuggling gang importing “a ton of marijuana weekly and 40 kilos of cocaine every few months” (Alder 1985, p14), thus giving the Alders a ready access to the wonderful world of high-level drug dealing!

There are many such stories which illustrate that much research is led by personal motivation and opportunity. However, whether the researcher seeks to expose these as the motivation for their subject choice at the start of the study is debateable. More often than not researchers, heading towards the end of their research, will attempt to justify their choice as a part of some grander plan. Nevertheless, it is rare to be led into research in an objective, righteous quest for knowledge. That research is in fact usually led through personal interest, often dominated by everyday, practical realities and human feelings is perhaps more true. But because academia and decision makers have applauded rationality and underlying objectivity, social scientists believe that researchers will attempt to mask their true motivations and feelings of what led to their research choices in a form of “self-deception”. Sometimes this self-deception is also carried through other stages of research, and researchers may attempt to cover field events, sterilise methodological dilemmas and produce what they feel will be regarded as a “proper” research account and knowledge that is acceptable to “respectable” bodies.

Whilst there is little doubt that social scientists continue to do this, there has since the 1970s been a growing literature on the importance of recognising personal feelings and motivation behind research, and an encouragement on subjective reflection throughout the research process. The mainstay of the argument is that there is no need to seek out the moulds of rationality that real life research may perhaps be squeezed into, but to be honest about subjective motivation and feelings. In fact, it is argued, a reflection on these will produce better research. For instance, during fieldwork, you will no doubt make note of timings, durations and events that occur during the course of research. This is a necessary and valid part of collecting data so that you can compile systematic records for analysis purposes at a later stage. However, besides recording the frequency, rates of events and any other observations, if you also reflect and record your own feelings of these events, you may be rewarded with deeper insights.

For example, below is an extract from an earlier piece of self reflection I wrote (Abbott 1995: 9–10) when working in the slum localities of Mumbai. This is about the methodological dilemmas of researching poverty and shows that admitting to your feelings and reflecting upon them can deepen understanding of one of the most complex real life issues, that of poverty. As you may be aware, poverty is often measured through indicators such as unemployment, illiteracy, Gross National Product or Income per capita, and Gross Domestic Product per capita. Explanations are sought through associations and correlations between these factors, and policy is made on that basis. However, read this account as an example of interpreting poverty through personal feelings:

> **Example of subjective reflection on poverty:** The question of being a foreign researcher has, in fact, posed a lesser dilemma for me than my ability to comment on poverty. Amongst other things, I continue to worry about my (comparative) privilege: How could I, who would possibly never experience poverty at this level, write about it? I also continued to be worried about exploitation: Have poor people not been “research objects” for long enough? Yet I cannot answer their question, “What will you do for me?” when it was me who was “after something” (my research perhaps?)
>
> Nothing in social science had prepared me for dilemmas like this, or taught me how to research poverty. My privilege kept on interfering and in their friendliness and hospitality, the women (in the slums) continued to remind me. Thus, they rushed to borrow a chair from a neighbour when I visited even when I insisted on sitting on the floor; they sent children out to buy soft drinks and milk even when I knew that these would never be bought for the children themselves; and they insisted on “honouring” me by cooking a “mutton curry” even when I am a vegetarian because this is a rare treat for them!
>
> Through their actions the women made it quite clear that there was a vast gap between us and that I would never be able to understand poverty except from a privileged position. Therefore…. my understanding of poverty came through my own reactions - an understanding which shocked me out of any assumptions I held about being poor and which, in turn, generated numerous other moral dilemmas.
>
> To give an example, social science had taught me that when conducting fieldwork, expect the respondents to ask questions about yourself and be prepared to give truthful replies. So when women asked me how many children I had, I replied that I had two. What came to me as a shock was their next question, “How many have died?” The matter of fact tones of this question (which occurred several times) and my own startled response to something I would never have dreamt of asking anyone at home (the UK), told me more about poverty (and my privilege) than any amount of quantitative data on the subject of infant mortality.
>
> In another instance, on a repeat visit to one woman, I saw her seven year old daughter lying on a mat. I stroked the child’s head and asked her what the

> matter was. Her mother informed me she had typhoid. I had to prevent myself from jumping and showing my panic at the thought that I had actually touched someone with typhoid, thinking I too would catch it. Having tried to control myself, I asked her if the child had received any treatment. The mother nodded and showed me a packet of the painkiller, paracetamol.
>
> In my supposedly objective role as a researcher, I faced many dilemmas in a matter of seconds. I cannot comment on how the mother must have felt because I had not faced that type of hopelessness. I could not inform the mother that the medicine on which she had spent (what was for her) a lot of money, would do little for the child. I could not “rescue” the girl because in poverty these things happen over and over again. Yet I could not but read into the mother’s eyes that she wanted me to give her some money for the child, and I could not but empathise with her because I had a child of about the same age.
>
> There are no sociological guidelines on how to deal with this or the “guilty” feeling I developed because I could walk away at any time, and the people who had been so friendly to me could not….

Whilst there is plenty of quantitative data available on poverty in big city slums, this kind of qualitative data allows you to move away from the need for objectification because here, subjectivity and subjective reflection which draw on your inner feelings help to throw light on multifaceted, complex concepts of privilege and poverty. In contrast to rationalist arguments, some social scientists argue that if you use methods that seek distance, your understanding of the subject will also be at a distance (Patton 2002).

It is for this reason, and the fact that some subjects in themselves are highly poignant societal issues, that it is difficult to ask the researcher to be distant. In fact a critical discourse on the notion of subjectivity and subjective reflection has become embedded strongly within certain disciplines -- women’s studies, cultural studies and psychology, for example. This is maybe because the subjects that these disciplines tackle are very contentious in themselves. Examples include domestic violence, sexual deviance, forced marriages, mental health, suicide, self-harm, racism and so on -- usually subjects that are not openly addressed by society, or indeed by the individual. For such subjects, increasingly we have been able to compile quantitative data, but qualitative social scientists will test this, and give it quality through a use of subjective experiences and values. For instance, in the UK, we have various types of census, police, local authority and government data on internationally displaced refugees, those seeking political asylum and/or arriving legally or illegally into the country. This data is used on many occasions by the media, politicians, service providers and campaign groups who do or do not support them. However, this data is based on numbers, and much “number crunching” goes on to create bias in whichever way the argument is leaning. There are then many contradictions in the figures, on who is arriving or leaving, where they are placed and what their position in the UK society is. Recently, however, qualitative studies that have included individuals from these marginalised groups and exposed their version to society (whether through on-line, printed or visual materials), have steered us towards examining societal myths and self-deception about our subjective selves and true feelings about what has been labelled an “influx” (Sigona and Andreea 2005).

The subjective in research is important in other ways too and can advance the researcher’s own theoretical understanding of the personal. For instance, people often do not know how to deal with disability, even if the disabled person is fairly confident in dealing with their disability. Here is a reflection from Bridget, the PhD student I mentioned earlier who is herself disabled, commenting on her fieldwork experience in Uganda (Figures 4.10 and 4.11):

Figure 4.10: Bridget conducting research with women farmers (Source: B Wise)

Figure 4.11: Bridget conducting research with women farmers (Source: B Wise)

> **Example of subjective reflection on disability:** Research embodies the prejudices of society towards people with disabilities, but also the web in which the research sits is connected by normative hegemony and thus creates the abnormal, the 'other', the disabled, the native, the colonised subject. Thereby the research replicates hegemonic notions of normativity. CouId I, as a disabled researcher, break the 'normative hegemony' which disrupts people's prejudices and asymmetrical structures of the norm? The elite don't like it, they try to push you down, or they treat you as non-threatening, or trivialisation.
>
> Differing disabilities are regarded more negatively than others and this connects to complicated social forces. For instance, disability is connected to the ability to produce in industrialised society, where some impairments are more disabling than others. So today in western society a cognitive disability, or lesser literary capability, is regarded as more disabling than another physical disability. This reflects western societal dependence upon the written word, computerisation and literary ability to negotiate the digital world is associated with postmodern productivity and power. Whilst conversing with farmers in the rural areas of Uganda during the research, aspects pertaining to impairment/disability arose constantly. A number of farmers could see the environment was physically challenging for me to

> function. My wheelchair, even with its mountain bike tractor-style attachment, jerked and jarred its way through rutted banana plantations. However, one women farmer commented, 'But look at how she can hold a pen and write… I cannot.' Farmers could see that I had a useful function of being able to write, while many of them could not write. Although, with my abilities, it would be a great strain for me to farm, in fact, it is unlikely I would be alive as the level of technology to keep me healthy and well is not available for the majority of people living in rural Uganda. This makes me feel quite strange at times. Another incident whilst conducting research was perplexing. At a visit to an organisation of disabled people, the secretary asked if she could try using my wheelchair as I transferred in to the 4x4. The women usually used "flipflops" (rubber sandals) on her hands, and got around on all four limbs, and knees at times. After unsteadily moving around the compound in my wheelchair, she decided she could do more, better and with greater speed without the wheelchair. I gave her a few pairs of my heavy duty pushing gloves, with which she was delighted.
>
> Both these real incidents made me question disability, culture, function, usefulness, commodification, impairment, and others, in a whole new light".
>
> (With kind permission from Bridget Leadbeater, field notes for work in preparation).

Bridget's example and subjective reflection gives us insight into the differing cultural contexts of research where research methods developed in a western academic world prevent rather than enable her in what she calls a 'normative hegemony'. Yet, in the mainly illiterate cultural context of the rural community she is working in, her ability to read and "hold her pen" is highly regarded. People do not appear to be in denial of Bridget's use of wheelchair, rather intrigued by it, with another woman almost challenging her in saying that she can go faster on her limbs than the wheelchair! You can see from the last sentence that the subjective-reflexivity enabled Bridget to boost her own understanding of disability, definitions of which emerge out of particular socio-cultural contexts. Here, the personal is the political and it is impossible to keep it at a distance as positivist research demands.

To sum up, in contrast to those who seek neutral and objective encounters and argue that their research is value-free and undeterred by standpoint or social positioning, many social scientists tease out the subjective feeling behind researcher reactions and use subjectivity as a methodological tool to enhance subject understanding. Research is thus something that is, and needs to be, understood as embedded in a personal and socio-political context.

Finally, remember that acknowledging the researcher subjectivity may prove very valuable in researching the lived experience of climate change, particularly to gain deeper insight into individual vulnerability and climate change. In fact, arguably it is perhaps impossible to study "lived experience" without accepting and using your own subjectivity. I would therefore encourage you to turn to Activity 12 in the Module 3 workbook where you can explore this further with your own example.

4.4 Rigour in the social sciences

Social scientists use several tools for data analysis, particularly when analysing qualitative data which I focus on here. Miles and Huberman (1994 cited in Berg 2004, p266) classify three basic approaches, all of which take enormous time and effort:

1) Interpretative approaches where social action and human activity are seen as a collection of symbols rooted in layers of meaning. To interpret data that are collected often through interviews and observations, interpretative approaches transcribe them into text which may be sorted, coded and organised at a later stage to decipher patterns of human action and the layers of meanings.

2) Social anthropological approaches where attempts at representing behavioural patterns, language, rituals, ceremonies and social relationships of everyday life of a particular group or community are made by drawing on data from field notes and several other methods (e.g. photographs, diaries, videos, drawings, artifacts). Again, information is presented as text and analysed for regularities and irregularities.

3) Collaborative social research approaches where data is gathered through collaboration with stakeholder groups who wish to generate social action (e.g. as with participatory research). This type of research necessarily generates complex, overlapping, diverse data and therefore analysis also employs various strategies. For example, data is also textually 'translated', coded, categorised for regularities and disparities, meaningful patterns and relationships, often through the knowledge gained from patterns and generalisations in previous studies and literature hunts.

As I suggest above, qualitative social science data takes much time and lengthy processes to analyse, for instance through semantics and word counts, theme counts, conceptual patterning, alongside several other units and categories of analysis as determined by the nature of the study. All are also often coded through coding frames [18] either manually or, for faster results, through computer programmes such as the Statistical Package for the Social Sciences (SPSS). Related software has also been specially developed for some stages of the process, for example newer versions of Atlas-ti, HyperQual, Nud.ist. There are cost and time implications of using these packages, which does raise the question of whether they help or hinder. And, of course, a human eye and brain is required to interpret anomalies and develop insights.

Nevertheless, because qualitative social science research often concerns deciphering symbols, meanings, definitions, rituals, social structures, social interaction and societal roles, it is difficult to see how the data generated from it can be reliable, especially as it is subject to researcher bias, and is more often than not, uncontrollable and unquantifiable. So it is not surprising that qualitative social science research is often scrutinised and attacked by the scientific school. Nevertheless, it is very possible for social qualitative science research to be systematic and rigorous and, (if it is necessary to satisfy the scientific community) replicable.

One way by which checks are carried out is through 'triangulation'. Berg (2004 p5) describes how the term was originally associated with map making, navigation and military practices. He explains that "In each case, three known points or objects are used to draw sighting lines towards an unknown point or object. Usually, these three sighting lines will intersect, forming a small triangle called the 'triangle of error'. The best estimate of the true location of the new point or object is the centre of the triangle, assuming that the three lines are almost equal in error. Although sighting could be done with two sighting lines intersecting at one point, the third line permits a more accurate estimate of the unknown point or object".

In social sciences (as with natural sciences), similarly triangulation is used to check error and minimise doubt by drawing on more than one method of investigation and analysis. This can be done in a number of ways, including comparisons of data-collection methods, theories, methodologies, field notes and any other records such as diaries, photographs and even those of different researchers. Triangulation therefore usually requires a multi-method approach for a systematic analysis as suggested by Denzin (1998 p295 cited in Berg ibid), in his four categories of triangulation:

i) "Data triangulation has three subtypes: (a) time, (b) space, and (c) person. Person analysis, in turn, has three levels: (a) aggregate, (b) interactive, and (c) collectivity.

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18 I have no space here to look at all the processes, but recommend Chapter 11, Berg 2004, p265–295 to explore coding frames and other processes of social science analysis as supplementary reading.

ii) Investigator triangulation consists of using multiple rather than single observers of the same objects.

iii) Theory triangulation consists of using multiple rather than simple perspectives in relation to the same set of objects.

iv) Methodological triangulation can entail within-method triangulation and between-method triangulation."

Thus for data triangulation, for instance, you can look for consistency between different points of time, varied settings, and people's differing perspectives and what others in a similar group are saying. For method triangulation, you may want to compare both qualitative and quantitative data collected in the study and see how these compare or diverge. Any major points of difference or 'blips' can then be questioned, perhaps allowing us to gain greater insights. You can also use multiple theoretical perspectives to examine and interpret the data when considering theory triangulation. Investigator triangulation can also be done by carrying out a review of findings and an analysis of how various researchers have interpreted the data, checking for consistency and seeing if there are any blind spots in the way events have been interpreted. In my study (1993) of women who feed the textile workers in Mumbai, for instance, I carried out similar triangulation. For example, when one of the women's reported income for the activity was higher than others, yet she had fewer clients, I had to check out how and why. This opened up another layer of inquiry and revealed an added dimension to how the women negotiated their livelihoods through additional dimensions, in this case drawing on relatives in obligatory arrangements and also sleeping with clients to achieve higher income and manage poverty. Through triangulation and comparative checking, I also discovered the huge differentiation between the women, and how religious affiliation affected their income activity. For instance, Hindu women were obliged to cook additional food everyday to feed clients who were (religious) fasting on different days of the week, thus doubling their labour input, Muslim women could not access Hindu clients and were far more restricted in their movements, thus curtailing their income opportunities.

Rather than seeing triangulation as a technique for validation or verification only, qualitative researchers thus use it also for enriching accounts, and to offer a vigorous, comprehensive and well-developed study. In this, Denzin's categorisation provides a way towards an analysis of apparently 'messy' data, and as such, triangulation is useful in validating the reliability of research findings. The notion of testing validity through a multi-method system in order to substantiate findings nevertheless remains contentious to a degree because there is an underlying assumption that we can somehow adjust for the flaw in one method through making more of another. There is also the assumption that triangulation will enable us to make sense of dissimilar or diverse accounts which may not, in real life situations, be the case.

Since Denzin's categorisation, the philosophical arguments regarding the value of social science triangulation have inevitably moved on. One argument is that triangulation in social sciences, is not just a tool for validation purposes and a technical exercise, but broadens our understanding through conceptual and theoretical linkages of more than one perspective[19]. Secondly, there is also some caution in making direct comparisons between concepts of triangulation, validity, reliability and replicabilty which are essentially embedded in positivist, naturalistic approaches and those that have been adopted for social science-based qualitative research. Referring to (Denzin, 1978), Golafshani (2003: 603), for instance, argues that,

> 'Reliability and validity are conceptualised as trustworthiness, rigour and quality in the qualitative paradigm. It is also through this association that the way to achieve validity and reliability of a research get affected from the

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19 See for instance, Olsen (2004) for argument on the mixing of triangulation methods.

> qualitative researchers' perspectives which are to eliminate bias and increase the researcher's "truthfulness" of a proposition about some social phenomenon using triangulation. (Creswell & Miller, 2000, p. 126) thus define triangulation as "a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study". Therefore, reliability, validity and triangulation, if they are to be relevant research concepts, particularly from a qualitative point of view, have to be redefined as we have seen in order to reflect the multiple ways of establishing "truth"'.

To end this chapter, the discussion has illustrated that qualitative social science is not an 'easy option' research. It too is demanding and requires rigour, reliability and validity similarly to that of natural sciences even if these are triangulated through social science related concepts.

5 Research ethics and moral values

5.1 From unethical to ethical research in both the social and natural sciences

It is not easy to pinpoint exactly how the discourse about ethics in research has evolved. However, arguably, in our historical legacy review (section 3.4.1) we saw the beginnings of strict moral codes in natural science. For instance, take the contentious issue of dissection which caused moral outrage in early scientific history. Galen could only dissect Barbary apes to help understand human anatomy because the accepted societal norms of the time excluded him from dissecting human bodies. In 1539 when human dissection continued to be illegal Vesalius (Padua University) was granted permission to dissect, but only on the bodies of convicted and executed prisoners, the ethical rationale being that somehow these criminals were sub-human and their bodies deserved nothing better. Similarly records show that in Edinburgh, Scotland (UK) during the 1800s, medical schools were allocated the body of one convicted criminal each per year, to aid the teaching of anatomy (www.scotshistoryonline.co.uk). However, with a sharp increase in student numbers, demand soon outstripped supply. This opened up an opportunity for body snatching, proving that, whatever the underlying ethics and moral code of society, there is always someone prepared to supply a desired commodity and another to pay for it!

What these historical examples demonstrate is that the philosophical debates about what is ethical and what is morally acceptable depend on the societal context of the time. You will have noticed, for instance, that any research you conduct these days will demand that you think of ethical considerations. You might even find that your own institution, whether this is a higher education one or a practitioner-based one (such as with medical workers or NGOs), will provide some guidelines in the form of written codes and/or internal advisory research ethics committees which will scrutinise your proposal. Whilst there is again no modern-day historical conjecture at which we can identify growing interest in research ethics, much of the literature points to two historical occurrences that have had a major influence on our collective conscience, and shaped an ethics discourse. These are: (i) the establishment of the 1949 Nuremberg Code for research on human beings following the inhumane treatment of thousands of concentration camp internees by the Nazi "Doctors of infamy"[20] during World War 2 under the semblance of "biomedical research"; and (ii) the 1950s/60s emergence of civil rights social movements that provoked questions of human rights, responsibilities and voluntary, informed consent for those taking part in the research.

These occurrences clearly indicate that ethics discourse for research is intertwined with a quest for knowledge, but how this is done is very much located within societal ideology and beliefs of what is morally acceptable at a given time as is evident from the wartime research example.

To allow you to grasp this point, let me offer you further detail with two examples of bad ethical practice that were commonplace within the early 1960s United States context.

Example 1: the research of Stanley Milgram, a psychologist based at Yale University.

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[20] The Nuremberg war crimes trials brought out the full horror of the "Angle of Death", Dr Mengele's medical experiments on people, particularly 3,000 twins, of whom only 100 survived. However, Dr Mengele escaped justice and managed to live secretly in Paraguay and Brazil until his death in 1979. For further detail, see http://www.longwood.k12.ny.us/lhs/science/mos/twins/mengele.html.

Taking a cue from the defence offered by Nazi war criminals during the World War II Nuremberg trials, which was that they were "following orders" during the holocaust, in the early 1960s Milgram conducted experiments on how far a person will go in obeying authoritative commands, and how they would handle the conflict created by the imperative to carry out these commands and their conscience. He also wanted to know at what point they would challenge authority.

Milgram therefore selected random respondents to act as 'teachers', teaching 'learners', hidden behind a screen. The idea was that if the 'learner' gave an incorrect response, the 'teacher' would initiate an electric voltage shock and hurt the pupil sitting on the other side of the screen. The "teachers" were informed incorrectly that the experiment was to explore the effects of punishment on learning, and did not know that the "learner" was an actor faking distress caused by the electric shocks. During the experiment, every time a wrong answer was given, an authoritative looking "laboratory assistant" standing in a white coat next to the "teacher" urged them to increase the voltage, which would of course "hurt" the learner even more. The experiment had some interesting results, with some "teachers" being clearly uncomfortable by the distress they caused as the voltage increased. Nevertheless, in spite of the obvious discomfort between what they were asked to do and their conscience, most continued to increase the voltage, with only a few protesting and withdrawing from the experiment. In contrast, a few others simply obeyed instructions, even taking pleasure in this. Whilst there is no doubt that the findings of this study were shocking in that the link between obedience to authority even in the wake of internal conflict is not clear, it raised several ethical questions. These related to unethical practices of the whole experiment where respondents were lied to (no matter how righteous the cause), and placed in a distressful position causing much internal guilt and moral conflict.

Example 2: the "Tearoom[21] Sex" PhD research of Laud Humphreys

Within the context of moral outrage and heavy police activity against homosexuality in the 1960s United States, Humphreys decided that is was important for society to gain a better understanding of what type of men engaged in homosexual activity with strangers in public places in order to gain quick, impersonal sexual gratification.

To carry out research on such an intimate and covert act, Humphreys adopted a "participatory observation" role in which he presented himself in a voyeuristic role of a "watch queen", watching out for the police before and during men's encounters. He chose this role as it gave him a chance to observe the men's behaviour as well as gain their trust. A year or so later, Humphreys also traced the men back to their homes through following them, tracking down their car number plates and pretending to be a health research worker, discovering much personal detail including detail of jobs, marital status and so on. From this he discovered that over half the men were married, were "respectable" with good jobs and families, with some holding high status positions in society. Whilst his research therefore did reveal findings that were surprising and challenged stereotypes of the time, there are several ethical questions about the way this study was carried out which concern the secretive and deceptive nature of it right from the start. In addition, there is also a major ethical question of lack of consent on the part of participants as well as a distinct immorality and distaste of following them using questionable tactics, tracing them and gaining information based

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21 Public convenience in places such as parks.

on further deceit a year on -- giving the research a double edge in secretly entering their homes and neighbourhoods.

These are only two examples concerning social research. Research history is littered with many more from both the social and natural sciences. Medical research has historically been fertile ground for unethical practices. For instance, in the 1960s United States, several questions were raised about publicly funded research concerning two infamous practices:

(i) In 1963–64, while at Tulane University, a surgeon, Keith Reemstma, transplanted 13 chimpanzee kidneys into human beings; In 1964, Thomas Stazl at the University of Colorado transplanted six baboon kidneys into human beings; and James Hardy, University of Mississippi transplanted a chimpanzee heart into a comatose 68 year old man supposedly with the consent of the patient (Shors 2009 p232) but not anyone outside of the immediate research team was involved in the experiment;

(ii) In 1963, with memories of wartime experiments on Jewish people still fresh, live cancer cells were injected into poor, debilitated but non-cancerous elderly patients without their consent or that of the hospital research review committee at the Brooklyn (New York) Jewish Chronic Disease Hospital (P McNeill 1993: 57).

A similar story, albeit with a differing approach, is the longitudinal study spanning 40 years (from 1932) known as the Tuskegee Syphilis study which aimed to observe the consequences of untreated syphilis. In what has become known as racism-related research, the United States Health Service selected four hundred, mostly uneducated, black tenant farmers suffering from syphilis in the Alabama region to test the view that untreated syphilis runs its course differently in blacks in comparison with whites. The purpose of the research was not clarified to the men nor was a possible cure - penicillin had been discovered in the 1950s, but this was withheld from them, with African American doctors being instructed not to treat them correctly either. The study was terminated in 1972 after it became known that between 28 to 100 men died agonising and horrible deaths directly as a result of untreated syphilis. The study generated a huge outcry and explosive backlash from the Black communities, leaving a legacy of mistrust between them and medical establishments (Jones 1993).

At the time of the above studies, legal redress, particularly for research, was also difficult with none of the practitioners involved in the Brooklyn cancer case being brought to charge. It is because of the public outrage that followed these revelations that medical research ethics came seriously into focus. Thus, the World Medical Association issued the Declaration of Helsinki (1964, later revised in 1975), which also underpinned the “Ethical Guidelines for Clinical Investigation” of the American Medical Association in the mid 1960s. Researchers were from then on required to follow set guidelines and values for clinical research, including informed consent from subjects.

Since these early days of an outrage-generated discourse, there has been much attempt to devise rigorous policies and laws to regulate experimentation and research on human subjects, to which one can also now add animal research. There are various national governmental committees that oversee medical research and drug trials in particular, with national civil society movements vetting the research and clinical trial activities of drug companies through internet campaigns, for example. What is interesting is that, in spite of detailed and explicit guidelines that have developed from the 1960s, unethical and morally wrong studies continue to this day, particularly those involving poor and vulnerable groups in developing countries which are often aimed at reproductive health. These include studies on HIV/AIDS, contraception, clinical drug trials which have been carried out without full consent and understanding of people in Bangladeshi, Indian, African and South American communities. You may want to explore this yourself and explore how your own country guides or monitors research in an ethical manner, in which case turn to Activity 13 in the Module 3 workbook.

Before I leave this section, I want to explain why I choose not to separate discussion on ethical principles of natural and social sciences, but treat both together. This is because, as I illustrate above, it is important to recognise that our moral values and ethical behaviour are shaped by the societal context, codes, policy and practices of the time. Thus even the most ‘pure´ science research is ultimately guided and located by this overall framework. Take for example, the current hotly debated issue of human stem cell research. At the centre of this is the question of morality about using, creating and destructing human embryos, in particular embryonic stem cells. The dilemma is two-fold. On the plus side, embryonic stem cells have the potential to develop and grow in a laboratory environment into any type of body tissue. This development could thus offer the chance to help many medical conditions, including degenerative conditions such as Parkinson’s disease and multiple sclerosis. Potentially, in the future, stem cell manipulation could also be used to repair damaged body tissue, for example burns and spinal cord injuries. The ethical dilemma arises because the current state of research enabling extraction of a viable stem cell line (a family of constantly dividing cells) involves the destruction of a human embryo. Various religious and pro-life groups believe that human life is sacred and that a human life begins at the point of conception, and so regard such research as immoral and the destruction of a human embryo as murder. Conversely, medical science is aware of the anticipated benefits and is lobbying for legislation to allow further use even if this is banned in some European countries.

Finally, in relation to research on the lived experience of climate change, we are dealing with the subjective side of human beings and the groups to which they belong. Inevitably, finding out about their lived experiences might require getting behind the data that can be obtained from interviews and observation. The methods used to ‘get behind’ will often pose ethical concerns.

5.2 Ethics, codes, practice

So, what do we mean by “ethics”? Essentially this is a very broad term spanning a range of philosophical debates which include questions of morality, values, codes of behaviour, individual conscience, personal beliefs, religious beliefs and how society views and conducts justice. The study of ethics is therefore expansive. However there are three major strands which run through it including:

i) “Meta-ethics” with its philosophical debates on the origin and meaning of ethical principles, asking whether these are a social invention or something that arises out of feelings and emotions. To answer this, meta-ethics theorises on the meaning and role of reason, what forms “universal truths”, and what chance the “will of God” plays in making value judgements.

ii) Normative ethics which attempts to question what makes moral standards, and how these are normalised as right and wrong conduct that is acceptable in society. Normative ethics thus focus on how societies communicate messages of what is good, acceptable behaviour, what our behavioural consequences for others are, and ultimately what our duties and responsibilities are.

iii) Applied ethics draws conceptual and theoretical notions from both meta-ethics and normative ethics to address (and possibly resolve) controversial societal issues-which are many at any given time! In the UK today, for example, nationally we are not agreed on many issues such as animal rights and fox-hunting with dogs, international conflicts that our country has been led into, acquisition and storage of nuclear weapons, use of nuclear energy, building of motorways and so forth. I am sure you too will be able to identify many such controversial ethical issues pertaining to your own country. Although these may remain unresolved, applied ethics enables some level of theoretical discussion around them.

Ethics thus has several connotations of morality and is closely located within a philosophical framework of values. It attempts to guide right and wrong societal behaviour, offering a systematic, considered code. However, whilst I have presented the above three strands separately, often in reality there are no clear distinctions between meta-ethics, normative ethics, and applied ethics. Take for example the topic of climate change. What are the moral and ethical dilemmas that this poses? We as human beings are aware that something is happening in terms of climate change – whether or not scientists agree or disagree as to the cause. We are therefore aware of the millions who are displaced and suffering every day as a result of drought, flooding and other extraordinary climatic events. See for example the Famine Early Warning Systems (FEWS) (www.FEWS.net) which give a clear indication of how many people are on the brink of chronic hunger and starvation because (alongside war and conflict) of climate events. At the same time we are aware of debates about geo-engineering of climate change, carried out to manipulate and control regional variations to find solutions, for example through rain seed cloud intervention (a technology led solution which may, of course, create further problems). There is also much credibility in the argument that the richer, consumer oriented countries contribute much more than poorer countries to wastage, release of carbon gases and the greenhouse effect. Even though we recognise the global nature of climatic linkages, as a world we are divided in our answers to the questions, "Whose responsibility is it?" and "What should be done about it?" Meanwhile, at a personal individual level, we make moral choices either to curtail our consumerism or ask instead, "Why should I care?" Issues related to climate change and lived experiences of food security, consumption and individual and social behaviour therefore generate many questions regarding morality, behaviour and ethics.

For our purposes, whilst controversial issues are grounded in the philosophical debates within the strands of ethics discussed above, the main domain arises from issues of unethical research discussed in the previous chapter. Thus research ethics are concerned with protecting the interests and rights of participants, being sensitive to marginalised and vulnerable groups and incorporating ethical considerations within all parts of the research processes. It also concerns responsibility and regard to the welfare of those who you are doing research with (both the research team and the respondents) through the researcher's behaviour in the field, during feedback and so on. In fact, it may be useful for you to think of how checks can be exercised systematically before, during and after research, taking each stage of the research process one at a time. If you wish, at this point you can refer back to Figure 2.1 of this module, which shows the differing stages of research, and do Activity 14 of the Module 3 workbook about how you can build ethical considerations into each stage of the research design.

Most institutes through which research is conducted nowadays either have a well-established ethical committee or are in the processes of establishing one. The role of these committees is to create codes and guidelines and monitor ethical practices. There are some codes of practice which are specific and subject related. This includes, for example, the British Psychological Society (BPS), The National Health Service (UK), The German Sociological Association (Deutche Gesellesahft fur Soziologie[22]). Members of such research committees usually come from various disciplinary backgrounds and will vet the quality of the proposal, whether it will add to existing knowledge, and the research approaches and behavioural intentions of the proposal. The committee will either accept the proposal, recommend changes or reject it. In all cases it should provide feedback as there are several reasons for its recommendation (and this may not be because you have not thought enough about ethics).

Institutional ethical research committees thus guard against unethical practices and check for general principles. Nevertheless, how these are operationalised in practice during research depends ultimately on how each stage of the research process is monitored by the researchers themselves. And, to do careful ethical research, all stages must be assessed for issues such as confidentiality, sensitivity, whether participation is indeed

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22 The ethical codes and guidelines are available on each website which you can obtain through search engines such as GOOGLE.

voluntary and consent has been sought in the true sense, whether political/social/financial power/powerlessness including that of children is considered, whether respondent integrity is maintained, whether the research is covert/overt, and so on.

What you emphasise will also depend on the nature of the research and the subject under investigation. For example, for qualitative social research on people, power is a critical discriminator, demanding a reflection on the relationship between the researcher and the researched, researcher and the funder, relationships within the cultural setting, questions of motivation and reciprocity. Please also note here that, whilst we are becoming more and more dependent on web-based resources, collecting data and communicating through the net, ethical considerations such as non-invasive data collection methods and maintaining anonymity also apply. Also, don't forget that the dynamics of web-based research are different, and questions such as debriefings must be separately addressed.

For climate change research, one major contemporary scandal has led to many ethical questions. This is the "climategate" scandal at the University of East Anglia (UEA, UK) where highly reputable scientists were accused in 2009 of having manipulated data to support the popular thesis that anthropogenic activity is largely responsible for climate change (Hickman and Randerson, 2009). The damage of these allegations to both the University and scientific community and their findings was so high that the UEA commissioned a special independent inquiry, the report of which can be accessed at (http://www.cce-review.org/pdf/FINAL%20REPORT.pdf). The scandal involved 1000 e-mails from the UEA Climate Research Unit (CRU) which were hacked into and made public by the mass-circulation media. The emails threw doubt on the work of the CRU, and the reliability of climate science generally which also spread to the work of the United Nations Intergovernmental Panel on Climate Change (IPCC) just prior to the important Copenhagen Summit on climate change.

The first inquiry was about the science being undertaken at CRU with the second inquiry examining the conduct of the scientists involved. The report reviewed aspects of behaviour of the CRU scientists, such as their handling and release of data, their approach to peer reviews, and their role in the public presentation of results. It also considered the allegations that actions were taken to promote a particular view of climate change and of improperly influencing the process of advising policy makers. In doing so, the review examined the honesty, rigour and openness with which the CRU managed the scientific research. (The Report of the Independent Climate Change e-mail review, p10). It may appear then that (like the examples of unethical research discussed in the previous chapter) it takes a scandal, in this case a cyber-space initiated one (and many would argue a maliciously initiated one), to make us think about ethics and how they relate to climate change! The UEA scandal now arguably paves the way towards future ethical research on climate change by reminding us to think more carefully about morality, values and integrity of research. It is important to note, however, that in this particular case the CRU scientists were in fact exonerated on all counts by the reports. They were found not guilty of unethical behaviour.

To end, in Chapter 5 I have discussed the importance of ethical considerations throughout the research process. Mainly, these revolve around broad issues of how to protect those taking part in the research and how to work within and maintain morality alongside truth. However, this is general guidance. Each project needs to be considered individually to work out appropriate ethical justifications. Without this, as the above examples suggest, research can cause a lot of damage!

6 Towards an interdisciplinary approach

In chapters 3 and 4 we discussed conventional approaches to both natural and social science processes of research and offered an account of the underlying assumptions for each. Let us now turn to current debates that focus on research approaches that are not boundaried within particular disciplines and attempt to understand why there is a current call to take interdisciplinary approaches, particularly to real life problems.

6.1 Real life “wicked problems”

The world that we live in has always posed hugely complex questions. Within the 21st century these have not diminished and, if anything, appear to have increased -- or maybe they were always there but we did not have the knowledge or awareness of them. Thus we struggle to both identify the heart of these problems and find solutions as reflected in our quest to fulfil the Millennium Development Goals (MDGs) that were established in 2000 by the United Nations to address global poverty and related challenges (see Module 2, Box 1.1 for a brief description of the MDGs).

For example, one of the most pressing problems the world has today is how to feed the hungry, particularly in economically poor countries where population growth rates are also high. As we now have advanced technological knowledge, a possible solution is the introduction of technology-led food production methods. This more or less began in earnest with the high-yielding wheat varieties (HYV seeds) developed by the Rockefeller and Ford Foundations around 50 years ago under the directorship of an agronomist Dr Norman Borlaug (who went on to win the Nobel Prise in 1970s for his achievements). In what became known as the ‘Green revolution’, the HYV ‘miracle’ was that farmers could plant wheat, maize and later on rice, with disregard to traditional growing seasons, and use dwarfed varieties which produced larger yields. Thus both grain-starved Mexico and India (and later, other countries) began to turn large areas of land to HYV wheat and maize production. In a celebratory mood, India even issued a commemorative stamp marking the era of self-sufficiency in food production and the ‘Green Revolution’[23]. Whilst I do not have enough space to go into detail here, it became quickly clear that the ‘miracle’ was short-lived, and whilst much tonnage of grain was produced, at the same time this was associated with many social and environmental problems.

Since the 1960s there have, of course, been further laboratory-led technological advances, including genetically modified (GM) crops. No doubt you will be aware of some of the controversial arguments behind these and will have your own personal thoughts on food from GM crops, so again I will not detail these.

It is also important to note that these and other issues do not just belong to the developing world, but equally affect developed countries. For instance, as I write (August 2010) there is controversy in the UK about stem-cell research and the leakage of cloned animal products into the human food chain (see Figure 6.1 below)[24].

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23 One benefit, it is often suggested, is that the ‘Green Revolution’ would ward off the ‘Red Revolution’ and the peasant uprising brought on by mass hunger.

24 See for instance Meikle, article from the Guardian newspaper, 11 August, 2010 (http://www.guardian.co.uk/uk/2010/aug/11/meat-cow-cloned-uk-food-chain).

Figure 6.1: Farmers in Hartland, Devon (UK) humorously protest that they sell real, not cloned, meat (Source: D Abbott

Real life concerns such as those exemplified above attract no simple answers and in fact generate many further complex questions and are thus known as “wicked problems”. A small story (sourced from Skaburskis 2008) on how this term was coined relates to the 1960s scenario, when on the one hand the United States was pioneering moon research, whilst on the other its urban social problems were exploding. In the wake of this, West Churchman, a research and system analyst, was given funding from NASA[25] to explore ways of transferring lessons from space exploration technology systems to solve urban problems. This gave him an opportunity to organise weekly seminars in 1967 at the University of California (UC), Berkeley on technology and social planning. One of the people who attended was Horst Rittel, himself a mathematician and the Professor of the Science of Design, who argued that there is much difference between scientific problems and those related to social policy and urban planning and presented a list of ten differences as outlined in Table 6.1 below which he refined later in 1973[26]. At the end of this, it is claimed that Churchman responded with “Hmm, those sound like wicked problems”, thus giving rise to a new area of inquiry regarding the nature of problems and their methodological analysis.[27].

25 The National Aeronautics and Space Administration (NASA), a USA government agency, was established in 1958 with a remit to conduct scientific space and aeronautics research (http://www.nasa.gov/).

26 Rittel H and Webber M (1973).

27 Although note that others had also formed parallel ideas at this time. Ackoff (1974 p21), for instance, formulated a similar analysis in arguing that “no problem exists in complete isolation; every problem interacts with other problems and is therefore is part of a set of interrelated problems, a system of problems” in what he called a “social mess” or “unstructured reality”. Arguably (as with a ‘natural science’ problem), an attempt to break down the complexity of this “mess” to seek out its fundamental elements in resolving the problem could lead to the mess becoming even worse!

Table 6.1: The attributes of "wicked problems" (Source: Skaburskis 2008 p 278)

1	There is no definite formulation of the problem. The problem includes a permanent feedback with its environment. The process of formulating the problem is interconnected with the process of its solution. To ask all the relevant questions to gain information on the problem, you must know all the conceivable alternative solutions.
2	There are no stopping rules. The logic inherent in the problem does not tell you when to stop the inquiry.
3	There are no criteria for correctness. There is nothing in the problem to say how the solution should be judged.
4	There is no immediate test of the quality of the solution.
5	There is no ultimate test of a solution.
6	Once committed to a plan of action, change is consequential. You can't make consequences not happen.
7	There is no list of permissible operations. (If you have a habitual set of actions or prescriptions, try to break out.)
8	There are no well defined solutions. You either have many solutions or none. The probability that a wicked problem has one solution is null.
9	Every wicked problem is unique.
10	The problem solver has no right to be wrong. Designers are responsible for their work. Unlike scientists, they do not put up work for rejection at a later time.

As time has progressed we have, of course, began to realise that "wicked problems" (such as social planning) defy linear approaches. As Rittel and Webber (1974, p. 161) argue, "The classical systems approach … is based on the assumption that a planning project can be organised into distinct phases: 'understand the problems', 'gather information,' 'synthesise information and wait for the creative leap,' 'work out solutions' and the like. For 'wicked problems', however, this type of scheme does not work. One cannot understand the problem without knowing about its context; one cannot meaningfully search for information without the orientation of a solution concept; one cannot first understand, then solve."

Following these types of arguments, recent literature has contrasted" "wicked" with "tame problems" which can perhaps be analysed within existing methods of investigation (more akin to natural rather than social sciences) as characterised in Table 6.2 below:

Table 6.2: The attributes of "tame problems" (Source: Conklin, J, 2001, p9–10)

1	Have a relatively well-defined and stable problem statement.
2	Have a definite stopping point, i.e. we know when the solution is reached.
3	Have a solution which can be objectively evaluated as being right or wrong.

4	Belong to a class of similar problems which can be solved in a similar manner.
5	Have solutions which can be tried and abandoned.
6	Comes with a limited set of alternative solutions.

In summary, “wicked problems” are thus not true or false, they have no complete resolutions, they have no moral implications (as maybe the term suggests), but are as complex as the world we live in. There is often little or no consensus to either what the problem is or how to resolve it, and if anything, “wicked problems” are forever dynamic and active in evolving even newer social dimensions and contexts, coming to life in our attempts to identify the problem itself, rather than solve it! This is well illustrated in the following quote from Laurence Peter (an educator and management theorist) used by Conklin (2005): “Some problems are so complex that you have to be highly intelligent and well informed just to be undecided about them.”

As suggested in the opening paragraph of this chapter, there are of course several “wicked problems” we face today. These include, for example, a global concern with drugs, terrorism, inequity, human rights, poverty alleviation, human displacement, environment – the list is endless. Add to this the critical concern over climate change, which has been labelled as a “super wicked problem” by some (Lazarus 2009: 1153). The complex enormity of these problems cannot be addressed within singular disciplinary modes of inquiry because: a) often there are several stakeholders from differing interest backgrounds, each with valid perspectives, and b) the more the contribution from various disciplines, the more the chance of constructing a wider knowledge base dealing with the layers of complexities embedded in “wicked problems”.

6.2 “Wicked problems”, transdisciplinarity and interdisciplinarity

Arguably, as an academic and practitioner community we are not always sufficiently equipped to deal with “wicked problems” because, at the least, we tend to:

i) Compartmentalise knowledge, often confining this to associated sectors (such as industry, energy, water, agriculture) or to particular disciplinary ways of thinking (physics, economics, politics, sociology – see the main chapters of Module 1 in this series),

ii) Create artificial subject/disciplinary boundaries (for example between human and physical geography) even though natural and human interactions need a holistic analysis.

iii) Lack sufficient collaborative links between researchers, practitioners, professionals and general civil society. We do this for many reasons which are not always immediately apparent to us. We need to make space to think about how we can address issues of knowledge construction based on rational, inclusive approaches instead of the narrow knowledge construct offered through “expert” and “professional” groups which are often confined by their segmented institutional specialisation, rules and regulations, bureaucracies, resource ceilings, and generally their individual motives and interests.

Thus there is a call to take an imaginative leap into what is known as ‘transdisciplinarity’. Whilst not going into the intricacies of the debates on the meaning and usage of this term (you can do your own research on it if you wish), the essence of transdisciplinarity is that it involves an attempt to generate collective knowledge through taking equal account of all stakeholders (including personal, specialist, and local accounts). This means building a collective knowledge base that reaches out beyond defined disciplines in a unified manner.

Transdisciplinarity can therefore be very ambitious and create problems such as how to deal with a large and varied database, how to deal with specialist subject knowledges and language, how to ensure equity of participation[28], how to manage skills and skill transfer, amongst other issues. However, this is counter-weighted by the many benefits transdisciplinarity offers. For instance, Lawrence (2010:17) comments that recent literature suggests that transdisciplinarity "challenges knowledge fragmentation; … deals with research problems and organisations that are defined from complex and heterogeneous domains (such as climate change or housing and health)... thus being characterised by its hybrid nature, non-linearity and reflexivity, transcending any academic disciplinary structure;…accepts local contexts and uncertainty;…implies intercommunicative and close and collaborative intercommunication; … including practical reasoning of individuals;…is often action-oriented."

The scope of transdisciplinary research is thus wide and capable of bridging gaps between theoretical explanations, academic discourse and that of decision–making and applied action research[29]. It often involves problem-solving, and is interactive allowing stakeholders to feed into the research process, commonly through dedicated websites.

The 'lived experience of climate change' (LECHe) project which has developed this series of three modules claims, however, to be *interdisciplinary* rather than *transdisciplinary*. Sometimes these terms are used interchangeably even if they have distinct meanings, but Gordon Wilson, the project coordinator, argues in a personal comment:

> "If I was to distinguish between interdisciplinary and transdisciplinary, I would say that the latter is anti-discipline whereas the former embraces disciplines in new ways. I personally prefer interdisciplinarity because it is grounded in where people are at, not some abstract idea….Interdisciplinarity relates to the interfaces between disciplines as the title infers. It accepts and acknowledges the depth of disciplinary understandings, but contends that significant gains in knowledge and understanding come from their interaction at the interfaces".

Interdisciplinarity thus brings together disciplines in a common endeavour to generate new knowledge out of their disciplinary overlaps. This draws on the concepts of the contributing disciplines but is not bound by them. Thus, in the project from which these modules are derived, we have attempted to develop an interdisciplinary approach where knowledge is derived and drawn from contributing disciplines. Sometimes (in Module 1 for example) they retain their distinct boundaries. At other times (Module 2 and here in Module 3) they converge and overlap to create something that is different.

In the Introduction to Module 1, Víctor Fairén outlines climate change as an interdisciplinary subject, despite its origins in natural science:

> "The subject of this module, climate change within sustainable development, is situated in an area in which natural science must address a problem that modern society and technology have created in part…. When speaking about climate and its variability (whether "natural" or not), we mean a highly dynamic system in whose description the equations of physics play a fundamental role. Therefore, it is of interest to physicists. But it is also an

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28 As previously discussed in section 4.2.4 on social science participation and observation.

29 Action research is used in many subject areas, for example, education to analyse classroom practice, development studies to analyse farming practices and so on. And because of this diverse use, there are several debates around the detail of the method. However, essentially action research is where researchers and practitioners evaluate their work at most stages of the research process, analysing how they can improve their own learning and that of others whilst comparing how this learning reflects on their theoretical beliefs and past practice. Theory and practice are thus linked in order to improve the end action on a particular problem. If you wish to find out more on the workings of action research, see McNiff and Whitehead (2006).

issue that has always transcended the boundaries of science and involves perspectives that derive from the fields of politics, economics or cultural and religious beliefs. As long as it is so, issues regarding climate are the subject of debate and disagreement, in part because science does not meet the expectations that society demands from it, but also because we weigh against one another different ways of understanding science and scientific knowledge and, above all, because it is interpreted in the light of the diversity of beliefs, values, attitudes, aspirations and behaviour. This problem is not unique to climate change. Biomedicine, ecology, resource management, just to name a few, are all topics where it is the same: their objects of study are complex, scientific understanding is limited and they have a profound impact outside the field of science."

In other words, in carrying out interdisciplinary research, the first step is the realisation that we have here a very "wicked problem", and one that cannot be boundaried within singular disciplines, but requires a more holistic picture drawing on both natural and anthropogenic related disciplines. To understand the problem (let alone the solutions) we thus draw on the strong scientific evidence that is already available, whilst at the same time we consider how anthropogenic (human-induced) climate change is a growing, global concern as it effects and disrupts lives and livelihoods in both the developing and the developed world, albeit with varied intensity.

To this Gordon Wilson, the project coordinator, adds in the Module 1 Introduction,

> "Proximate explanations of climate change are to be found in the natural sciences. Human contextual explanations are to be found in: a) the dominant model of economic development and its fundamental dependence on energy; b) the challenges facing political leaders and policy makers to agree and enact courses of action for mitigation and adaptation. While human beings impact on climate change, mainly through their energy requirements, climate change in turn impacts on them, their lives and livelihoods. Such impacts, however, are felt unevenly across human societies, being mediated by social relations of wealth, power and inequality."

The second step to the LECHe interdisciplinary approach in Module 1 is to introduce students to different disciplinary perspectives through bounded individual chapters (this can be described as multidisciplinary). The third step is to bring these perspectives together in the final chapter. Thus, Module 1's structure is described in the Introduction as follows:

> "*Chapter 2* covers the science of climate change;
>
> *Chapter 3* covers the economics, including economic and technological approaches to mitigating climate change and their importance when making policy;
>
> *Chapter 4* overlaps with Chapter 3 as the economics always spawns a politics. It addresses the geopolitics of climate change: the international institutional setting and the factors that influence the effectiveness of global governance.
>
> *Chapter 5* examines the social impacts of climate change, and how these impacts are mediated by social relations of power and inequality.

> *Chapter 6* is the module Conclusion. It brings together Chapters 2, 3, 4 and 5 within the broad idea of sustainable development, while providing a critical examination of the concept. This final Chapter also draws together issues of ‘scale’ and inter-scalar connections. The inquiry in Chapter 2 on the science is necessarily focused on the planet Earth, while that in Chapters 3 and 4, on the economics and politics of climate change respectively, is conducted both at national and international scales. In contrast, Chapter 5 is at the local scale as it examines the impacts on people and communities. Thinking of these scalar dimensions raises two basic questions for Chapter 6. How does the national and international affect the local? How does the local affect the national and international? The module ends by briefly examining these questions.”

Even within the Science chapter (Chapter 2) of Module1, the curriculum has contributions from different scientists who draw from their own disciplines and methodological tools to discuss various aspects of climate change, including paleoclimate and geological evidence. Whilst the project group has a registered user website and meetings where they confer to develop curriculum direction and strengthen their understanding of climate change in an interdisciplinary fashion, the whole exercise is necessarily coordinated by one person (the project coordinator) who negotiates the inputs, the balance between disciplinary ideas and manages often overworked, “argumentative” professors!. The project itself is therefore a good example of an interdisciplinary approach to a “wicked problem”.

6.3 Interdisciplinary imagination, realism and knowledge

6.3.1 Realism and knowledge

Finally, to appreciate the value of what I call an interdisciplinary imagination for achieving a better grip on “wicked problems”, it is necessary to examine the underlying assumptions of knowledge and the reality that shape explanations. Take climate change – where the one point we agree on is that this is a complex issue with numerous facets of further intricacy. The rest is a highly contentious debate encompassing several scientific as well as anthropogenic explanations. Which of these explanations do we trust and which do we reject? To discuss this further, I will now consider the essentials of the debates on underlying assumptions of what constitutes “knowledge” and “reality”, what limits our understandings, and argue that an interdisciplinary approach can help to shape our knowledge of a particular issue in a fuller way.

It could be said that the pursuit of “knowledge” is initially located in our understanding of what is “reality”. If you recall, in section 2.1 (Box 2.3) I suggested that one of the assumptions underpinning research was based on ontology and the nature of reality with the lead question, “*What set of specific assumptions are we making about the basic nature of reality and what exists?*” At the risk of simplifying what has been a learned discourse, the philosophical debate which has emerged around this question takes two opposing positions: those who identify with the schools of realism and anti-realism. Whilst there is much contest and difference even within these schools, to oversimplify, realists generally go along with the view that reality is based on the “real” world out there, where the “real” world is something that is independent of the narrow human perception of it. Thus when we study something, we are usually focussing on one aspect of it rather than its fuller material existence which is beyond the human mind. Anti-realists, on the other hand, argue that the only reality that exists is that which is constructed by the human mind. Thus we, as humans, make our own reality in our minds and this construct may, of course, change as new knowledge comes to light.

To give you a timely example as I write in September 2010, the world-famous scientist Stephen Hawking has published a new book “The Grand Design”, co-written with United States physicist Leonard Mlodinow, which challenges his own previous ideas of the role of God in the creation of universe. In his previous book, "A Brief History of Time" (1988), Hawking appears to accept the role of God in the creation of the universe and says: "If we discover a complete theory, it would be the ultimate triumph of human reason – for then we should know the mind of God." However, in "The Grand Design", he sets out to challenge Issac Newton's belief that the universe must have been designed by God as it could not have been created out of chaos.

In this new book, he argues, "Because there is a law such as gravity, the universe can and will create itself from nothing". Thus, "Spontaneous creation is the reason there is something rather than nothing, why the universe exists, why we exist… It is not necessary to invoke God to light the blue touch paper and set the universe going." Stephen Hawking thus argues that universe was not created by God (Gabbatt A, 2010). He has created a notion of reality (or in this case, a grand reality) that is provocative and certainly not to everyone's liking or agreement. Realists may challenge his idea by questioning where gravity arises from in the first place (is it God-created?), and there is, out there, a fuller material existence which is incomprehensible to the human mind. Anti-realists for whom reality exists as a human construct, which changes as humans encounter new ways of seeing and thinking, may support Hawking in changing his previous views, in that he shows that models of reality can and are modified with further investigation.

Thus, for instance, to construct knowledge on the phenomenon of 21st century climate change, there is a need to grasp the scientific knowledge we already have, together with that of the underlying mechanisms and structures of social interaction and behaviour that produce anthropogenic activity. This is within a framework of realisation that our knowledge is a social construct and, being human-led, is still in the process of developing. Perhaps this is why the emphasis on sole pure-science led explanations has shifted and modern literature on climate change looks at both natural science and human interaction. Two examples are:

i) Behringer (2010) who traces climate change cultural history from the global warming and cooling of the Holocene period to the Little Ice Age with the cultural consequences for the Modern Warm period.

ii) In examining Earth evolution from its origin to the Mid-Pilocene, Glacial and Interglacial cycles, evolving humanity and the modern times of a warming climate, Penna (2010) considers the "Human footprint through a global environmental history".

6.3.2 Knowledge, truth and reliability

Another underlying important question concerns what we can consider as reliable knowledge. For example, recently there has been much heated debate on the exact nature of climate variability patterns, the reasons for the change and future predictions. So, whose account is most reliable? And, as the often repeated Habermas question asks, how is reliable knowledge possible? (1972 p3).

There is nothing new in this scepticism. The debate on knowledge and its reliability has, of course, raged since time immemorial. For instance, we saw in sub-section 3.4.1 ('Natural science' historical legacy) that 'truths' are very much located and developed or constrained within the societal context of their time. We also noted that the ontological position of positivists is their underlying belief in the consistency and regularity of the world – which shapes their understanding of the fundamental tenets of existence. The positivist view of the universe is therefore one of homogeneity and linearity, enabling predictable and definite responses. Thus in a positivist world, the only reliable knowledge is that which is generated through direct observations of physical things without human subjectivity and bias. A general critique of positivism is that this approach is in effect a "closed" one and does not apply to the complexity and uncertainty that differentiates the real world!

There is, of course, more specific critique of the positivists' view offered by both Popper and Kuhn (also discussed in Section 3.4.1). For instance, one specific argument is that of Popper's which suggests that, in seeking knowledge, both our capability and cognitive powers as human beings to work out solutions to every known problem are limited. Nor are we fully equipped to recognise any further problems that our solutions may cause. Therefore, in a dynamic, complex world which undergoes rapid change every day, how can we be so sure about future events or whether patterns of today will hold true for tomorrow? In fact, if anything our future is far from predictable – it is in fact very uncertain! Seeking knowledge is, however, an endeavour – to find out the reality of the world – as long as we are modest in what we expect to achieve.

There is little doubt that evidence and logic can generate much knowledge, but a fuller insight requires a paradigm shift to move from a narrow to a broader knowledge base as Kuhn (Section 3.4.1) suggests. For instance, it is only recently that we have begun tapping indigenous knowledge and started to build "knowledge communities" between academics and local people in order to scrutinise knowledge that has taken generations of learning to build. In that we have begun a process of critical interaction where we look at knowledge context, and discover how "truths" have been shaped historically and even denied. For instance, throughout the colonial period in various parts of the world, indigenous knowledge was undermined in order to legitimise rule of the many by so few -- a trend that arguably continues even today. In African countries, this includes knowledge of agricultural practices especially that of subsistence cropping such as rice production as land was given over for cash crops. During this process, much indigenous knowledge was lost and is still suppressed in many areas. Thus there are deliberate efforts to attempt to recapture lost knowledge as exemplified in the extract in Box 6.1.

Box 6.1: Rain makers of Kenya

Long vilified as sorcerers, Kenya's Nganyi rainmakers, with meteorological equipment consisting of trees, pots and herbs, are being enlisted to mitigate the effects of climate change. Kneeling in the dank shade of a small coppice near Maseno, in western Kenya, Alexander Okonda blows through a reed into a pot embedded in a tree hollow and containing a secret mixture of sacred water and herbs. "This contains so much information. It is something I feel from my head right down to my toes," says Alexander, after completing his ritual.

The young man is a member of the Nganyi community, a clan of traditional rainmakers that for centuries has made its living disseminating precious forecasts to local farmers. The croak of the frog, the movement of the termites, the leafing of certain trees all carry information, the interpretation of which the Nganyi have transformed into a ritual art hovering between legend and science.

"This skill is in the family, it runs in our blood. When I was a six-year-old boy, I could already feel so many things," Alexander explains. The Nganyi's fame was sealed when his great-grandfather — "the greatest rainmaker in the family" — was detained in the 1910s by the British colonial authorities who believed he was responsible for poor rainfall. He had 30 wives and was buried in a sitting position with a rainmaker's pot on his head in a site near the western town of Kisumu which is now one of the main natural "shrines" used by his descendants to concoct their forecasts.

Modernisation slowly eroded the community's aura but the Nganyi have recently been offered a way of reviving their traditions through a project aimed at using indigenous knowledge in disaster prevention. Funded by Britain and Canada, the programme brings the Kenya Meteorology Department (KMD) and traditional rainmakers together to produce more accurate forecasts and disseminate them to a wider number. "We knew that we had good scientific forecasts but that many people didn't believe them," explains Gilbert Ouma, a meteorologist from Nairobi University.

More than the variation in the volume of rainfall, the consequence of climate change that many African communities suffer from the most is the disturbance in the cycle of rainy seasons. Delayed or early rains upset planting that had taken place at set dates for decades, with devastating effects on yields… (Source: Ecology Press 2009, http://www.ecologypress.com/?s=rainmakers accessed March 2012)

Of course evidence and observations of the type illustrated in Box 6.1 cannot be evaluated or authenticated in a logical, rational manner. Yet this knowledge is important for critical social interaction between and within communities and lays down values and grounding for inter-generational learnt knowledge and respect. Thus whilst observations, rationality and cognitive processes are not formalised, they are instead set within social values and norms. In the above example, rainmaking has become a social activity where there is passed knowledge and critical deliberation based on what Habermas (1972: 3) calls a 'non-arbitrary' mode of connecting evidence, rationale and theory. The authentication of knowledge then arises from critical self-reflection through which the community identifies and values the knowledge that is helpful for future generations. These future generations, of course, stretch beyond the local, across space and world citizenry.

It is important to realise that there is no clear-cut, dualistic demarcation between differing theoretical perspectives, which in fact do take into account a critique from opposing views. What I have given you above are the essential bare bones and tenets of the debate. Gordon Wilson, the author of LECHe Module 2 in this series sees "knowledge" as a construct and highlights nuances between the debates on knowledge:

> "What is the nature of this knowledge, in other words what is its epistemological basis? Do we discover it over time, making mistakes undoubtedly on the way, but nevertheless engaging in a linear process of discovery of something we call knowledge which exists independently of us and which can be found in books, or on the internet, or from others? Alternatively, instead of discovering knowledge, do we construct it out of a myriad of influences and our own actions?
>
> Knowledge as discovery has a label – positivism. So does knowledge as constructed – constructivism… Although they can give rise to strongly contrasting positions, where, in an allied formulation, positivist knowledge is seen as objective and constructivist knowledge subjective, this need not be the case. Even the most committed constructivist will acknowledge that many scientific laws do exist beyond human contexts, for example the laws of physics that enable aeroplanes to fly and which explain phenomena such as global warming. Conversely, equally committed positivists will acknowledge that discoveries are always open to human interpretation in both the natural and social sciences, and human interpretation cannot be totally devoid of the context of the interpreter…..[This] constructivist approach does not mean that there can be no discovery. People listen to others and, if they are literate, read. In so doing, they often 'discover' information which they did not know before. This might be information about changing temperature and rainfall patterns… The important point, however, is that they do not simply receive and assimilate the information they have discovered from whatever source. Rather they interpret it in the light of their existing knowledge, their everyday interactions and experiences. It is this process of interpretation which transforms information – which represents a construction of others – into knowledge." (Modul2, Section 3.1)

Finally, to end this chapter, 'Towards an interdisciplinary approach', I want to leave you with an astute observation made by William James, a pioneering psychologist (1842–1910): "The greatest enemy of any one of our truths may be the rest of our truths." This quote indicates that there are some "truths" we rather would not know as they may cause too much disruption. We therefore remain, or choose to remain, ignorant of them.

Smithson (2010: 85), for example, argues that there is a blind spot in research design where we do not question enough the role played by ignorance and uncertainty in human cognition, culture and politics. He argues:

> “These roles are no more marginal than those played by knowledge. Nor are they simply opposite. People have a vested interest in ignorance. Knowledge is power, so is ignorance.”

He suggests that this is not particular to any one discipline but is spread across various disciplines reflected in the way that there is a lack of communication between the academic community about the unknown, socially constructed ignorance and absolute ignorance. Even concepts such as probability, risk, and doubt associated with uncertainty have either technical or social meanings that mean different things for different disciplines. It is only through a breaking of disciplinary boundaries and looking to transdisciplinary and interdisciplinary dialogue that we can hope to challenge ignorance and uncertainty.

We will continue to refer to the points made in this chapter by discussing a worked example of the interdisciplinary approach in the following Chapter 7.

7 Designing an interdisciplinary approach to your dissertation

7.1 Choosing your project proposal

If you are studying for a Masters degree, it is likely that you will be thinking about your final dissertation/thesis/project[30] as you proceed through the 'Lived experience of climate change' (LECHe) modules. At this stage of studying this module, you might be ready to identify the dissertation you want to research and write about. You will no doubt wish to discuss your proposed title and details with your individual supervisors. However, to guide you in that choice, please look at the LECHe website resources which contain a repository of appropriate dissertation titles[31]. You might wish to turn to these now to gather some ideas.

Below I offer an example of an interdisciplinary project which will also suggest how you can identify a research problem, problematise it, investigate it, and evaluate it. You can also follow the presentation style of this example or any others you may find on the LECHe website. Now read the example below.

7.2 Example of an interdisciplinary project

7.2.1 Title of project: Water demand, supply and quality in the Anti-Atlas

Background and general problem

This project formed part of a British Council Higher Education funded LINK partnership between the Institute Agromique Veterinaire, Agadir (Morocco) and the University of Derby (UK). One of the principal aims of the partnership was to improve the health and quality of life for the rural poor, and in particular for women and children through a research study of the management, conservation and quality of water supplies in the Anti-Atlas Mountains, Southern Morocco. The work focused on a village scale investigation between 2000 and 2006 and, while this project was not explicitly linked to climate change, it concerned a major predicted impact of climate change in many parts of the world – water scarcity. Here I discuss how the project was operationalised in an interdisciplinarity mode.

Water scarcity is a major concern in arid and semi-arid Morocco. The people living in the Anti-Atlas Mountains of southern Morocco (Figure 7.1) already experience infrequent rainfall events and periods of drought. To combat this they have developed local strategies of water harvesting during times of plentiful rainfall to extend water availability during times of deficit. Rainfall is collected from roofs and the ground surface and directed into enclosed tanks, called "noutafia" or open air tanks and small reservoirs called "ifard". This enables villagers to plan and manage their water supplies for themselves, their animals and crops. However, problems of supply, demand and water quality occur when the expected rains fail and water is scarce. Water scarcity impacts on the health of the local people through diseases like diarrhoea (often induced by drinking contaminated water), especially in children. In particular water scarcity impacts on the quality of life for women and young girls as they are required to travel further and further on hilly terrain to collect water for domestic and livestock purposes.

As suggested in the starting paragraph, in addition to a current crisis of water scarcity are the implications and challenges that longer term climate change will bring to their lives.

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[30] The generic title of the final product of Masters research varies across European Universities. From this point, I will use the term 'dissertation', but note that I could have used any of the other generic titles.

[31] Over time, it is planned that this repository contains some completed projects in the subject area.

Macro-scale climate prediction models (such as the UK Meteorological Office's HadCM332) predict that water availability will be reduced and water scarcity increase across much of North Africa (Wilby 2002). However, these coarse-resolution General Circulation Models[33] (Figure 7.2), operating at typically 300km^2 resolution, do not fully capture important localised phenomena such as clouds and convective precipitation or take into account extreme events in arid and/or the complex mountainous terrain of the Anti-Atlas Mountains.

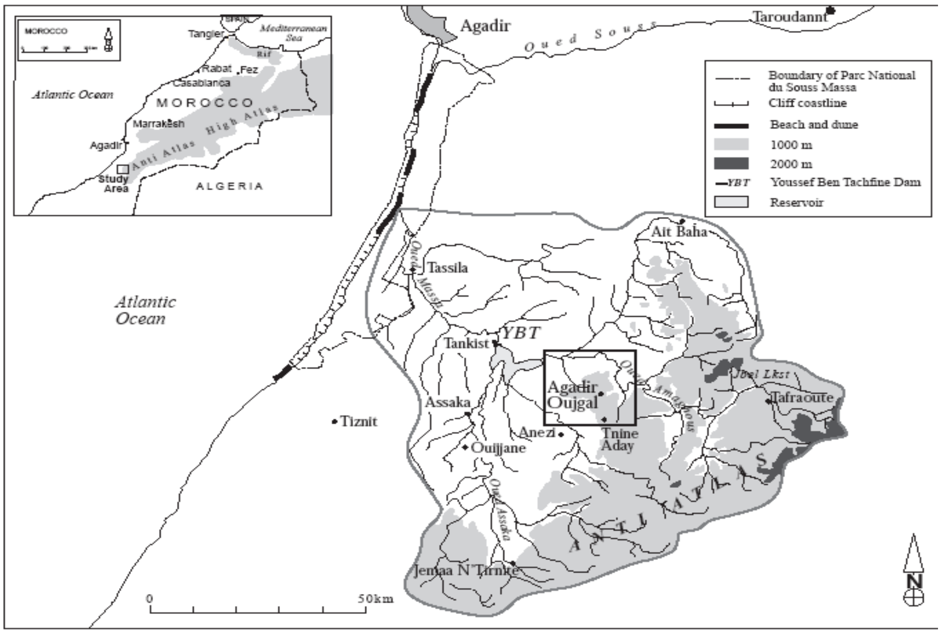


Figure 7.1: Location of the Anti-Atlas mountains and the study village Agadir Ouguejgal (Source: H Moore).

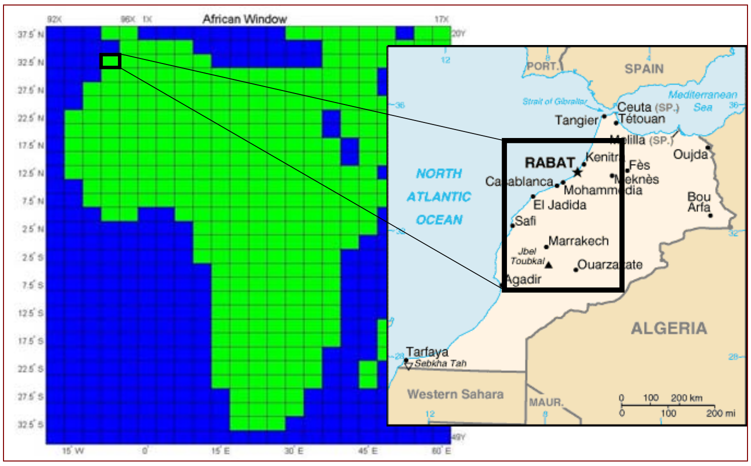


Figure 7.2: Land mask and grid-resolution of the UK Met Office coupled ocean/atmosphere GCM HadCM3 (Source: Wilby 2005 p3)

To try and refine the model's predictions a Statistical Down Scaling Model (SDSM) (Wilby et al 2002 and 2005) has been used to predict precipitation levels for the Anzi region of Southern Morocco (Table 7.1). This suggests that the projected reductions in

32 See http://www.metoffice.gov.uk/research/modelling-systems/unified-model/climate-models/hadcm3 (accessed 14 March 2012) for further detail.

33 See Module 1 section 2.4.4 for an account of GCMs and issues concerning course resolution.

wet season precipitation totals are relatively modest for winter (December, January, February), but proportionately greater in spring (March, April, May) and autumn (September, October, November). Overall we can conclude that the people of the Anzi region, including the case study village of Agadir Ouigal, are likely to have even less rainfall to harvest, in the decades up to 2080.

Table 7.1: Changes (%) in seasonal precipitation totals at Anzi with respect to the 1961–1990 average, downscaled from HadCM3 under Medium-High (A2) and Medium-Low (B2) emissions (Wilby 2005 p4).

	A2			**B2**		
	DJF **Dec, Jan, Feb.**	**MAM** **Mar, Apr, May**	**SON** **Sep, Oct, Nov.**	**DJF**	**MAM**	**SON**
2020s	2	-1	-6	-3	-3	-8
2050s	3	-12	-19	3	-20	-9
2080s	-10	-39	-36	-1	-30	-20

Whilst we could appreciate the longer term problems for the region, the aim of this research was more immediate and action-orientated. It focused on developing a short term strategy which would help to improve the health and quality of life of the rural poor and in particular the women and children of Agadir Ouguejgal.

Before I explain more about the detailed objectives and methodologies, it is necessary to provide some contextual information so you can appreciate the constraints that the project was operating under.

Geographical context

The location of the research village Agadir Ouguejgal was shown in Figure 7.1 above. The village is situated at approximately 1500m above sea level in the Anti-Atlas Mountains in a mountainous terrain as you will note from Figure 7.3.

Figure 7.3: The mountainous terrain in which Agadir Ouguejgal is located (Source H Moore)

The actual village is situated on top of a steep mountain divide composed of Precambrian conglomerate and sandstone rocks which are not conducive to the development of a substantial groundwater body. Average rainfall figures are 230mm per year. In 2000/01 Agadir Ouguejgal received 173mm of rain over 13 rain days, a rainy day being one when it actually rains. The mountain top location means the village only has a small hydrological catchment from which to harvest rain, and whilst small dams have been constructed to collect surface runoff in the headwater valleys to the east of the village, storage is limited (Figure 7.4).

Figure 7.4: Local reservoirs "le petit barrage". The arrow points to where water is collected from at the bottom of the mountain during drought years (Source H Moore).

Soils are inherently thin and nutrient levels are supplemented by manures from cows and donkeys. Local natural vegetation is sparse after decades of clearance for agriculture and as a traditional fuel for cooking. Subsistence agriculture to support both people and livestock is predominantly based on cereal and alfalfa production using steep terrace systems of farming. The natural terrain is rugged but accessible to robust vehicles that can cope with dirt roads. There is only one road leading to this village which is often impassable after heavy rains. Travel times are therefore lengthy due to the tortuous and steep mountain roads. This means that the village is fairly isolated for many, and to put this into context, the nearest school is a 1.5 hour walk away and the nearest doctor is 1.5 days by donkey.

Cultural and social context

The area of study is a Berber tribal area. Berbers are said to be the indigenous peoples of North Africa who spread all over Morocco and Algeria prior to the arrival of Arabs. However, with the coming of the Arabic influence across North Africa in the 7th century, the traditional Berber tribes were pushed into peripheral and more remote mountainous areas such as the Anti-Atlas. These tribes later embraced the Muslim faith and today about 40% of Moroccans claim a Berber heritage. The early 20th century saw European rivalry over the growing interest in Morocco. Following various negotiations between Britain, Germany, France and Spain, the Treaty of Fez was signed in 1912 dividing Morocco as a shared French and Spanish protectorate. The Franco/Spanish agreement came to an end in 1956 when Morocco became a sovereign state and Sultan Muhammad V was established as the King of Morocco in 1957, with his son King Hassan II inheriting the title in 1961.

Soon after independence, Morocco established Arabic as its official language, replacing French. However, French is still used for all education and official purposes while the transition to a fuller use of Arabic continues. As suggested earlier, post independence saw the Berber culture marginalised to remote areas and its demonstration in public was frowned on until the 1990s. Since then, Berber culture has gained increasing recognition and now there are opportunities for children to be educated in their mother tongue at school or university. The year 2000 also saw the first Berber radio and television programmes.

In working with the Berbers, the project had to take into account several considerations. Firstly, the majority of people we needed to talk to and work with were Berber speaking, using the Tashelhaït dialect, whilst we spoke English with some conversational and technical knowledge of French. Therefore it was important to ensure that we had male and female research staff who could converse in Tashelhaït but were also fluent in Arabic, French and English. Secondly, it was also important to respect the Muslim culture and appreciate the implications of this on the project organisation. Dealings with women required particular sensitivity. For instance, women from this village could not meet or converse with men who were not related to them. Thus research discussions and surveys involving women could only be conducted by female researchers and translators.

The population of Agadir Ouguejgal in the 1994 Census showed 97 people in 19 households. However, these figures do not show that the majority of local working age men are usually absent from the village, either in the larger cities such as Casablanca or overseas in France or Belgium. Consequently the population of the village was predominantly women with young children of both sexes, together with much older men and women. Economically the villagers generated income from surplus agricultural produce but were mainly supported by remunerations from absent husbands and sons. This village was also part of a local organisation called the Imzi Association. This cooperative of 45 villages worked together using remuneration monies for self-help development in the local area (Figure 7.5). For instance, some of this money received in the past had been used in the Agadir Ouguejgal region to improve roads and access.

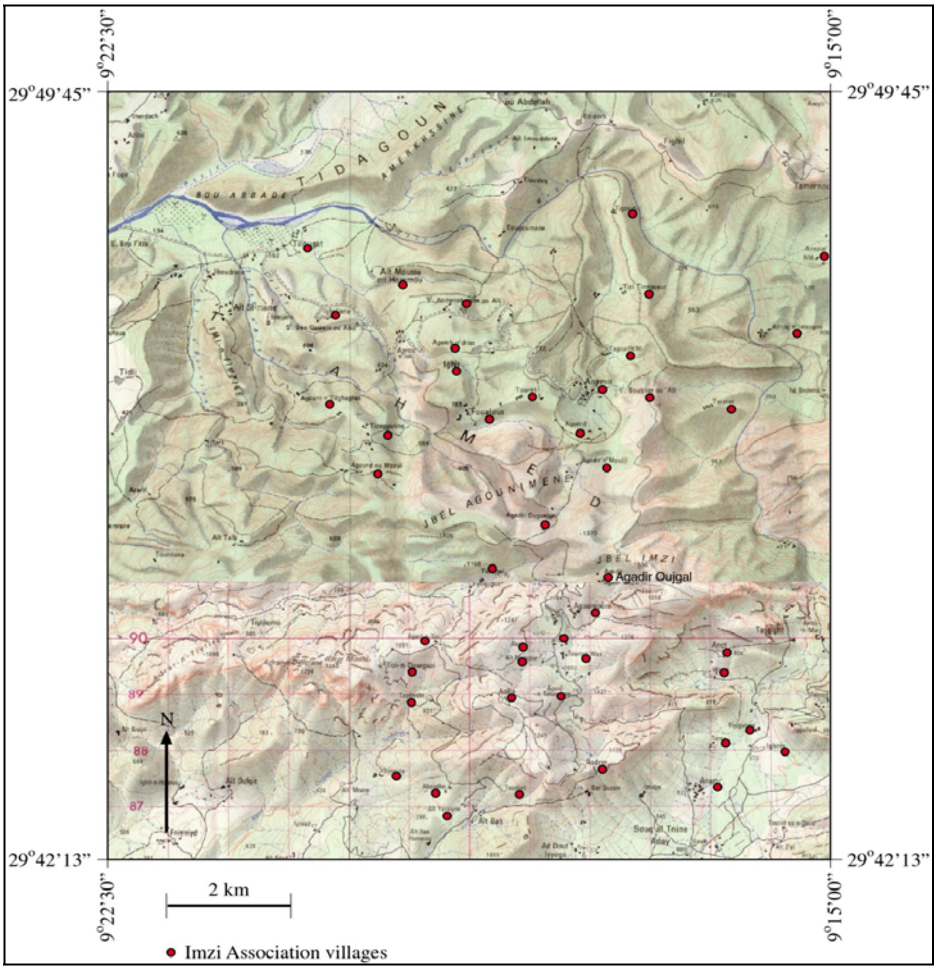


Figure 7.5: Spread of Imzei cooperative villages across the Anti-Atlas (Source: Imzi Association)

Research Methodologies

As you will appreciate, this is a complex project which requires a holistic approach incorporating natural and social science, objectives, and a research methodology which would allow both quantitative and qualitative data (Table 7.2). By using a planned series of observations, experiments, surveys, discussions and participation groups, the project team intended to obtain a comprehensive overview of the current water situation and the future needs of the village.

Table 7.2: Project objectives and methodological considerations.

Meeting natural and social science objectives (compartmentalised here for convenience, but inevitable overlaps)				
Objective	**Method (Natural science)**	**Approach**	**Method (Social Science)**	**Approach**
Investigation of contextual data	Collect background rainfall data. Collect medical data from hospitals	Communication with nearest rainfall station at Anzei Participatory	Meetings with representatives of the Imzi Association Visits to the local schools and doctor's surgery.	Participatory Participatory
Investigation of current water availability harvesting and storage	Mapping of village and households Establishment of local rain gauge Survey of ""noutafia"" and "ifard" location and capacity	Field Survey Empirical observations and measurement Quantitative	Participatory journeys to water sources with women Calculations about the amount of water collected per household per day	Participatory Quantitative
Investigation of current water quality	Samples of water taken from ""noutafia"" and "ifard" for immediate and laboratory chemical analysis	Experimental	Household survey including observations and discussions about water storage in the home	Participatory
Improve awareness of water related disease and re-hydration methods to improve health			Discussions and demonstrations with women	Participatory

of the villagers.				
Suggestions for alternative water harvesting and agricultural strategies	Discussions with local men and women	Participatory	Discussions with local land users and owners	Participatory

7.2.2 Operationalising research objectives

Investigation of water availability, harvesting and storage

The village is a maze of a combination of old traditional Berber and newer cement houses (Figure 7.6), bound together by small alleyways. To help plan and coordinate field activities, a map was made of the village and the different households numbered for our convenience (Figure 7.7). Using a satellite (Garmin 12XL) Global Positioning System (GPS) the exact positions of the “noutafia” and “ifard” were mapped (Figure 7.8). As indicated earlier, there are two types of water harvesting cisterns in the village, the covered “noutafia” and the uncovered “ifards” (Figures 7.9a, 7.9b and 7.9c). Most were dug directly into the weathered bedrock of the ground around the village and gather surface runoff from small rills and channels on the adjacent slopes. Others have been constructed in concrete adjacent to buildings and these generally gathered water from roofs and other artificial surfaces.

At each site a water supply survey sheet was completed to ensure systematic and comparable quantitative data (Figure 7.10). The “noutafias” and “ifards” were numbered, measured and water storage capacities in (vol m^3) calculated and summarised in Table 7.3. Differential access information was also recorded, for example, communal “ifards” were generally uncovered and freely accessed by villagers. On the other hand, dug cisterns owned by single families were usually fenced (Figure 7.9a, 7.9b) and in the case of “noutafia” provided with concrete heads and lockable covers (Figure 7.9c).

Figure 7.6: Traditional Berber house (left) and modern cement house with new “noutafia” in the foreground. (Source H Moore).

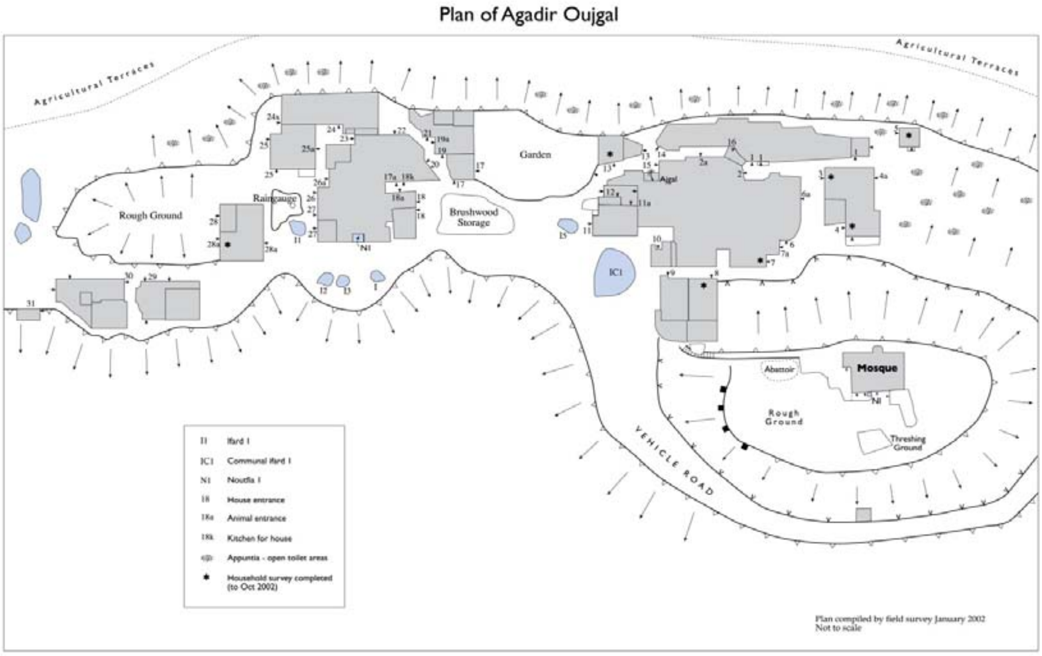


Figure 7.7: Mapping the village (Source H Moore).

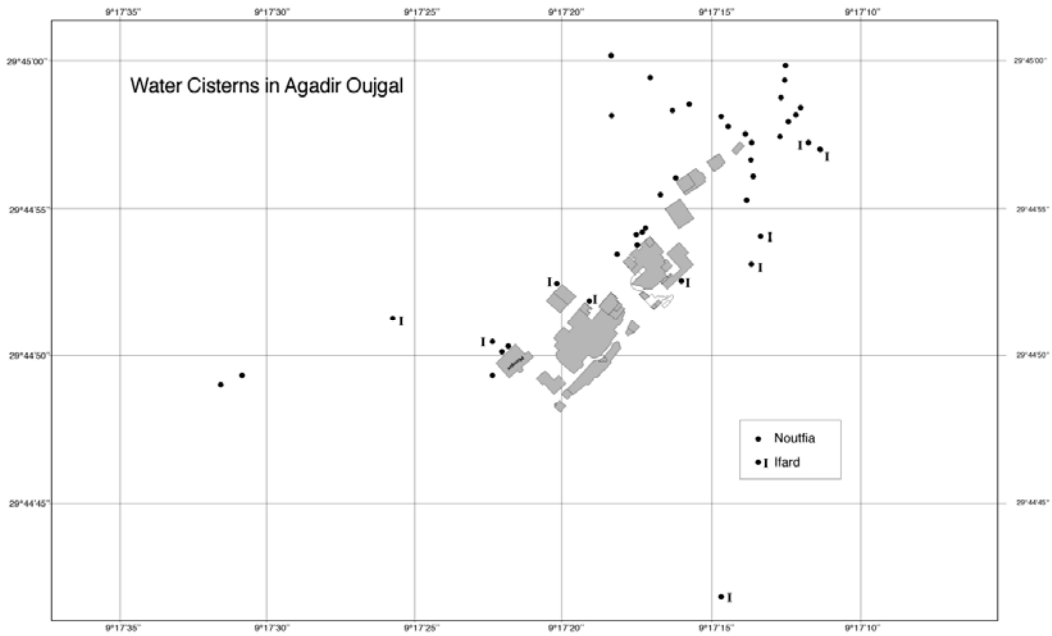
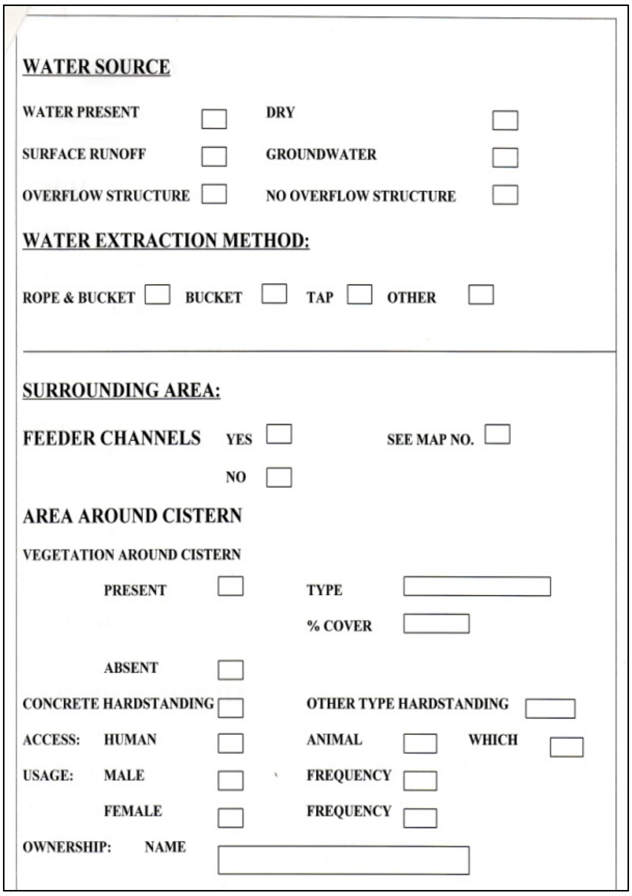


Figure 7.8: GPS locations of “noutafia” and “ifard” water cisterns (Source H Moore).

Figure 7.9a: A privately owned, uncovered "ifard"– note the fencing.

Figure 7.9b: A communal "ifard" against a mountain slope (Source H Moore).

Figure 7.9c: Women collect water from a covered "noutafia"



WATER SOURCE

WATER PRESENT ☐ DRY ☐
SURFACE RUNOFF ☐ GROUNDWATER ☐
OVERFLOW STRUCTURE ☐ NO OVERFLOW STRUCTURE ☐

WATER EXTRACTION METHOD:

ROPE & BUCKET ☐ BUCKET ☐ TAP ☐ OTHER ☐

SURROUNDING AREA:

FEEDER CHANNELS YES ☐ SEE MAP NO. ☐
NO ☐

AREA AROUND CISTERN

VEGETATION AROUND CISTERN
PRESENT ☐ TYPE ☐
% COVER ☐
ABSENT ☐

CONCRETE HARDSTANDING ☐ OTHER TYPE HARDSTANDING ☐
ACCESS: HUMAN ☐ ANIMAL ☐ WHICH ☐
USAGE: MALE ☐ FREQUENCY ☐
FEMALE ☐ FREQUENCY ☐
OWNERSHIP: NAME ☐

Figure 7.10: Data collection sheet for field work (Source H Moore).

Data collection in the field generated quantitative information on water storage capacity and access as enumerated in Table 7.3 below.

Table 7.3: Quantitative data about water storage capacity and access.

“noutafia” (N) “Ifad” (I)	Maximum Depth (m)	Volume (m3)	Water Source	Covered (C) Uncovered (U)	Locked (L) Unlocked (U)
N1	4.3	10.8	Roof*	C	L
N2	5.1	122.4	Roof*	C	L
N3	4.5	116.5	Gully	C	L
N4	3.1	66.6	Slopes	C	L
N5	4.3	69.2	Gully	C	L
N6	6.7	27.4	Gully	C	L
N7	6.6	118.2	Slopes	C	L
N8	5.1	181.1	Slopes	C	L
N9	6.0	117.7	Slopes	C	L
N10	4.2	115.3	Gully	C	L
N11	6.9	697	Slopes	C	L
Il	3.8	21.3	Tracks	U	U

I2	3.2	26.6	Tracks*	U	L
I3	3.5	27.7	Tracks*	U	L
I3	3.5	27.7	Tracks*	U	L

At each "noutafia" and "ifard" easily measured water quality characteristics were measured directly in the field and included temperature (°C), acidity pH and alkalinity pH, dissolved oxygen (mg l^{-1}) and electrical conductivity ($mscm^{-1}$). In addition water samples were collected at different times of the year, in July 2000, January 2001, March 2001 and November 2001 from four "noutafia", three "ifrads" and at the well in the next village which is often used during times of drought. The budget prevented all sites from being sampled, so a representative sample was taken. Samples were kept below 5°C, and transported to the Laboratoire Regional D'analysis et de Recherches Veterinaries D'Agadir for analysis. They were analysed for the water quality indicators indicated in Table 7.4. The values are presented for Total and Faecal coliforms[34] in Table 7.5.

Table 7.4: Suite of laboratory analysis for water quality indicators

Total aerobic bacteria 22°C /ml ($x10^3$)
Total aerobic bacteria 37°C /ml (10^3)
Total coliforms/100mls
Faecal coliforms/100mls
Anaerobic Sulphide reducers / 20mls

Table 7.5: Agadir Ouguejgal characteristics of Cistern Water *=no water present; NS = no sample

Sample	Total Coliforms / 100ml					Faecal Coliforms / 100ml				
	7/00	1/01	3/01	11/01	Mean	7/00	1/01	3/01	11/01	Mean
N1	110	6	13	8	34	18	0	5	3	7
N3	530	7	0	140	166	310	2	0	120	83
N7	130	120	7	12	67	25	0	0	3	7
N9	30	22	28	110	48	3	0	0	66	17
I3	76	90	10	38	54	50	12	5	9	19
I4	92	120	20	210	111	45	22	2	55	31

[34] A coliform test is generally used to determine bacterial content and the hygienic and sanitary conditions of the food or water being tested.

I5	50	290	13	*	84	35	20	4	*	20
Well	250	110	NS	170	177	130	4	NS	96	77

The presence of coliforms provides evidence of recent faecal contamination. The presence of these faecal indicator bacteria gives no indication whether the source is human or animal, but it is widely accepted that human faecal matter is more likely to contain human pathogens than animal faeces (Ashbolt et al 2001: 299). Therefore even a very low level of faecal contamination may be considered to present a risk to human health. If present, the World Health Organisation recommends further action to identify potential sources of contamination, with an objective of zero total coliforms per 100ml of water for drinking supplies after treatment (WHO 2008: 283).

Participatory research discussions

To complement the quantitative water survey data, participatory discussions were held inside several houses to provide qualitative information (Figures 7.11). We held discussions with various groups of women and individuals. As is usually the case in field research, some were more forthcoming than others. Although the discussions were very informal, and sometimes chaotic, we had a survey sheet to remind ourselves to ask all the pertinent questions. This was usually completed by an observing and listening researcher, not one actually leading the discussions, to minimise interference (Figures 7.12a, 12b). All the women were illiterate and had never been to school, and in the beginning they found it difficult to listen to each other, as they tried to shout the loudest and be heard first. We had to encourage them to take it in turns to speak and listen to one another. This behaviour was possibly a result of the hierarchical relationships in their daily life or simply the way meetings are conducted in the tribe. Also, because of their religious and cultural background, they appeared to sit in a linear formation, in contrast to a more egalitarian circular one dictated by participatory modes (Figure 7.11). They were often veiled (see the sitting woman in Figure 7.11) which creates a communication barrier between the researcher and the respondents. However, the picture does not accurately record the whole situation because the veils were put across the face when photos were taken and came down again afterwards.

Figure 7.11 Participatory discussions with Berber women (Source: H Moore)

Figure 7.12a: A research assistant with language and literacy skills translates and explains (Source H Moore).

WATER SUPPLY

W1. Time of Interview ________

W2. Name of household ________

W3. Location ________

W4. How many people are there in your household?

- Elderly men > 60 ________
- Elderly women >60 ________
- Adult men ________
- Adult women ________
- Boys 5-15 ________
- Girls 5-15 ________
- Infant Boys <5 ________
- Infant Girls <5 ________

W5. Who fetched water to the house yesterday?

____

W6. Type of container used

- Metal ________
- Plastic ________
- Other ________
- Covered ________
- Uncovered ________
- Please show me later

W7. What was it used for? **Container type**

- bathing
- washing clothes
- cooking
- drinking
- other

W8. Where did you get water from yesterday for?

- bathing ________
- washing clothes ________
- cooking ________
- drinking ________
- other ________

W9. Can you show me later?
(Ref. No. of cistern)

W10. Is it the same place when the weather is wet **Yes/No**

W11. If not, where from?

____

W12. Can you show me later?
(Ref. No. of cistern)

W13. How many visits were made to collect water yesterday?

____

W14. When was water collected yesterday?

- before 6am
- 6 - 9am
- 9 - 12noon
- 12 - 3pm
- 3 - 6pm
- after 6pm

W15. How long did it take for one round trip to collect water yesterday?

____

W16. Do you know how much water was used in your household yesterday?

- bathing ______
- washing clothes ______
- cooking ______
- drinking ______
- other ______

W17. Is it more or less than when the weather is wet?

- more ______
- less ______

W18. Is water stored in your household?

	Inside	**Outside**
bathing	____	____
washing clothes	____	____
cooking	____	____
drinking	____	____
other	____	____

W19. Can you show me later how it is stored?

- metal ______
- plastic ______
- other ______
- covered ______
- uncovered ______

W20. Was/is any water remaining from yesterday's collection

Yes/No

- bathing
- washing clothes
- cooking
- drinking
- other

W21. How many other households collected water from the same source yesterday?

______

W22. Please name them.

______
______
______

W23. Please locate them

______
______
______

W24. Do any further households have the right to collect water?

Yes/No

W25. Please name them

______
______
______

W26. Please locate them

______
______
______

W27. Is your water source locked?

Yes/No

W28. Is your water source covered?

Yes/No

W29. Who is responsible for the maintenance of your water supply?

______

Figure 7.12b: Example of water supply interview sheets.

To help record qualitative data from participatory and other opportunistic encounters, transcriptions were made as soon as possible after the interviews. An example of some field notes transcriptions is shown in Box 7.1.

Box 7.1: Field notes, household survey

Issues to be discussed: Describe house, woman's name, husband's name, daughter(s) here and age, son(s) here and age, daughters away, sons away, grand daughters, grandsons, animals: cow, donkeys, chickens others. "Noutfia", "Ifard", Roof tank, toilet arrangements, describe kitchen and photo, cooking fuel, lighting for house, radio, TV, Solar power, transport and last trip out of village.

Household 3: Interviewed 15/1/02

Interview conducted beside house wall, access not permitted. Traditional stone, wood and mud house.

Households 3&4 were probably one building, which has been subdivided at some point. Woman: Aicha, this is not her home village. Husband Banfama, works part time in Agadir. (Respondent names changed for anonymity).

One daughter aged 13 lives in village and never went to school, one boy 14 now working in Tafraout and he attended primary school. Only Aicha and her daughter sleep here usually. Has no animals, no fodder. Water today collected from the "petit barrage" i.e. the public "ifard". She thinks it's clean water. Collected 3 x 20 litres for 6 persons (visitors), and to clean her in-laws' house next door while her mother in law is away at a funeral. At an average round trip of one hour per visit this would have taken 3 hours. Kitchen uses brushwood fuel on fire. She uses candles for lighting and has a radio. The toilet is outdoors in the environment. She undertook fetching water, cleaning and cooking for her and her in-laws in Household 4.

Household 5 interviewed 16/1/02

Access gained. Traditional stone, wood and mud house, highly decorative door entrance, slate patterns (HRF took photo). House is roughly square and arranged around a central well down which you can see the animal stables. It was kept loosely covered by sheets of corrugated plastic. 4 people usually live in this house

Wife: Fadma, (the woman with the bad chest pains) originally from Ait Ihia. Husband: Ali, who was described as a little mentally ill and has never worked. One daughter not married lives in this house, 2 sons: 1 in Rabat is married and his wife comes from this village and lives in this house, 1 in Casablanca who is unmarried. No grandchildren. Animals 1 cow and 1 donkey and 3 chickens, kept on ground floor of house. Fodder fetched every day, green from the fields, although they had a fodder store on first floor which contained chopped straw, bushes and dry leafs for bad weather periods. Stairs to first floor. On landing at the top of the stairs was a gas stove, but it was only used for weddings and feasts. On the first floor there was a sitting room, the married son's bedroom where the daughter in law slept, a bedroom for Fadma and her daughter, two fodder stores and a kitchen. Kitchen: wood fuelled traditional dome bread oven and water boiling facilities. Women fetch fuel wood. Fire lit 2/3 times per day. Advised Fadma not to sit in the smoke filled room, it will aggravate her breathing difficulties. Large water pot in the corner, water used for drinking and the water looked very clear. Today's water collection was 2 x 20 litres . per day for 4 people. 20 L extra if washing / bathing was required. Source of drinking / cooking water in rainy season small barrage – public ifards, in the dry season is the furthest well below next village. (One I walked to). Water for washing clothes and animal drinking water came from Ifard Ic1. A corner of one of the fodder stores was used as a washroom, two small buckets and bottle of shampoo on floor. Toilet was outside in the appuntia for both men and women for most houses. No specific areas for men and women. House has had solar power for 2/3 years and there is electric light (even in the fodder stores). Cables and switches around the first floor walls. They have a TV and a radio and watched the TV last night, however the battery is a problem. Fadma travelled by car 1 ½ years ago, in the summer, to see the doctor in Anezi. More recently she travelled to her home village during Ramadan. On the roof terrace was a separate room where her husband slept. The top of the central animal pit opened out up here. The TV aerial was positioned in one corner. A tremendous view of the small barrage area, cemetery and "appuntia" toilets. House directly below the mosque (H Moore 2002).

Photographic evidence is also an important part of qualitative data. For instance, the photographs in Figures 7.13 and 7.14 immediately indicate water storage and contamination problems.

Figure 7.13: Water storage for human consumption and domestic usage in a modern village house. (Source: H Moore).

Figure 7.14: Water storage for human consumption stored next to domestic usage water in a traditional village house (Source: H Moore).

Figure 7.15: Womens' back-breaking task: Water collection across a mountainous terrain, often twice a day. (Source: H Moore).

From discussions with the women in focus groups, it soon became apparent that the main issue in times of water scarcity was the access to clean drinking water for human consumption. The women shown in Figure 7.15 have to walk long distances over mountainous terrain to meet the family's water needs, carrying 20 litre water containers on the return journey, a task that takes up to 2.5 hours to complete (Source H Moore). The drinking water is sourced from the "noutafia". Most families had access to a small ""noutafia"", but in drought years, like 2000, these became empty. Some richer families were able to refill them with clean water delivered by tanker. However, for the poor families, the struggle to fetch clean drinking water involved the women undertaking a 4-hour round trip down the steep mountain to a well. This well was owned by another village down in the valley and it caused tension when they visited. The walking and carrying also had long term health implications for these women and they were only excused from the task if they were pregnant or physically ill. The young girls were also involved in this routine rather than attend school.

Another equally important concern was water for animals (donkeys, goats, cattle) for which the women are also responsible on a daily basis. This water is accessed from the "petit barrage" public "ifard" for the animals and is also used for general purpose household washing. However, there is an awareness that water from the uncovered "ifards", often in close proximity to appuntia (cactus) areas used for toilets, is not clean enough for human consumption and great care is taken in keeping differing usage waters separate.

Towards research-oriented action

The aim of this research was to develop a short term strategy which would help to improve the health and quality of life of the rural poor, and in particular the women and children of Agadir Ouguejgal. Water was of particular concern because of the relatively low annual rainfall and the unreliability of the rainfall regime. The "noutafia" and "ifard" system provided water of questionable quality and represented a health risk to local inhabitants. The overriding issue was one of water scarcity. This impacted on all aspects of life.

It was during informal discussions with the women that a proposed solution emerged, namely a very large capacity, public access "noutafia", near the village, within easy walking distance and away from the open-air toilet areas. Eventually, after two years and much heated discussions, the details were agreed by the local men. I think part of the problem with the delay was their absence from the village for long periods and, as men are the decision makers, things moved slowly.

In due course, however, the women became very frustrated at the delays and wanted to take things into their own hands to build the structure. One angrily said to me, "Oh give me the spade and I'll dig it!!" Our water harvesting survey, together with local knowledge, helped identify where to build the new "noutafia". After many delays construction began and cement was imported by lorry. Money came from British Council funds and local sources, and the 320,000 litre capacity "noutafia" was completed in 2006 (Figure 7.16). Since the "noutafia" has been completed, discussions have continued about village sanitation arrangements. In addition there have been proposals to help the villagers diversify their agricultural crops. In particular it has been suggested that varieties of apples which can tolerate the lower rainfall that is predicted by climate change models could be grown at these altitudes, and also give an additional source of income.

Figure 7.16: The new "noutafia" site against the mountain side (Source H Fox).

Concluding the project

The initial aim of the project has been achieved. The completion of the 320,000 litre "noutfia" has enabled the whole village to have equal access to clean water, particularly during times when water is scarce. This will also help to combat further water shortages that are predicted by climate change models.

The women and girls are no longer compelled to make 4-hour treks to find clean water down in the valley well and mothers know that the water they are providing for the home is clean with minimal contamination. They are also aware of how to handle and store water in the home to avoid further contamination. Since the project finished a new school has been built closer to Agadir Ouguejgal (30 minutes' walk away) and now for the first time girls are also attending school regularly. Nationally there has been an initiative to encourage women to attend school led by the King of Morocco's sister. The women in Agadir Ougjal are now offered the choice to attend school. Hopefully relief from water fetching duties will enable them to have more time to attend these classes.

These people live in a very marginal area, both in terms of physical remoteness and in terms of their survival. At present the communities rely on absent men and remunerations from city wages, whilst the women and older people struggle to maintain links with the traditions of the village and work family-owned land. This project enabled us to work with one village to help the inhabitants address their current situation. However, everyone needs to look forward and ask whether their way of life is truly sustainable in the long term. In the medium term the use of alternative drought-tolerant crops, solar power and composting toilets may improve the quality of life further. Looking further ahead, the climate change prediction for less rainfall in this area over the next three generations (50 – 80 years) will make life increasingly hard and even more marginal. In addition, as children and women's literacy rates rise, so too will their expectations and life choices. In the longer term these two factors could be the drivers for net outward rural migration from the Anti-Atlas Mountains.

This kind of 'lived experience' research relies on the successful merging of the quantitative and qualitative, objective and subjective methodologies which together can lead to practical solutions. It is research that presents several challenges when you try to operationalise it and you might like to attempt Activity 15 – 'Problems associated with a multi-disciplinary research approach' - in the Module 3 workbook to explore some of these challenges. Nevertheless, I hope that what I have provided in this chapter will inspire you towards an interdisciplinary approach towards your Master's dissertation.

To end, it is acknowledged that this research project was funded by the British Council and appears with the kind permission of the research team which include Dr H. Fox, Dr I. Brightmer and Dr H. Moore, (University of Derby) in partnership with Prof C. Harrouni and Prof A. El Alami (Institut Agronomique et Vétérinaire (IAV) Hassan II).

8 Module evaluation

The learning outcomes for this module were identified at the start, and I repeat them here so that you can revisit them..

a) *Demonstrate your knowledge and understanding of*

- i) Interdisciplinary research methods
- ii) The underlying assumptions and philosophical arguments that direct research methodologies.

b) *Be able to:*

- (iii) Develop and critique interdisciplinary research approaches for dissertations or other investigations requiring primary data, while seeking complementarities to those defined by your own disciplines.
- (iv) Locate and use your preferred methodology within an interdisciplinary framework.
- (v) Apply interdisciplinary methods and analysis to given case studies of lived experiences of climate change.

c) *Apply the following key skills*

- (vi) Understand and engage critically with the theoretical arguments regarding research methodologies.
- (vii) Assess the dominant methodologies and boundaries within your own discipline and explore how these can be extended through crossing disciplinary boundaries.
- (viii) Develop a research proposal using your chosen methodological approach.

At the end of this module, please now spend a few moments considering whether you have achieved these learning outcomes and whether you still need to explore further materials to help you develop them. You can do this by carrying out your own on-line research through website resources, electronic libraries or other places. You may, of course, have found some materials more interesting than others. Again, you may wish to explore why. Above all, I hope you enjoyed this module and found the underlying philosophical arguments about research methods motivating.

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