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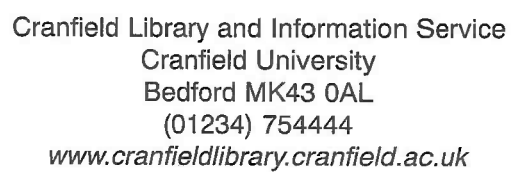
**GIS tool to assist the management, display and archiving of water
catchment areas and their diffuse pollution pressures**

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Cranfield University at Silsoe

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MSc Thesis

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MADI-JIMBA YAHYA

**GIS tool to assist the management, display and archiving of
Water Catchment Areas and their diffuse pollution pressures**

Supervisor: Dr Tim Brewer

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Cranfield Univeristy at Silsoe

Madi-Jimba Yahya

MSc Geographic Information Management

Academic Year: 2005 – 2006

**GIS tool to assist the management, display and archiving of
Water Catchment Areas and their diffuse pollution pressures**

Abstract

This project aims to develop an application to illustrate the extent at which relational database management can be used to improve catchment area management within the Environment Agency through the application of Geographic Information Systems (GIS). The goal is to advance fundamental understanding of the spatial dimensions of these databases, their inter-relationships and how they can aid decision making.

The Environment Agency (EA) has possession of a lot of GIS data that is not fully utilized and this project is a first step in the right direction to getting more users within the EA to make full use of the data available within their organization to aid them make informed strategic and tactical decisions. This was done by developing a Graphical User Interface (GUI) that is user friendly and helps access the database quickly and easily. A toolbar was also developed to host command buttons that have been customized to make the use of ArcMap easier. The user will be able to execute functions without the need of extensive background knowledge of ArcGIS and the intricacies associated with each individual function.

Ordnance Survey MasterMap data is also used (to a limited extent due to time constraints) to illustrate the scenarios faced and the decision processes that will need to be followed. This example will show how the relationship between Hazard assessment and risk mitigation within catchments can be linked through a GIS system.

Madi-Jimba Yahya

MSc Geographical Information Management

Dedications

Bismillah ar-rahmani ar-raheem,

All praise is due to Allah for every past bounty and every future (bounty).

To my father and mother, thank you. May Allah reward you tenfold.

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List of Figures

- Figure 1: Functions surrounding the ArcMap document
- Figure 2: Catchment_area.mxd as displayed when opened in ArcGIS
- Figure 3: Interaction of toolbar and running of the macro
- Figure 4: Customised toolbar with both preset and customised buttons
- Figure 5: Catchment at scale 1: 100,000 and (inset) 1:75,000
- Figure 6: Catchment at scale above 1:50,000
- Figure 7: Catchment at scale below 1:50,000
- Figure 8: DEM viewed in ArcScene
- Figure 9: Soil types and vulnerability index overlaying the 3-D DEM
- Figure 10: RDMS viewing User Interface for quick reference to database
- Figure 11: Searching for files to be viewed
- Figure 12: Editing rights requires a Password
- Figure 13: Unauthorised user prompt
- Figure 14: Choosing a field to edit
- Figure 15: Field error prompt
- Figure 16: Editing the Animals field
- Figure 17: Animal editor with search button activated
- Figure 18: The 1 hectare square drawn out in the middle of the screen
- Figure 19: Zoom into the specified points
- Figure 20: Quick help tabs
- Figure 21: MasterMap data showing roads, rivers and land parcels
- Figure 22: Fertilizer field populated by newly collected field data
- Figure 23: MasterMap data overlaying GWV vulnerability layer

List of Abbreviations

BOD:	Biological Oxygen Demand
CSFO:	Catchment Sensitive Farming Officer
RDBMS:	Relational Database Management System
DEFRA:	Department of Environment, Food and Rural Affairs
DLL:	Dynamic Linked Library
DSS:	Decision Support System
EA:	Environment Agency
ECSFDI:	England Catchment Sensitive Farming Delivery Initiative
ESA:	Environmental Sensitive Area
ESRI:	Environmental Systems Research Institute
GIS:	Geographical Information System
GUI:	Graphical User Interface
GWV:	Ground Water Vulnerability
IT:	Information Technology
N:	Nitrate
NPS:	Non-Point Source
OCO:	Oxygen Consuming Organics
OS:	Ordnance Survey
SEPA:	Scottish Environment Protection Agency
SPA:	Special Protection Areas
SWOT:	Strengths, Weaknesses, Opportunities and Threats
VB:	Visual Basic
VBA:	Visual Basic for Applications
VBE:	Visual Basic Editor
HM:	Her Majesty
WFD:	Water Framework Directive

List of Appendices

Appendix A:	Peak Catchment Dales Geodatabase
Appendix B:	Ordnance Survey MasterMap geodatabase
Appendix C:	Minutes of Meeting with the EA representative
Appendix D:	Questionnaire to CSFOs
Appendix E:	Prioritization of CSFOs' activities
Appendix F:	Files used for the GUI database viewer
Appendix G:	User results on database and GIS user proficiency
Appendix H:	Code sample embedded within the ArcMap document
Appendix I:	Compact disc containing ArcMap document

Table of Contents

1. Introduction	- 1 -
1.1. Background	- 1 -
1.2. Aims and objectives	- 4 -
1.2.1. Aim	- 4 -
1.2.2. Objectives	- 4 -
1.2.3. Deliverables	- 4 -
2. Literature review	- 6 -
2.1. Catchment areas	- 6 -
2.1.1. Definition	- 6 -
2.1.2. Pollutants	- 6 -
2.1.3. Management of Catchment Areas	- 8 -
2.1.4. Catchment Sensitive Farming	- 9 -
2.1.5. Sensitivity of Rivers	- 10 -
2.2. Geographic Information Systems	- 11 -
2.2.1. Definition	- 11 -
2.2.2. Integration of different IT software	- 11 -
2.3. Datasets and database structures	- 12 -
2.4. Application development	- 13 -
3. User Requirements and Methodology	- 15 -
3.1. Questionnaire results	- 15 -
3.2. Requirements analysis	- 16 -
3.3. Workable solutions	- 16 -
3.4. Hardware requirements	- 17 -
3.5. Developed application	- 18 -
3.6. Toolbars and Command Buttons	- 21 -
3.6.1. Mapscale button	- 23 -
3.6.2. Access database button	- 23 -
3.6.3. Draw 1 Ha square button	- 24 -
3.6.4. Zoom to coordinate button	- 24 -
3.6.5. Quickhelp button	- 24 -
3.6.6. Launch ArcScene button	- 24 -
3.7. Operating Arcmap	- 25 -
3.7.1. ArcScene document	- 26 -
3.7.2. Database query form	- 28 -
3.7.3. One Hectare Square Box	- 32 -
3.7.4. Zoom to coordinates	- 33 -
3.7.5. Quickhelp	- 34 -
3.8. Working with MasterMap	- 34 -
3.9. Coding	- 37 -
4. Testing, Training and Modification	- 39 -
5. Results and Discussion	- 40 -
5.1. S.W.O.T analysis	- 40 -
6. Conclusion and Recommendations	- 42 -
7. References	- 45 -
8. Appendices	- 48 -

1. Introduction

1.1. Background

Water pollution from multiple, or diffuse sources is now the greatest challenge to further improving water quality. Diffuse water pollution arises from many sources which individually may be small and comparatively insignificant but whose cumulative impact can have serious consequences for the environment.

Diffuse pollution or Non-Point Source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources and is transported by many dynamic mechanisms such as rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even underground sources of drinking water. These pollutants include:

- Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas;
- Oil, grease, and toxic chemicals from urban runoff and energy production;
- Sediment from improperly managed construction sites, crop and forest lands, and eroding stream banks;
- Salt from irrigation practices and acid drainage from abandoned mines;
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems.

However, the biggest source of diffuse pollution is from agriculture. This is perhaps unsurprising as agricultural land use represents over 70% of England and Wales, and materials that can cause diffuse pollution including nutrients from fertilisers and manure are integral parts of farming. Research suggests that agriculture, through leaching and run off, is responsible for 40-50% of phosphate pollution in the water systems (DEFRA, 2004 .a).

A new initiative, Catchment Sensitive Farming seeks to reduce diffuse water pollution by helping farmers to manage land in ways that are sensitive to the

ecological health of connected water bodies. In turn, this will deliver a range of benefits such as more robust river systems, healthier fisheries to cleaner drinking and bathing waters and increased recreation and tourism. Tackling diffuse water pollution is an important part of improving the sustainability of English and Welsh agriculture.

The joint Defra - HM Treasury consultation "Developing Measures to Promote Catchment-Sensitive Farming" sought views on the broad possible approaches and measures (including regulatory, voluntary and economic measures) to reduce diffuse water pollution from agriculture. The consultation, which closed on 9 September 2004, stressed the need for action to further improve water quality and to help meet the requirements of domestic and international targets including the Water Framework Directive. It also suggested that a package of different measures were likely to be needed. (DEFRA, 2004 .b)

There was a widespread response and a variety of views were brought forward. One thing lay in common with all the respondents. There was broad support for the concept of a package of measures; many respondents suggested the potential for regulation as a means for targeting catchments that are particularly environmentally sensitive or where there is a particular problem from diffuse water pollution from agriculture

Any proposals that were developed would need to be compatible with existing and planned policies, in particular CAP reform, the Entry Level and Higher Level agri-environment schemes and the Whole Farm Approach. Any proposals selected for further consideration were not only effective and efficient, but also delivered environmental improvements in ways which minimised the burden of compliance on the industry. A delivery initiative was formulated after the consultation process.

The England Catchment Sensitive Farming Delivery Initiative (ECSFDI) 2006-2007 covers the period from 1 April 2006 to 30 June 2007, with a total budget of £13.75 million. It will focus on forty priority catchments which have been identified, after technical assessment, by the Environment Agency as the

competent authority for the Water Framework Directive (WFD) and English Nature. The ECSFDI is funded by Defra but will be delivered by Natural England working in partnership with the Environment Agency. Once Catchment Sensitive Farming Officers (CSFOs) are in post, it is expected that they will work together with other organisations (water companies, conservation bodies, farm advisers) who may be already operating within the catchments. The roles of the CSFO is to co-ordinate and facilitate local action and the activities of Catchment Steering Groups. CSFOs will organise workshops, seminars, farm demonstrations, and other extension activities to raise awareness, to disseminate and share technical knowledge. CSFOs will be responsible for a programme of farm visits to selected farms in the catchment. CSFOs will have an important role to play in catchment appraisal, data collation and communications activity. CSFOs will be expected to encourage take up of agri-environment schemes (DEFRA, 2004.c).

GIS will be used by these CSFOs to manage their respective areas in the most efficient manner. They will be able to view the characteristics of their area, update data when necessary concerning changes occurring within that area and edit the data files when a change in land cover is noted. The ArcGIS Suite from ESRI will be the likely standard to be used.

Using a software package such as ArcGIS can be daunting to a novice GIS user. One way in which a novice can make use of the software is by running an application specifically designed to undertake the tasks required by the user. The application developed in this research presents a menu or series of menus from which selections and options can be chosen that automatically carry out such tasks. The user in this situation need not have any extensive knowledge of the commands or mouse clicks required to run ArcGIS other than the initial navigation from the Start menu to run the application. Such applications can be developed using Visual Basic for Applications (VBA) or other COM compliant programming language (Cranfield University, 2006.a).

In this research, an application is described which was developed on behalf of the Environment Agency (EA) as a prototype for efficient incident response and management of the Catchment area. Incident response is an organized

approach to addressing and managing the aftermath of an incident. The goal is to handle the situation in a way that limits damage and reduces recovery time and costs. An incident response plan includes a policy that defines, in specific terms, what constitutes an incident and provides a step-by-step process that should be followed when an incident occurs. This application will utilize some of the tools available in VBA to design a User Interface (UI) that meets the requirements of the CSFOs. The area of study will be from the peak catchment Dales located in the Peak District.

1.2. Aims and objectives

1.2.1. Aim

To develop a GIS tool to be used by Catchment Sensitive Farming Officers (CSFOs) operating within water catchment areas. This tool will help ease the process of viewing, collecting and archiving of spatial data.

1.2.2. Objectives

There are five primary research objectives, namely:

- Review current practice for recording information by field officers to identify the role of the proposed GIS application;
- Identify key issues related with the needs of CSFOs and to what extent GIS can be applied;
- Develop a GIS updating and editing tool to archive changes within the current data to increase efficiency and management;
- Design a GIS viewing application with a user friendly interface linking all spatial data with a database;
- Test and evaluate the final product.

1.2.3. Deliverables

There are four main deliverables associated with this project. These deliverables are as follows:

- A customized ArcMap application for performing data management activities;
- Visual decision support capabilities within ArcScene for incident response mapping systems;
- A report outlining the concepts used for developing the application.

2. Literature review

2.1. Catchment areas

2.1.1. Definition

A catchment is a region or area with natural hydrological boundaries draining to a particular watercourse or water body (Reimold, 1998). Sometimes known as a Watershed, it is also referred to as an area of land that collects water, which drains to the lowest point in an area which could be a natural lake, a reservoir, or the sea. Rain falling on the land will make its way to this lowest point, via creeks, rivers and storm water systems.

As well as rivers, creeks, lakes and reservoirs, a catchment also includes groundwater, storm water, waste water, water-related infrastructure, animals as well as humans and their anthropogenic impacts (Reimold, 1998).

2.1.2. Pollutants

Commonly dissolved pollutants include acidic run-off from mines, copper, dissolved oxygen, hydrogen sulphide, mercury, lead, zinc and excessive Oxygen Consuming Organics (OCO's). Biological oxygen demand (BOD) directly reflects the pollution degree of OCO's (Xinghui et al, 2004). These are all contributors to diffuse pollution. Diffuse pollution is defined here as all pollution pressure excluding specific discrete pollution incidents.

The potential for diffuse pollution is sub-divided into emissions factors (Nitrogen, Phosphate, Arable pesticides, Sheep dip and Sediment). All the emissions factor data are derived from those used for the River Basin Characterisation work for the Water Framework Directive (WFD). The data are all stored at the 1km² level for England and Wales (Environment Agency, 2006.a).

The **N pressure** from an area of land is measured in Kg N ha⁻¹ and derived from information on arable and livestock farming. N pressure from cropping systems in the form of nitrate was estimated by taking into account the crops' leaching potential, together with sowing time and residual N after harvest. N pressure from livestock was estimated by multiplying the numbers of each

livestock class by 'standard' figures for the N content of manures derived from DEFRA Fertiliser Recommendations for Agricultural & Horticultural Crops. The total N pressure in an area is estimated by adding the inputs from crops and livestock. (Environment Agency, 2006.a)

Phosphate delivery to waters from land is controlled by a combination of cropping patterns, livestock numbers (and types) and sediment delivery. P production factors for livestock & crops were derived from the NUPHAR project (A Risk Assessment Methodology for Determining Nutrient Impacts in Surface Freshwater Bodies). Land uses determined from agricultural census data were grouped according to the NUPHAR categories and phosphate inputs, estimated from standard application, were applied to each category. (Environment Agency, 2006.a)

The risk posed by **arable pesticides** to sensitive aquatic organisms will broadly depend on a combination of amount and type used, the transport pathways present, and sensitivities of the receiving water body. The occurrence of pesticides in waterbodies also depends on factors such as physico-chemical properties (of the pesticide), soil types, application timing and method, and weather. The impact of pesticides on surface waterbodies depends on combinations of factors such as the toxicity to different forms of aquatic life, persistence in water and the strength of partitioning between water and sediment.

Defra agricultural census data and generalised pesticide usage survey information were used to estimate the total usage of each chemical for each 1km square across the country. The pesticides used have then been classified according to their persistence, mobility and toxicity. These environmental factors have then been combined with the amount of each chemical used, to produce a pesticide pressure score for each area of land.

Sheep dips are members of a distinct group of pesticide chemicals termed 'veterinary medicines'. Very little information is available on the amounts of these chemicals used. The environmental emissions method though, is similar to that used to estimate the pressure from arable pesticides but involves a greater degree of estimation. Generalised usage figures for sheep dip 'per sheep' have been combined with sheep numbers from the Defra agricultural census data. This calculated sheep dip usage amount has been combined

with the 'toxicity to generic sensitive surface water receptors' of the different sheep dips and a score produced for each 1km² of land. (Environment Agency, 2006.a)

The **sediment** method has been taken from work to support targeting of the Defra Catchment Sensitive Farming (CSF) areas. The method combines soil types and hydrology, land management, rainfall and slope to classify areas of land posing an increased risk of sediment delivery to watercourses. (Environment Agency, 2006.a)

2.1.3. Management of Catchment Areas

Significant investments are made in the national economy committed to the development of water supplies for the major cities as these outgrow the geographical resources on which they were originally founded. The ECSFDI has been assigned a total budget of £23.75 million for a period of two-years and has a particular focus on local engagement, and further partnership working, with farmers, farm advisers, conservation organisations, water companies and a wide range of other interested parties (DEFRA, 2006.d).

As a first step, the Government is extending implementation of the Nitrates Directive. This will require farmers across 55% of England to implement actions to reduce nitrate pollution of waters. The farmers will be educated and monitored by the CSFOs and the government will reward farmers for the continuing stewardship of their existing assets and encourage all farmers to make environmental enhancements.

The water sources have been monitored previously by the private water companies who have an even greater vested interest. Common problems include obstruction of underground water courses by digging of wells and boreholes and channeling of ground water for irrigation by farmers. The farmers who intend to carry out any activities which may interfere with water courses need to apply for permission to do so. This has given the stakeholders better control of water activities thus improving both the quality and the quantity of free flowing water.

Contemporary watershed based decision making involves five steps:

- Information collection;
- Problem assessment ;
- Prevention control, restoration and management alternatives;
- Goal and priority setting and funding;
- Implementation- defining roles and responsibilities (Reimold, 1998).

Catchments and agriculture have been governed previously by statutory legislation or by uptake of agri-environmental initiatives and schemes on a voluntary basis by farmers. All advice pertaining to land management was on an *ad hoc* basis from advisors and charitable agricultural farming groups such as FWAG and LEAF.

2.1.4. Catchment Sensitive Farming

This involves promoting farming practises that are sensitive to the catchment areas needs for a sustainable environment to provide clean unpolluted fresh water. Some of the management practises that are encouraged are described below.

- Management of surface cover: Different types of vegetation affect the amount of soil erosion to a certain magnitude. Farmers are encouraged to plant vegetation that will help reduce soil erosion.
- Soil management: The amount of tractor markings in a field can also determine the amount of sealed, compacted and impermeable soils within a field. Tractors are limited to certain paths in arable land in order to reduce the amount of sealing and compaction of the soil.

The amount of livestock on a farm will also determine the amount of erosion that can occur on a patch of land. The more animals per unit area, the more the soil is compacted and made impermeable. Livestock can contribute to soil erosion through trampling (or poaching) and damaging the soil structure and vegetation cover, increasing run-off and soil detachment. Therefore stock

control needs to be put into place to inhibit overpopulation of livestock. (Godwin et al, 2003)

- Ground pressure control: Flatter tyres exert less pressure on the ground and so there is less probability of soil compaction.
- Change of plough direction: Farmers are being educated on the advantages of ploughing across the slope. Plough lines along the slope lets the water pick up momentum and can carry more soil as it moves down the slope (Li et al, 2001).

2.1.5. Sensitivity of Rivers

Sensitivity to sediment in aquatic systems is greatest in areas where the benthic community relies on clean, clear water. The benthic community is made up of organisms that live in and on the bottom of the ocean floor, lake beds or other water bodies. These organisms are known as benthos. Benthos include worms, clams, crabs, lobsters, sponges, and other tiny organisms that live in the bottom sediments. Situation of Benthic habitats can be a great concern.

- **Salmonids**

Benthic communities, which require clean gravels, are particularly at risk, as are species which lay eggs within gravels, such as salmon and trout. Salmonid fish have a known sensitivity to silt and are important for their commercial and conservation value. Primary salmon catchments are identified by taking the local catchments for which the Environment Agency has produced Salmon Action Plans into account and where there is a significant fishery supported by a wild salmonid population.

- **Chalk Geology**

Chalk streams, with a high groundwater flow contribution may be particularly at risk due to the reduced flushing of sediment from the system. Hydrological conditions can also increase susceptibility to sediment. Chalk geology was

therefore also used as an indicator of increased sensitivity to silt. Chalk streams have been used as sites for watercress production, due to the constant temperature and clean, alkaline, mineral rich, spring water. Much of that management has been aimed at producing the best conditions for fly fishing and the chalk streams hold a good number of wild brown trout, grayling, stocked brown trout and stocked rainbow trout.

2.2. Geographic Information Systems

2.2.1. Definition

Geographic Information Systems (GIS) are computerized systems for the storage, retrieval, manipulation, analysis, and display of geographically referenced data. Since they can include physical, biological, cultural, demographic, or economic information, they are valuable tools in the natural, social, medical, and engineering sciences, as well as in business and planning (Mark et al, 1997).

2.2.2. Integration of different IT software

A Decision Support System (DSS) is an interactive computer-based system intended to help decision makers use data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions. Decision Support System is a general term for any computer application that enhances a person or group's ability to make decisions (DSSResources, 2006). At the heart of the move towards increased use of Decision Support Systems (DSS) is the coming together of several previously separate branches of Information Technology (IT): namely databases, GIS and modelling. The CSFOs will be equipped with a GIS application that will have the strength of dealing with softcopy data offering a means to make greater and more systematic use of the powerful new participatory methodologies developed. These methodologies are becoming increasingly mainstream and cannot be ignored any longer (Moriarty, 1999).

The application will be designed around ArcMap, which is the central tool in the ArcGIS software suite. In it, viewing, querying and editing of spatial data is

possible. ArcMap can be thought of as a continuous active session where you view and display data with various symbologies at specific spatial extents. The structure and functionality of ArcMap tools will help to better organize the work (Indiana University, 2005).

2.3. *Datasets and database structures*

Database Management Systems (DBMS) are important in underpinning all the activities of a spatial management system by providing the basic storage and retrieval technology. The application software sends data to and receives data from the DBMS. Great claims are made for different types of database and their particular offerings. However, the better databases are not mutually exclusive to one type of database structure (Biblio-Tech, 2001). The different types of DBMS structures are:

- Hierarchical: Now almost obsolete;
- Network structure: Inflexible but fast and efficient. Used in airline booking systems;
- Relational structure: The most popular of the structures, thus technical development ensures that advances appear quickly and reliably;
- Object Oriented DBMS: Has the capability of storing and retrieving objects in addition to mere data. Products like Oracle with their Oracle8 have announced object capability (Cranfield University, 2006.b).

The most commonly used structure is the relational database structure and can be used in conjunction with spatial data, as seen in the Scottish Environment Protection Agency (SEPA). SEPA has a comprehensive database on the location, size and other details of all marine (and freshwater) fish farms. This information is held in a relational database. Supplementary information can be kept on chemical use and monitoring surveys. The database will be the key to linking information on inspections, fish farm records and monitoring and may be used in conjunction with a Geographical Information System (GIS) so that farms in different categories can be shown

on maps and linked to other available data (SEPA, 1998). A spatial relational database that is set on a Microsoft Access database structure is a Geodatabase (Appendix A). The geodatabase provides the common data access and management framework for ArcGIS that enables the deployment of GIS functionality wherever it is needed. This architecture has provided the tools to assemble intelligent geographic information systems from the data obtained. (ESRI, 2006)

The datasets provided were made available late into the project. The Catchment shapefiles were made available at the beginning of August and the MasterMap data was available on the 15th of August 2006. The project deadline was 24th August 2006.

2.4. Application development

There are a number of applications that already exist for assessing suitability for alternative crops, abatement strategies, and planning the sustainable management of land. CatchIS is one such tool for planning the strategic and operational management of both surface and underground waters (aquifers) and for intervention in the management of land where appropriate. (NSRI, 2005) It provides a management decision support system for investigating the impact of organic contaminants such as pesticides and nitrates as they affect the surface and groundwater resource. The approaches adopted in the CatchIS system are equally applicable to other areas of the UK and Europe. The CatchIS system is not tied to one geographical area, and can be customised to cover all areas of England and Wales with the appropriate spatial databases. Potential users of the CatchIS system include: Environmental and Agricultural Consultancies, Government Departments and Agencies, Educational Institutes, The Water Industry, Water Regulators, Public Utilities, the Agrochemical Industry and Contract Laboratories (NSRI, 2005). Another project by an educational institute attempted to outline a methodology that can be used as an aid to the design of hydrometric networks with the use of ArcInfo GIS and data from the Environment Agency's Catchment management plans. A digital model of the catchment was created and sub-watersheds were delineated using the tools available in ArcInfo.

These were then combined with the various value added datasets in order to attempt to assess the similarity and differences of potential hydrological response between the various sub-watersheds across the catchment. It was done as a comparative analysis of the sub-watersheds' catchment characteristics (UCL, 1996)

The existence of such specialized applications indicates that there is an increasing need to make available proper management tools developed to help conserve the environment. The application being developed is not as complex as these previous projects but will be more useful to the CSFOs due to the not so complex structure of the whole program. As time develops, so will the level of skill among the users and there will then be a need for a more complex system that integrates more datasets.

3. User Requirements and Methodology

The methodology followed was based on decisions made after the analysis of results obtained from a questionnaire. After evaluating the standard of GIS skill that is within the target group, the functions of the application to be developed was decided upon as not to be extremely in-depth or complicated. Many tools were left out to help the user ease into the system. Teaching basic GIS skills like attribute joins and categorical symbology will be dealt with after the user is comfortable with the initial application.

3.1. Questionnaire results

A questionnaire was sent out to the EA staff to enquire about the user requirements and the level of GIS use and understanding within the Catchment Sensitive Farming Officers (Appendix D). a questionnaire was used to be able to reach more people in less time and to reduce bias. The researchers own opinion will not influence the respondent to answer questions in a certain manner because there is no verbal or visual contact between the respondent and the researcher. (StatPac, 2005)

A total of 25 questionnaires were sent out to randomly selected CSFOs. Correspondence with the client (EA representative) was done via electronic mail and a second set of questions regarding the functionality and design of the application to suit the CSFOs was sent to him through this media (Appendix E). Constant communication over e-mails and telephone conversations has kept the user aware of the development of the application and any arising questions during development were attended to promptly and answered comprehensively.

A final meeting was held with the representative of the Environment agency on the 10th August 2006 to demonstrate the development of the project and to get first hand feedback on the application of the GIS as perceived by the end users (Appendix C)

According to the meeting conducted before setting out the projects objectives, the ArcMap tool was going to be used primarily as a visual tool. Different types of data were required at different scales and therefore the GIS was to

be used to categorise the data according to scale. This was done by having different data visible at specific scale ranges.

3.2. Requirements analysis

From the questionnaires received, 78% of the CSFOs had used GIS software using it mainly for presentation and exploration purposes. 50% of them had also used databases before as end users working with user interfaces that have been customised for particular tasks at hand (Appendix G). The level of GIS users was substantial to get a good start into the project without a lot of resources going into training. Many of them were also capable of using a GPS unit and thus the general feedback was that a simple system with a lot of emphasis on viewing and making decisions based on graphical data rather than numerical data was to be made so that the CSFOs can take to the system quickly and development can continue from there. The questionnaire was designed to be very brief to avoid any form of hesitance from the CSFOs. Other feedback was communicated orally through telephone conversations. Some of the GIS softwares used by the Catchment Officers are Arcview 8.x, MapInfo, Map Explorer and GENI.

3.3. Workable solutions

Research was conducted in order to solve compatibility software and coding issues. In the case of ArcGIS, the programs come with an embedded Object Oriented Program known as Visual Basic for Applications (VBA). Unlike Visual Basic, VBA is not a standalone program. It provides an integrated programming environment, the Visual Basic Editor (VBE), which lets you write a Visual Basic (VB) macro and then debug and test it right away in ArcMap or ArcCatalog. When you type Visual Basic source code into the computer, the computer processes these statements into Visual Basic language. The statements in Visual Basic, however, do not have multiple meanings within the same context as spoken languages do.

Some common reasons to choose the VBA environment are:

- It's fast and easy to create, test, and debug macros inside ArcMap and ArcCatalog;
- The standard ESRI type libraries are already referenced for you;
- Important global variables, such as the Application and Document, are available;
- It's simple to assemble UI forms using VBA and ActiveX components;
- It's straightforward to integrate VBA code with new ArcObjects UIControls;
- It's relatively easy to migrate VBA code to VB ActiveX DLL projects;
- Many code samples available in the help system are macros that can be cut, pasted, and run with the VBA environment (ESRI, 2006).

The Environment Agency uses GIS data formats that are convertible into ArcGIS and this was done through ArcCatalog to be accommodated within a geodatabase. To access this geodatabase, some Visual Basic coding was needed to provide the user with a friendly Graphical User Interface (GUI) that makes querying and editing grid data very easy. Therefore, Visual Basic tutorials, model building and ArcToolbox were extensively used.

The data that was available was in a different format and was converted for use in ArcGIS and was stored in a geodatabase. The geodatabase provides the common data access and management framework for ArcGIS that enables the deployment of GIS functionality and business logic wherever it is needed (ESRI, 2006).

The types of datasets converted into the geodatabase are the typical files used within the Environment Agency for everyday spatial decision making.

3.4. Hardware requirements

The required software will be ArcGIS desktop 9.1. The CSFOs will be equipped with individual laptops and the hardware system requirements for running ArcGIS 9.1 on a laptop computer, with Windows 2000 or XP as operating system, are as follows:

- ArcGIS 9.1;

- Operating system Windows NT, 2000, XP, UNIX;
- 256Mb minimum, 512Mb recommended RAM memory;
- 1.6 GHz processor or more;
- Total starting package requires 3 Gb disk space;
- Hard disk data space will require 500 Mb.

3.5. *Developed application*

The ArcMap document was set as the central operating point for all the actions and functions that take place. Forms within ArcGIS are used to obtain parameters for a process through input boxes within the form. Within this application, one of the major uses of forms are to relay certain types of information and most of the ones used have been used to get access to the database and to display attributes of the grid files. In figure 1, the dotted lines in the “quick help” and “store x,y coordinate points” indicates that further research needs to be done in these areas.

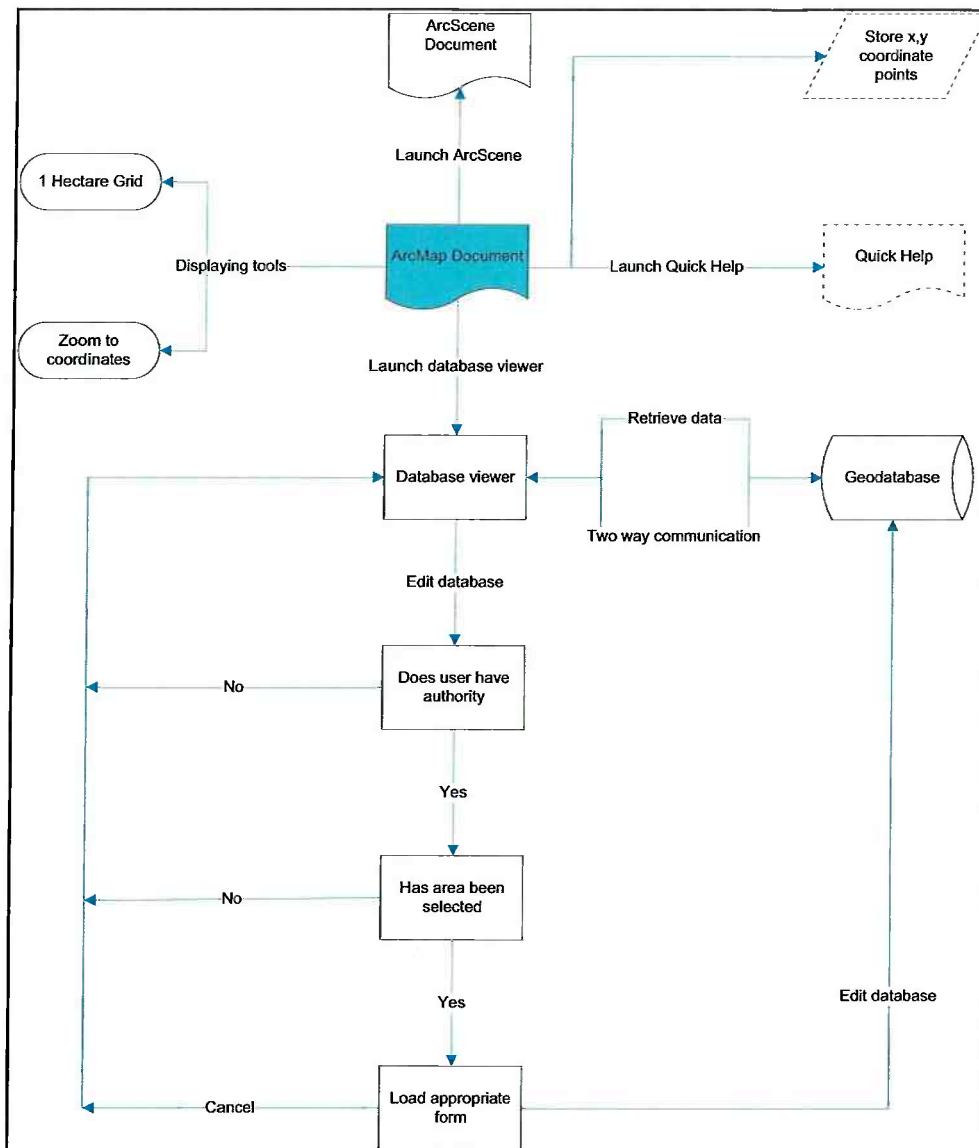


Figure 1: functions surrounding the ArcMap document

Another form is used to get access to the Quick-help. Where a help file is stored with simple explanations for executing simple tasks. All of this is saved in an ArcMap document (*.mxd) (refer to Appendix I).

An *.mxd file (also called a map document file, akin to an ArcView 3.x project file) has the following properties that are maintained within it:

- The extent to which the Data Frame was zoomed;

- Which features are present and visible (turned on) in the Table of Contents;
- The symbology used to portray each feature in the Table of Contents;
- Any Map Layouts, or maps you have created by clicking the **View** menu and selecting **Layout**;
- Pointers indicating the location on the file system for data elements in the Table of Contents.

(Indiana University, 2006)

Saving the ArcMap session in a map document only saves in the *.mxd document the settings and pointers to the data. The user can therefore return to the same extent previously used with all the settings as before.

To launch this application, the user will open an ArcMap document from the normal commands in ArcMap.

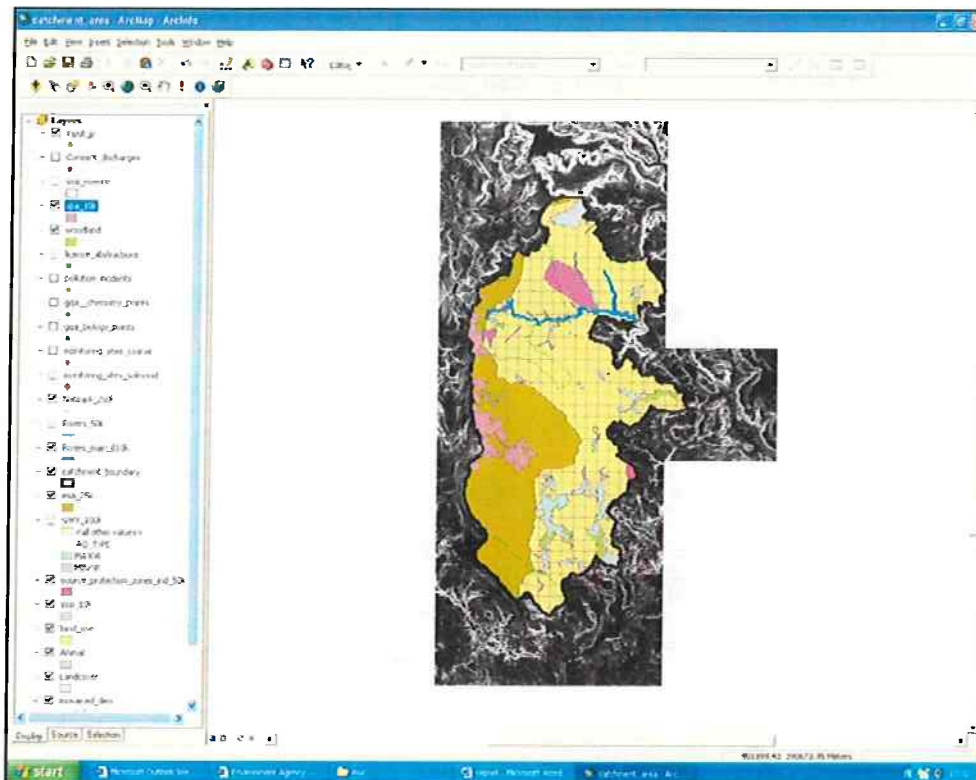


Figure 2: The map Document (Catchment area.mxd) as displayed when loaded up.

3.6. Toolbars and Command Buttons

A special toolbar was created and all the developed buttons were included in this toolbar using the customise option within the ArcGIS desktop. The toolbar was made to fit the users requirements i.e. the buttons on the toolbar are the only ones necessary for primary use. The toolbar contained both the preset and the customised buttons. A toolbar is used instead of a drop down menu because it is easier to view all the available application tools without having to click on anything to investigate its contents.

Preset buttons are the already available buttons on a standard ArcMap template. The customised buttons are those that have been developed to undertake set procedures, as demonstrated below.

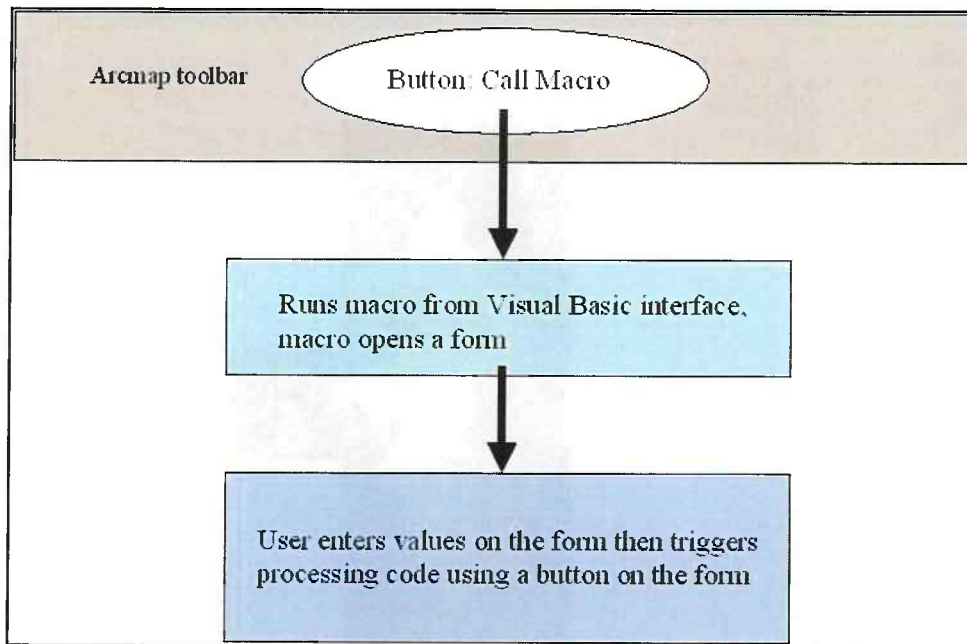


Fig 3: A schematic of the typical interaction of toolbar and running of the macro.

As illustrated in figure 3 above, interaction with ArcGIS using VB or VBA is done by having a button on a toolbar which calls a form. This is a common method for ArcGIS users. The processing code could be added directly to either the form or the document.

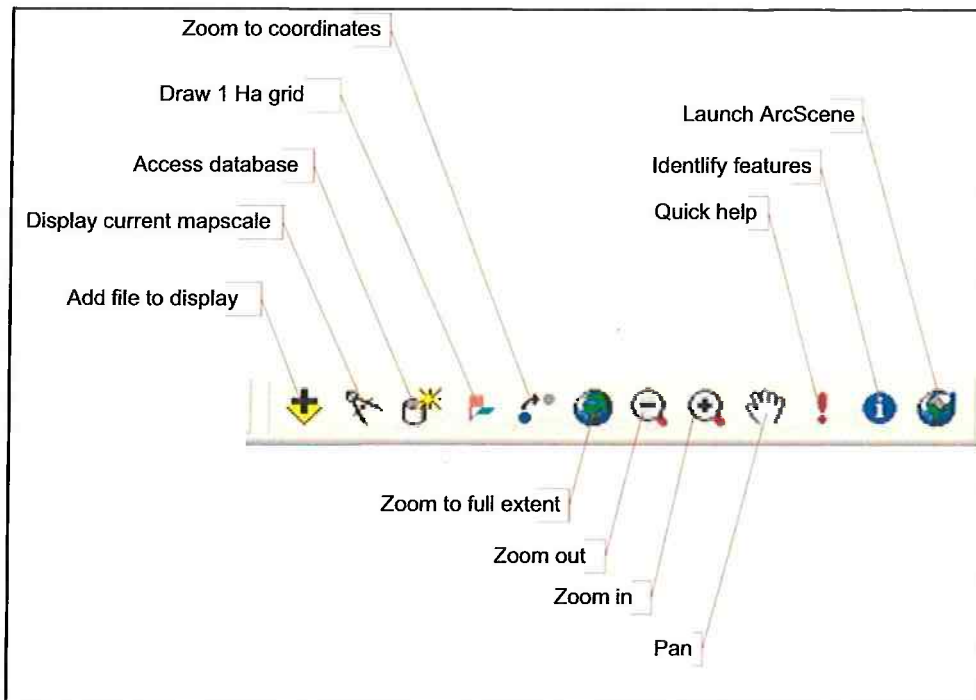


Figure 4: Customised toolbar with both preset and customised buttons

The command buttons (figure 4 above) were used in the document's toolbar that was individually customized to include only the command buttons that are necessary for the use of the application. Some of the buttons in the toolbar are standard functions within ArcMap e.g. Zoom in, Zoom out. The buttons that are not standard functions within a normal *.mxd file are explained below.

3.6.1. Mapscale button

This button displays a message box that will state the accurate scale at which the map is being viewed at. However, a text box is available to type in the desired scale and the map will automatically zoom to the preferred extent.

3.6.2. Access database button

To be able to view the contents of the database, a button is used to launch the user interface that will display all the important fields of the data that are needed for making decisions and that might be need to be edited.

3.6.3. Draw 1 Ha square button

To give the user an idea of distance and size, a 1 hectare square can be displayed in the centre of the screen. This square measures 100 metres by 100 metres and can be used by the user to put all features into scale to determine the extent of erosion, pollution, deforestation etc

3.6.4. Zoom to coordinate button

Once the user has identified an area of interest, the coordinates of the point can be stated and the screen will zoom into the coordinates specified at a specified area extent. This makes manoeuvring within the GIS very easy.

3.6.5. Quickhelp button

After training the users how to operate ArcGIS, some of the more common tasks within the application that might be easily forgotten are outlined in a form that has pages that give instructions on what to do step by step. These tasks are not complicated but include simple things like, how to add data, how to use the "identify" button etc (figure 20).

3.6.6. Launch ArcScene button

This button is used to launch ArcScene, which is another module of ArcGIS that allows the visualisation of images in 3-Dimensions where the catchment officer can have an aerial view of the area of interest and gives the CSFO a realistic view of the terrain of the catchment and the integration of the features within it. In this project, ArcScene is used as a visual tool only.

3.7. Operating Arcmap

Figure 5 illustrates the GIS displaying different datasets of the same focus area at different scales.

When looking at the catchment area as a whole, the things that will be of importance are the Special Protection Areas (SPA) that are usually within the Environmentally Sensitive Areas (ESA), the main rivers and the locations of the woodlands. That is why these are the only files visible when looking at the entire catchment at a scale of over 1: 100,000.

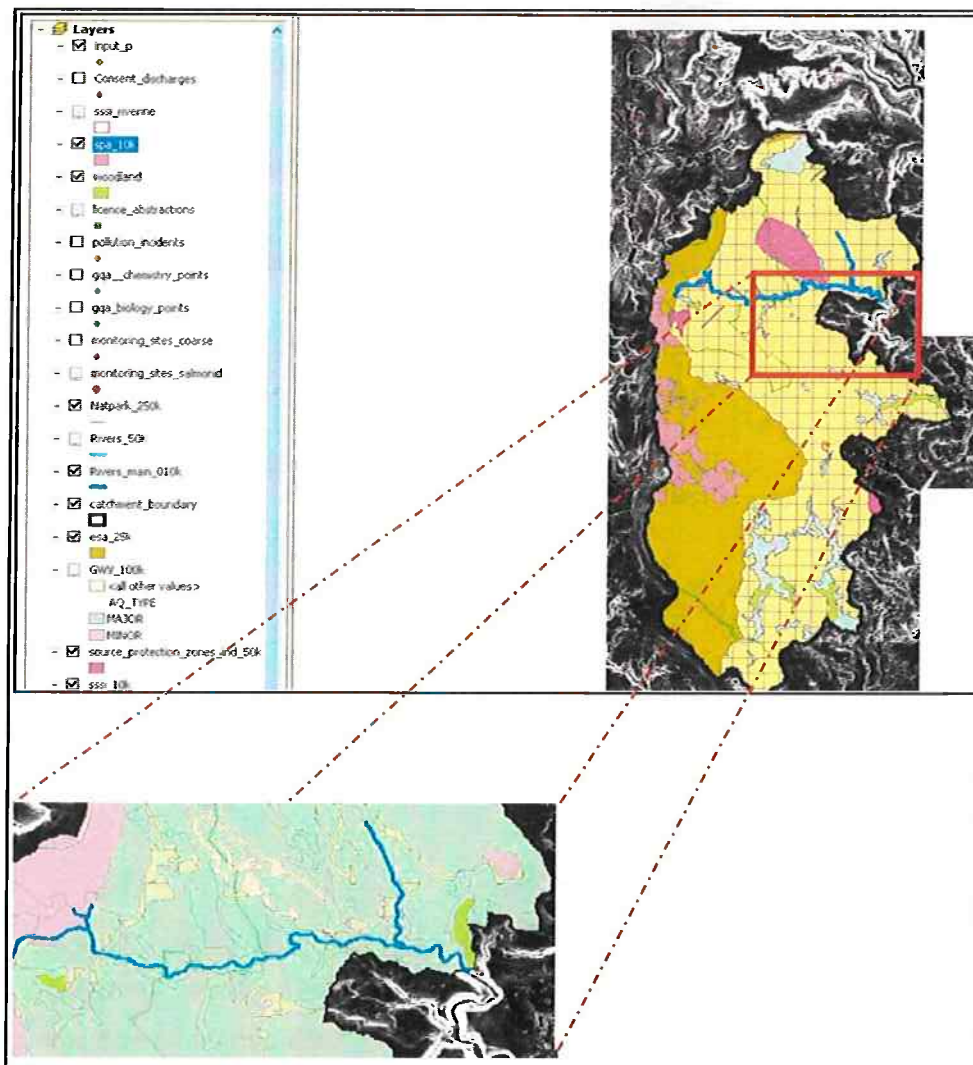


Figure 5: Scale above a) 1: 100,000 and b) 1:75,000 (inset)

When the area in focus is zoomed into at a scale range of 1:100,000 to 1:75,000, other features that are used locally start to appear, for example, Ground Water Vulnerability zones (in green) appear in figure 6. This kind of data is that which can be used by the CSFO at a more regional level.



Figure 6: Scale above 1:50,000

In figure 7, the green points along the river that appear are the water abstraction licenses issued. The CSFOs will only need to access this information when they are working at a local level where they can inspect the state of abstraction and notify licence holders of their status, for example, if their licenses have expired, renewal of licences etc.



Figure 7: Scale below 1:50,000

3.7.1. ArcScene document

To view the images in 3-dimensions, the user can click on the “Launch ArcScene” button and this will open the program ArcScene. Within ArcScene, a *.sxd document can be opened and the catchment area can be viewed with the help of a Digital Surface Model (DSM) and the other feature layers draped

over it. Figure 8 demonstrates the catchment boundary and river system within the peak catchment overlaying the DSM as it would appear within ArcScene.

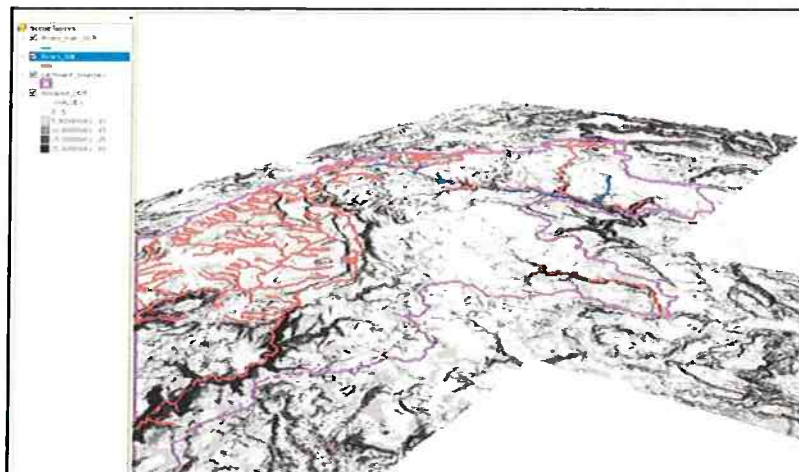


Figure 8: DEM viewed in ArcScene

The figure 9 below shows 1 km cells that display attributes from two different feature classes. This was done by performing a join between attributes of feature classes which have similar fields. This analysis is done by pre-processed data that has been joined for this purpose. As the CSFOs increase their understanding of ArcGIS, they will be able to understand the processes of joining fields from different files and using them for analysis. However, at this stage, this data is created by joining two fields from corresponding files and saved as a feature class under the name *Vul_diffuse*. Several joins can be done between data and displayed ready to be loaded and the CSFO only has to load up the documents to help make an informed decision.

The fields categorised in the document are soil erosion vulnerability and soil type. This linked with the DSM image that will illustrate slope and terrain, and can actually give the CSFO a true and sufficiently accurate scenario of the level of focus to be directed towards certain areas that might be at risk of any form of soil-related environmental hazard.

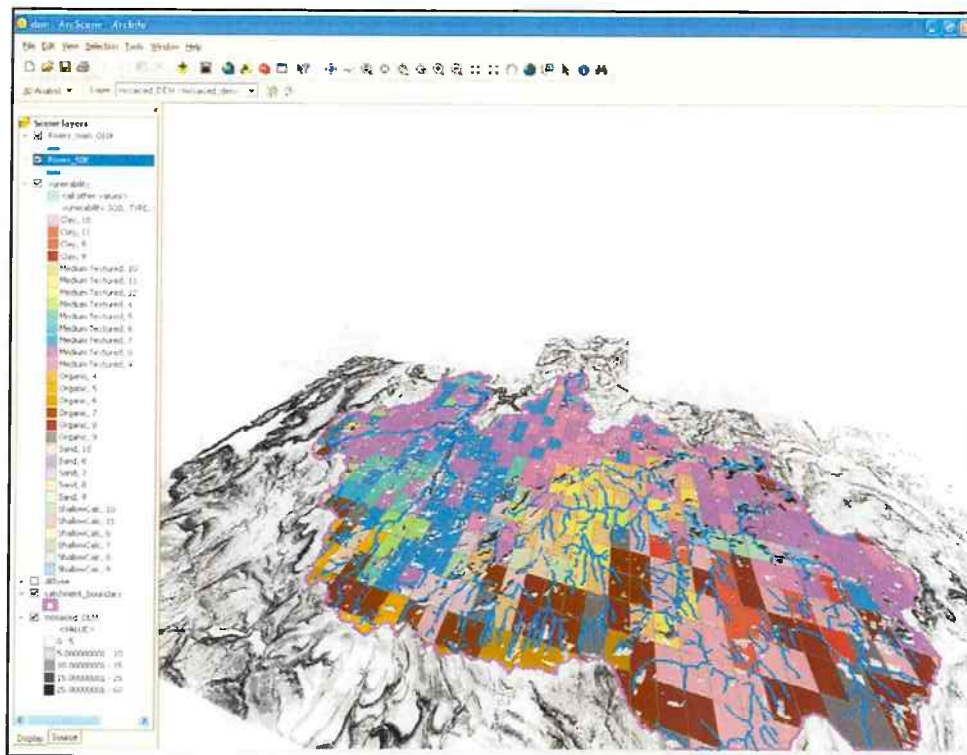


Figure 9: Soil types and vulnerability index overlaying the 3-D DEM

3.7.2. Database query form

To view attributes of data stored within the database, a form is used to query the database. This is done by creating a form with an ActiveX Data Objects (ADO) which allows the development of an application to access and manipulate data in a database server through a database provider. The program that enables native access to the data is called a database provider (Microsoft Jet 4.0 OLE DB Provider). The advantages of ADO use are high speed, ease of use, low memory overhead, and a small disk footprint (IBM, 2006).

An ADO object instance (shown in figure 10 with text "scroll here") is therefore used in these forms to access the datasets. Three feature classes of the 1km square grids were used (Appendix A shows a feature classes). The data contained within these grids are useful to the CSFO (as noted in the 10th August client meeting, Appendix C). A Main form is used to access the

database and to view the data (figure 10). The data used in these forms are 1km square grids with attributes of the area. (Appendix F)

View and Edit

Grid ID: 393400

All values below are the calculated average values per sq km

Animal Count

Cattle	Sheep	Poultry	Pigs
100	100	100	100

% LandCover

Cereal	Root crops	Brassica	Oilseed	
100	100	100	100	
Fallow	Horticulture	Grassland	Orchards	Other
100	100	100	100	100

% LandUse

% Sea cover	% Urban	% Water	% Rough	% Grass	% Arable
100	100	100	100	100	100

Buttons: Edit, Search, OK, Cancel

Scroll bar: Scroll here

Figure 10: Main viewing UI for quick reference to database

The current datasets contain more than 400 records and the scroll bar is not sufficient to locate a GRID and its properties. An interface that will help locate the grid is therefore used to search the datasets and retrieve data of a specified grid id. This is done by clicking the “Search” button which runs a program that has been designed to go to the beginning of the files (primary key) and run through the entire system searching for a property within the file that has the same number as typed into the text box. In this case, the primary key is GRIDID. It is present in all three tables and serves as the link between the data.

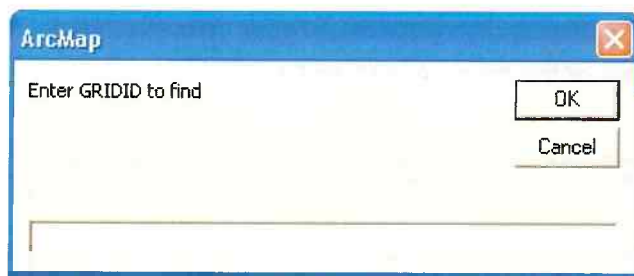


Figure 11: Searching the files to be viewed.

If the CSFO notes changes to be made to the current data, they will be able to edit using the “edit” button on the “View and Edit” form (figure 10) frame. However, editing rights are reserved to only specific users and a password is used to prevent unfortunate incidences of data loss or changes by unauthorised users (figure 13).

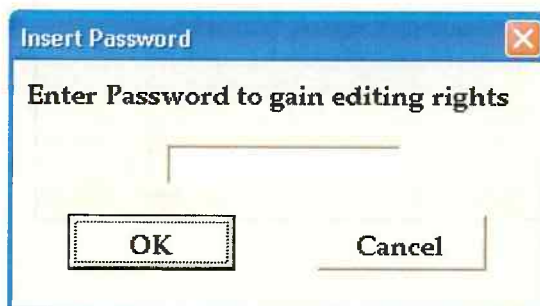


Figure 12: Editing rights requires a Password

In the event that a wrong password is entered, a message box will appear stating the reason for not being able to continue.

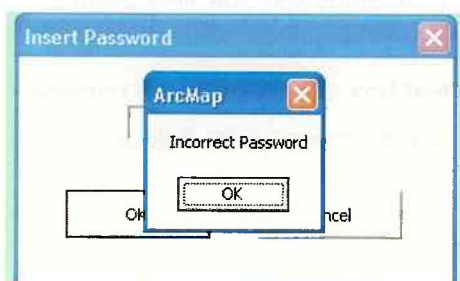


Figure 13: in the event of an unauthorised user

Once a correct password is entered, the user is able to select a database field that will be of interest from a drop down menu, and make the necessary changes.

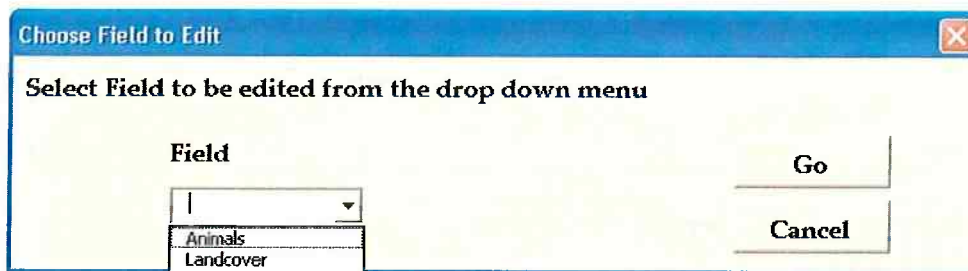


Figure 14: Choosing a field to edit

If no field is selected, the form will be unable to load anything else and will display you a prompt asking you to choose your desired field.



Figure 15: field error prompt

Once a field is selected, an editing form will appear where all the data within a record can be changed. The three database fields appear in three different forms to ease the editing pattern and to reduce potential confusion. One can also search for the grid and undertake edits within that grid instead of scrolling through the entire dataset.

Edit Animals

To make changes, delete field and type in new values for that field. Once completed, click Save.

Grid ID	Cattle count	Sheep	Poultry	Pigs
383-109	10.729	315.993	247.102	0.123

Search

First Previous edit animals Next Last

Save **Cancel**

Figure 16: Editing the Animals field

ArcMap

Enter GRIDID to find

OK **Cancel**

Edit Animals

To make changes, delete field and type in new values for that field. Once completed, click Save.

Grid ID	Cattle count	Sheep	Poultry	Pigs
383-109	10.729	315.993	247.102	0.123

Search

First Previous edit animals Next Last

Save **Cancel**

Figure 17: Animal editor with search button activated

The search button seeks from the database the record whose primary key matches the user's search criteria. The same forms and setup applies to the other datasets of land use and land cover.

3.7.3. One Hectare Square Box

A 1 hectare box can be displayed on the screen to give the user a spatial reference in terms of distances and sizes of the area in question. This square measures 100 metres by 100 metres and is displayed in the centre of the screen by the click of a button and can be moved around. The CSFO will then

be able to make quick estimates of the size of fields and features within the selected focus area.

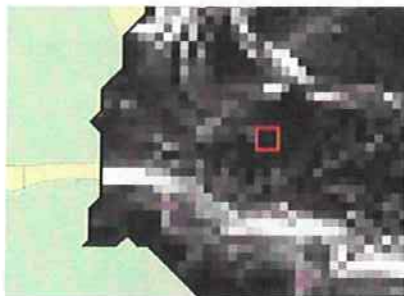


Figure 18: the 1 hectare square drawn out in the middle of the screen

3.7.4. Zoom to coordinates

Once a point has been identified for investigation, the user can type in the coordinates of the point or general area and the map will zoom in to the specified points at a specific size indicated on the form (fig. 19). For example, by typing in 10,000 the display window will show an area 10km wide and 10kms long with the specified point centred in the middle of the window.

A screenshot of a software dialog box titled "Zoom to Coordinates". The dialog box has a blue title bar with a close button (X) in the top right corner. The main content area is white and contains the following elements: a bold instruction "Insert x,y coordinates to zoom to point. Specify extent of view in metres"; two input fields labeled "X coords" and "Y coords" with placeholder text "Enter X" and "Enter Y" respectively; a label "Zoom Area" followed by an input field containing the value "10000"; and two buttons at the bottom, "OK" and "Quit".

Figure 19: Zoom into the specified points

3.7.5. Quickhelp

To assist the user, a quickhelp file is available to give tips on how to execute certain processes. This form (fig. 20) is linked to a text file where the contents can be edited making it a very flexible tool that will not be interfered with when changes to the ArcMap document are made.

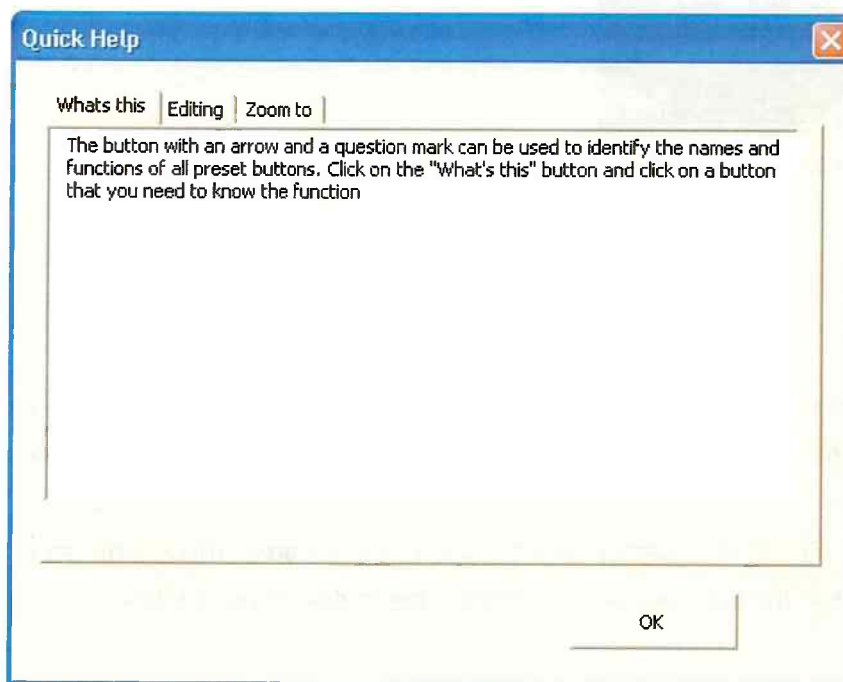


Figure 20: Quick help tabs appear with different topics linked to different tabs.

As development of the application becomes more complicated, the quick help tabs will help explain processes that are not available through the normal help files. The system is designed to make these help features easily extensible.

3.8. Working with MasterMap

OS MasterMap is a digital representation of the real world containing several million uniquely identified geographic features created by the Ordnance Survey (OS) of the United Kingdom. The OS MasterMap Topography Layer, a polygonised and seamless topographic database product, was made

available for this project. It is the most flexible and intelligent topographic information ever produced by the Ordnance Survey (OS, 2006).

However, the arrival of the MasterMap data was ill-timed (Tuesday 15th August) and therefore only a theoretical concept has been formulated based on a hypothesis that seems to be demonstrably practical. The application practicability will have to be further investigated as the use of GIS develops within catchment management. The MasterMap data was transformed from Geographic Markup Language (GML) to Feature classes and stored in a Geodatabase for operational use within ArcGIS (Appendix B).

By joining the MasterMap data and the National Land and Property gazetteer database, the land demarcations together with the property owner's details will become easily available to the user.

The MasterMap data structure can be adjusted to form a data collection tool that will assist in overall management of the catchment area. This is best illustrated by the example outlined below in figure 21.

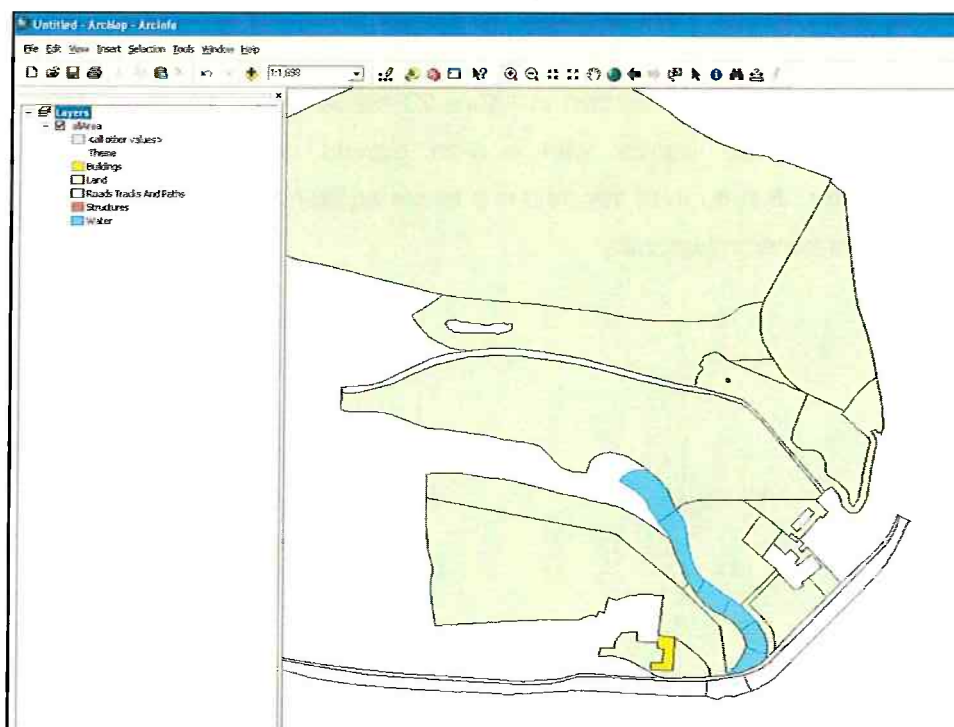
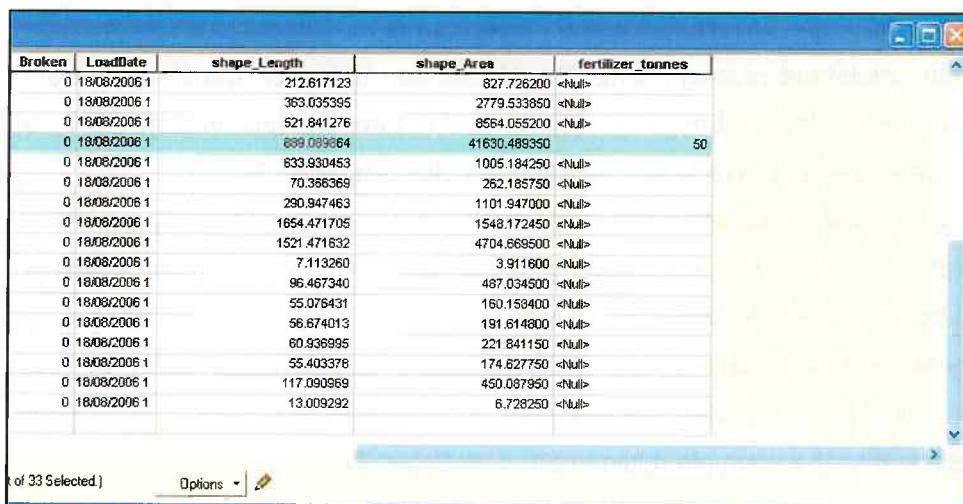


Figure 21: Mastermap data showing roads, rivers and land parcels

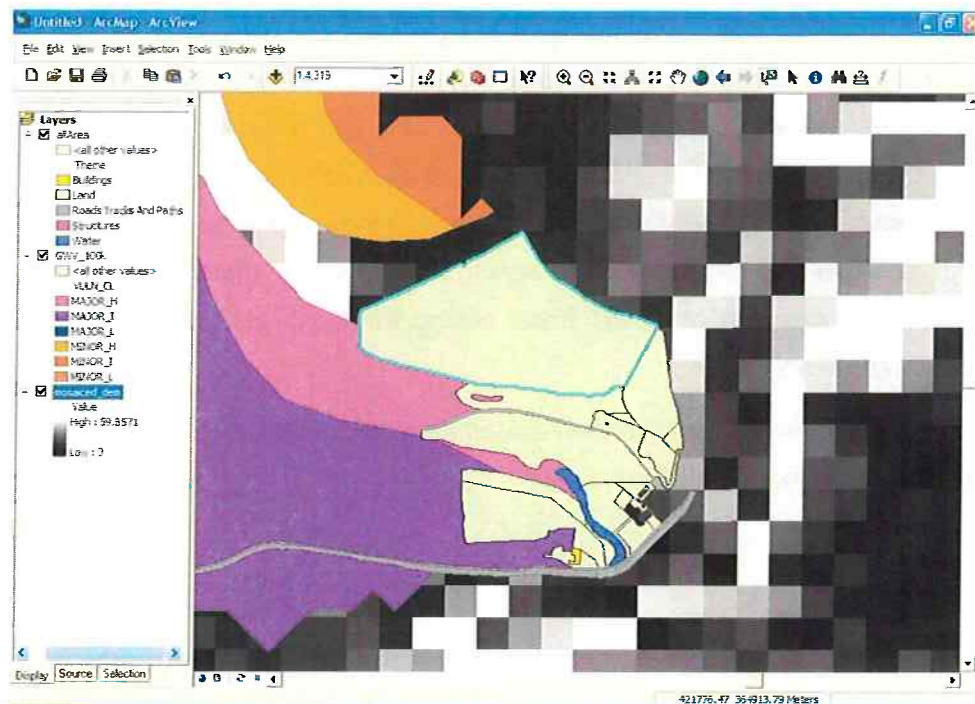
As the CSFOs do their rounds through the catchment area, they will pick up data from individual farms and can fill them into the MasterMap land database by adding a field e.g. tonnes of fertilizers used in the last year. And this is recorded and stored as shown in figure 22 below.



Broken	LoadDate	shape_Length	shape_Area	fertilizer_tonnes
0	18/08/2006 1	212.617123	827.726200	<Null>
0	18/08/2006 1	363.035395	2779.533850	<Null>
0	18/08/2006 1	521.841276	8564.055200	<Null>
0	18/08/2006 1	699.089664	41630.489350	50
0	18/08/2006 1	633.930453	1005.184250	<Null>
0	18/08/2006 1	70.386369	252.185750	<Null>
0	18/08/2006 1	290.947463	1101.947000	<Null>
0	18/08/2006 1	1654.471705	1548.172450	<Null>
0	18/08/2006 1	1521.471632	4704.669500	<Null>
0	18/08/2006 1	7.113260	3.911600	<Null>
0	18/08/2006 1	96.467340	487.034500	<Null>
0	18/08/2006 1	55.076431	160.159400	<Null>
0	18/08/2006 1	56.674013	191.614800	<Null>
0	18/08/2006 1	60.536995	221.841150	<Null>
0	18/08/2006 1	55.403378	174.627750	<Null>
0	18/08/2006 1	117.090969	450.087950	<Null>
0	18/08/2006 1	13.009292	6.728250	<Null>

Figure 22: Fertilizer field populated by newly collected field data.

The field being observed is shown in figure 23 below outlined in blue. This farm lies in a major aquifer with a high ground water contamination vulnerability risk. Just north of this field is a minor aquifer with an intermediate risk for ground water vulnerability.



Once the CSFOs have a concept of the magnitude and locations of the incidences, they are then faced with decisions that will require their expertise as technical officers in sensitive farming. How big a buffer should be observed between zones? Is the farmer in the specified field allowed to use two different amounts of fertilizer/ pesticide in his field? Can this be done as long as the levels are maintained within the zones? Will the surrounding fields lying in the intermediate zones have to regulate their applications to cater for the overlap areas with the high vulnerability zones? Should buffer zones be created to cater for such discrepancies?

3.9. Coding

The amount of code used was relatively less than expected because VBA is object based and choosing properties of objects is done easily through the properties toolbar. The main function of the code was to undertake error-trapping. By setting some parameters on the kind of data, e.g. numbers or floats, some amount of error handling is done. For example, in the case of

zooming to coordinates in figure 19, if not all fields are filled in correctly, a form will appear prompting you to enter fully all coordinates coordinates. The coordinates can also be within a certain limit only and a range has been set within the code. One can therefore not type in x,y coordinates for a point that is not within the catchment area and its surroundings and expect the GIS to zoom to those coordinates. Error trapping prevents breakdowns within the program. An example of Visual Basic coding for the 1 Ha grid square is attached (Appendix H).

All coding was embedded into the ArcMap document and can be edited and improved using the Visual Basic Editor.

4. Testing, Training and Modification

The application was tested and by a third party who is competent with ArcGIS so that the project's applicability is tested and given a decent critique. According to the feedback from the independent testing, the explanations for the use of the forms were not quite clear and so further improvements were undertaken, thus:

- General information of the contents in all the forms was added;
- Simple colours were used instead of the initial green and yellow environment Agency's colours. The user said the bright colour previously used was distracting. The default grey colour was used to emphasize simplicity;
- Development of the scale factor in the "Zoom to Coordinates" function. The extent of the view can now be declared before the area of focus is zoomed to.

After these minor adjustments and modification, the development phase of the project was completed but due to time constraints, the project could not enter the next phase. A next phase was anticipated which involved training a non-GIS user on how to operate the application with the preparation of having minimal systems support in the field thereafter.

A subject had been identified and some preliminary training was done but was neither documented nor purposely done when the application was ready. The subject's selection criteria was that they had to have no prior experience in the use of a GIS software but would preferably have an environmental background.

5. Results and Discussion

The final application produced an ArcMap document with a customized toolbar that can aid in the following:

- Query into a database and can view different layers within Arcmap at different scales;
- Access ArcScene which will also help the CSFOs to make informed decisions based on terrain;
- Display a 1 Ha square grid that gives a true representation of the ground situation;
- Zoom to a selected GPS point using a preferred scale range.

This will aid the prioritizing of activities and their interest zones and areas to monitor more frequently. Depending on the users and the adaptability of the CSFOs, the application provided will give them an idea of how to work with ArcGIS and how to use it in making informed decisions.

5.1. S.W.O.T analysis

A SWOT analysis stands for Strengths, Weaknesses, Opportunities and Threats and is a simple and powerful way to analyze a projects feasibility situation. The SWOT analysis for this project is as follows:

Strengths

The document is user friendly and does not require the user to perform complicated analysis or processing. Although simple, the document is based in a robust environment within ArcGIS and a similar concept can be used in the field with minimal maintenance problems

Weakness

Training of some CSFOs is required and the fact that no central data source in the organisation exists can lead to a loss of updated records and data.

The whole project is very expensive to implement. A large relational database must be created with a robust structure to be able to handle regular updates from the CSFOs and disseminate the same information to other stakeholders e.g. water companies and other government agencies.

Opportunities

Opportunities within this project will continue to grow as the skill levels of the CSFO grows. With the use of GIS, the CSFOs are able to capture more information about fields and the catchment areas on a whole. This, linked with OS MasterMap, catchment conditions, farm properties and the National Land and Property Gazetteer can form a national database that can be used by several Government agencies and stakeholders. Such a database will help improve management practices thereby decreasing the amount of pollution going into the water systems and also destroying the environment. This data can be shared between stakeholders and increase environmental management practices sufficiently.

Threats

One of the biggest threats of such a project is the lack of resources, both human and monetary, within the Government, which could hinder these first steps of a well-timed idea. With the proliferation of GIS and the high computer skill levels among staff and graduates, as identified from the questionnaire, the use of GIS for the CSFO will be more than welcome and easily adopted.

6. Conclusion and Recommendations

At the beginning of the project, a number of objectives were set out. The level at which they were attained varies as follows:

- The reviewing of the current practice for recording information by field officers to identify the role of the proposed GIS application, established that there was no such position as a CSFO previously and that all data was collected by other officers not related to the CSF project. The CSFO concept is a new initiative and the CSFOs will therefore require training in data collection;
- Identifying the key issues related with the needs of CSFOs and to what extent GIS can be applied was outlined in the literature review of the activities of the CSFO the process of decision making when using MasterMap data and viewing slope classifications from the DEMs can aid in knowing site locations and terrain;
- Developing a GIS updating and editing tool to archive changes within the current data to increase efficiency and management was demonstrated in the GUI developed which helps in editing the existing data. One shortcoming was, there was no provision for creating new data in the databases unless the location of the individual file was known and how editing of all files was done in order for the data to be maintained at a consistent level;
- Designing a GIS viewing application with a user friendly interface linking all spatial data with a database. This was done by using the central ArcMap document and developing all applications around that;
- Testing and evaluating the final product was done but not comprehensively due to time constraints. No formal documentation was filed to illustrate the extent of testing. However, from feedback of the informal testing, the changes made to the product have increased functionality and made it more robust for use in the field.

The preparation of ArcMap and the customisation of it, together with ArcScene, which gives a bird's-eye view of the entire area, will help the CSFOs prioritise the areas to visit and to make quick informed decisions. This

study is a starting point but what is essential is the practical and applicable use of GIS within the Environment Agency and Natural England in order to utilise all the data available within the organisation. Most of the data available within the EA is not used as efficiently as it should be and this project is a first step in making changes happen.

Project recommendations and areas of further development will include the following:

- Training the CSFOs in data collection techniques;
- Developing a program that can associate Grid id's in Arcmap with the same coordinate system in ArcScene and getting a way to load up an *.sxd file already zoomed in to the area of focus;
- Getting the 1 Ha square box to work at certain scales only. This will make its use suitable in localized areas as opposed to the entire catchment area now;
- Populating the OS MasterMap data with extra fields where more information can be collected by the Catchment officer during his farm visits. A more detailed database can then be developed through data collection and more training of the CSFOs. Data such as field cover and soil types can be stored in this geodatabase alongside owner's information and farming practices. A data collection tool can be modelled around the user requirements of the CSFO and the integration of MasterMap and already existing feature classes in the peak_catchment geodatabase;
- A tool that will help incorporate new points collected by GPS into the MasterMap data and populating them into the already existing categories to increase the information accessible within the database;
- A method to maintain data integrity when using updated MasterMap data which has a change in boundaries;

Apart from catchment management, this data can then be used for several other purposes including new policy formulation and re-strategising of the England Catchment Sensitive Farming Delivery Initiative. This, of course is a

long term plan but a much cheaper option as compared to having a national project to collate all this data over a small period of time.

7. References

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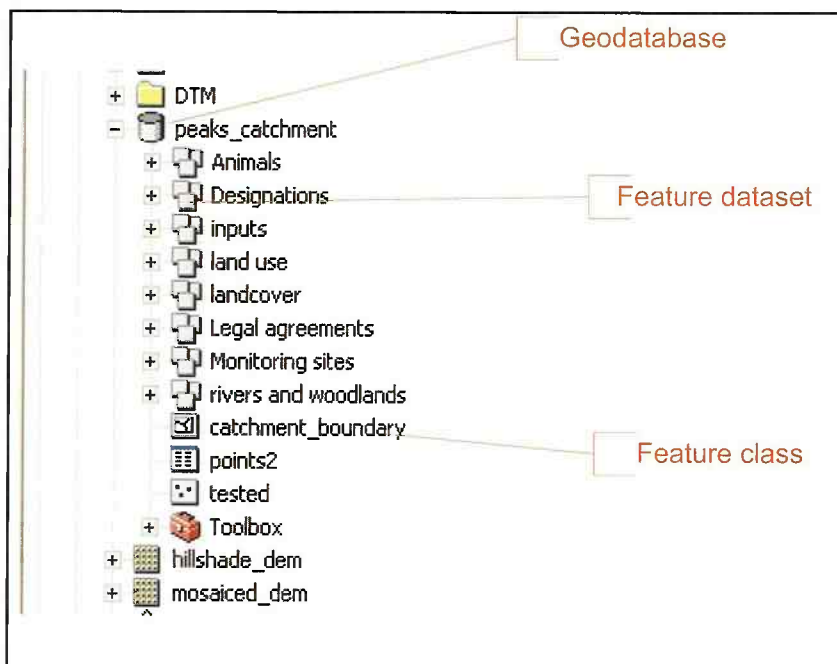
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8. Appendices

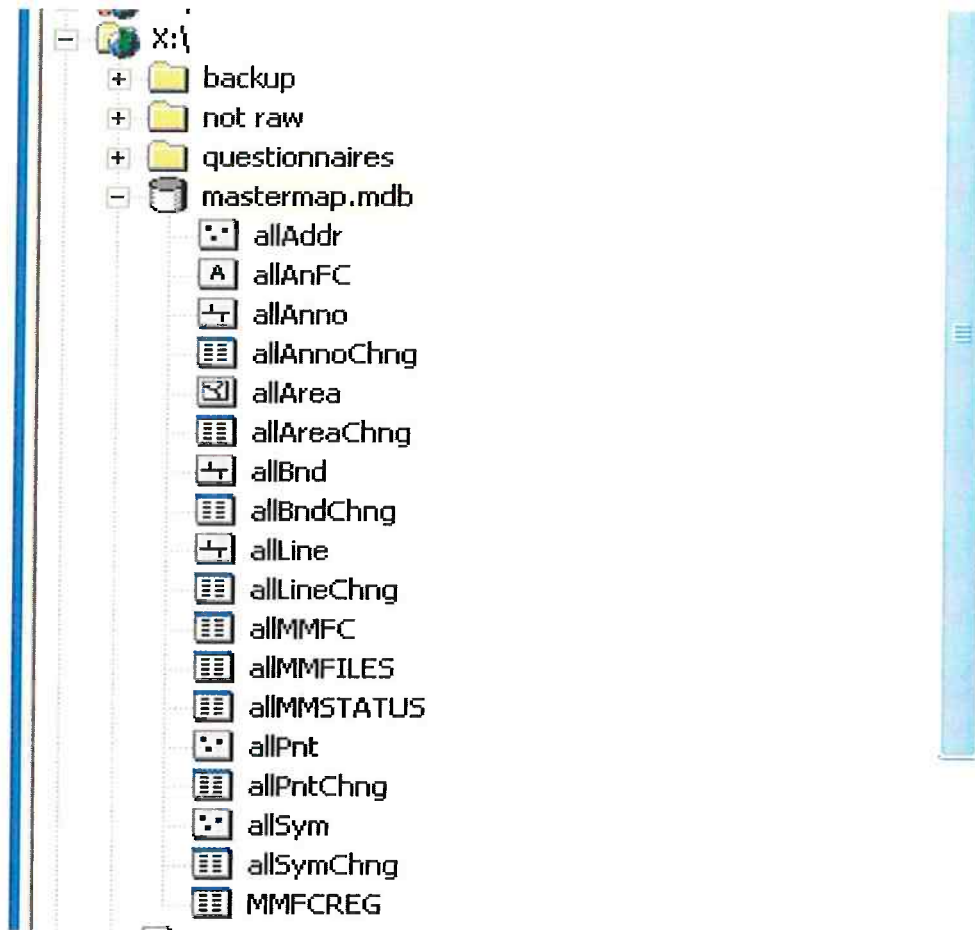
Appendix A

Peak Catchment Dales Geodatabase



APPENDIX B

Ordnance Survey MasterMap geodatabase



APPENDIX C

*Minutes of Project Meeting with the Environment Agency representative
1030 hrs, 10th August 2006
Cranfield University, Silsoe Campus*

Members attending in person:

Madi-Jimba Yahya
Dr. Neil Preedy (Senior Soil Scientist, Environment Agency)

AGENDA

- Confirmation of all data received
 - State of the Master map data and the relevant shapefiles
 - Demonstration of application and program design
 - Feedback and recommendations
 - AOB
-

1. First agenda item

A list of all the data the Environment agency has sent to Mr Yahya was presented and Dr Preedy confirmed that the list was complete. This was because of problems of transfer of the files through the internet. Some files were missing during this process and it took several attempts to get all the data through.

2. Second agenda item

MasterMap data has been sent to the University by means of Post and should be received very soon. More data was produced by Dr Preedy. This compact disk contained shapefiles of areas of risk.

Decision: Because of the lack of time, the data received will only be used for a visual add-on to the existing interface. There will be no database linkages etc.

3. Third agenda item

The application was loaded and a run through was conducted with all the forms and buttons explained. Dr Preedy was pleased with the application but wanted more images to be presented in 3D rather than in 2D. Mr Yahya said that will require the use of ArcScene and it was agreed that Arcscene will be used for visual presentation of the data using the Digital Elevation Model (DEM) and the shapefiles that Mr Yahya will deem of importance. MasterMapo will be used also in the event that it does come through the post.

Follow-up: Both persons agreed to follow up on the MasterMap data and track its whereabouts. The DEM will be used as a backdrop in the Arcscene document and all shapefiles will be draped on top of it.

4. Fourth agenda item

Madi-Jimba Yahya

MSc Geographical Information Management

Dr Preedy was pleased with the progress attained but had a few things to point out.

Accessing of the database is a fine idea but will not be utilized at the moment. The main part of his requirements was to view the items in 3-Dimensions so that the catchment officers can have a 'helicopter' view of their surroundings and how this can influence their activities and their decisions. Mr Yahya said that this is attainable as shown in the demonstration, but will have more of an impact when the MasterMap data is availed.

5. Fifth agenda item

Some reading material was provided by Dr Preedy to help Mr Yahya understand the exact operations of the catchment officers and their requirements and their day to day decisions.

Minutes prepared by: Mr Madi-Jimba Yahya on 11th August 2006

Approved: Dr. Neil Preedy

APPENDIX D

Questionnaire to Catchment Sensitive Farming Officers

A Geographic Information System (GIS) is used to input, update, store, manipulate and retrieve spatially referenced data. GIS could be a useful tool to help Catchment Sensitive Farming Officers (CSFOs) to efficiently manage their respective areas. GIS offers CSFOs the ability to view geographical information relating to their immediate location and surrounding area or to the catchment as a whole. GIS offers the capability to update data when changes occur within an area, interrogate spatial data and also edit the visual representation of data display on maps.

Using GIS software can be daunting to a novice GIS user. Therefore, understanding the existing level of the GIS knowledge amongst CSFOs will help target the appropriate level of GIS for future development of software support.

This questionnaire will take no more than five minutes to complete. Please answer the following questions as accurately as possible.

Section 1

1. What is the name of your CSF catchment area?

Section 2

1. Have you ever heard of Geographic Information Systems (GIS)?
☐ Yes ☐ No
2. Have you ever used a GIS software before? (If no, skip to next section)
☐ Yes ☐ No
3. If yes, please state type of GIS software you are aware of/have used (e.g. ESRI ArcView)

4. Level of competency in GIS? (please tick appropriately)

<i>Tick as appropriate</i>	<i>Tick</i>
Presentation –displaying of a static map	
Exploration –examination or addition to the current maps already displayed	
Analysis – selection of features based upon criteria	
Synthesis – combining existing data or creating one's own data into a new map	
Visualization – a dynamic process of searching for new spatial patterns by altering the way the data is represented	

5. How useful do you think GIS software will help in efficient delivery of your duties as a Catchment Officer?

- ☐ Very useful
- ☐ Somewhat useful
- ☐ Not very useful
- ☐ Not useful at all

Section 3

1. Have you ever used database software before?

- ☐ Yes ☐ No

2. If yes, please state type (e.g. Microsoft Access) (if no, please skip to next section)

3. Level of competency in databases (Please tick appropriately)

<i>Tick as appropriate.</i>	<i>Tick</i>
End-user. Working with a form based user interface	
End-user. Minor editing with a form based user interface	
Data manager- Inputting data into the system	
Data manager- Processing data	
Database designer	

4. What size of database have you worked with? (approximate number of users)

Section 4

1. Are you familiar with Global Positioning (GPS) technology?

2. Are you competent with the use of GPS?

3. Are you equipped with a Global Positioning System (GPS) receiver?

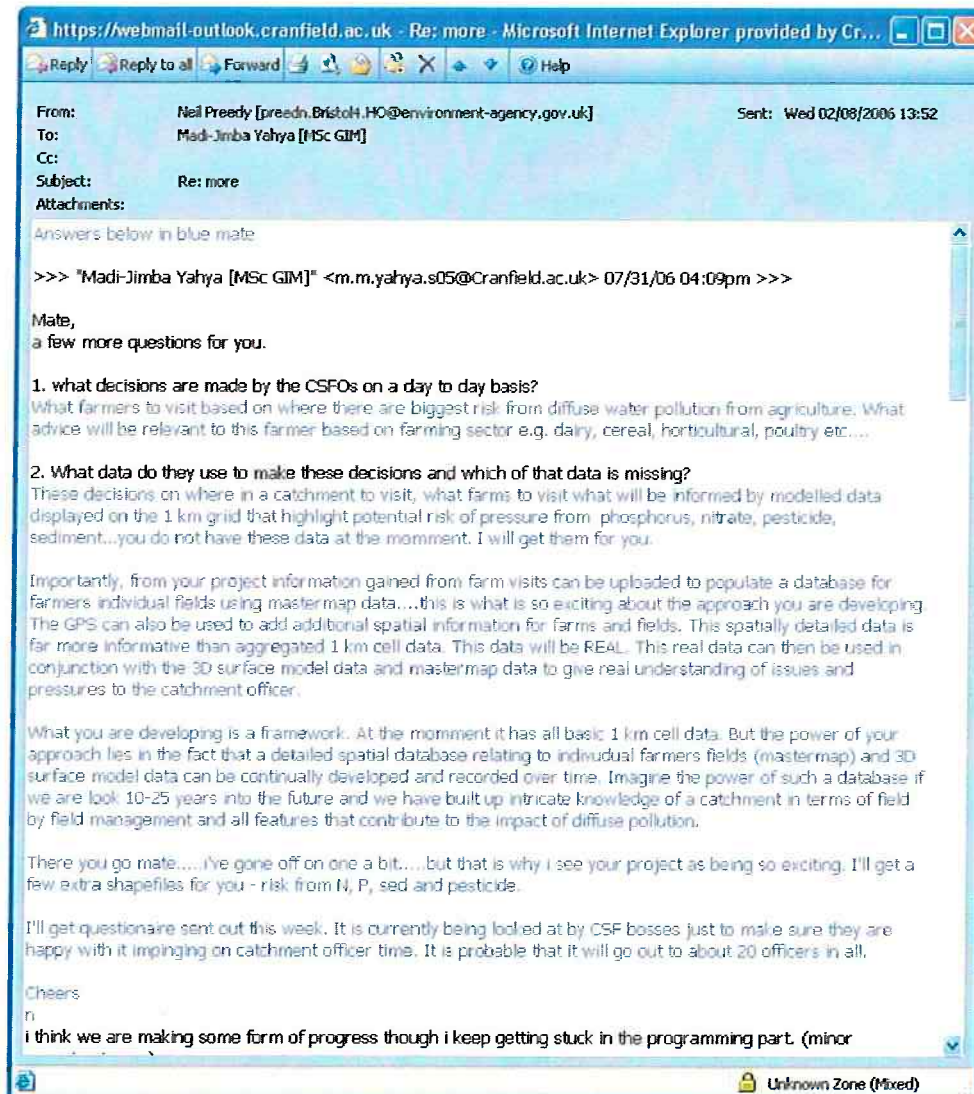
☐ Yes

☐ No

4. Are you equipped with any other data collection tools e.g. palmtop computers, Personal Data Assistants (PDAs) etc? (If yes, Please state type)

APPENDIX E

Correspondence stating the prioritization of catchment officer's activities



Madi-Jimba Yahya

MSc Geographical Information Management

APPENDIX F

Files used for the Graphical User Interface database viewer.

Files contained in the database viewer

Table	Field	Value	description
Animals	GRIDID	numeric	
	Cattle	numeric	
	Sheep	numeric	
	Pigs	numeric	
	Poultry	numeric	
Landcover	cov004_LAN	numeric	Sea
	cov005_LAN	numeric	Urban
	cov006_LAN	numeric	Water
	cov007_LAN	numeric	Rough
	cov008_LAN	numeric	Arable
	cov009_LAN	numeric	Grass
Landuse	C1		cereal
	C2		root crops
	C3		Brassica
	C4		Oilseed crops
	C5		Fallow
	C6		Horticulture
	C7		Grassland
	C8		Orchards
	C9		Other arable crops

APPENDIX G

User results of questionnaires on database and GIS user proficiency

Catchment	GIS Use (0,1)	Level	Database Use (0,1)	Level
Yealm	1	5	1	4
R.eye	1	2	1	4
Little ouse	1	5	0	0
Yorkshire Ouse	1	3	0	0
Exe	1	3	0	0
Waveny	1	4	1	2
Deben	0	0	0	0
Wyre	0	0	1	2
Lincolnshire	1	2	1	3
Pevensey	1	1	0	0
Rivers waver	1	4	1	2
Bassenthwaite	1	2	0	0
West mids	0	0	0	0
Kennet	1	1	1	1
Lugg	0	0	0	0
Ooter axe	1	4	1	1
Wensum	1	4	0	0
Avon	1	2	1	2
Average use	77.78%	2.33	50%	1.17

APPENDIX H

Code sample embedded into the catchment_area.mxd file (ArcMap document)

```
Private Sub cmdCentre_Click() 'moves the active layer to a new centre point

'declare variables
Dim pmxdocument As IMxDocument
Dim pActiveView As IActiveView
Dim pMap As IMap
Dim pCentre As IPoint
Dim pEnv As IEnvelope
Dim CurWidth As Double
Dim CurHeight As Double
Dim DesDistance As Double

'gets the active map
Set pmxdocument = ThisDocument
Set pMap = pmxdocument.FocusMap

'checks for null user input

If Val(txtX.Text) > 0 And Val(txtX.Text) < 800000 Then
    If Val(txtY.Text) > 0 And Val(txtY.Text) < 800000 Then
        'Zooming Code
        'puts user coordinates into variables
        vXcoord = Val(txtX.Text)
        vYcoord = Val(txtY.Text)

        'new point with user defined coordinates

        Set pCentre = New Point
        pCentre.PutCoords vXcoord, vYcoord

        Set pActiveView = pmxdocument.FocusMap

        CurWidth = pActiveView.Extent.Width
        CurHeight = pActiveView.Extent.Height

        DesDistance = Val(txtZoomD.Text)

        'sets pEnv to the extent of the active dataframe
        Set pEnv = pActiveView.Extent

        'Get zoom scale
        pEnv.Expand (DesDistance / CurWidth), (DesDistance / CurHeight), True

        'centre the envelope
        pEnv.CenterAt pCentre

        'move the active dataframe a position defined by the envelope
        pActiveView.Extent = pEnv

        'refreshes the dataframe
        pmxdocument.ActiveView.Refresh

    Else
```

```
        MsgBox "Invalid y-coordinate, please ammend.", vbOKOnly, "Error"  
        txtY.SetFocus  
        Exit Sub  
    End If
```

```
Else  
    MsgBox "Invalid x-coordinate, please ammend.", vbOKOnly, "Error"  
    txtX.SetFocus  
    Exit Sub
```

```
End If
```

```
End Sub
```

APPENDIX I

Compact disc containing catchment area.mxd file (ArcMap document)