T869 Climate Change: from science to lived experience

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

WORKBOOK

By Dina Abbott (with specialist natural science activities by Heather Moore)

Disclaimer

This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Grant agreement number *2009-3532/001-001*

Contents

Module 3 workbook

Welcome to the workbook for Module 3: *Interdisciplinary methodologies for investigation into the 'lived experiences' of climate change*. This workbook complements the textbook for this module and also makes use of the *Water Case Study* which is used in all three modules, audiovisual links, and links to additional reading.

This workbook assumes *either*:

> That you have at least read quickly the textbook for Module 3, and preferably also the *Water Case Study*.

Or

> You are currently reading the textbook for Module 3 and are attempting to do the workbook activities as and when they are suggested in that textbook.

This workbook should help you realise the learning outcomes as set out at the start of the textbook. More generally it aims to:

- Enable you to deepen your understanding of the ideas, concepts frameworks and issues that are raised in the textbook.
- Allow you to explore in greater depth any particular issues that are of interest to you.
- Allows you a further opportunity to prepare for your final dissertation/thesis/report and reflect on appropriate research methodologies.
- Develop 'transboundary competence' (see previous module workbooks) through participation via the virtual learning community in group work and engagement with others.

These aims lead to the overall purpose of the workbook: to increase your satisfaction of studying this module through your active and deep engagement with it. The workbook is not confined to academic frames of reference, therefore, and is equally appropriate for registered Masters students and for those who are studying it more informally as a 'lifelong learning' experience.

The workbook is structured through a number of Activities for you to undertake. These Activities are designed for you to extend and deepen your learning, and with one possible exception[1], not directly for formal assessment. Apart from the possible exception noted, you do not have to do them, but I hope you do for the aims and overall purpose cited above.

The Activities are varied and their directed tasks typically ask you to apply critically the textbook ideas and concepts. Often, after an Activity, a 'Discussion' is provided which comprises the author's personal attempt to do at least part of it and might also contain a further commentary on anything of interest the Activity has raised. Please do not take this Discussion as the definitive answer to the Activity, rather use it as a point of critical comparison with your own attempt. Do, however, attempt the Activity yourself before reading the Discussion. The nature of this module means that there are only rarely objectively 'right' answers.

---

[1] The exception concerns any workbook activities which might be deemed compulsory by your accrediting institution. The obvious example is 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.

Each Activity contains an indicative maximum time which you should spend on it, assuming that you have read the textbook and relevant chapters already, and what the Activity is aiming to achieve. I stress that this is the maximum time. You can cut corners, and you may be familiar enough with the ideas which an Activity is exploring to reduce the time significantly. Also, you do not have to follow the Activity format as set out exactly. Adapt it as you wish. All of the Activities can be adapted. We, the authors, particularly recommend that, instead of attempting them as an individual, you adapt them where appropriate for collective discussion in the electronic forums.

Activity 1: Thinking further about hypothesis and generalisation (maximum time 2 hours)

Section 2.1 of the Module 3 textbook considered the first stage of a research process -- generating a research question -- and drew a distinction between a hypothesis and a generalisation. This activity is designed to help you explore ways you can generate a research question based on either a hypothesis or a generalisation. Please do the tasks identified below prior to reading my take on these.

Task 1: Refer to the Water case study on the Nile and Rhine river basins which accompanies these modules.

Task 2: With reference to Section 2.3.2 Example 1 (The Sahel drought), think of a hypothesis that you can formulate to explain the 1968-1974 drought.

Task 3: Are there any alternative hypothesis that might also explain the drought?

Task 4: Draw a generalisation based on Section 2.4.3 (Stakeholder participation) in relation to the Nile Basin.

Task 5: Can this generalisation be carried over also to the Rhine Basin (Refer also to Section 3.4.3.)? If so what are the similarities and differences?

Discussion

Tasks 1-3: The example in Section 2.3.2 suggests that the Sahelian drought, which had devastating results in the period 1968-1974, was caused by environmental degradation that occurred over many years. I could straightaway develop a hypothesis that “The Sahelian drought (1968-1974) was a result of long-term environmental degradation” and a related null hypothesis could be that “The Sahelian drought (1968-1974) was not a result of long-term environmental degradation”.

However, if I did this, I would immediately hit some huge problems, one main one being “where do I start” in proving or disproving the causality between the drought and “long-term environmental degradation” as the concept is so large! “Long-term environmental degradation” can be connected with many forms of human activity (for example, deforestation, overgrazing, and population densities) or climatic changes (for example, rainfall patterns, and temperature changes) and is therefore too complex an issue to narrow down to one cause. Thus, I would have to consider several variables. Also, how am I going to determine the differences between “short-term” and “long-term” environmental degradation? What enormous data types and data ranges will this require?

Therefore, I have firstly to make the hypothesis less ambitious, more manageable and practical. To do this, I will pick on one variable which may have contributed significantly to the Sahelian drought. For example, I could follow the Curry-Lindhal (1986[2], cited in

---

[2] I look at arguments from the 1980s because these are examples of the typical responses that followed the Sahelian drought.

Adams 2009, p219) argument on the causes of this drought. Using a neo-Malthusian[3] argument he suggests that development agencies probably drew incorrect conclusions on the cause of the 1970s Sahelian drought. In pointing to overpopulation and overgrazing, Curry-Lindhal argues instead: ‘They called the effects of the drought a “natural disaster” and blamed the climate! The real root of the problem, that Man himself was responsible, was not recognised or admitted: it was too unpopular a message’ (p107).

A hypothesis that can arise from Curry-Lindhal’s argument might be: “The Sahelian drought (1968-1974) was a result of overpopulation”.

An alternative hypothesis can be drawn through counter arguments based on a null hypothesis that overpopulation was not the direct cause of the Sahelian (1968-1974) drought. Counter to the neo-Malthusian view, others, for example Horowitz and Little (1987, cited in Adams 2001 p197), have argued that it is government policies designed to settle semi-nomadic peoples in one place that are responsible for skewing the balance between overuse of resources, environmental degradation and eventual desertification (which can result from drought). The logic is that if you do not do not pressurise nomadic people to settle in restricted zones, environmentally-led disasters can be averted. Therefore an alternative hypothesis might be: “The Sahelian drought (1968-1974) was caused by poor pastoral policies”.

Tasks 4-5: Section 2.4.3 of the Water Case Study highlights the importance of stakeholder participation in contributing to sustainability of the development of the Nile basin. Whilst stakeholders (which include diverse groups such as members of the household, local farmers, fisher people, government agencies and so on) all have their own individual interests (stake) in ensuring water access, they also have a long-term interest in working together to ensure water sustainability. Therefore, whilst there may be conflicts of interest between the stakeholders, it is important that there is some level of agreement if common goals are to be met. Thus, a broad generalisation might be: “Stakeholder convergence of interest is important for water sustainability of the Nile Basin”. However, to investigate “convergence of interest” between large numbers of stakeholders is difficult and so I might narrow this down further by identifying particular groups of stakeholders, for example, women and small-scale farmers. This changes the generalisation to “Small-farmers’ participation is important for water sustainability in the Nile Basin”. Narrowing in this way makes the generalisation far more manageable in terms of gathering and analysing data. If at the end of my investigation I discover that the generalisation is valid, I will be able to apply it broadly to other examples, for instance, to hypothesise similarly about the sustainability of the Rhine basin even though the context of the two basins (geographically, historically, socially, economically) is very different.

Activity 2: Social construction of events (maximum time 2 hours)

The aim of this activity is for you reflect on how interpretations of events in society are socially constructed and how that influences the way research processes are approached. This Activity and the next draw on Section 2.2 in the module 3 textbook.

Task 1: Read the text in Box 1 and answer the following questions:.

a) How are the actions of the three agencies involved in this scenario (the aid workers, men and women villagers) socially constructed?

---

[3] Neo Malthusians take arguments developed originally by Thomas Malthus, a political economist writing over 200 years ago, to blame environmental degradation and its consequences on factors such as overpopulation, agricultural intensification and overgrazing which challenge the “carrying capacity” of the environment. Carrying capacity refers to the level at which human populations, animals and vegetation can be managed within a specific, local context. The reasoning behind the carrying capacity argument is that there is a fixed amount or number of animals and people that the environment can accommodate.

b) How does the social construction shape research questions and research outcomes?

c) What type of philosophical questions regarding the relation between research, research theory and practice may arise from this example?

Task 2: Attempt to answer the Task 1 questions in relation to an example that you have chosen yourself. The example should again concern the social construction of interpretation of events in society and how this influences the research approach. Also, it should preferably relate to climate change.

Box 1: Somewhere in the late 1960s, I was told this simple story which nevertheless highlights how our understanding of how given situations in society are socially constructed, without an understanding of which we can end up doing more harm than good.

Some foreign aid workers undertook a research project in a local village in Kenya from which they hoped to emulate and generalise findings for other locations. The research question was how to enhance potato production for small-holders using participatory methods. On their arrival, the aid workers were greeted by the village elders and men of the community with whom they held a meeting on problems with potato production on small-holdings. The meeting ended with each villager receiving a kilo of a new variety of seed potato to plant for an experiment in increasing production. On their agreed return date, the aid workers discovered that villagers had nevertheless continued to use the old variety of seed potatoes and the harvest had not radically improved. On enquiry, they discovered that the men had taken the new seed potatoes to their wives, who believing these had been purchased for supper, promptly stewed them for the family's evening meal. The crucial fact that the aid workers had missed was that vegetable farming, both in rural and urban areas, is regarded as women's work in many parts of Africa, including Kenya, whilst men tend to work with cash crops. It is therefore the women who are responsible for growing potatoes on their own plots and marketing them, not the men who are often simply responsible for purchasing them. Of course, therefore, it is the women as the primary vegetable farmers who should have been consulted in the first instance and not men.

Discussion (in relation to the Task 1 questions only)

My answer in brief:

a) The actions are socially constructed through issues of class, race, and gender. This is manifest through power relations between the aid workers as experts and givers of opportunity and the villagers who are mentally constructed as somewhat passive receivers of that opportunity. The assumption of gendered roles between men and women in the village is also socially constructed in the perceptions of social etiquette, men and women's place in society. This social construction lies both within the village and between aid workers and villagers.

b) Here social construction and mental positioning of the dominant group (aid workers) omits to take into account gender issues and thus the research is inadequate and the questions asked erroneous. The outcome is therefore flawed and does not meet the project objectives. To meet these, the aid workers might begin by identifying who the small-holders are and who is responsible for farming potatoes in order to move away from any assumptions they hold about hierarchical and work relationships within the village.

c) Questions and debate are raised in relation to power, perceptions of power and standpoint, 'knowledge' and underlying assumptions.

Activity 3: What is your standpoint? (Maximum time 2 hours)

This activity draws again on the module textbook Section 2.2. It aims to enhance your understanding of how standpoint influences research processes, in particular the shaping of the research question.

Task 1: Read the extract in Box 2, from the Oxfam Briefing Paper 116, *"Survival of the fittest: Pastoralism and climate change in East Africa"*, available at: http://www.oxfam.org/en/policy/bp116-pastoralism-climate-change-0808.

Task 2: Develop a research question that will help you to understand the relationship between pastoralist behaviour and climate change vulnerability.

Task 3: Consider how this research question might be influenced by your individual standpoint. Here, think of how your individual standpoint can be shaped through factors such as the country you live in or from which you originate. For instance, if you live in East Africa, your knowledge of pastoralism will be perhaps more direct and different from someone who lives in the Europe. For an East African, tribal affiliations, ethnicity, race, gender will all shape the way you perceive and understand pastoral livelihoods and climate change. How will the standpoint arising from these perceptions and understanding influence what research questions you will choose and will be interested in?

There is no Discussion to this Activity.

Box 2: Challenges faced by pastoralist communities (adapted slightly from Oxfam Briefing Paper 116, p11-14)

Pastoralists face many challenges that hinder their way of life and stifle their ability to adapt to changes in their external environment. These challenges can be grouped into four main categories: climate change, political and economic marginalisation, inappropriate development policies, and increasing resource competition.

Communities across the world are starting to learn to live with the reality of climate change, adapting as best they can to its impacts. This is happening even though global average temperatures have not yet exceeded a 1°C rise above pre-industrial levels. As temperatures rise further, risks will be magnified. A rise of 2°C above pre-industrial levels is now widely accepted as the threshold at which highly dangerous, and possibly dramatic and unpredictable, climate changes become much more likely. Global action is urgently needed to keep the global temperature rise as far below 2°C as possible. Rich industrialised countries, which have both historic responsibility and the greatest capacity to act, must take the lead and cut their own emissions first and fastest.

The pastoralists who inhabit the dry lands of sub-Saharan Africa are among those who are living with the effects of climate change. Pastoralists have been managing climate variability for millennia. However, the unprecedented rate and scale of human-induced climate change is beginning to pose more problems.

Scientific understanding of climate dynamics makes clear that in the short term (10–15 years) the climate variability that pastoralists have seen over the last few years will continue. In Kenya, Tanzania, and Uganda the main climate-related vulnerabilities over recent decades have been:

*Successive poor rains: Pastoralism is well adapted to coping with a single rain failure in a particular area, but when successive rainy seasons fail there is simply insufficient regeneration of grazing land, and pasture shrinks. Pastoralist communities from Kotido in north-eastern Uganda report that the long rains that used to occur between March - August are now beginning as late as May.

*Return rate of drought: The frequent droughts in recent years have meant that households have had no opportunity to rebuild their assets, including livestock, with many becoming locked into a spiral of chronic food insecurity and poverty. Reports from the Kenya Food Security Group and from pastoralist communities show that drought-related shocks used to occur every ten years, and they are now occurring every five years or less. A pastoral association in Wajir District in Kenya reported that their animals don't have time to recover physically from drought and can no longer withstand the dry spells. Camels used to require watering only once every month, when the water points were hundreds of kilometres away, but these days they need it once every week. Cattle begin dying after just two months of a dry spell and are continuously being lost every dry period, whether there is a drought or not.

*Unpredictable and sometimes heavy rainfall events: These make it difficult to plant and harvest crops (growing numbers of pastoralists plant crops opportunistically on a small scale) and sometimes are partly responsible for causing flash floods. Floods can damage both crops and infrastructure. They also result in a higher incidence of some human and animal diseases.

It is likely that over the next 15 years agricultural areas in Kenya and Uganda will continue to experience unpredictable rainfall, including both heavy rainfall events and the failure of rains and the loss of crops that comes with this. In marginal agricultural areas pastoralism may in fact provide food resources and secure a viable livelihood where climate change and other pressures lead to lower reliability of farming. Indeed, where climatic conditions become more variable without leading to the destruction of rangelands, pastoral livelihoods have the potential to sustain populations in the face of climate change where other livelihoods might fail.

After the next 15 years the weather patterns will change again. Whereas global climate models have an impressive ability to simulate global climate, they are much less reliable at the scale of region or country. That said, climate models for East Africa show a greater consistency in their projections than is the case for almost anywhere else in the world. This gives a degree of confidence to the predicted trends. The Intergovernmental Panel on Climate Change (IPCC) climate models show:

*Increasing temperatures: Most models and scenarios estimate that temperatures will be around 1ºC higher by 2020 compared with the average temperature between 1961–1990. The increase will continue to around 1.5ºC by 2050 and nearly 3ºC by the 2080s.

*Increasing rainfall: More rain is predicted to fall in the short rains (October-December) over much of Kenya and Uganda as soon as the 2020s, becoming more pronounced in the following decades. These rains are projected to increase by up to 60 per cent by 2050 and to have nearly doubled by the end of the century. The length of the rainy seasons is unlikely to increase, so short rains will be more intense, especially over northern and western Kenya, Uganda, and north-western Tanzania. Failure of the short rains may become less common, and years of heavy rain more common. The increase is more modest for coastal Kenya and northern Tanzania, and southern Tanzania is predicted to become drier, with extreme dry years becoming increasingly common.

*Trends in the long rains (March-May) are less well understood but an increase seems likely, especially in western Kenya and north-western Tanzania.

Pastoralists in Uganda and most of Kenya could benefit in some respects from this predicted climate change. A substantial increase in rainfall will bring more dry-season pasture and longer access to wet-season pasture. A decrease in the frequency of droughts will mean grazing lands, livestock, and people have more time to recover between droughts and assets can be built up over time. More rainfall also means an increased likelihood of a good small-scale crop harvest.

However, there will also be significant negative consequences. In southern Tanzania, the combination of increasing temperature, decreasing rainfall and extreme dry years becoming more common is likely to significantly increase water stress and drought for people and livestock. Throughout East Africa, increasing temperature is likely to cause heat stress to livestock (especially cattle – sheep and goats are less susceptible to heat stress). In Uganda and most of Kenya, increased rainfall may make more of the arid lands attractive to agriculture, and so agricultural encroachment, land speculation, and potentially conflict between pastoralists and agriculturalists may increase. The increased intensity of rainfall in these areas is likely to mean that floods become more frequent, as some argue is already happening. Some human and livestock diseases are likely to become more common.

Activity 4: Variables and Scientific Method (maximum time 6 hours)

This activity draws on the module 3 textbook chapter 3, especially Section 3.3. It contains two tasks which give you an overview of a good experiment and of designing your own experiment. The Discussion is bound up in the Tasks and is therefore not provided independently.

Task 1: Read Box 3 ‘Experimental plant growth in saline water’, and summarise in 500 words (maximum) the main requirements of an objective and rigorous experiment.

Box 3: Experimental plant growth in saline water

To help you appreciate further how scientists work, below I give you a detailed example of experimental research conducted some years ago at an agricultural research institute in Southern Morocco at the Complex Horticole d’Agadir (AIV) which is a part of the Institut Agronomique et Veterinaire Hassan II. This is a large teaching and research institution focused on improving agricultural potential in the region.

Here Daoud et al (2001) and Harrouni et al (2003) established a research project with a clear research question. They wanted to investigate the salt tolerance of a number of indigenous halophyte plants (plants that grow naturally in saline soils) in order to assess their relative potential as agricultural cash crops. This would be particularly beneficial in coastal areas where saline seawater had seeped into the fresh groundwater supply, or in areas where seawater could be used for irrigation. Salination is an issue in regions of increasing water scarcity and rising sea levels, both of which are related to climate change. Figure 1 summarises the processes of the experiment. It gives you an indication of its systematic organisation and expectations and the various stages leading to analysis and dissemination of results.

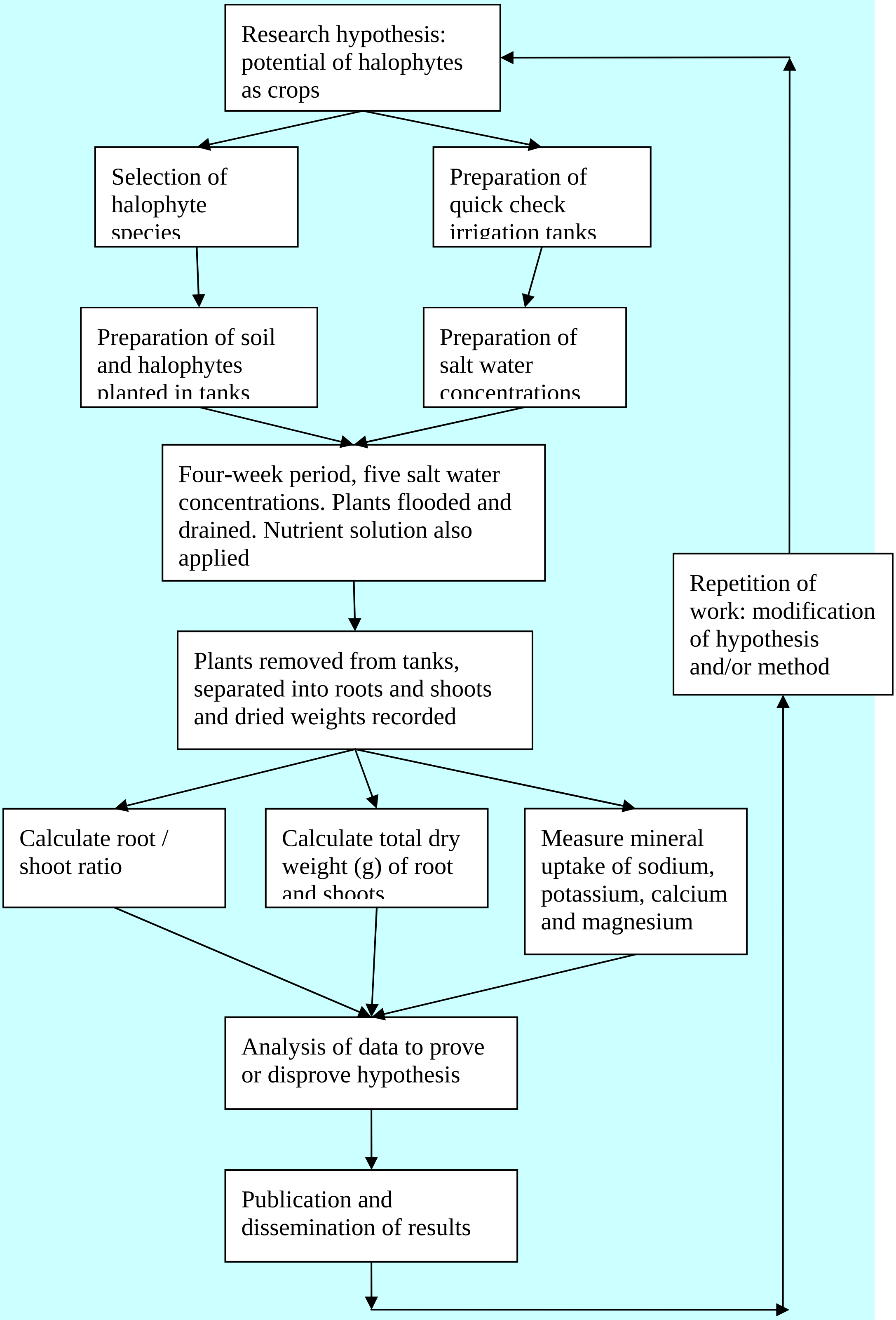

Figure 1: The halophytes experiment

Rather than monitor the response of plants outdoors on the coast, where soil and weather characteristics vary with space and time it was decided to bring eight halophyte species into a controlled greenhouse. The species selected were Avicennia germinans; Aster tripolium; Batis maritima; Limoniastrum multiflorum; Rottboellia fasciculata; Sesuvium portulacastrum; Sesuvium verrucosum and Spartina alterniflora. The hypothesis was that sea water treatments have an effect on plant development.

The plants were cultivated in tanks filled with a naturally occurring coastal sand substrate from the local area. Four replicates were prepared of each species, to eliminate chance. The tanks were part of an automated irrigation and drainage system, and regularly flooded with water. Tanks were watered with five concentrations (0% control, 25%; 50%; 75% and 100% seawater) obtained by diluting seawater with tap water (See Figures 2a, 2b and 2c below).

Figure 2a: Halophyte experiment greenhouse (outside and inside)

Figure 2b: Young Halophyte plants in tanks at 100% and 75% sea water

Figure 2c: Mature Halophyte plants after four weeks growth and watchful scientists (Source: All images, H Moore)

Plants were adjusted to saline water irrigation by raising the salinity of the solution in increments of 1/8th every 2 days until the required concentration was reached. A nutrient solution containing 60mg/l nitrogen, 6.5 mg/l phosphate, 40 mg/l potassium and trace elements was also added to fertilize the five treatments. Temperature was monitored daily with a “mini-maxi” thermometer. The plants remained in the tank conditions for four weeks.

At this point we can review that the design fulfils the main requirements of a good experiment. There is a single independent variable (sea water concentration), several dependent variables (the different species of plants) and control variables (soil type and nutrient solution application) as indicated in Table 1 below. The design holds the soil type and nutrient solution constant but gives the researchers the ability to consciously manipulate the concentrations of sea water applied to each tank and monitor changes in the plant growth. Having four plants of each species fulfilled the need for replication.

Table 1: Halophyte experiment summary table of independent, dependent and constant variables.

Independent variable	Dependent variable	Constant variable(s)
Seawater concentration 100% 75% 50% 25% 0% 'Pure' tap water	Avicennia germinans; Aster tripolium; Batis maritima; Limoniastrum multiflorum; Rottboellia fasciculata; Sesuvium portulacastrum; Sesuvium verrucosum and Spartina alterniflora.	Soil; coastal sand Nutrient solution; 60mg/l nitrogen 6.5mg/l phosphorous 40mg/l potassium Plus trace elements

After the four week period the researchers needed to quantify how well the plants had grown within the different sea water concentrations. An apparent observation was that some plants had grown because they were taller and larger, than others. However, just reporting that "species A was bigger than species B" does not provide the rigour required when looking for cause and effect. For instance, what does "bigger" mean? This is a subjective characteristic, whereas 'scientific method' demands objectivity. In addition the plants varied in their physiology, that is some were naturally taller whilst others grew closer to the ground.

Remember the hypothesis was that the sea water treatments have an effect on plant development. Consequently, a suite of experiments was designed to provide quantifiable, objective, and value-free characteristics, indicative of plant growth and health (see Figure 1). The characteristics chosen were the (i) root to shoot ratio, (ii) total dry weight of shoots and roots, and (iii) mineral uptake into the plant material, specifically sodium, potassium, calcium and magnesium. On the basis of these measurements direct cause and effect could evaluated. This suite of experiments was conducted in the soil laboratories at the Institute in Agadir, Morocco (Figure 3) and are outlined below.

Figure 3: Soils Laboratory at Complex Horticole d'Agadir (IAV) HassanII (Source: D Abbott)

To begin this suite of experiments the plants were all prepared in exactly the same way. They were removed from their tanks and each washed with distilled water through a fine sieve. This cleaned the plants of all soil residues. The washed plants were cut at the soil line and separated into shoots (the above-ground organic material) and roots (the below-ground organic material). Each sample was placed in an individual dish, labelled and placed in an oven at 65-70 °C for 48 hours. This is a standard procedure of having a sufficiently high temperature and length of time to ensure the plant material has dried.

When dry the separate weights in grams for both the roots and shoots of each plant were recorded. Using these values the root/shoot ratio could be calculated using the equation:

(i) root dry weight / shoot dry weight = root:shoot ratio.

And the results of the calculations are shown in Table 2 below.

Table 2: Root /shoot ratio for the plants in the five seawater treatments.

Plant Species	Tap water	25% sea water	50% sea water	75% sea water	100% sea water
A.tripolium	0.39	0.40	0.57	0.42	0.61
A. germinans	0.81	0.85	0.65	0.68	0.69
B.maritima	0.45	0.41	0.35	0.26	0.25
L.multiflorum	0.22	0.19	0.21	0.17	0.22
R.fasciculata	0.30	0.13	0.17	0.20	0.30
S.verrucosum	0.30	0.21	0.22	0.20	0.23
S.portulacastrum	0.15	0.13	0.14	0.16	0.12
S.alterniflora	1.03	1.17	1.25	1.38	1.84

The second characteristic the total dry weight of shoots and roots (g) was easily measured.

(i) Total dry weight in grammes (g) = root dry weight + shoot dry weight.

And the results are presented in Table 3.

Table 3: Dry matter production (g) in shoots and roots of plants in five treatments

	Tap water		25%		50%		75%		100%	
Plant Species	shoot	root	shoot	root	shoot	root	shoot	root	shoot	root
A.tripolium	21.40	8.25	12.33	4.95	8.67	4.95	10.83	4.54	4.63	2.81
A. germinans	2.06	1.67	2.55	2.16	2.98	1.93	1.42	0.96	1.31	0.9
B.maritima	6.38	2.63	7.17	2.83	10.16	3.33	9.67	2.33	9.17	2.16
L.multiflorum	10.86	3.04	13.06	2.87	8.95	2.18	8.52	2.05	7.98	2.55
R.fasciculata	11.00	3.00	132.25	1.5	12.5	1.88	7.88	1.5	7.75	2.25
S.verrucosum	5.38	1.53	5.5	1.13	4.63	1.0	3.25	0.63	3.13	0.7

S.portulacastrum	3.50	0.5	3.88	0.5	3.38	0.45	2.5	0.38	1.75	0.2
S.alterniflora	40.79	53.72	20.68	25.85	16.99	22.92	14.57	21.96	8.86	18.13

The final experiment focused on the uptake of minerals into each species. The total dry shoot and root residues produced by experiment (ii) were ground in an electric grinder. From the material produced, replicates of 500 mg samples were taken. Having more than one sample at this point added rigour to the experiment and avoided chance. Each 500 mg sample was then burnt in a furnace at 485 °C. The difference in weight before and after burning enabled a measurement of the ash content of each plant type.

Using these ash residues of known weights the mineral composition of both shoots and roots for each species was determined. Sodium and potassium contents were determined by flame photometer after dissolving the ash in a particular concentration of hydrochloric acid. Calcium and magnesium contents were determined with an atomic absorption spectrometer. Concentrations of these minerals in plant tissues were expressed on a dry weight basis.

Once the measurements had been made and collated, analysis of the results allowed description of the causal effects of different water treatments on each plant species. In summary, the results showed that most species had their maximum biomass production in low (25%) salinity treatments. High sea water concentrations reduced plant growth of all species with the exception of A.tripolium and S.alterniflora The team have published their results in a peer reviewed academic journal (Harrouni et al 2003) and additionally presented the work at workshops in Morocco, Egypt and Germany. Other natural science researchers now have the opportunity to read and learn about this experiment and repeat it accurately, around the world, using their own indigenous plant species and soil types. Thus, through repetition and verification, it is possible to increase knowledge. This is very important and allows the building of a network of researchers and agronomic data.

This experimental work has been an important step, particularly in the Middle East where countries share a common problem of water shortages in arid areas. With climate change and lower rainfall, this research on the potential of halophytes as crops and using seawater for irrigation is becoming increasingly important. It has also given the researchers a clear indication of which plant species would be best for agricultural production in the coastal areas considered.

However, a word of caution: we must remember that there are limitations involved with such an experimental approach. The growing conditions in the tanks were a simulation of the plants' natural environment, and probably do not reflect what is really happening in the more complex real world. For example, in the real coastal environment the plant growth would also have been affected by rainfall and windborne salts in the atmosphere.

Acknowledgement: The research is reproduced here with the kind permission of Prof C Harrouni, The IAV, Agadir, Morocco.

Task 2: Go through the following process of designing and conducting your own experiment to measure water evaporation rates

Water evaporation rates are of great interest to climate scientists. A warming climate means higher water evaporation rates, increased cloud formation and increased rainfall. On the face of it (although the actuality is not so simple – see chapter 2 of module 1), this should further increase global warming as water vapour is a greenhouse gas.

In Task 2, you will record your results and perhaps share them with other researchers on-line. We are not trying to be too ambitious here! The experiment suggested can easily be undertaken in your home or garden. It is safe, practical and does not require specialist equipment. In fact you can improvise by using saucepans from your kitchen! However, in planning the experiment, you will need to think carefully about how many saucepans you want, and how you will set these up!

Step 1: Starting the report sheet

Before you begin, please print out or copy to your computer the blank report sheet below to help you direct your experiment systematically and also to record its progress. The hypothesis, equipment and variable boxes must be completed before the experiment begins. You can of course modify the sheet and add further detail. This sheet simply gives you a skeletal guideline.

Experiment Report Sheet 1

Experiment title:		
Researcher Name:		
Date:		
Country location:		
Hypothesis:		
Equipment:		
Independent Variable:	Dependent Variable:	Control Variable:
Results:		
Summary report:		

A straightforward research question might be: "At what rate does water evaporate from an outdoor open water surface over a 5-day period?" To answer this question, you simply need to measure the decrease in depth of water in your pan and divide it by the length of time in days since the previous measurement. Do this at daily intervals over 5 days (which means that you will divide by 1 if you do it at exactly the same time each day). Or you might like to include a variation based on water surface areas, or temperatures, for example. In case you wish to do that, note that the time of day you measure is important. So is where you place the pan – under a shady tree or within direct sunlight! This is because evaporation rates from open water bodies measured in mm/day are at their highest in arid and semi arid areas of the world. These areas rely on water harvesting and reservoir storage to supplement rainfall when crops are under stress. On the other hand, an open water body can be a large reservoir, a canal used to transport water long distances or a small open ditch which, when open to the atmosphere during very hot periods, will evaporate at an increased rate from the water surface. It is difficult to measure evaporation losses from such large surface areas so scientists traditionally use an "evaporation pan" to measure evaporation rates. Two major designs are used and these are listed below in Table 4.

Table 4 Design and situation of evaporation pans (Source: Withers and Vipond (1988 p88).

Pan	Dimensions	Situation
USWB Class A	1.22m diameter 250mm deep	Mounted 1.5m above the ground
British Standard	1.83m square 610mm deep	Sunk into ground. Rim protrudes 75mm

Step 2: Recording your results

It is important to record systematically. One way is to divide the results box into columns to record your own measurements consistently, clearly and accurately.

Step 3: Summarising the experiment

After the experiment is finished, reflect on it by writing a 500 word (maximum) summary of your observations. It will further help to summarise your results as a graph to illustrate trends or patterns. Also include in your report a critical reflection on the methods you used, any problems you may have encountered during the experiment and what you would do differently if you could repeat it.

Step 4: Sharing your results

If possible, share your findings with other students through a discussion forum. It will be interesting to compare results with others who live in different countries with different climatic and resource variations.

Activity 5: Engaging with phenological data (maximum time 6 hours)

This Activity draws on the module 3 textbook Section 3.3, especially 3.3.2. It aims to demonstrate the scientific value of observation and monitoring in relation to climate change. You will check your understanding of phenology and investigate various web sites where phenological data are collated at local and national scales. You will also be asked to reflect on how you could contribute to a network of data collection, and hence make a contribution to your own lived experience of climate change. You will do this through three set tasks as suggested below.

Task 1: Explain the meaning of the term "phenology" in 50 words maximum.

Task 2: Search and explore one or more websites from Europe or beyond that require the participation of the public in the collection of data. Some links may enable you to participate and share with the rest of your family. Two examples from the UK, where I live, are:

http://www.naturescalendar.org.uk/map/all.htm

This website investigates particularly how patterns of phenological data are presented as interactive maps.

http://frontpage.woodland-trust.org.uk/garden/

This link enables you to consider climate change in your own garden.

Task 3: Reflect on how you (or your whole family, community and/or workplace) could contribute to observing and monitoring a particular species which is sensitive to climate change in your area. Contact an organisation if you wish to engage further with the issue of climate change.

Activity 6: Computer modelling (Maximum time 3 hours).

Drawing on the module 3 textbook, Section 3.3.4, this activity aims to reflect critically on issues associated with computer modelling. It involves comparing two case studies on how computer modelling can operate at different scales. Note that this Activity also serves as reinforcement for your study of climate models that was introduced in Module 1 Chapter 2.

Task 1: Work through Box 4: Weather prediction computer models and Box 5: Computer modelling at Pride Park, Derby (UK).

Box 4: Weather prediction computer models

As with the kitchen model discussed in Section 3.3.4 of the module 3 textbook, 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 a designer measures the room to predict the final kitchen design, meteorologists need to measure current weather conditions to make a weather forecast. Each day in my country, the UK, The Meteorological (Met) Office receives about half a million current weather measurements, including temperature, pressure, wind speed and direction, humidity and others from receivers attached to ships, aircraft, satellites, buoys, weather stations and balloons located across the earth's surface. These are situated geographically on the land or sea surface, high in the atmosphere or at depth in the oceans. These observations, made 24 hours a day, are passed to all the world's major weather forecasting centres including the Met Office.

After downloading into the Met Office supercomputer, the data is processed through complex mathematical equations. These equations numerically model the 3-dimensional dynamics of the atmosphere and the oceans. The Met Office's principal model for weather and climate prediction used since 1990 is the Unified Model (Figure 4). This is not really one model but a whole family of models which use a different configuration to predict across a range of scales from short term, local weather forecasts to long term global climate change. The Unified Model is configured for short range weather predictions over 36 hours and is based on a high resolution atmospheric model. However, climate change predictions are usually based on lower resolution models and involve a 3-dimensional representation of the ocean and sea-ice components coupled to the atmosphere model. The use of a coupled atmosphere and ocean circulation model is essential for accurate climate change prediction. The coupled atmosphere - ocean - carbon-cycle chemistry model is known as the Earth system. The different model configurations are each designed to best represent the processes which have most influence on the timescale of interest to us.

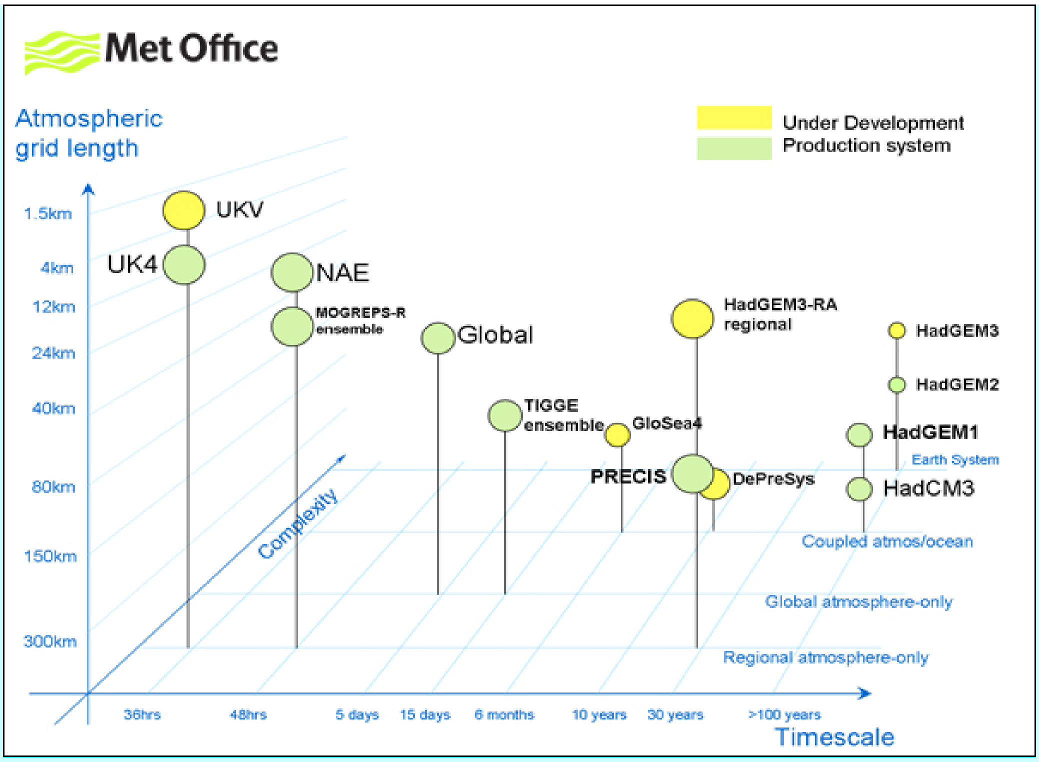

Figure 4: The Unified Model used by the Meteorological Office UK (source Met Office web site accessed at http://www.metoffice.org/).

So how reliable are these models? There are four main issues;

i) Firstly they are mathematical models, built on current knowledge of the different processes that occur in the atmosphere and the oceans. However, scientific knowledge of weather and climate processes is incomplete (although, as module chapter 2 points out, it is getting better all the time), so like all computer models these are a simplification of a very complex situation.

ii) Secondly computer model predictions need to be tested against reality. Verification and validation are important to prove that the predicted scenarios and figures are reliable and trustworthy. The model predictions also need to be reproducible. Climate change predictions are tested in a number of ways but mainly they are tested by trying to reproduce the climate of the recent past.

iii) Thirdly models rely on the input of good quality measurements and if this is not available the model could be compromised. For example, there are some areas of the earth's surface that are not covered by weather monitoring devices, e.g. large parts of the ocean, remote areas of land and the higher levels of the atmosphere. Hence there are geographical "gaps" in the observational data for the Met Office model. This is overcome by a process of assimilation which involves combining actual measured values outside the gap with forecasts based on past predictions within the gap. Obviously these assimilated values for the "gaps" are not reality but a best guess and this may have an impact on the weather and climate predictions for these areas.

iv) Finally these model projections incorporate emissions scenarios, such as the level of CO2 emissions increasing or decreasing. These scenarios are based on estimates of economic and social growth, and hence add a major source of uncertainty into the model. Although they started life as weather prediction tools, we can now appreciate the interdisciplinary nature of these models involving inputs of social factors like fuel consumption and population growth as well.

Despite these limitations weather and climate models can be used widely to help plan. The Unified model can predict at a variety of scales and time frames. Local weather forecasts can predict several days in advance. This aids people to plan their day to day activities, and five day forecasts can aid farmers plan field operations like ploughing. Advanced forecasts can help supermarkets plan the stocks they need of certain commodities, for example, barbeques for a predicted hot summer! Advanced weather warnings are increasingly useful for the emergency services to plan for possible flooding or avalanche events. On a more regional scale, climate models can help predict the direction and intensity of tropical storms. Knowledge about the likelihood of tropical storms is helpful to the insurance sector in setting their premiums.

Long term climate predictions can be used to map patterns of change. For example, Figure 5 shows change in annual average surface air temperature across the world (and there are similar maps in module 1 chapter 2). From maps and data such as these, scientists can extrapolate to predict the impact of climate change. For example the Met Office Hadley Centre is able to produce data which shows predicted sea level rise (Figure 6). Many millions of people are expected to be flooded every year by the 2080s, especially in densely populated and low-lying settlements. The places affected most will be the mega-deltas of Asia and the small oceanic islands,(BBC News Climate Change website at http://news.bbc.co.uk/1/hi/in_depth/629/629/6528979.stm#coasts).

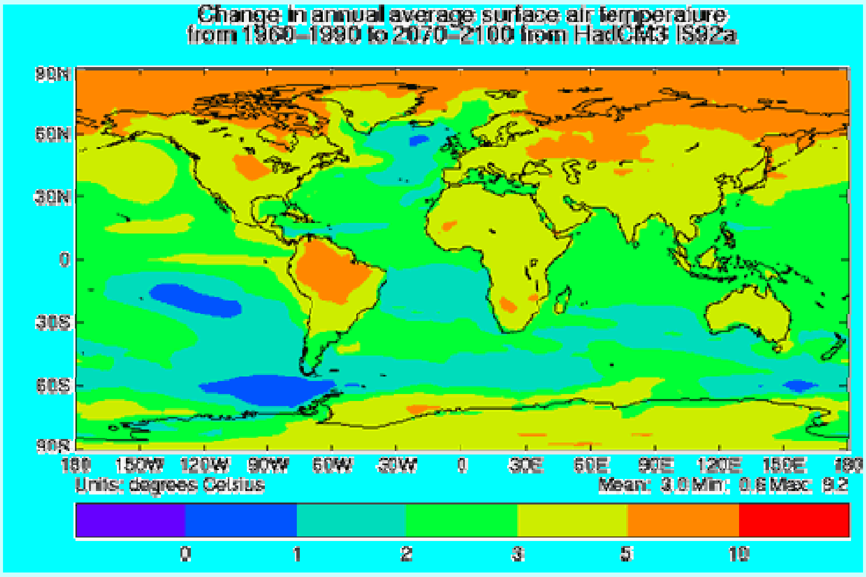

Figure 5: Pattern of change in annual surface air temp © British Crown copyright [2010], the Met Office.

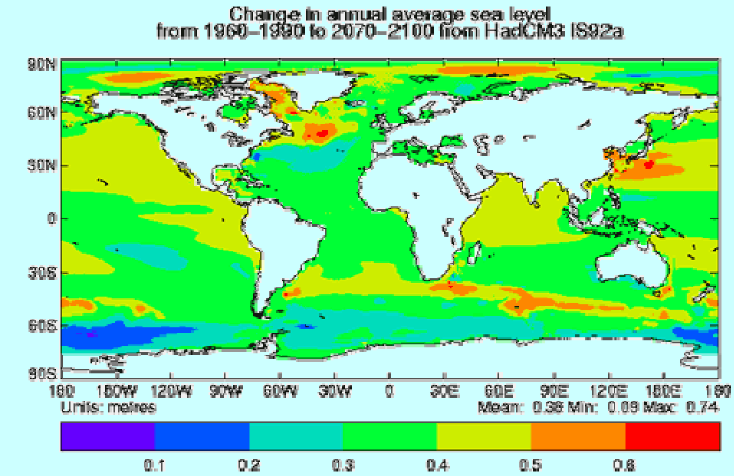

Figure 6: Pattern of change in annual average sea level © British Crown copyright [2010], the Met Office.

Because of the severity and global nature of the issues, scientists frequently come together. Research is undertaken in a number of national and international research laboratories. The Met Office's Hadley Centre for Climate Prediction and Research in Exeter, UK is only one of these. Others include the National Centre for Atmospheric Research in the USA and the Max Planck Institute for Meteorology in Hamburg, Germany. The work of these institutions is coordinated worldwide through The World Climate Research Programme, hosted by the World Meteorological Organisation (WMO). All these bodies report to the Intergovernmental Panel on Climate Change which was established by the United Nations Environment Programme and the WMO to provide the world with a clear scientific view on the current state of climate change and its potential environmental and socio-economic consequences http://www.ipcc.ch. The IPCC is discussed in other modules.

Box 5: Computer modelling at Pride Park, Derby (UK).

This case study will show you that computer models can also help predict events at a more local scale, which in turn inform management strategies for smaller areas of land.

The city of Derby, in the midlands of England, has been an industrial city since the 1800's. In 1994 its Pride Park site comprised 96ha of derelict land close to the city centre (Figure 7). The legacy of dereliction included approximately one third of the site as a closed landfill with another third being an old gas works. The remainder of the site comprised a former heavy engineering works and gravel pit workings (Barker et al 1998).

Figure 7: Pride Park development area 1994 (Source: G Davis)

One of the objectives of the remediation strategy was ensuring that contaminants (such as toxic metals) and organic materials (such as tars) did not migrate into the adjacent River Derwent, which borders the site on the north and east, during and after the reclamation and development works. This is partly because downstream of this site, the River Derwent is a source of potable water and any pollution would compromise the water quality.

A number of site investigations (surveys) were carried out totalling over 800 soil samples to analyse for 22 different determinants. Ground water samples were also taken. The results showed contamination such as oil, tars, phenols, heavy metals, ammonia, boron, and even some low level radioactive materials below the landfills (Barker et al 1998 p 51). Site engineers from the international design and engineering consultancy firm, Arup, developed a soil contamination classification: Class 1 (uncontaminated) to Class 4 (very contaminated). Similarly, ground water samples were classified on a scale of Class 1 – 4, based on European Commission directives.

Just like other models we have examined, the model developed on this site used measured data. The soil sample data was used as input into the computer model and Arup engineers were able to build a 3-dimensional computer simulation of the site. The computer simulation helped to identify particular areas of elevated contamination for both soil and water, so-called “hot spots”. This was vital in developing a strategy of how to deal with the site as, for example, a class 4 phytotoxic (poisonous to plants) metal may not impose the same constraints as a class four phenol (carbolic acid) (NCE 1997 p3). The model was also able to plot contaminants at various depths below the surface, which is important when planning remediation options.

From analysis of the simulation, Arup discovered that the Pride Park site could be divided into two. The soils and groundwater of the eastern half, including the old landfill site and the gasworks, were heavily contaminated to a depth of 10m. In the western half, areas previously used for gravel extraction and heavy engineering, contained smaller soil “hot-spots” whilst the ground water was mainly uncontaminated (NCE 1997 p 3).

So far you can see that a model has helped to map soil and groundwater contamination levels. However, that was not the end of the modelling process. Contamination of soils and groundwater to a depth of 10m in the western half of the site made physical removal of these contaminants impractical and uneconomic. To ensure that these contaminants did not migrate into the River Derwent, the solution was to isolate them by completely enclosing this area with an impermeable bentonite cement cut-off wall which was sealed into the underlying Mercian Mudstone. This 3km long vertical wall includes a central impermeable HDPE (high density polyethylene) liner surrounded by a 600mm thick bentonite slurry wall bedded at least 1m into the Mudstone geology. Before this wall was installed at vast cost, 3-dimensional hydro-geological modelling was undertaken to predict the effect that the cut-off wall would have on ground water flow across the site. There was a natural flow of water through the site towards the river and also an aquifer below the landfill forcing water upwards, (Figure 8). Further modelling allowed a prediction of groundwater flow and levels once the containment wall was inserted (Figure 9).

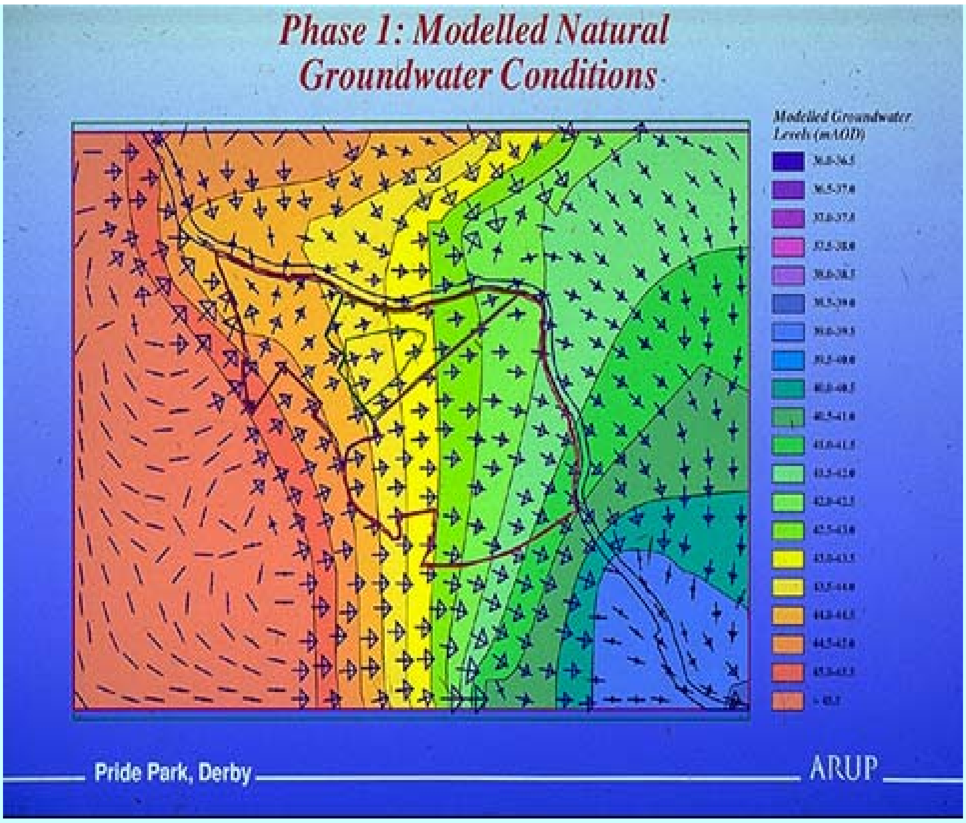

Figure 8: Groundwater condition modelling (Source: © ARUP)

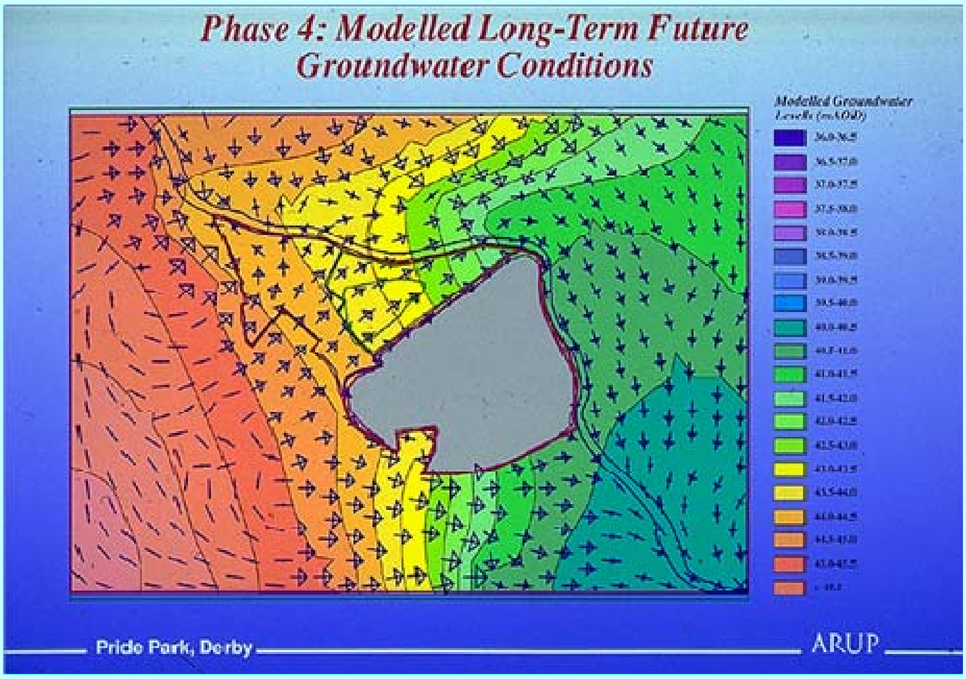

Figure 9: Long-term groundwater condition modelling (Source: © ARUP)

The model predicted that the groundwater level outside would rise by 0.7m as it backed up against the impermeable wall. This was manageable, but of more concern was the prediction that the water level inside the wall was predicted to rise by 1m largely due to recharge from the aquifer below. If this was allowed to happen, there would be a danger of contaminants migrating out through the mudstone at the base of the wall and into the river. In addition, if the wall should fail or be breached, contaminated water would flow out rather than clean water in. To rectify this, a system of abstraction wells were constructed inside the wall, which ensures that the levels of groundwater inside are always at or below the outside levels. The pumped water is treated at a treatment plant before discharge into the river Derwent.

Obviously some of the limitations of this kind of model are similar to the climate models discussed above. However the Arup models were less complex and therefore less expensive. The initial 800 points of soil data were reliable true values on which the model could predict contamination across the site. The second stage of hydro-geological modelling was imperative to justify the need and hence the cost of the 3km bentonite wall. This example demonstrates how two local scale models helped to predict outcomes and manage resources. The reclaimed area is now where Derby County football club has its new football stadium, constructed inside the cut-off wall! (See Figure 10).

Figure 10: Pride Park 1998 with the football stadium almost completed.

Task 2: Summarise the two types of models using the following table. You may expand the table to add other characteristics if you wish. I have started the Table with a couple of suggestions.

Characteristics of model	**Case study 2: Weather prediction computer models**	**Case study 2: Computer modelling at Pride Park, Derby (UK).**
Data types utilised		
Time span of simulation		
Geographical extent of simulation		c 5ha in area and to a depth of 10m

Positive uses and outcomes		
Limitations of the model	Geographical “gaps” in the observational data	

Activity 7: Calculation and comparison of carbon footprints (maximum time 6 hours)

The aim of this activity is for you to calculate and compare carbon footprints. Carbon footprint calculation combines the collection of both qualitative and quantitative data and quite simple ‘models’ (module 3 textbook Section 3.3.4) have been developed for this purpose. Furthermore, the activity encourages you to think of how you could impact on your personal lived experience of climate change.

Task 1: Visit the following website www.carbonfootprint.com. Write a definition of the term carbon footprint, and the units used to measure it. As is typical of many websites of this kind, the answer is not obvious because it tends to be assumed that you already know! I was able to construct my definition from the measurement of carbon footprint provided in the ‘free calculators’ link (and the ‘quick start’ for the individual/household calculator).

Outline the main elements which make up a carbon footprint. In particular differentiate between a primary carbon footprint and a secondary carbon footprint. Also note the difference between the direct and indirect emissions of carbon dioxide involved.

Task 2: Using the individual/household calculator (‘Quick Start’) on the www.carbonfootprint.com website, calculate your personal carbon footprint. You will be asked a series of questions about your household, travel arrangements, and your attitudes and behaviour to issues like diet, recycling and packaging. It will be useful to look through and familiarise yourself with the questions first so you have all the data required to hand, for example, gas and electricity bills. If you do not have access to these utilities then leave these parameters blank.

As you work through, make a note of the qualitative and quantitative data being collected. Note down the questions. At the end, your personal carbon footprint results will be displayed.

Task 3: On the Discussion forum:

a) Place your personal carbon footprint calculation and its summary breakdown into the different categories (House, etc.) from the above source on the discussion forum.

b) Provide a short personal reflection on your personal calculation, including how the total compares with your country/industrialised nations/world average and climate change target, and the impact (for better or worse) of your personal lifestyle.

Task 4: On the discussion forum, compare your personal carbon footprint with that of at least one other student. If there is time, have an exchange of views on how you might make changes in your lifestyle to reduce your personal carbon footprint, and what might stop you from doing so. You could discuss this with your family and/or on the LECHe electronic forum.

Outline discussion for Tasks 2 and 3

Figure 11: Personal carbon footprints (Source: Calculator accessed March 2012 http://www.carbonfootprint.com).

One of the contributors to this module (Heather Moore) has calculated her own carbon footprint from the Task 2 website in tonnes CO2 as shown in Figure 11 above. She writes:

> "The output compares my results to the UK national average, the world average and the world target! I can see that I am doing slightly better than the average person in the UK (7.76 tonnes C02 compared to 9.8 tonnes). Maybe this is because I fly very infrequently (no more that once a year on shorthaul flights) and I do not drive more than 6,400 km per annum (pa) for leisure or business. My largest footprints are for the "House" (2.38 tonnes pa) and "Secondary" (3.9 tonnes pa) categories. This implies that I must try to reduce the amount of energy, particularly gas and electricity, that I use in my home and in addition change aspects of my lifestyle in relation to recycling, eating and purchasing of goods, in order to lower my carbon footprint. To be honest, despite these changes, I doubt I will ever achieve the global target of 2 tonnes and therefore I must explore further the website's carbon offset options. These focus on; tree planting in Kenya, the UK and South America; and supporting programmes of clean renewable energies around the world. Now let me see what individual action I can take to improve mine and my family's carbon footprints. I also need to explore and participate in neighbouring and community initiatives if there is to be any change at all!"

Activity 8: What social scientists do (maximum time 3 hours)

Linked to the module 3 textbook, Section 4.1, this activity aims to explore in further depth what social scientists do and how their findings filter down to policies and actions in society. (Note here that the term “social scientists” is broad and stretches to embrace several disciplines, including anthropology, politics, economics and sociology.)

Task: Explore the website of a research council (or other research body) in the country where you live, or from where you originate. The website should be linked to the social sciences broadly defined, or one of its disciplines. Natural scientific and engineering websites may also be accessed if they contain a social science component. Find an example of research findings in your chosen website which potentially could be used. Make notes on how the research conducted through this website might influence national or international policy and action. As you have seen from this and other modules in the series, social science has a wide capacity to enhance understanding of climate change. It would be useful, therefore, if you identified an example that is in relation to climate change theory and/or action, although, for the purposes of this Activity, you do not have to do so.

If you wish, you can compare/discuss your examples of what social scientists do with other students in the discussion forum.

Discussion

I have gone to an important research council website for the UK. (Note to UK students, you might also go to this website but choose a different example from it to the one in this Discussion).

My example is that of the Economic and Social Research Council UK, which funds economic and social research and training, (http://www.esrc.ac.uk). There, I clicked onto ‘case studies archive’ to see the varied types of research that have been carried out on social and economic issues and which have led to radical new ways of understanding a problem and possible ways forward. I copy here (Box 6)) an example from the website case study archives which relates to our understanding of hunger and famines.

Box 6: People do not suffer in famines because of food shortages

Many people believe that famines are caused by a shortage of food. But in the 1980s, while at Oxford University, Amartya Sen showed that people suffer in famines not because of food shortages, but because they lack the resources or other entitlements needed to obtain food.

Sen noted how, even in poor and hungry regions, there are always a few, rich landowners, who can afford to buy food, who control a disproportionate amount of land, and who serve their own financial interests by exporting agricultural produce. Both Ethiopia and Bangladesh exported food during times of famine.

For economists and policymakers, this was a new insight which explained some of the world's terrible famines.

It also pointed towards a way to create a world without famine - for example, to provide entitlements to those who need them, and to create a world-wide insurance policy to compensate those in need of aid.

Some 20 years on, most scholars agree that there is currently sufficient food to feed the world (source: http://www.esrc.ac.uk), and that one needed to develop policies to improve access for all to what is produced by strengthening ‘entitlements’ (education, skills, etc.). [My note: This is what is suggested on the website. However, many argue that in the coming decades we may not have sufficient food to feed the ever-growing world].

(Amartya Sen was awarded the Noble prize in 1998 for his work. There is plenty of material available on the internet and libraries if you wish to find out more about him and the immense range of scholarly activities he has been involved in.)

You will gauge from the example in Box 6 that Sen's work, whilst having been critiqued by many over the years since he developed his theory of entitlements, has nevertheless dramatically altered our understanding of what is happening during famine. It has also generated global debate, policies and action that both national and world governments can take to prevent famine. An example of this is in the Famine Early Warning Systems that have been set up, which although not perfect in generating action (especially timely and coordinated action), act as a constant reminder of the hunger crisis around the world. If you wish, you can examine the Famine Early Warning Systems website (http://www.fews.net/) to view what is happening globally or in the country you live in. You may complement this with latest data on world food and agricultural production from the United Nations Food and Agriculture Organization website (www.fao.org).

Activity 9: Choosing social science methods (maximum time 2 hours)

The aim of this activity is for you think further about which social science methods you can choose for research. It draws on the module 3 textbook, Section 4.2, especially 4.2.1.

Task 1: Think of a research question that you might wish to explore further for your Masters (or your job or just for interest). Alternatively, you can refer to the hypothesis and/or generalisation developed in Activity 1 (e.g. Sahelian drought: a result of overpopulation or poor pastoral policies). Or else you could use the Nile and Rhine water case studies to think of areas you would like to investigate further.

Task 2: Consider the range of social science research methods and techniques and reflect on which methods would be most useful in investigating your question. Do remember: a) to be realistic and not too ambitious, and b) that you will need to use these methods to collect justifiable data. Therefore, think of how each method will complement the other. Write a brief account (300-500 words) about your choice of research methods and, if possible, discuss this with others on the electronic forum.

Discussion for Task 2

If I were to investigate the overpopulation thesis for the Sahel, for instance, I would want background quantitative information on population densities, the people who live there and their modes of livelihood. This information can often be gathered through official statistics of which a census is the largest and most reliable. I would also need geographical data showing me, for instance, levels of desertification, precipitation patterns, temperature changes, migration and movement of semi-pastoralists. I would require some qualitative historic information on pastoralist practices with herding and settlement, how groups manage their society, what knowledge they hold and how their historical and traditional behaviour has enabled them to manage their livelihoods over the centuries.

Armed with this information, I can then compare with present day data through information I can gather from semi-structured interviews, participatory approaches and stories of lived experience from selected groups and individuals. This is by no means exclusive and you may want to review critically my suggestions here and ask, a) whether these methods complement each other in order to maximise information-gathering and b) whether they are realistic in terms of time and what is required in, for example, a Masters thesis.

Activity 10: Experimental techniques in social science (maximum time 4 hours)

This Activity enables you to explore a study that overtly used experimental techniques for social science research, as discussed in Section 4.2.3 (experimentation for micro-credit behaviour) of the module 3 textbook.

Task 1: Open the link to the following paper: Jeffrey Carpenter and Tyler Williams (2010) "Peer Monitoring and Microcredit: Field experimental evidence from Paraguay, Federal Reserve Bank of Boston, Working Paper No 10-6": http://www.bos.frb.org/economic/wp/wp2010/wp1006.pdf

Task 2: Read the paper, including examination of Section 10 which uses statistical analysis and mathematics to produce, tables and graphs, and Section 11 which provides insight into field work participant instructions. (Note that these sections appear after the references at the end of the paper and for the purpose of the exercise it is not necessary to understand fully the statistical terms that are used).

Task 3: Reflect on the techniques used in this research and compare them with Section 3.3.1 of the module 3 textbook which discusses experimentation for pure science subjects.

Discussion of Task 3

When drawing comparison with the module text book Section 3.3.1, I firstly drew out some commonalities of language and expression for experimentation used by both natural science and social science experimental methods identified in this article.

The paper, for example, refers to experiments on group lending initiatives that are designed in a laboratory and then transferred to the "field" (e.g. a Peruvian large market, p2) and refined into a new experiment (p60). There is also concern with "internal validity", t-testing (p14), and predictability (pp2/3). The survey and behavioural study requires "a large set of controls", sampling (p4), formulation, linear probability (p11), probit models (pp14, 15) and testing. You don't need to understand the meaning of these statistical terms, but to note their use in developing the summary statistics as represented in the various tables and graphical representation in Section 10. Statistics and its associated terms are normally associated with natural scientific approaches, but here they have been adapted to research on micro-credit finance in relation to lifting the poor out of poverty in Paraguay. Another observation I have is that somehow the authors think that experimental methods that replicate the natural sciences will lead to more concrete results and provide "more solid evidence" (pp1-4).

There are differences, however, the main one being that the experiment is being carried out on a group of women about to enter a loan programme. In other words, it is being carried out on human beings, and therefore controls and measures have to take into account unpredictability of human behaviour and responses. Also there is a variation difference in the "laboratory" (the field) which makes me wonder whether the empirical findings are as tight as the paper would lead us to believe. I would further question why there is not even a paragraph on ethical considerations which social science research certainly has to address, even if in some cases pure science does not require this justification.

Activity 11: Social science prediction models (maximum time 2 hours)

The aim of this Activity is to reflect on what you have learnt about social science research methods and how prediction models are used in social sciences (see module 3 textbook Section 4.2, especially 4.2.3), The Activity should give you an insight into how your own country is influenced by social science prediction models derived from data such as the national census figures. You might like to use specific findings from a census report to narrow your search, for example, on emerging family structures, emerging educational trends, in/out migration patterns and so on.

Task 1: Do an internet search and make notes on how the government of the country you live in, or from which you originate, has collated information on societal trends by reflecting on the variables that have been used to gather that information.

Task 2: Make notes about where and how the results have they been disseminated. Have these findings generated policy? Have any policies been adjusted in accordance to these findings?

There is no Discussion to this Activity.

Activity 12: Reflecting on subjectivity in research (maximum time 2 hours)

In the module 3 textbook Section 4.3.2 (*Ontological assumptions: celebration of the subjective*), I offered you an example of how reflection on my subjective feelings on poverty offered me deeper insights into a) the lived experience of poverty, and b) the overall issue of poverty.

In a similar way, this Activity asks you to develop an example of your own where you may have felt that a reflection on your subjective feelings has helped you understand a real-life complex issue such as climate change in greater depth?

Task 1: Think of an example of climate change lived experience which you may personally have knowledge of

Task 2: Make notes on how this could be researched through obtaining both qualitative and quantitative data.

Task 3: Make notes on the extent to which reflection on your own subjectivity will help you gain a deeper insight into the issues raised by this example.

Task 4: If possible, discuss your example and reflection with other students on the electronic forum.

There is no discussion to this Activity.

Activity 13: Ethical research (maximum time 3 hours)

The aim of this Activity is to understand further the importance of ethical research and how various official bodies attempt to guide and monitor research in ethical terms. It relates to the module 3 textbook Section 5.1:

Below is an extract from The Parliamentary Office of Science and Technology UK, “Research Ethics in Developing Countries”, April 2008, 304, p2 (also available http://www.parliament.uk/parliamentary_offices/post/pubs.cfm if you wish to explore the fuller report). This is an example of guidance offered by official national and global bodies on ethical research, in this case, that carried out in developing countries. The extract below focuses on health-related research. Read this extract and do the three tasks below it.

Research ethics regulation and policies

Numerous legislative and guidance documents on research ethics exist, at international, national and institutional levels.

Legislation

Legislation affecting researchers in the UK includes the EU Clinical Trials and Good Clinical Practice Directives (2001 and 2005) and the UK Medicines for Human Use (Clinical Trials) Regulations (2004, amended 2006).

International guidance

Documents include the World Medical Association's Declaration of Helsinki (2000), which sets out ethical principles, as well as regulatory instruments such as the Good Clinical Practice guidelines of the World Health organisation (1995) and the International Conference on Harmonisation (1996). The Council for International Organisations of Medical Sciences has produced guidelines outlining how the Helsinki declaration can be applied in developing countries. The United Nations Educational, Scientific and Cultural Organisation adopted the Universal Declaration on Bioethics and Human Rights in 2005, to assist member states in the formulation of national legislation, regulations or policies.

National guidance

The Medical Research Council and the Wellcome Trust in the UK have each produced ethical guidelines on research in developing countries. The Nuffield Council on Bioethics' report, The Ethics of Research Related to Healthcare in

Developing Countries (2002, followed up in 2005), is also frequently referred to by researchers and RECs [Research Ethics Committees] in the UK and in many other countries. Several institutions in developing countries have also produced ethics documents, including the Indian Council of Medical Research and the Kenyan National Council for Science and Technology.

For research in the developing world there are further considerations. These include: which legislation or guidance should be followed; whether RECs have sufficient capacity and expertise; how informed consent can be obtained; and how projects will relate to and meet participants' needs.

Task 1: Identify aspects of climate change that you may wish to research. Examples can include health and climate change, vulnerability of livelihoods, migration and displacement. You may even narrow this down to a specific topic. For instance, in looking at health and climate change, you may focus on nutrition and climate change, or something totally different such as vectoral disease and climate change, in relation to a specific country/region.

Task 2: Do an internet search on whether there are any guidelines offered by any official sources on the ethics of research in your chosen topic or specific area.

Task 3: Reflect on how useful these are for possible research in your chosen area of study and share your findings and reflections with others on the electronic forum if you wish.

Discussion

One of the major questions for me, particularly when researching with people in poverty is what ethical considerations I need to take on board regarding their time. I am aware, for instance, that in researching the lived experience of climate change an important source of knowledge will derive from people in poverty, possibly in developing countries. Yet, if they stop to answer research questions, they will "waste" valuable time they could otherwise dedicate to making a day-to-day living.

I thus tried to do an internet search on specific ethical guidelines I could find on researching climate change and the use of time for poor people. This was difficult and I could not find any specific official guidelines on this. The nearest I came is http://www.chronicpoverty.org/uploads/publication_files/toolbox-1.pdf

While the ethics toolbox on this page unsurprisingly does not refer to climate change specifically, it nevertheless did offer guidance on time considerations in researching with people in poverty. Thus, it suggests that:

Anyone researching poverty should think carefully about the ethics of their research and about their actions and those of their research assistants and survey teams. Five particular issues must be borne in mind:

1) Researchers, interviewers and enumerators can reinforce existing social relationships (that keep poor people poor) by not treating poor people as social equals.
2) Research can be intrusive and, at times, can generate conflict within and between households and more widely.
3) Research takes up poor people's time – this is often a scarce resource especially at 'peak' times of the year, during market/trading periods and for 'triple burdened' women.
4) The objective of policy relevant research is to produce policy advice – a public good for 'all' poor people. However, the poor's input is private time.
5) You are almost certainly being rewarded (in terms of money, status and education) through your specific research activities – what's in it for the woman/man at the receiving end of your questions?'

This was then a useful exercise in discovering that within the lack of official guidelines on this specific issue, there is yet room to develop an argument for ethical time-considerations of research on all subjects which require people to give up their time to be interviewed, complete surveys and so forth. This is particularly important if their time is required for your climate change research and investigations

Activity 14: Building ethical considerations into stages of research design (maximum time 2 hours)

This Activity builds on Section 5.2, 'Ethics, codes, practice' in the module 3 textbook. To do it, however, please refer back to Figure 2.1 (Section 2.1) of the textbook which shows the differing stages of research as a set of circles, and complete the following tasks on how you can build ethical considerations into each stage of the research design.

Task 1: Write 2-5 bullet points or comments for each circle in Figure 2.1 which relates to ethical considerations.

Task 2: Make notes on how you might bring these considerations into designing and planning your Masters research, or your own workplace-led or other investigation.

Discussion for Task 1

Here I only offer help with the first stage to set you going. This is circle a) in Figure 2.1: 'Generating a hypothesis or generalisation which leads to a research question(s)'.

Thus, my comment on circle a) in relation to ethical considerations is:

Apart from the research question being meaningful, does it take into account ethical considerations, for example through:

- Meeting the ethical guidelines of my profession, official bodies and ethical acceptability?
- Affording dignity and respect for the participants?
- Taking account of and minimising risk, stress, mental or physical discomfort to the participant?
- Minimizing potential conflict within households, local society

- Offering anonymity, confidentiality, honesty?

Activity 15: Problems associated with a multi-disciplinary research approach (maximum time 1 hour)

The Water case Study (Section 4.1.1) argues that:

> “Studying the water system does not solely concentrate on the natural resource, rather it integrates various aspects of different sectors. The water system brings together environmentalists, hydrologists, engineers, climatologists, water managers, politicians, sociologists, economists, farmers, fishermen, and the list continues. Therefore, water is a system that requires a multidisciplinary approach as it concerns everyone in one way or another.” (For a fuller version, turn to the above reference).

As illustrated in the overall message of Module 3, it is possible to draw on multiple methods from both the pure science and social science methodologies to obtain a fuller research picture and to draw out the complexities of what we are investigating. However, there are problems with involving a diverse body of people with diverse interests and several ways of interpreting problems and solutions.

In order to develop an effective approach to investigation, you then need to not only think about an appropriate range of methods drawn from multi-disciplines (as with the Morocco case study, Module 3 Section 7.2) but also the problems associated with this.

Task. Now refer to the Water Case Study and make notes on the types of problems you might encounter in using a multi-method approach and how you could possibly work round these.

Discussion

With the water case study, as with other multidisciplinary research, there are some prime problem considerations which are:

- *Researcher personalities*. Even at the start problems can arise if people working on an enquiry are not open-minded and receptive to other disciplinary stances. It is important that they are willing to be flexible and ready to learn outside the box of their own disciplines. In fact, multidisciplinarity requires that that disciplines accommodate to other approaches.
- *Privileging of a particular epistemological perspective.* This is an important consideration because how you accommodate all perspectives will change the nature of the enquiry and the results. Privileging one discipline can impair and be counterproductive to the aim of epistemological pluralism and understanding.
- *Privileging of particular research methods:* Problems arise if the validity of methods outside a particular disciplinary boundary is questioned instead of viewing them as different methods of inquiry. Arguably, problems arising from methodological issues are paramount in multi-disciplinary inquiry. These include:

  The difference between natural scientific theories that seek to predict systematically, in comparison to social science disciplines which emphasise explanations (rather than prediction) of phenomena.

  The strict systematic process of hypothesis, testing, hypothesis predictions, and then testing of those predictions in natural science, in comparison to social science which does not appear to be a strict process of rigid and well defined methodology.

Methodological issues can mean that not only will research proceed in a disjointed way, but the very questions being addressed could potentially be phrased poorly and, thus, it becomes difficult to then obtain the most out of such research. Not only that, but it is important for there to be an essential recognition that operationalizing these different approaches may require continual negotiations.

- *"Translation" and "language"*. The 'translation' problem is that the same or similar terms used in each discipline may mean such different things, and that problems arise due to disagreements over those definitions and how to use the terms. Many teams who work on multidisciplinary projects begin with meetings to work through this problem so that they are "reading from the same page", i.e. they share meanings of underlying concepts, for example shared meanings of 'cultural' issues as mentioned several times in the Water Case Study. Agreeing shared meanings can thus help overcome intellectual disciplinary barriers and begin the process of incorporating cultural issues in hydrological models in the way ecohydrological models attempt to do.
- *Stakeholder participation.* Similarly, stakeholders, whose diversity of knowledge and disciplinary stance enables a more rounded analysis, may in fact raise several other problems. These are discussed more fully in the exercise associated with Section 3.4.3 (Stakeholder participation) of the Water Case study.

Possibilities for working around the above problems. It is for reasons such as these and the increasing realisation that both scientific and social knowledge is crucial in studying complexities such as those highlighted in the water case study, that there is an attempt to create new methods of analysis. One way to do this is to create an Integrated Assessment (IA) computer model (see also chapter 6 of module 1 of this series).

Earlier attempts at IA have taken a 2-Dimensional approach to incorporate both scientific and social data. For example, in a study of Barton Springs, Texas, Jakeman and Lecher (2003) wanted to combine scientific data on groundwater availability as well as stakeholder concerns in the face of rapid urbanisation. To do this they turned to a standard geological survey software simulation tool MODFLOW that allows hydro-geologists to analyse groundwater flows. A second dimension to incorporate the key parameters and decision variables of social concerns raised by stakeholders was added to this. By creating a version of a 2-D IA model, Jakeman and Lecher were able to comment on optimal pumping and extraction policies, in turn allowing authorities to determine specific mechanisms and permit limits for extraction, based on both scientific and social knowledge.

Recent studies have drawn on more sophisticated models. Kragt et al (2011), for example, use Bayesian Network (BN) modelling techniques to develop an integrated assessment of hydrological, ecological and economic systems. BN is based on probabilistic and causal graphical models which are commonly used to analyse knowledge diversity and reasoning for natural resource management such as that of water. This is partly because BN modelling allows us to represent relationships between variables even if the relationships are based on prediction rather than certainty (as is the case with complex water issues). Thus BN can be useful in modelling situations where a diverse knowledge range and variables need to be taken into account.

You may wish to augment these examples with your own search on how to get around the problems of integrating scientific and social knowledge from internet resources.

References

Adams W (2001) (2nd ed) Green development: Environment and sustainability in a developing world, Routledge, Abingdon.

Adams W (2009) (3rd ed) Green development: Environment and sustainability in a developing world, Routledge, Abingdon.

Curry-Lindhal K (1986) “The conflict between development and nature conservation with special reference to desertification”, in Ecosystem theory and application, Polunin N (ed), John Wiley, Chicester p106-130)

Horowitz and Little (1987) “African pastoralism and poverty: some implications for draught and famine”, p 59-82 in Glantz M (ed) Draught and hunger in Africa: denying famine a future, Cambridge University Press, Cambridge.

Jakeman A and Letcher R (2003) “Integrated assessment and modelling: features, principles and examples for catchment management”, Environmental Modelling & Software, 18(6), July, p 491–501.

Kiome R M and Stocking M (1995) “Rationality of farmer perception of soil erosion: The effectiveness of soil conservation in semi-arid Kenya”, in Global Environmental Change, 5:4, September, 281-295.

Kragt M et al (2011) “An integrated approach to linking economic valuation and catchment modelling”, Environmental Modelling & Software, 26 (1), January, p92–102.

Mortimore M, Tiffen M and Gichuki F (undated) “Sustainable growth in Machakos” (available on www.metafro.be/leisa/1993/9-4-6.pdf)

Mortimore M, Tiffen M and Gichuki F (1994) “More people, less erosion: environmental recovery in Kenya”, Chichester, John Wiley & Sons, 311 pp. Also in Bulletin of the School of Oriental and African Studies, 58, p 431-432 .