

Declaration of Russell L. Hore

I, Russell L. Hore, declare as follows:

1. I have personal knowledge regarding all the facts set forth in this declaration.
2. I am not being and have not been compensated for my time in preparing this declaration.
3. In the 2011-2012 time-period, I was employed at Capgemini as a senior developer. I was also a member of the Ogwen Valley Mountain Rescue Organization (“MRO”). At that point, I had been involved with the Ogwen Valley MRO for more than 20 years. I was also working as an IT Coordinator for the Ogwen Valley MRO. I have been retired since about 2014-2015.
4. Prior to this time, and starting in 2007, I developed a system known as “SARLOC” (Search and rescue location) that was intended to assist in the geolocation of a lost individual. The system would collect and relay the individual’s location to a rescue team where it could be displayed on a map.
5. The system worked (and continues to work: it is still in use today) by sending a text message with a URL to the lost individual’s smart phone. The individual would access the link which would in turn cause the individual’s phone to collect the phone’s location and report it to a server where it can then be relayed to appropriate rescue personnel.

6. This system was discussed in various publications, including a publication I authored entitled “MRMap and SARLOC – Mobile ‘phone Geolocation for Search and Rescue.” I will refer to this publication as the “SARLOC paper” throughout this declaration. A copy of the SARLOC paper accompanies this declaration as Exhibit A.

7. I wrote the SARLOC paper for use and publication in connection with the GISRUK 2012 conference.

8. GISRUK, or Geographical Information Science Research UK, is an organization of academics and practitioners dedicated to advancement of spatial sciences.

9. GISRUK holds an annual conference—attended by both academics and those involved in industry—to discuss contemporary trends in spatial analytics and geographic data science.

10. Individuals like myself, who both develop and use geolocating and positional systems (SARLOC is an example of one such system), attend GISRUK conferences to learn about available technology, recent advances, and use cases for this type of technology

11. I attended the GISRUK conference in 2012.

12. Again, I prepared the SARLOC paper for the GISRUK 2012 conference.

13. The conference occurred from April 11-13, 2012 at Lancaster University.

14. Prior to the conference, I submitted a copy of the SARLOC paper to the conference organizers. The SARLOC paper was then included in a complete conference “proceedings” publication. A copy of the proceedings publication from GISRUK 2012 accompanies this declaration as Exhibit B.

15. The complete conference proceedings were made public and freely available immediately after the conference online via the GISRUK website (<https://gisruk.org/conference/proceedings/>). The proceedings were also published as an official document with an ISBN on www.lulu.com (see for example, <https://www.lulu.com/shop/barry-rowlingson-and-duncan-whyatt/proceedings-of-the-gis-research-uk-20th-annual-conference-volume-1-presentations/ebook/product-20023453.html?q=gisruk+2012&page=1&pageSize=4>). The 2012 proceedings were no different. The complete proceedings—along with my SARLOC paper—were available for viewing on both sites. I have consulted these websites over the years and expect that many in the industry have done the same.

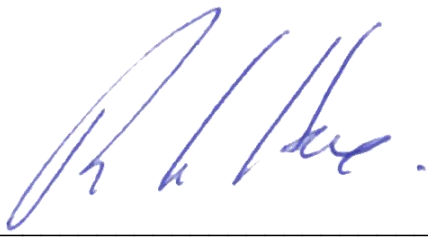
16. Based on my observations, I estimate that approximately 200 academics and industry members were in attendance at GISRUK 2012.

17. Additionally, while at the conference, I showcased my work with SARLOC on a large-format A0 poster outside the main presentation theatre. The

poster highlighted the main features of SARLOC, and directed those interested to the SARLOC paper that was available in the GISRUK 2012 proceedings for further information. While manning the poster, I recollect talking about SARLOC with at approximately 40-50 conference attendees.

18. I declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements are made with knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1000 of Title 18 of the United States Code.

Date: 21-March-2025



Russell L. Hore

Exhibit A

MRMap and SARLOC – Mobile ‘phone Geolocation for Search and Rescue

Russell Hore¹

¹18 Greenway Gardens, Pattingham, Wolverhampton, WV6 7DH

Tel. +(44) 7710 459 633

russ@russ-hore.co.uk, <http://www.russ-hore.co.uk/>

Summary: MRMap and SARLOC are two tools that have been developed by Mountain Rescue personal to assist Search and Rescue Teams in the UK. MRMap allows real-time tracking of team resources using GPS enabled radios. SARLOC is a system that can be used to locate ‘lost’ people using the geo-location API of the web browser on many ‘smartphones’ without having to install any software

KEYWORDS: SARLOC, MRMap, mountain search and rescue

Abstract:

Dedicated teams of volunteers provide Mountain Rescue in the UK. Although highly trained and competent people, there is an increasing demand to look after their safety whilst operational. Logistically, it is highly desirable to have a current picture of where assets, whether people or vehicles, are. Volunteers are generally part of a Mountain Rescue (MR) Team, thus tracking individual members is normally accepted by the membership and well established. Most MR teams have good radio communication network *in-situ*. MRMap is a system that has been in use for over six years. The handset of a team member’s radio contains a GPS receiver that can be used to transmit the location of the handset to a distant station where it can be displayed on a map.

MR teams deal with many types of incident involving missing persons. Within my team (OVMRO) we receive numerous calls where the caller has a mobile ‘phone but little other equipment to aid their navigation e.g. map and compass or GPS. SARLOC is a system whereby the lost person’s ‘smartphone’ can pass its location to the MR teams. Existing systems are available to track ‘phones but these normally have to be installed on a users ‘phone prior to use. SARLOC utilises functions of the ‘smartphones’ web browser to obtain a location for the handset. SARLOC is currently undergoing testing within the UK and Ireland but has been used successfully on a number of occasions to significantly reduce the ‘search area’ for the teams. In the medical world, the importance of reaching an injured person within the ‘Golden Hour’ is paramount. Reducing the search area can significantly reduce the time required to locate and recover a person.

MRMap

The original work on tracking via GPS enabled radios was carried out by Robert Brookes, himself an MR team member, in 1997 using SRM9000 radios donated by Simoco. The proof of concept confirmed the technique worked but was only suitable for tracking of vehicles due to the size of the radios. Simoco subsequently produced a portable radio containing a GPS in the handset. This enabled tracking of both search dogs and people.

During this development, the software used to display the locations underwent a considerable price increase making it prohibitively expensive for volunteer teams. MR team member, Dave Binks (Duddon and Furness Mountain Rescue Team), developed a bespoke application called MRMap that

could take the location data and display it on Ordnance Survey (OS) maps at various scales in real time.

MRMap is a Windows™ application developed using C++. It receives positional data in latitude/longitude format from a base station radio via a serial port on a PC. This is converted to OSGB36 format for overlay onto digital maps. Each MR Team radio is allocated a unique ID. When MRMap receives a data packet it can retrieve the radio ID, latitude and longitude and plot the ID on a map.

SARLOC

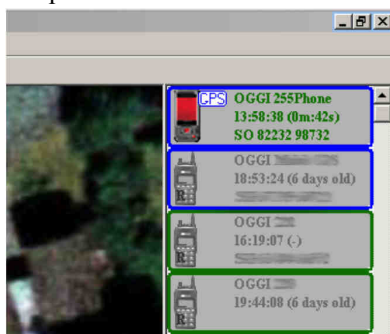
MRMap is used by many MRTs and is ideal for tracking MR personnel through their team radios. MR teams often receive calls for assistance from people on the hills who have mobile 'phone contact but little if any navigation equipment i.e. map, compass, GPS and/or little knowledge of how to navigate in remote areas. The increased presence of 'smartphones' which are location aware led to the development of SARLOC in an attempt to utilise the 'phones to assist MR Teams in finding the lost people.

Steve Fletcher (Bolton MRT) actively developed an application that can be installed on 'phones which will interrogate the 'phone and pass its location to MRT. This works well but relies on the application being installed and configured on the users 'phone.

SARLOC does not require any applications to be installed on the 'phone and uses the geo-location API of the 'phone's web browser to obtain it's location. The lost person only needs to browse to the SARLOC web page, the URL of which is sent to the person as an SMS message. SARLOC uses both PHP and JavaScript to request the 'phones location and to pass it to a web based database which can then be interrogated by the MRT. Most 'phones have a privacy setting that controls access to the location API. The privacy setting can prevent SARLOC obtaining the location but the user may be prompted to allow the browser access to the information. If the web page obtains the location it uses an Ajax call to update the online database. The users location can then be retrieved from a web page showing the tabular data as below;

OS Ref.	LAT	LON	ACC	ALT	ALT_ACC	HEADING	SPEED	TAG	TIMESTAMP
SN604812	52.41020	-4.05274	24	119	0	0	0	Cas 1	2012-02-09 14:23:40
NY055852	55.15221	-3.48317	48	122	0	0	0	Cas 2	2012-02-06 21:13:27
TQ280046	50.82581	-0.18174	88	11	18	0	0	Cas 3	2012-02-06 20:27:11

The location is also shown in MRMap:



Case Histories

Searching for a lost/missing person is one of the more resource hungry tasks MRT have to conduct. Where the person has little idea of their location a protocol is followed to narrow down the area searched. This is generally based on team member's local knowledge and 'gut feeling'. From this procedure areas of high probability will be identified and resources deployed to search the area. The limited number of resources dictates how many areas can be searched at the same time. The time taken to search these areas will reduce when the distance a searcher can see reduces due to nightfall, weather and the ground conditions they are searching under. A significant amount of work [1][2] has been carried out to try and improve the way searches for missing person(s) are carried out. SARLOC can provide a huge saving in terms of both manpower required and time to recover the lost person by providing an accurate location for them.

One example of this was a search on Yr Wydfa (Snowdon, North Wales) where the party were unsure of their position. Normally a number of search teams would be sent onto the hill to sweep the areas of higher probability. SARLOC was activated and a fix received within a few seconds that allowed the team to deploy just two MR members to walk directly to the lost party.

The urgency to locate a party is increased where a casualty is injured or has a medical problem. If the casualty is unsure of their position, SARLOC can be used to report their location. This allows the MRT to tell the casualty they know where they are and will be with them in a much shorter time than if they had to search for them. This can significantly improve the moral of the casualty.

An example of this is a search on Moel Siabod (North Wales) in November 2011. Two walkers had descended from the summit. They had limited equipment and eventually became totally lost and disorientated in the cloud. They rang for help as the light faded and could only give a vague idea of their location. One of them had a medical condition and was deteriorating so search parties were sent out immediately. SARLOC provided a fix with a reported accuracy of 12m. The location was radioed to the hill parties who were planning to search what would have been the wrong side of the mountain. They entered the location into their GPS and walked straight to the casualty.

Conclusion

In conclusion we can see that MRMap is a well-established system to track team personnel and equipment while operational. SARLOC is a novel new application to rapidly locate lost people by simply using the smartphone they have made the rescue call with. With the continuing expansion of broadband coverage and smartphone ownership SARLOC's importance as a tool to resource strapped MR Teams can only continue to grow. MRMap and SARLOC show how developments in geo-location are helping MR teams to find lost people efficiently, instilling much needed calm and confidence in them, while minimising team resources required and staying safe themselves.

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- [1] D. C. Cooper, J. R. Frost, R. Quincy Robe (2003). Compatibility of Land SAR Procedures with Search Theory. *U.S. Department of Home Security United States Coast Guard Operation (G-OPR) Washington D.C. 20593-0001.*
- [2] R. Koester, D.C. Cooper, J. R. Frost, R. Q. Robe (2004). Sweep Width Estimation for Ground Search and Rescue. *Potomac Management Group Inc.*

Exhibit B

Proceedings of the GIS Research UK
20th Annual Conference

Volume 2 – Posters

GISRUK 2012
Lancaster University, Lancaster, UK

Editors: Duncan Whyatt, Barry Rowlingson

11th – 13th April 2012

Proceedings of the GIS Research UK 20th Annual Conference
Volume 2 – Posters

Edited by: Duncan Whyatt and Barry Rowlingson

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Published by The University of Lancaster, Lancaster, United Kingdom

ISBN: 978-1-86220-295-5

On behalf of the organising committee I would like to extend my warmest welcome to all speakers and attendees of the 2012 Geographical Information Science Research UK conference (GISRUK) which is being hosted by Lancaster University. This conference once again brings together theoreticians and practitioners, users and academics from the numerous related disciplines involved in the processing and analysis of spatial data. This year's conference is particularly special, being the 20th in the series, and also provides us with an opportunity to celebrate the lifetime achievements of one of our most distinguished academics, Stan Openshaw.

The initial call for papers for GISRUK 2012 was issued in July 2011. Contributions were sought from researchers worldwide on all aspects of Geographical Information Science. We received a total of 96 papers from a variety of national and international universities and research institutions. Each paper was subject to review by at least two members of the programme committee and 54 were accepted for oral presentation. A further 30 were selected for poster presentation.

I wish to thank the members of the programme committee without whose comments and prompt reviews a conference of this type could not be successful. I also wish to extend my thanks to the seven members of the local steering committee, Lancaster University Conference Centre and student volunteers from Lancaster Environment Centre.

GISRUK has prospered over the years due to the generosity of many sponsors who support the conference and the many associated prizes, workshops and social events. This year is no exception and we thank them once again for their generosity. I would also like to thank our invited speakers Mei-Po Kwan, Pete Atkinson and Tyler Mitchell and eagerly anticipate their keynote presentations.

So welcome to GISRUK 2012. We hope you have a stimulating and enjoyable conference and that you enjoy the academic and social programmes in equal measure.

Duncan Whyatt
Chair GISRUK 2012

Local Organising Committee

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Duncan Whyatt	University of Lancaster
Adam Winstanley	National University of Ireland, Maynooth
Aidan Slingsby	City University London

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Virtual globe visualisations to improve public engagement with an urban fringe landscape: Gaywood Valley Project, Norfolk, UK

Harwood, A. R.¹, Lovett, A. A.¹, Turner, J. A.¹

¹School of Environmental Sciences, University of East Anglia, Norwich Research Park, Norwich, NR4 7TJ, United Kingdom.

Tel: +44 (0)1603 591353 Fax: +44 (0)1603 591327
amii.harwood@uea.ac.uk

Summary: Virtual tours were produced using Google Earth as a platform to actively engage the public with spatio-temporal information. These tools were developed in the scripting language KML and were augmented with HTML and COLLADA three-dimensional models. They were made available on the Internet for public download. Tours encompassed information on landscape characteristics, accessible greenspace and walks, as well as providing a guide through educational data such as geological outcrops and past climates. This research contributed to a wider project aimed at increasing the awareness and use of a river valley which is currently under-utilised by both urban and rural communities.

KEYWORDS: Google Earth; KML; virtual tours; Google SketchUp.

1. Introduction

Three-dimensional visualisation of a place on Earth using a virtual globe offers more interactive possibilities than traditional static 2D mapping. Virtual globes can help users interpret their present environment and plan for the future (e.g. Sheppard and Cizek, 2009; Pettit et al., 2011); they can also provide a window into the past, e.g. through geological modelling (De Paor and Whitmeyer, 2011). Furthermore, users of virtual globes can be made aware of spatial trends and implications while not explicitly realising they are being educated (Patterson, 2007).

As part of the Gaywood Valley Sustainable Urban Fringes (SURF) Project an innovative set of virtual globe visualisations were commissioned to help raise awareness and use of the local landscape by neighbouring communities. These tools are now available to download from a University of East Anglia- (UEA) hosted website (<http://www.uea.ac.uk/env/research/reshigh/gaywood>, accessed November 2011). For more information on the SURF partnership and the background to the Gaywood Valley Project, the reader is referred to the official website (<http://www.sustainablefringes.eu>, accessed November 2011).

2. Research themes and data sources

Google Earth was selected from of the available virtual globes (e.g. NASA World Wind, Microsoft Bing Maps, ESRI Arc Explorer, see review in Tuttle et al., 2008) because it is freeware and arguably the market leader. It also has a comprehensive support network. Keyhole Markup Language (KML) was used to render geographic data and auxiliary information. A comprehensive discussion of basic KML is provided by Wernecke (2009).

Three research themes were established through consultations with core members of the Gaywood Valley Project. These themes included physical attributes of the catchment and changes through time.

At the start of the Project there was an absence of publicly available information about Gaywood Valley, certainly there was no centralised reference source. A GIS was used to collate information and generate new spatial data e.g. on points of potential interest to local communities.

1. Introduction to Gaywood Valley

The first theme gave an overview of the catchment, the river and places that may be recognisable by the end user. The user is taken on a virtual tour from the river source to the mouth at the port of King's Lynn, Norfolk. Key points of interest are highlighted and described. Information was gathered from consultation with members of the Gaywood Valley Project and collated from numerous online sources and official websites.

2. Geology and Past Climates

The Geology and Past Climates tour was designed to help users appreciate the link between the types of rocks that outcrop at the surface, their changes with depth and the time period and conditions under which they formed. Key data sources were: the British Geological Survey (<http://www.bgs.ac.uk/data/services/kml.html>, accessed November 2011) and the Norfolk Geodiversity Partnership (2010).

3. Green Infrastructure

The final tool focused on showing users how to get out into the valley by displaying public rights of way, cycle routes, health walks and accessible greenspace. The majority of data were obtained from Norfolk County Council (NCC).

3. Tool development

3.1 Basic conversion of GIS data into KML

At a basic level, Google Earth can be used to view satellite and aerial imagery of the catchment. Thematic layers can then be draped over the surface of the globe as 'ground overlays' and locations on the globe, specified by a longitude and latitude, can be marked with an icon (these are known as 'placemarks'). GIS data were converted into a format compatible with Google Earth (KML) using ESRI's ArcGIS. Placemarks were also digitised directly in Google Earth. Custom icons were used and placemark balloons were enhanced with HTML coding for formatting, colour scheme, hyperlinks and photographs (Figure 1).

3.2 Three-dimensional models

The full abilities of KML are not unlocked without linking the virtual globe with COLLADA 3D models (De Paor and Whitmeyer, 2011). COLLADA is the scripting language of Google SketchUp and, like KML, also be viewed and edited in a text editor.

Several 3D models were created in Google SketchUp by drawing and extruding shapes. These included the ruins of a church, a geological cross-section, an arrow showing the long axis of the Gaywood Valley and an arrow depicting the direction that glaciers moved across the catchment. The models were exported from SketchUp as KMZ files. KMZ files are compressed folders that can be read by Google Earth. In this case they contained a COLLADA model (*.dae) and an associated KML file that would open the model in Google Earth. Using Network Links (Werneck, 2009) these KML files could be linked to other KML files in the same theme.

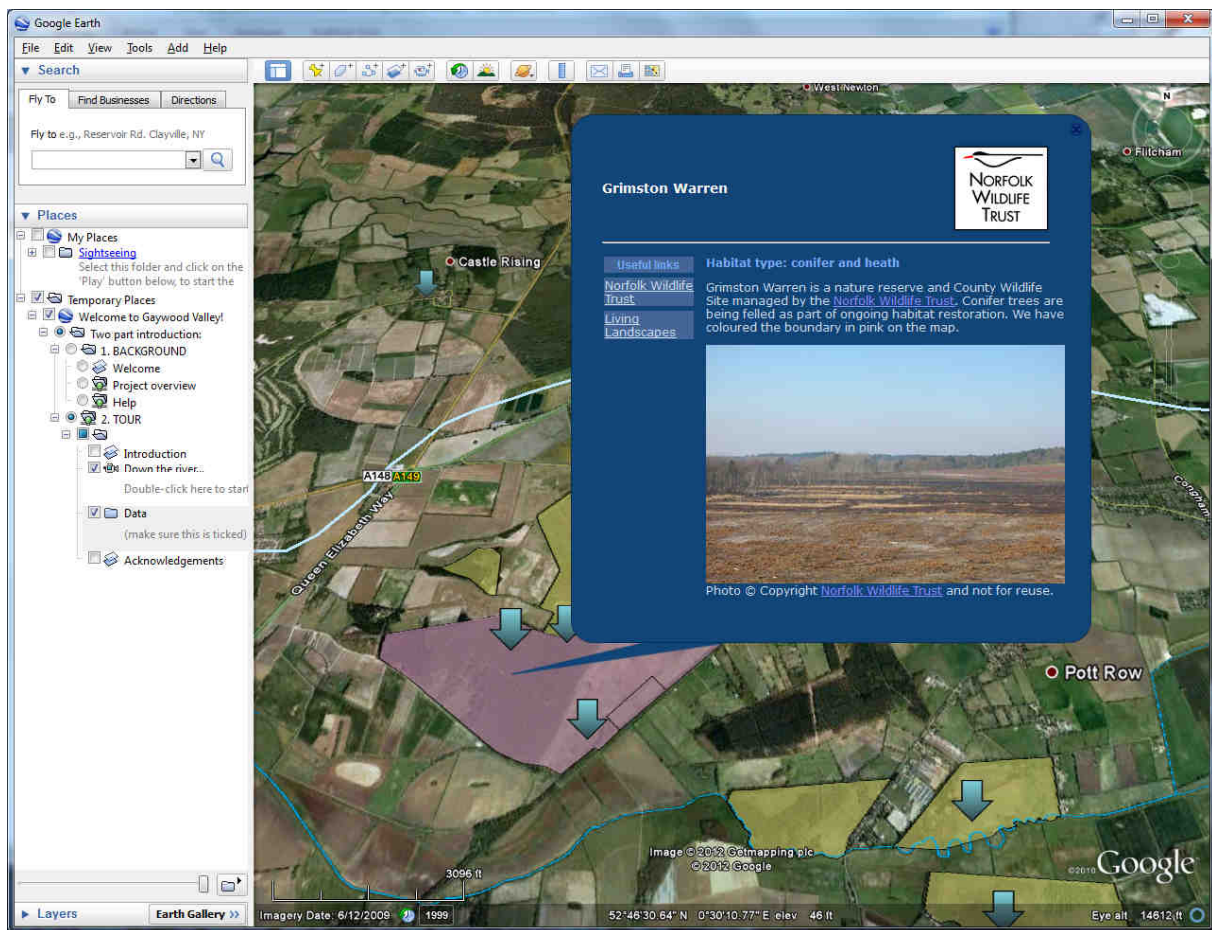


Figure 1. Custom arrow icons are placemarks with custom balloons coded in HTML.

3.3 Touring and animation

Tours were not only used to move the user around the Gaywood Valley. A combination of different camera angles, pauses, screen overlays and moving 3D models provided an engaging experience for the user. A complete on-screen narrative was provided for the Introduction and Geology tours. These narratives included user instructions supplemented by a series of screen overlays which explained the other information shown on the screen (see Figure 2). However, users could also leave or pause the tour and explore the virtual globe and layers for themselves, at their own speed.

Several of the 3D models created in SketchUp were initially given a negative altitude so that they were not visible. A model could be updated to rise to a new altitude over a fixed duration of time; therefore models could appear slowly from the ground (e.g. Figure 2).

The appearance (and disappearance) of screen overlays and the movement of models were controlled using 'AnimatedUpdate' tags in the KML of the tour.

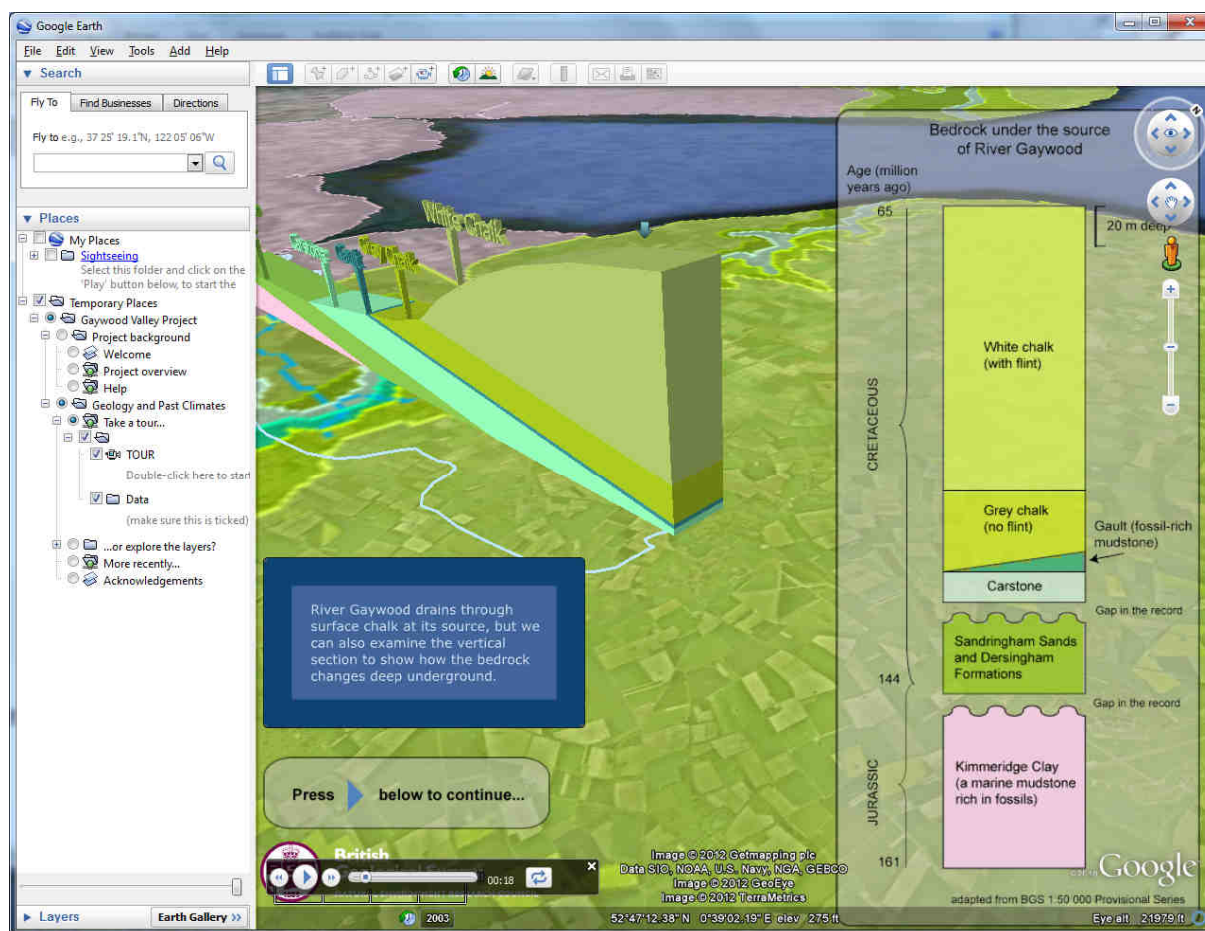


Figure 2. The Geology and Past Climates Tour has a combination of ground overlays, screen overlays, placemarks and 3D models; these work together to form a narrative for the end-user.

4. Evaluation

Evaluation of the uptake of this research is in progress at the time of writing. The first step has been to produce three deliverables (KMZ files) which are being used by members of the public. Over three-hundred visits have been made to the KMZ download website in the first three months since it's unveiling.

The public launch of the Gaywood Valley Project in May 2011 allowed testing of near-complete virtual globe tools. In this first outreach session, a public demonstration was given and a passive version of the Introduction to Gaywood Valley tour was shown. UEA researchers were available to answer questions and receive informal feedback from members of the public and town council. These tools are also being tested at several events with primary school children. Supplementary worksheets and other teaching materials have been developed for this purpose.

5. Conclusions and future research

- This is an academic research project where a set of deliverables have been produced and are currently being used to engage members of the public with the landscape on their local urban fringe.
- The three Google Earth tools can be utilised by different age groups and the extent of interaction can be controlled by the user.

- It is the network links between KML files, screen overlays, placemarks, 3D models, time-sliders and tours that are particularly powerful when combined to form a narrative and make this project innovative.
- The techniques described in this paper have potentially much wider uses in environmental science education and also as a mechanism for the dissemination of scientific research.

6. Acknowledgements

This research was funded by the Gaywood Valley Sustainable Urban Fringes Project which is supported by the Interreg IVB North Sea Region Programme and is partly funded by the European Regional Development Fund. Data were obtained from NCC, BGS and the Norfolk Geodiversity Partnership. Special thanks to Gemma Clark at NCC, Tim Holt-Wilson at the Norfolk Geodiversity Partnership for geological advice and Lauren Parkin for creating initial drafts of the teaching materials. This project has also benefitted from helpful comments by Richard Treves.

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8. Biography

Dr Amii Darnell is a Senior Research Associate at the University of East Anglia, Norwich. Amii has a BSc in Environmental Earth Science and postgraduate qualifications in Geographical Information Science (PhD, 2010). Her research interests include: error and uncertainty in spatial models and GIS as an aid to decision making. Professor Andrew Lovett is a Professor of Environmental Sciences at the University of East Anglia with a particular interest in the use of GIS for environmental decision making and landscape visualisation. Dr Jenni Turner is a lecturer in Earth Sciences at the University of East Anglia, with research interests in tectonics, sedimentology and Quaternary palaeoclimates.

MRMap and SARLOC – Mobile ‘phone Geolocation for Search and Rescue

Russell Hore¹

¹18 Greenway Gardens, Pattingham, Wolverhampton, WV6 7DH

Tel. +(44) 7710 459 633

russ@russ-hore.co.uk, <http://www.russ-hore.co.uk/>

Summary: MRMap and SARLOC are two tools that have been developed by Mountain Rescue personal to assist Search and Rescue Teams in the UK. MRMap allows real-time tracking of team resources using GPS enabled radios. SARLOC is a system that can be used to locate ‘lost’ people using the geo-location API of the web browser on many ‘smartphones’ without having to install any software

KEYWORDS: SARLOC, MRMap, mountain search and rescue

Abstract:

Dedicated teams of volunteers provide Mountain Rescue in the UK. Although highly trained and competent people, there is an increasing demand to look after their safety whilst operational. Logistically, it is highly desirable to have a current picture of where assets, whether people or vehicles, are. Volunteers are generally part of a Mountain Rescue (MR) Team, thus tracking individual members is normally accepted by the membership and well established. Most MR teams have good radio communication network *in-situ*. MRMap is a system that has been in use for over six years. The handset of a team member’s radio contains a GPS receiver that can be used to transmit the location of the handset to a distant station where it can be displayed on a map.

MR teams deal with many types of incident involving missing persons. Within my team (OVMRO) we receive numerous calls where the caller has a mobile ‘phone but little other equipment to aid their navigation e.g. map and compass or GPS. SARLOC is a system whereby the lost person’s ‘smartphone’ can pass its location to the MR teams. Existing systems are available to track ‘phones but these normally have to be installed on a users ‘phone prior to use. SARLOC utilises functions of the ‘smartphones’ web browser to obtain a location for the handset. SARLOC is currently undergoing testing within the UK and Ireland but has been used successfully on a number of occasions to significantly reduce the ‘search area’ for the teams. In the medical world, the importance of reaching an injured person within the ‘Golden Hour’ is paramount. Reducing the search area can significantly reduce the time required to locate and recover a person.

MRMap

The original work on tracking via GPS enabled radios was carried out by Robert Brookes, himself an MR team member, in 1997 using SRM9000 radios donated by Simoco. The proof of concept confirmed the technique worked but was only suitable for tracking of vehicles due to the size of the radios. Simoco subsequently produced a portable radio containing a GPS in the handset. This enabled tracking of both search dogs and people.

During this development, the software used to display the locations underwent a considerable price increase making it prohibitively expensive for volunteer teams. MR team member, Dave Binks (Duddon and Furness Mountain Rescue Team), developed a bespoke application called MRMap that

could take the location data and display it on Ordnance Survey (OS) maps at various scales in real time.

MRMap is a Windows™ application developed using C++. It receives positional data in latitude/longitude format from a base station radio via a serial port on a PC. This is converted to OSGB36 format for overlay onto digital maps. Each MR Team radio is allocated a unique ID. When MRMap receives a data packet it can retrieve the radio ID, latitude and longitude and plot the ID on a map.

SARLOC

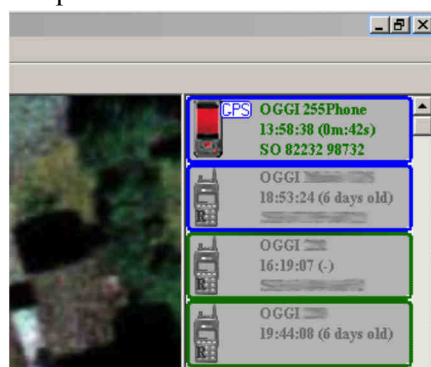
MRMap is used by many MRTs and is ideal for tracking MR personnel through their team radios. MR teams often receive calls for assistance from people on the hills who have mobile 'phone contact but little if any navigation equipment i.e. map, compass, GPS and/or little knowledge of how to navigate in remote areas. The increased presence of 'smartphones' which are location aware led to the development of SARLOC in an attempt to utilise the 'phones to assist MR Teams in finding the lost people.

Steve Fletcher (Bolton MRT) actively developed an application that can be installed on 'phones which will interrogate the 'phone and pass its location to MRT. This works well but relies on the application being installed and configured on the users 'phone.

SARLOC does not require any applications to be installed on the 'phone and uses the geo-location API of the 'phone's web browser to obtain it's location. The lost person only needs to browse to the SARLOC web page, the URL of which is sent to the person as an SMS message. SARLOC uses both PHP and JavaScript to request the 'phones location and to pass it to a web based database which can then be interrogated by the MRT. Most 'phones have a privacy setting that controls access to the location API. The privacy setting can prevent SARLOC obtaining the location but the user may be prompted to allow the browser access to the information. If the web page obtains the location it uses an Ajax call to update the online database. The users location can then be retrieved from a web page showing the tabular data as below;

OS Ref.	LAT	LON	ACC	ALT	ALT_ACC	HEADING	SPEED	TAG	TIMESTAMP
SN604812	52.41020	-4.05274	24	119	0	0	0	Cas 1	2012-02-09 14:23:40
NY055852	55.15221	-3.48317	48	122	0	0	0	Cas 2	2012-02-06 21:13:27
TQ280046	50.82581	-0.18174	88	11	18	0	0	Cas 3	2012-02-06 20:27:11

The location is also shown in MRMap:



Case Histories

Searching for a lost/missing person is one of the more resource hungry tasks MRT have to conduct. Where the person has little idea of their location a protocol is followed to narrow down the area searched. This is generally based on team member's local knowledge and 'gut feeling'. From this procedure areas of high probability will be identified and resources deployed to search the area. The limited number of resources dictates how many areas can be searched at the same time. The time taken to search these areas will reduce when the distance a searcher can see reduces due to nightfall, weather and the ground conditions they are searching under. A significant amount of work [1][2] has been carried out to try and improve the way searches for missing person(s) are carried out. SARLOC can provide a huge saving in terms of both manpower required and time to recover the lost person by providing an accurate location for them.

One example of this was a search on Yr Wydfa (Snowdon, North Wales) where the party were unsure of their position. Normally a number of search teams would be sent onto the hill to sweep the areas of higher probability. SARLOC was activated and a fix received within a few seconds that allowed the team to deploy just two MR members to walk directly to the lost party.

The urgency to locate a party is increased where a casualty is injured or has a medical problem. If the casualty is unsure of their position, SARLOC can be used to report their location. This allows the MRT to tell the casualty they know where they are and will be with them in a much shorter time than if they had to search for them. This can significantly improve the moral of the casualty.

An example of this is a search on Moel Siabod (North Wales) in November 2011. Two walkers had descended from the summit. They had limited equipment and eventually became totally lost and disorientated in the cloud. They rang for help as the light faded and could only give a vague idea of their location. One of them had a medical condition and was deteriorating so search parties were sent out immediately. SARLOC provided a fix with a reported accuracy of 12m. The location was radioed to the hill parties who were planning to search what would have been the wrong side of the mountain. They entered the location into their GPS and walked straight to the casualty.

Conclusion

In conclusion we can see that MRMap is a well-established system to track team personnel and equipment while operational. SARLOC is a novel new application to rapidly locate lost people by simply using the smartphone they have made the rescue call with. With the continuing expansion of broadband coverage and smartphone ownership SARLOC's importance as a tool to resource strapped MR Teams can only continue to grow. MRMap and SARLOC show how developments in geo-location are helping MR teams to find lost people efficiently, instilling much needed calm and confidence in them, while minimising team resources required and staying safe themselves.

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The WISERD Geoportal: An innovative tool for discovering social science research data

Berry, R.¹, Fry, R.¹, Higgs, G.¹, Orford, S.², Jones, S.²

¹Wales Institute for Social and Economic Research, Data and Methods (WISERD), GIS Research Centre, University of Glamorgan, Pontypridd, Wales, UK, CF37 1DL
Tel. +44 (0) 1443 483377 Fax +44 (0) 1443 483715
raberry@glam.ac.uk, www.wiserd.ac.uk

² Wales Institute for Social and Economic Research, Data and Methods (WISERD), Cardiff University, 46 Park Place, Cardiff, Wales, UK, CF10 3BB

Summary: This paper describes the development of the WISERD Geoportal (WGP) – an innovative web-based GIS for improving the discovery of social science research data in Wales. The research focuses on the key methods used in the building of the WGP, including the creation of a rich database containing metadata for socio-economic data in Wales and the development of the application using an open source software stack. In the conference presentation we will offer our thoughts on the future developments of the WGP, its ongoing sustainability and its potential importance in the social science research landscape.

KEYWORDS: Geoportal; metadata; GIS; open source; social science

1. Introduction and Background

The Wales Institute for Social and Economic Research Data and Methods (WISERD) is an interdisciplinary, cross-institutional academic research group based in Wales, UK. WISERD was formed in 2008 with aim of boosting the strength of social science research in Wales by creating a large group of researchers based at the five main Welsh universities (Aberystwyth, Bangor, Cardiff, Glamorgan and Swansea). The aim of the WISERD is to draw upon collaborative inter-institutional working and wide-ranging expertise in order to improve the sustainability of social science research in Wales and produce major innovations in research methods.

One of WISERD's key research objectives is to develop innovative technological approaches to facilitate the discovery, visualisation and analysis of social science data. WISERD recognises that, while there are a large and diverse number of datasets in Wales (and the UK) that are potentially available to social scientists, economists and analysts, there are few effective mechanisms for discovering these data (UK Data Archive excepted). As a result, potentially useful data that has been collected are often under-used or not used at all, for research and analysis. Given the current economic climate, it is important that the value of data held in various repositories throughout Wales is optimised, in line with current UK Government thinking on the reuse and repurposing of existing data sources (National Data Strategy, 2009). In response to this, WISERD are developing a web portal in order to help researchers and analysts discover socio-economic research data more efficiently and, in doing so, encourage the re-use of existing data and help stimulate collaborative research between researchers and organisations.

The web portal has been (temporarily at least) assigned the name 'WISERD Geoportal' (WGP), since much of the metadata contained within its database is geographically referenced and is accessed/queried via GIS-style cartographic user interface. While there is no universal agreement on the precise definition of a *geoportal* (unsurprising given the variation in scope and scale of online mapping/GIS applications that have been labelled with the term), many tend to agree with the principle that a geoportal is some kind of web-based application used to discover and/or access

geographic data and geographic information services (see for example Armstrong et al., 2011; Beaumont et al., 2005; Goodchild et al., 2007; Maguire and Longley, 2005; Tait, 2005; Tang and Selwood, 2005). Many geoportals are effectively front ends to spatial data infrastructures (SDIs) permitting various degrees of access to data at local, regional and national levels or in the case of the European Union's INSPIRE geoportal (<http://www.inspire-geoportal.eu/>) at the pan-national level (see Masser (2011) for a recent overview). In addition, some geoportals have been developed with narrower thematic remits in mind; for example for the management of subsurface data in the Netherlands (Lance et al., 2011) or to access data on risk to natural hazards at the global scale (Giuliani and Peduzzi, 2011).

Based on an on-going review of worldwide geoportals, we believe that the WGP is innovative in that it focuses on the discovery of socio-economic research data, supporting both quantitative and qualitative social science research and analysis. Another noteworthy aspect of the WGP is that it has been produced almost exclusively using Free and Open Source (FOSS) software in favour of proprietary software, mainly due to the flexibility that FOSS affords in terms of customisation and flexibility during development. Also, FOSS is currently a 'hot' topic in GIS research internationally and this, coupled with the current UK Government drive to promote the use of open source software at all levels of government (CIOG, 2009), means that there is an opportunity to add to the knowledge in this research area and contribute a novel FOSS4G (Free and Open Source Software for Geospatial) 'case study' application.

This paper concentrates on the technical development of the development of the WGP, building upon an earlier paper that provided a conceptual background and a more detailed discussion of its place within WISERD and the wider social science research landscape (Berry et al., 2009). The remainder of this paper focuses on the key methods used in the building of the WGP, including the creation of the 'WISERD Metadatabase' (WMDB) which underpins the WGP and the open source 'software stack' used to develop the application. We then outline further proposed developments of the WGP before offering our conclusions.

2. Methodology

2.1 Database

The WMDB contains detailed metadata for a diverse range of quantitative and qualitative socio-economic research data related to Wales including government surveys (down to the question and response level), primary WISERD interview transcripts, 'grey' data (e.g. academic publications) and administrative data (e.g. school-level education data). By using a spatially-enabled relational database (PostGIS-PostgreSQL), metadata records, where possible, have been linked to real-world locations allowing the database to be searched using GIS-based spatial search tools. In order to ensure quality and consistency the database has been designed so that metadata conform to both international and national non-spatial and spatial metadata standards respectively (i.e. Dublin Core, DDI 3.0, INSPIRE/GEMINI 2.1). A general overview of the contents of the WMDB is shown in Table 1. Bespoke data management tools (VB.NET Windows application; PostgreSQL database functions) are being developed in order to semi-automate the task of maintaining the WMDB and ensure on-going adherence to the relevant metadata standards.

Table 1. Summary of the contents of the WISERD Metadatabase

Data type	Data source	Statistics	Geographic data link
<i>Quantitative</i>	Surveys (Government and Academic)	96 Surveys (9760 questions)	Official UK administrative boundary data
	Administrative data	7 Years of Education Data	Official UK administrative boundary data
<i>Qualitative</i>	WISERD interview transcripts	47 Interview Transcripts	Gazetteer based geo-referenced locations (x,y coordinates)
	'Grey' data	9 PhD Theses	Gazetteer based geo-referenced locations (x,y coordinates)

2.2 Technology Stack

The basic system architecture of the WGP is shown in Figure 1. It shows how two bespoke software programs have been developed in order to populate the WMDb. The first of these is a web-based qualitative metadata entry tool that allows users to automatically generate semantically important keywords and geographic place names from text documents using the OpenCalais web service (OpenCalais, 2011) and the EDINA Unlock web service (EDINA, 2011) respectively. The second application is a desktop program which is designed to streamline manual data entry of survey questionnaires whilst generating standards-compliant metadata down to the question-response level. Both of these programs upload data to a database server running PostGIS where it is accessed by the end user via a secure web server (running Windows Server 2008 OS) based at the University of Glamorgan.

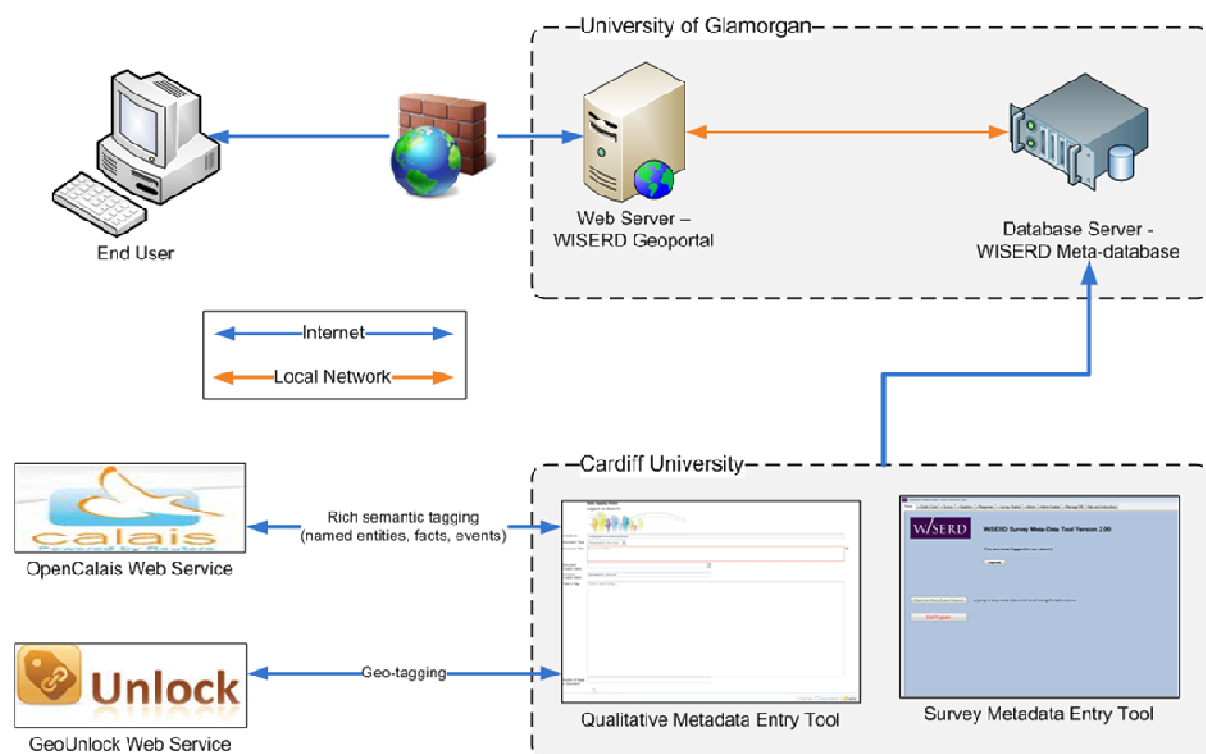


Figure 1. Basic system architecture of the WISERD Geoportal

As discussed previously, we have used exclusively FOSS components to develop the WGP, an approach that was felt offered the best flexibility in terms of being able to select and customise the best available applications and code libraries for producing a geoportal (Figure 2). A PostgreSQL database, spatially-enabled with a PostGIS database extension was selected for handling the data management duties as it offered better functionality than alternative FOSS databases such as MySQL and SpatialLite (Obe and Hsu, 2011). Importantly, PostGIS is able to output data in a variety of formats suitable for consumption by JavaScript libraries such as OpenLayers, GeoExt and ExtJS that were used to create the WGP's graphical user interface (Figure 2). The ASP.NET MVC development environment was used to create the WGP application itself on the web server (running IIS7/Apache), with the latest version of Geoserver handling the rendering of map layers generated from database queries. The open source theme is extended to the base mapping data, which is currently provided by the Ordnance Survey (OS OpenDataTM).

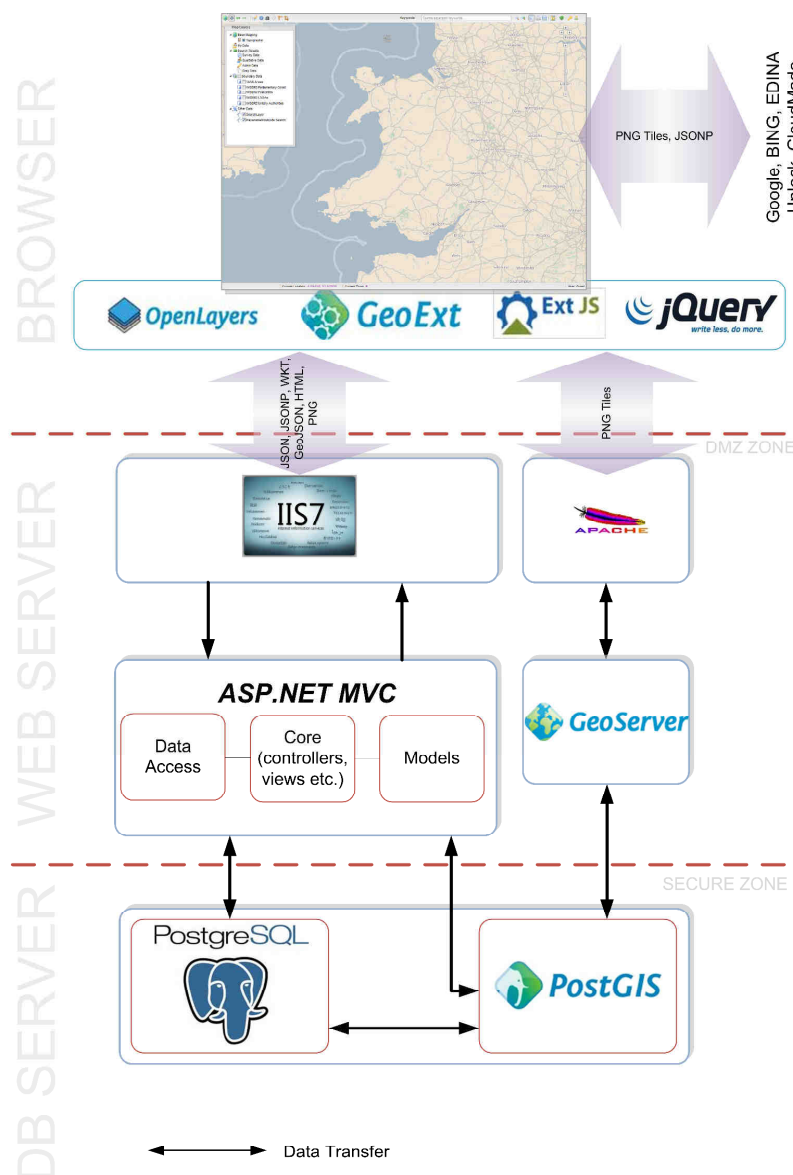


Figure 2. The WISERD Geoportal software stack

2.3 Functionality

The main window of the WGP GUI is shown in Figure 3. From this main window, users are able to access four different kinds of tools for: 1) account management (add/edit personal details, report bugs, 'bookmark' maps, print view; 2) basic GIS analysis (measure tools, 'identify features, annotate map); 3) textual database search and 4) spatial database search. Of these the latter search tools are the most significant as these are used to discover, visualise and analyse the metadata in the WMDB.

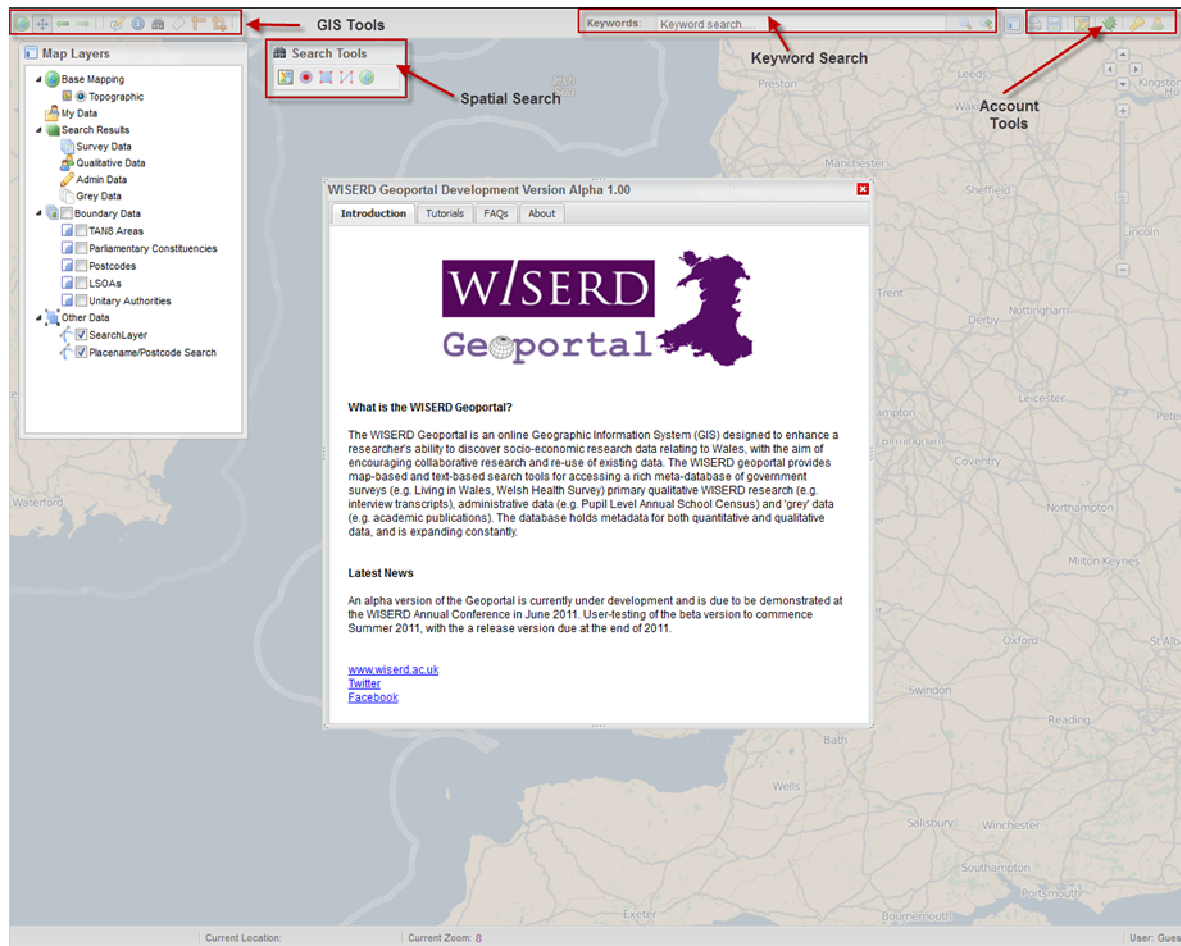


Figure 3. The main window of the WISERD Geoportal's graphical user interface (GUI)

The text search utilises the PostgreSQL text searching functionality to search for matching keywords in the quantitative and qualitative metadata records, although a more advanced search form is currently being developed that will allow users to refine their searches using a number of parameters. Results from textual database searches are then returned as a table within a JavaScript (ExtJS) window. Spatial searches can be conducted in a number of ways. Users can: 1) enter a place name and specify a distance (circular buffer) around that location in which to conduct a search; 2) drop a pin anywhere on the map and specify a buffer distance; 3) click and drag a rectangular search area or; 4) draw a custom polygon in which to perform the search. The results of a spatial search are returned as map layers (users can specify which ones to render) in the WGP's table of contents (Figure 4).

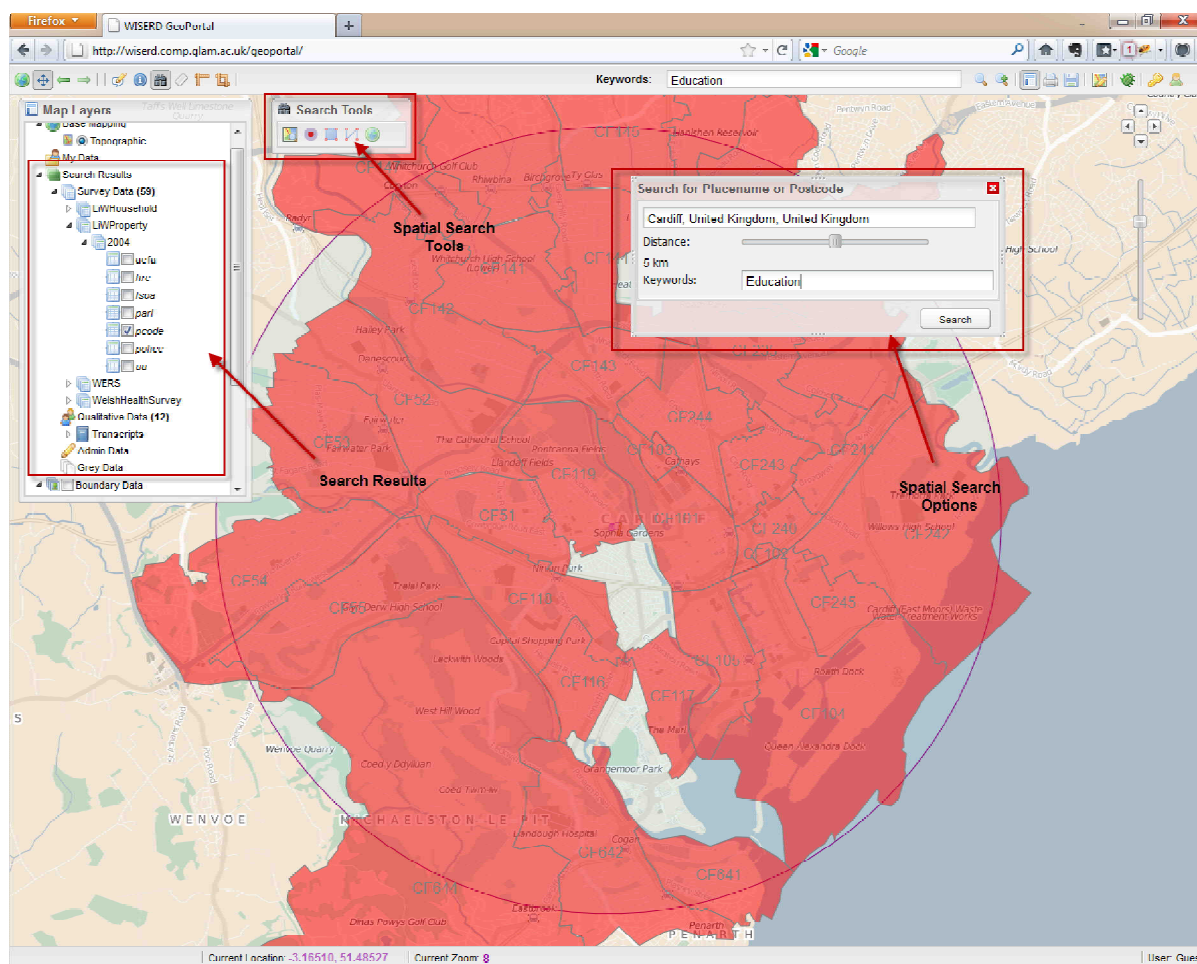


Figure 4. Mapping the results of a spatial search using the WISERD Geoportal

Once records have been retrieved from the database following a text or spatial search, the user is able to explore the metadata in more detail using a number of tools. For example, detailed metadata forms can be viewed for each record. For the surveys this would include comprehensive metadata at the survey, question and response level as well as a full Dublin Core metadata record. Analysis tools are also being developed in order to extract further value from the metadata. For example, where survey response data exists, interactive charting tools can be accessed that enable a user to visualise response statistics for a particular administrative/geographical area. A number of tools also exist for visualising qualitative metadata. These include a ‘word cloud’ function to quickly and effectively visualise the occurrence of key words within an interview transcript for example, and a charting tool that allows users to draw graphs showing the frequency of selected place names in a text document (e.g. academic journal paper). The purpose of these tools is to provide a researcher with a feel for the thematic and geographic focus of a research interview, without disclosing any potentially sensitive information.

3. Future Developments

The WGP is currently in its ‘Alpha’ stage of development with delivery of a ‘Beta’ release version scheduled for the end of December 2011. Further development of the WGP will then continue until at least July 2012, with further funding opportunities being sought to sustain its future in the long term. In the meantime the team will be working on several important developments, including:

- Structured user evaluation/usability testing (early 2012).
- Re-branding of the WGP (feedback from dissemination events has indicated that the term

geoportal is unsuitable given the target audience of social scientists who are primarily non-GIS users).

- Continued expansion of the WMDB.
- GUI improvements (taking into account usability evaluation feedback).
- Improved cartographic rendering.
- Expansion from Wales-only to UK-wide metadata.
- Investigating the use of other semantic tagging services (e.g. GEMET Thesaurus) for generating metadata.
- Transfer of web server/database infrastructure to a cloud computing platform for greater reliability and scalability
- Automated data exchange between the WGP and external organisations (e.g. Welsh Government, UK Data Archive) and service provision to important initiatives such as the UK Location Programme and www.data.gov.uk.

4. Conclusions

The WGP has been specifically developed to improve the discoverability, accessibility and usage of social science data amongst academics and policy makers in Wales. In our view it is a unique geoportal in that it is dedicated to supporting both quantitative and qualitative social science research, pioneering a new application area for web-based GIS. Having both spatial and non-spatial data of this nature integrated into a single web-based framework is a positive step forward from the current status quo - the WISERD Geoportal now offers the opportunity for a 'one stop shop' where the need for a desktop GIS to conduct basic spatial analysis and visualisation of social science data could be potentially dispensed with. Also, the wide range of disparate metadata contained in its database is proving to be attractive to potential end-users, providing the impetus for continued development of the WISERD Geoportal in order to establish it as an indispensable tool for researchers and analysts working with social science research data.

5. Acknowledgements

This paper is based on research supported by the Wales Institute of Social and Economic Research, Data and Methods (WISERD), funded by the Economic and Social Research Council (ESRC) (Grant Reference: RES-576-25-0021) and the Higher Education Funding Council for Wales (HEFCW).

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Biographies

Dr Robert Berry is a post-doctoral researcher at the GIS Research Centre, University Glamorgan, and is part of the WISERD Data Team. His research interests include public participation GIS, landscape visualisation, web GIS, open source GIS, and the application of GIS for social science research and hazard and disaster management.

Dr Richard Fry is a post-doctoral researcher at the GIS Research Centre, University Glamorgan, and is a part of the WISERD Data Team. His research interests include web and open source GIS and the application of GIS in transport and health research.

Prof Gary Higgs is currently Director of the GIS Research Centre in the Faculty of Advanced Technology, University of Glamorgan and a co-Director of WISERD at Glamorgan. Over-arching research interests are in social and environmental applications of GIS, most recently in the areas of health geography, the emergency services and environmental justice.

Dr Scott Orford is a senior lecturer in spatial analysis and GIS in the School of City and Regional Planning, Cardiff University, and the co-ordinator of the WISERD Data Team. His research interests include the analysis and modelling of socio-economic process, innovation in data integration and data construction and the mapping and spatial analysis of qualitative data.

Samuel Jones is a research assistant at WISERD based at Cardiff University and is part of the WISERD Data Team. He has responsibility for providing technical assistance and data management skills to the WISERD team and assisting with the data integration and management programme.

Developing a Statistical Methodology for Improved Identification of Geographical Areas at Risk of Accidental Dwelling Fires

Emma Higgins¹, Mark John Taylor¹

¹School of Computing and Mathematics,
Liverpool John Moores University,
Byrom Street,
Liverpool L3 3AF,
United Kingdom

Tel. +44 151 296 4346

Email e.higgins@ljmu.ac.uk, m.j.taylor@ljmu.ac.uk

Web address www.ljmu.ac.uk

Summary: This paper outlines recent research completed in partnership between Liverpool John Moores University and Merseyside Fire and Rescue Service. The aim of the research was to investigate ways to implement a statistical methodology into the corporate GIS system that could be used to enhance the identification of areas most at risk from accidental dwelling fire. Further to this, the toolkit developed was expanded to include a second strand of research that looked into ways of integrating a bespoke customer segmentation methodology developed using local geographic and demographic data to further support the identification of risks and needs.

KEYWORDS: fire risk; risk management; GIS development; geographic data; customer insight

1. Introduction

This paper presents a partnership project between researchers at Liverpool John Moores University (LJMU) and staff at Merseyside Fire and Rescue Service (MFRS). The aim of the project was to develop a new statistical methodology that could be embedded into the corporate geographic information system (GIS) system used at MFRS for enhanced identification of areas that are at greatest risk of accidental dwelling fire.

Systems and methodologies to enhance the identification of risk are playing an ever more important role in UK Fire and Rescue Services today. Recently published fire statistics show that UK fire and services attended at total of 36,000 accidental dwelling fires between April 2010 and March 2011 and of these there were 213 fatalities (Communities and Local Government, 2011). Accidental dwelling fire fatalities account for two thirds of fire deaths in the UK (Communities and Local Government, 2011). An accidental dwelling fire is defined by the Department for Communities and Local Government as a fire in the home where the cause was not known. (Communities and Local Government, 2007). The increased probability of suffering from an injury or becoming a fatality in the home prompted the introduction of the Home Fire Safety Check (HFSC). This scheme resulted in the reduction of accidental dwelling fires by approximately 50% since its introduction in 1999 (Safer Houses, 2008). In addition to this, the number of accidental dwelling fire related fatalities has decreased by 40 percent since 1999 (Merseyside Fire and Rescue Service, 2011). Although there is a general downward trend, the year on year decrease in the number of fatalities associated with accidental dwelling fires is starting to plateau. This is echoed nationally (Cheshire Fire and

Rescue Service, 2010) (Tyne and Wear Fire and Rescue Service, 2009), suggesting a need to enhance the risk identification process. Another crucial matter is that sixty percent of accidental dwelling fire fatalities between April 2010 and March 2011 occurred in areas typically defined having a lower risk of fire (Merseyside Fire and Rescue Service, 2011). This highlights a need to develop a system that will understand *why* accidental dwelling fires occur, in order to understand *where* accidental dwelling fires may occur in the future.

2. Literature Review

The current Government model available to UK fire and rescue services does not currently analyse lifestyle factors that can contribute to dwelling fires (Communities and Local Government, 2008)(Office of the Deputy Prime Minister, 2004). This model links fire to deprivation (Office of the Deputy Prime Minister, 2004), but this model does not take into account that there is an increasing proportion of accidental dwelling fires and fatalities occurring in areas that are classified as ‘low’ risk – i.e. low levels of deprivation. It is well documented that various different lifestyle factors such as smoking, binge drinking, living alone, to name a few, are associated to increased risk of accidental dwelling fire (Holburn, Nolan, & Golt, 2003)(Duncanson, Woodward, & Reid, 2002)(Leth, Gregersen, & Sabroe, 1998). As these lifestyle factors are not limited to typically deprived areas (Annear et al 2009), they can be useful to aid the identification of accidental dwelling fire risk, regardless of the levels of deprivation within the area. This became an interesting starting point for developing a GIS risk identification toolkit that looks at the causal factors and lifestyle indicators that could potentially lead to an accidental dwelling fire.

3. Statistical Methodology for Accidental Dwelling Fire Risk Identification

There were two steps involved in developing the statistical methodology. These were identification and collection of data to inform the model and running a statistical analysis to obtain risk scores for each geographic area.

3.1 Data Collection

The first stage of the research was to determine whether the data required to produce a statistical model could be obtained. It was also important to ascertain whether the data was available to the required geography, was timely and up-to-date. In total over 80 data variables were identified as being potential causal factors for accidental dwelling fire, however this was narrowed down to 11 variables based on what could be realistically and economically accessed (Table 1). Often there was no data available for many of the causal factors or the data was not collected frequently enough for a reliable analysis.

Dataset Name
Number of Smokers
No Smoke Detector Fitted through a HFSC
Incapacity Benefit Claimants
Disability Living Allowance
Binge Drinking
Elderly Residents
Indices of Multiple Deprivation
Living Alone
Mental Health Issues
Lone Parents
Number of Dwellings

Table 1 - Data used for developing a statistical model for identifying areas at greatest risk of accidental dwelling fires

The data sources identified in Table 1 were collected to Lower Super Output Area (LSOA), which is a Census geography consisting of approximately 1,500 residents (Office for National Statistics). Measures of social homogeneity to encourage areas of similar social background were included in the development of LSOAs (Office for National Statistics).

3.2 Statistical Analysis

After identifying data, the next step was to determine whether there was an association between the data, or causal factors, and the number of fires seen historically. A correlation analysis illustrated that there was an association, which allowed for a regression analysis to be completed giving a risk score for each LSOA. The correlation between the calculated risk score and number of fires was 0.71. In addition, the coefficient of determination showed that the variance explained by the model was 0.51. Both of these statistics illustrate that there is a strong relationship between the calculated risk score and number of historical fires with each LSOA.

4. A Community Risk Mapping Tool for Merseyside

The next stage of the research was to integrate the statistical analysis into the corporate GIS at MFRS to create a simple, user friendly tool that support staff could interrogate to identify potentially high risk and vulnerable areas.

The Unified Modelling Language (UML) object-oriented design approach (Pooley & Stevens, 1999)(Sommerville, 2010) was used to design a GIS that was able to perform a number of queries that were requested by MFRS (Figure 1). These included a number of spatial queries such as the number of properties within a high risk area that were due a HFSC revisit, or how many elderly residents lived within a given area. The outputs of the GIS were used to target specific interventions and initiatives to the local community and its residents.

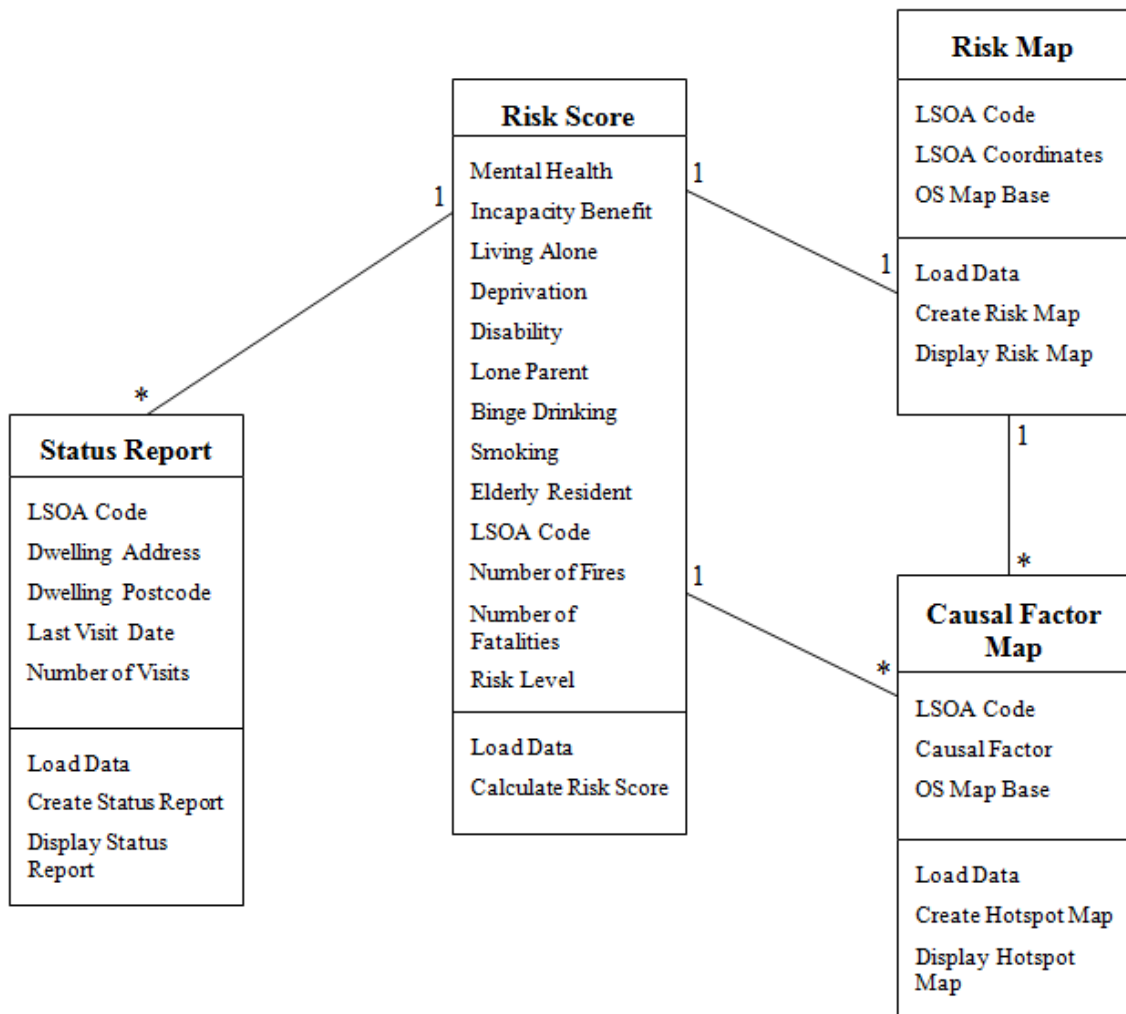


Figure 1 - The UML Class Diagram for the Risk Identification Toolkit

The toolkit also provided the functionality to map risk. The risk scores were grouped into 3 bands (high, medium and low risk), which were illustrated on a map of the Merseyside area (Figure 2). Additional functionality allowed users to create ‘hotspot’ maps of the risk and each of the causal factors, which showed the distribution of each variable across Merseyside and allowed the identification of areas where intervention may be required. The linking of the GIS toolkit with the reporting tool Crystal Reports (SAP Crystal Reports, 2011), allowed users to export addresses that have not been visited, or that may be due a revisit within high risk areas. This was given to operational crews who would target these properties as a priority.

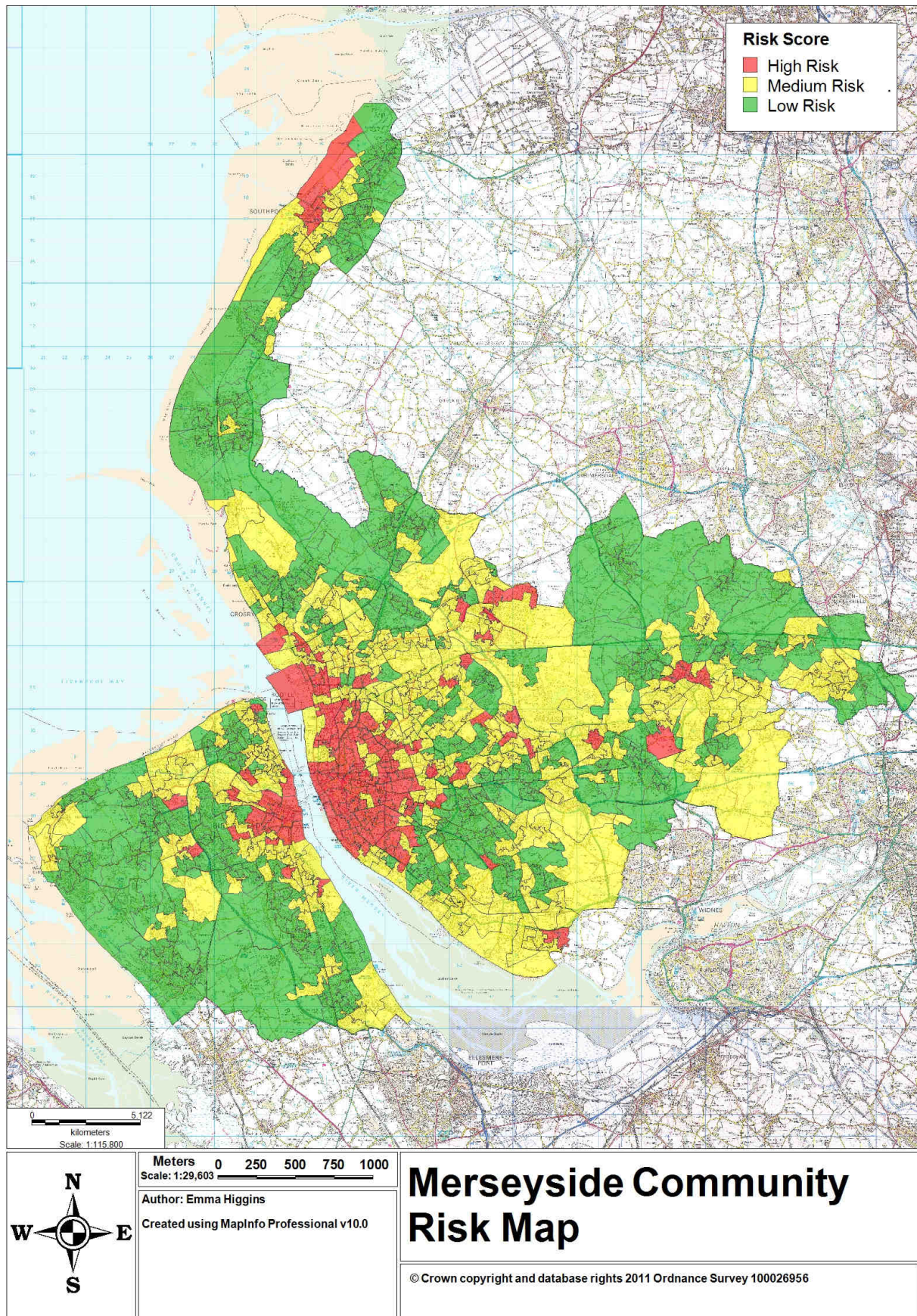


Figure 2 - Map produced by the risk identification toolkit showing areas of high risk (red), medium risk (yellow) and low risk (green) across Merseyside

5. Customer Insight

The initial research also identified a potential for further development of the toolkit to include community profiles and vulnerable person profiles. Many public sector organisations use national profiles for geodemographics, which is the study and grouping of people in a geographical area according to socioeconomic criteria (Adnan et al, 2010). Commonly used national profiles include Experian Mosaic (Experian, 2009) or CACI Acorn (CACI). The research identified that there was a need to focus on local demographics, risks and needs. This phase of the project involved creating another statistical methodology using the SPSS k-means clustering tool (SPSS, 2010) and developing 10 bespoke profiles for Merseyside. The data analysed was available from local sources and indicated potential areas of need to be addressed within communities. Application of this methodology supported the 'Localism' bill (UK Parliament, 2011) that was introduced in November 2011 by UK Government.

The profiles will be integrated into the existing risk identification GIS toolkit, and will allow users to further identify and understand risk and also allow for prioritisation of individuals based on their risks and needs. It also supports partnership working with other local authority organisations, which aims to join up public sector bodies to improve satisfaction and meet needs and risks.

6. Conclusions

In this paper, we present two phases of a partnership project between Liverpool John Moores University and Merseyside Fire and Rescue Service to develop a bespoke GIS for enhanced identification of accidental dwelling fire risk. The goal of this work was to link a statistical methodology for calculating risk with the corporate GIS system used at MFRS. The research proved useful and robust to the fire and rescue service and has resulted in a greater understanding of why an area is at risk. This allows MFRS to proactively target their resources to the community and to residents based on their risks and needs. The success of the first phase of this project resulted in further collaboration work between both organisations to develop community profiles. This phase of the project has allowed MFRS to work more closely with other public sector organisations to deliver services to the most vulnerable people within the community.

7. Acknowledgements

Research in this paper is supported by Merseyside Fire and Rescue Service who generously provided data and staff resources for the development, implementation and continuing improvement of the tool.

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9. Biography

Emma Higgins

Emma is a Project Manager at LJMU and has worked on developing and implementing unique GIS solutions for decision support at MFRS. She is also finishing her Master of Philosophy thesis looking at the development of risks maps used in the Fire and Rescue Service.

Dr Mark Taylor

Mark Taylor is a senior lecturer in the School of Computing and Mathematical Sciences, Liverpool John Moores University. He is a Chartered IT Professional, a Chartered Scientist, a Fellow of the British Computer Society and a Fellow of the Higher Education Academy.

Flood Vulnerability Assessment: Contributions of the Bogardi/Birkmann/Cardona (BBC) framework

Zeinab Rezaee Ardestani, Pete Fisher, Heiko Balzter

Department of Geography, University of Leicester, Leicester, England, LE1 7RH

Email: zr12@le.ac.uk, pffl@le.ac.uk, hb91@le.ac.uk

Summary: Understanding the pattern of vulnerability in a community plays a fundamental role in emergency management. Place-based vulnerability assessment is a way to evaluate vulnerability that takes into account the bio-physical and socio-economic characteristics of the target groups within the study area (Cutter 1996). However, there are gaps in terms of a holistic framework that constitutes diverse aspects of vulnerability. The aim of this study is to implement the BBC conceptual framework (Bogardi, Birkmann 2004, Cardona 2001, Cardona 1999) for vulnerability assessment in the context of England in order to propose an appropriate Vulnerability Index (BBC-VI) and methodology that reduce the vulnerability and ensure sustainable development.

KEYWORDS: Vulnerability assessment, Place-based vulnerability, BBC conceptual framework, Flooding, Yorkshire (UK)

1. Introduction

GIS is widely used in Comprehensive Emergency Management (CEM) as part of a more general disaster preparedness strategy. More specifically, GIS tools can play a vital role in the mitigation phase of any disaster. Disasters have been a threat to nations, both economically and socially, and their impact can be both local and global (Cutter 2003). Societies have attempted to reduce the amount of losses inflicted by disasters with pre- and post-disaster activities in the framework of Comprehensive Emergency Management (CEM), also called Emergency Response Cycle or Emergency Management Cycle (Figure 1; (Cutter 2003, Drabek, Hoetmer 1991, Committee on Planning for Catastrophe: National Research Council 2007).



Figure 1: Comprehensive Emergency Management (CEM)
Source: NRC, 2007

In the light of CEM, mitigation has been viewed as a phase in which GIS is most effective, where vulnerability and risk management are interesting parts for scientific work. However, there are multiple definitions of vulnerability and researchers have developed bespoke definitions (Green 2004, Cutter, Mitchell & Scott 2000).

There are three general origins of vulnerability:

- Physical vulnerability focuses on the nature of the bio-physical hazard;
- Social aspects of vulnerability characterises the population at risk, their coping capacity, and resilience to hazard; and
- Place-based methods are a third group which combine the social and physical approaches.

Place-based vulnerability assessment further includes frameworks as follows: the Double structure framework defines two aspects of vulnerability; internal and external (Bohle 2001). The framework of hazard and risk community views vulnerability as a component of hazard and background risk where risk is defined through hazard, exposure, vulnerability, external context, emergency response, and emergency recovery capacity (Davidson 1997, Gabor, Griffith 1980). The global environmental change community focuses on vulnerability as a broader concept characterizing vulnerability with exposure, sensitivity, and resilience within a human-environmental system (Liverman 1990, Turner et al. 2003). The political economy approach describes the disaster as a hazard event that influences vulnerable people (Wisner et al. 2004). The Pressure And Release (PAR) method has been widely utilized in this framework, where $Risk = R(H(E_h).V(E_v))$ (Blaikie et al. 2004). The holistic approach to risk and vulnerability assessment defines a broad dynamic system that takes into account complex parameters (Cardona 2003).

The BBC conceptual framework is based on the work of Bogardi and Birkmann (2004) and Cardona (1999, 2001). This framework borrows elements from other schools of thinking and focuses on the concept of sustainable development with exposed and susceptible elements and coping capacity where vulnerability is a process and should be examined from social, economic, and environmental aspects (Figure 2).

Vulnerability assessment is sensitive to the type of hazard and the region of study, and so defining these is the first step for analysis. Floods are the most common type of natural disaster with nearly half the reported disasters in 2010 being from this cause (Centre for Research on the Epidemiology of Disasters - CRED 2009). This is as true for Europe and the UK, as much as for the rest of the world. Here floods cause the greatest loss (economic, physical, and social). Flooding has been the main cause of human and economic damage in the UK in past decades (Centre for Research on the Epidemiology of Disasters - CRED 2009). To explore the BBC method more fully, we focussed on flooding in Yorkshire, UK.

2. Methodology

The BBC framework is simple to understand, and complex enough to capture the reality of vulnerability. The BBC conceptual framework is summarised in Figure 2 (Birkmann 2006). This model is based on the view that vulnerability goes beyond damage assessment, towards a dynamic process that continuously evaluates vulnerability as a combination of social, environmental, and economic aspects and links them to risk reduction and sustainable development (Green, Parker & Tunstall 2000).

In the BBC model it is argued that there are two opportunities for vulnerability reduction. One before the disaster strikes ($t=0$) which is closely related to concepts of preparedness and mitigation in CEM, and one after and during disaster ($t=1$), the main phase of disaster management. The BBC framework

makes the potential to reduce vulnerability and risk with intervention systems such as land use policies, which is an important distinctive priority of this model compared to others. Infrastructure arrangements are important in risk reduction; however, their effectiveness greatly depends on the implementation capacity (Katsuhama, Grigg 2010). In this context vulnerability is viewed as a combined concept of coping capacity and exposed/ susceptible elements.

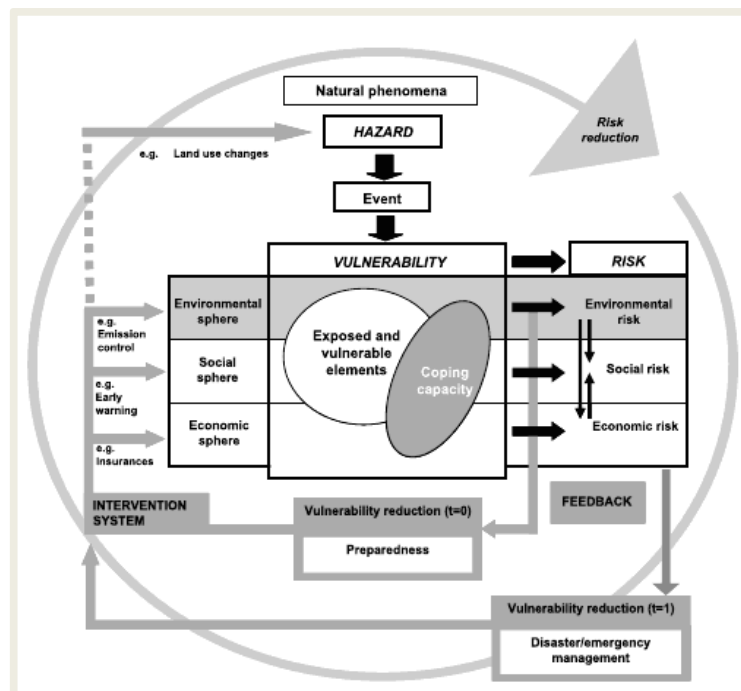


Figure 2: The BBC conceptual framework (Source: Birkmann, 2006: 34)

3. Experimental Analysis

For Yorkshire, basic socio-economic data at OA level were downloaded from the CASWEB website (Table 1). These indicators have been suggested by Cutter et al (2000) as a broad experimental socio-economic vulnerability index. For each of the three characteristics; population and structure, differential access to resources, and level of physical vulnerability and wealth, some indicators have been put forward that can represent them. However, this table can be a matter of discussion as many specialists have proposed various indicators.

Table 1: List of social vulnerability indicators proposed by Cutter et al. (2000)

Social Vulnerability Indicators	
Characteristics	Variable
Population and structure	Population Number of homes
Differential access to resources	Number of females Number of non-white residents Number of people under age 18 Number of people above age 65
Level of physical vulnerability and wealth	Number of mobile homes Average household size

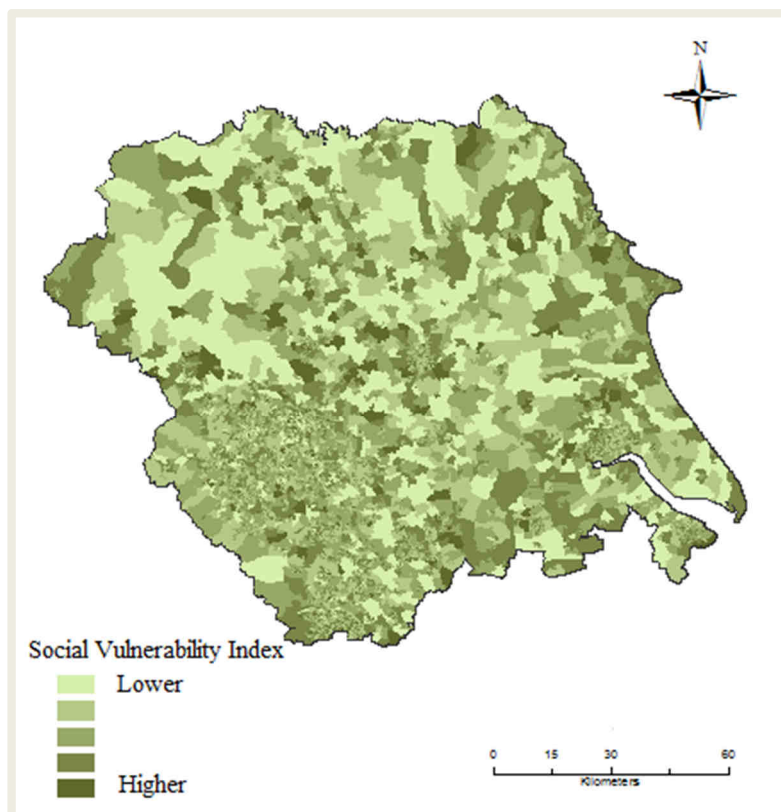


Figure 3: Composite social vulnerability zones in Yorkshire

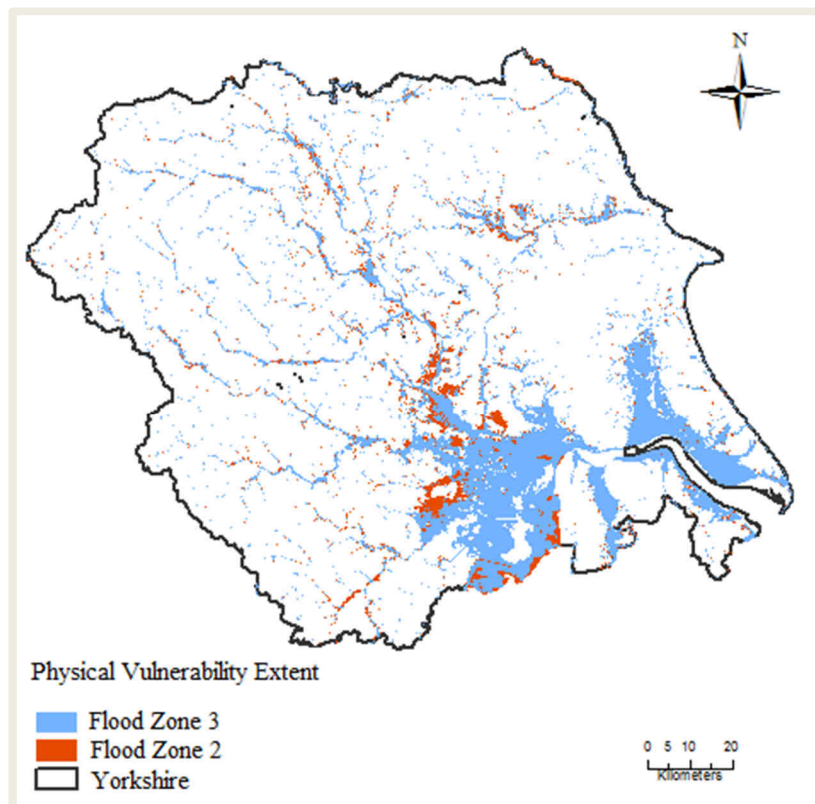


Figure 4: Biophysical hazard of flooding presented by 2 type of flood zones
Source: The Environment Agency

To extract a social vulnerability index, all the variables were standardized by first determining the ratio of the variable in each OA to the total in the study area for that variable, and dividing that by the maximum of the ratio to generate an index for each variable ranging from 0 to 1, where the higher value relates to greater vulnerability. These indices were summed to give an overall vulnerability for each OA. Since there is not a common weighting scheme for indicators in the literature, no priority was given to any variable, assuming they have equal influence on the vulnerability. Figure 3 maps the social vulnerability.

For the physical vulnerability map, flood zone data were provided by the Environment Agency, and used here (Figure 5):

- Flood zone 2: chance of flooding in any year is greater than 0.1% and less than 1%.
- Flood zone 3: chance of flooding in any year is greater than 1%.

Here we assume a Boolean physical vulnerability:

$$PhVI = \begin{cases} 0 & \text{if OA does not intersect with flood zone 2 or 3} \\ 1 & \text{if OA intersect with flood zone 2 or 3} \end{cases}$$

The resulting map is used as a mask for social vulnerability as a data layer in order to extract the final vulnerability index. As there is no solid literature about the relative of importance of either social or biophysical aspects of vulnerability, no priority was given to either.

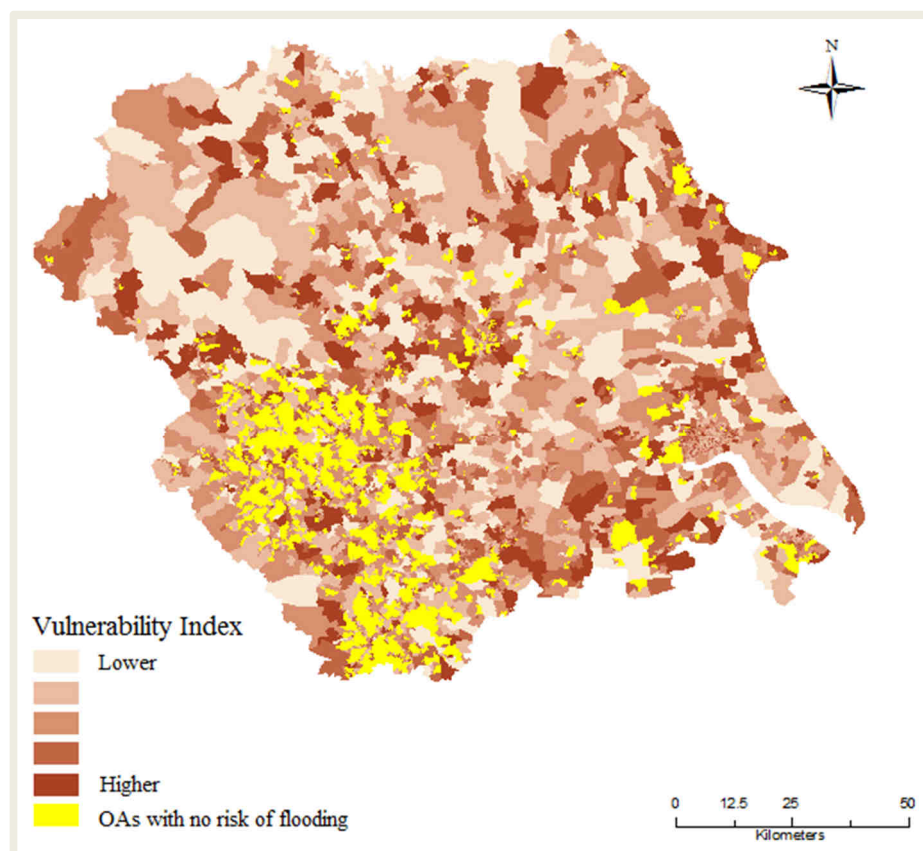


Figure 5: Place-based vulnerability index in Yorkshire.

Figure 5 shows the final vulnerability map which takes into account both socio-economic and physical factors of vulnerability to flooding. Yellow polygons are OAs that have been masked out with regards lack of biophysical vulnerability. A nice pattern of vulnerability has been demonstrated in the map, showing the regions that are vulnerable to flooding and need more attention to be prepared for potential flooding events. An issue which come up is that there are some OAs in yellow, but they are relatively close to the boundary of flood zones, which means they may be in danger of flooding (at least part of the OA). For that reason, applying a buffer to the masked area might be fruitful.

4. Conclusion and Further work

As shown in figures 3, 4, and 5, the overall vulnerability of an area to flooding is not the result of social or physical factors separately. An OA may have a high social vulnerability index, but if the vulnerable population do not live in the areas at risk of flooding then mapping it as vulnerable may be meaningless. This fact highlights the importance of research in the geographical footprint of the different categories of socio-economic and physical vulnerability. The indicators for both physical and socio-economic aspect of vulnerability are a simplistic version. The result of this work, is best for public awareness and decision-maker information to be prepared and aware of areas wit higher sensitivity to the impact of flooding.

Furthermore, the vulnerability indicators need to be investigated as well; there are great lists of biophysical and socio-economic factors that might be considered for further work. In addition, there are questions in terms of weighting and combining variables. The way variables are put together and weighted can dramatically change the resulting vulnerability map.

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7. Biography

Zeinab Rezaee A. is a PhD researcher at the University of Leicester who is interested in GIS applications in the field of emergency management. She holds an MSc in GIS and BA in Industrial Engineering.

Pete Fisher is Professor of Geographical Information at the University of Leicester, best known for his research in spatial uncertainty.

Heiko Balzter is Professor of Physical Geography at the University of Leicester and Director of the Centre for Landscape Interactions and Change. His research investigates spatio-temporal environmental change processes using remote sensing and modelling techniques.

On the Fuzzy Distance Between Fuzzy Geographical Objects

Firdos Almadani, Peter Fisher and Claire Jarvis

¹Department of Geography
University of Leicester
Leicester LE2 3TD
fma7@le.ac.uk

²Department of Geography
University of Leicester
pffl@le.ac.uk,

³Department of Geography
University of Leicester
chj2@le.ac.uk

Summary The distance between geographical entities is an important geographical measurement. The geographical distance between two Boolean entities is found with the Pythagorean equation, but the distance between fuzzy geographical entities is a more complex phenomenon. Distance is no longer a single number but has to be modelled as a set of values, and modelling this set as a fuzzy number or numbers has the advantage that fuzzy mathematics can be applied to the resulting values. The basic approach to doing this is explored in this paper.

Keywords Fuzzy sets, Fuzzy Distance, Euclidean Distance, Fuzzy Numbers

1. The distance between two fuzzy spatial entities.

The geographical distance between two places is one of the fundamental metric relations between any two different locations (Gatrell, 1983). Within a Boolean concept of space, the distance between two locations is simple and well understood, but if the model of the objects is changed from Boolean to fuzzy then the problem of identifying the distance between them is vastly complicated. If we model locations in space as fuzzy sets or entities, then any location can belong to a set (a place) to a degree, recorded as a real number between 0 and 1 (Fisher, 2000; Zadeh, 1965). This paper addresses the issue of the distance between two such fuzzy geographical entities.

The issue of fuzzy distances has been explored in the past. Altman (1994), for example, presented a fuzzy distance function, but his function yielded a non-fuzzy number, with which it is hard to perform subsequent mathematical operations. In the fuzzy set literature, however, Rosenfeld (1985), Voxman (1998), Bloch (1999) and Guha and Chakraborty (2010), among others have examined the issue. Most of these extend the concept of distance to subsets of a metric space, and they argue for the representation of fuzzy distance as fuzzy numbers. These studies tend to suggest many potential applications for different areas, including pattern recognition, image processing, robotics, computer graphics and engineering. However, few if any make use of geographical distance or link fuzzy distance to real world phenomena although Guesgen and Hertzberg (2001), Guesgen et al. (2003) and Fisher and Almadani (2010) have all looked at the related topic of fuzzy buffering.

One important concept of the fuzzy set literature, which is extensively exploited in this paper, is the α -cut. An α -cut set is a Boolean (or classic) set, where an object or location belongs to a particular α -cut of a fuzzy set if its membership in that set is greater than or equal to α . It therefore follows that any fuzzy set can be divided into a large number of α -cuts or, more

correctly, α -cut sets. Further, from a group of α -cuts of a particular fuzzy set, it is possible to recreate the original fuzzy set; indeed, this is one one method for generating fuzzy sets in the first place (Pedrycz and Gomide, 1998, p20).

2. The distance between two Boolean geographical objects

If we have two Boolean objects, A and B, modelled as point locations (for the present), then both A and B are conceptualised to occupy infinitesimally small areas at particular x, y locations, x_a , y_a and x_b , y_b . The distance between them can be found very simply by the usual Pythagorean equation (1).

$$DIST(x, y) = \sqrt{(x_a - x_b)^2 + (y_a - y_b)^2} \quad (1)$$

This equation is a special case of the more general Minkowski distance (Pedrycz and Gomide, 1998, p49), where the power term can attract any value and its reciprocal. The Boolean case means that the distance between the two locations is a single value. For locations A and B in this study their separation when modelled in this way is 150 distance units.

3. The distance between a Boolean and a fuzzy geographical object

When one of the two locations is modelled as a fuzzy entity, then the situation is complicated. There are number of possible distances between the Boolean object and the fuzzy object, which can be modelled as a fuzzy number. The situation is illustrated in Figure 1, and the distances for each α -cut through the fuzzy sets illustrated in Figure 2, giving rise to a fuzzy number (Table 1) illustrated in Figure 3.

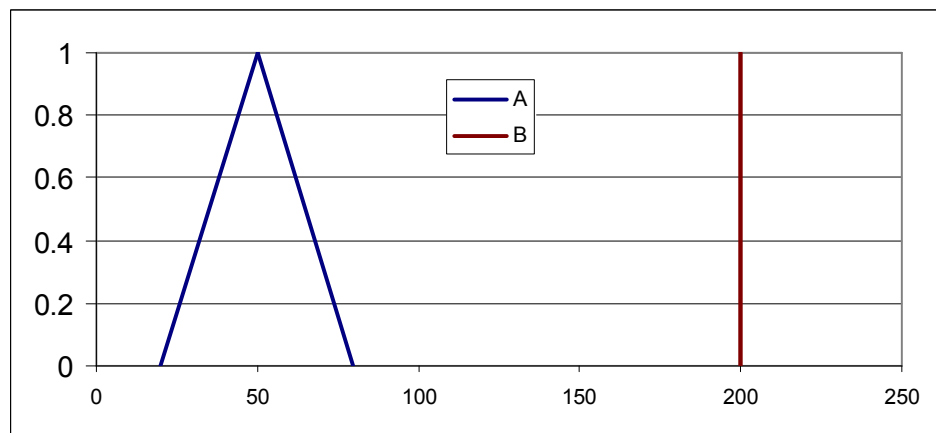


Figure 1. Modelling Entity A as a fuzzy set and Entity B as a Boolean point.

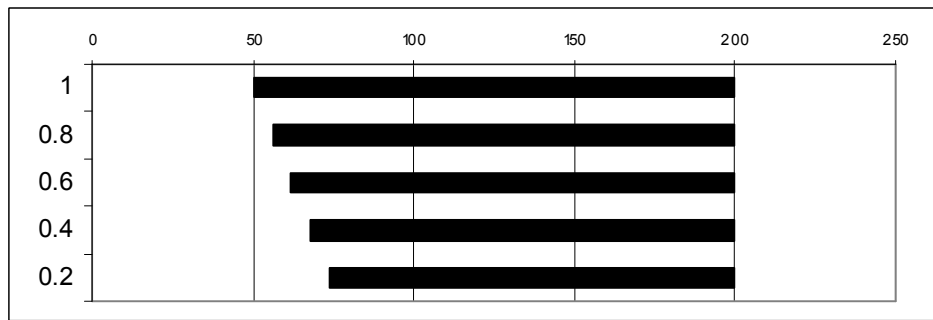


Figure 2. The α -cut distances between the fuzzy entity and the Boolean point

Table 1. α -cut distances between fuzzy A and Boolean B

α -cut	Distance
1	150
0.8	144
0.6	138
0.4	132
0.2	126

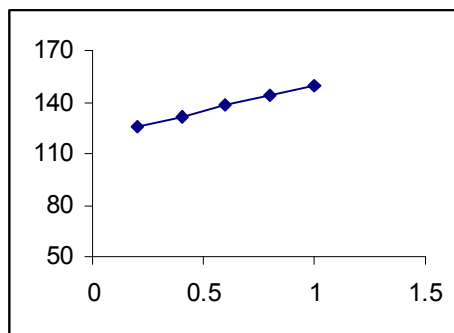


Figure 3. A graphic illustration of the fuzzy number of the distance between fuzzy A and Boolean B.

4. The distance between two Fuzzy geographical objects

When both A and B are modelled as fuzzy sets, the situation is complicated still further. In the first place, the model can be illustrated as in Figure 4.

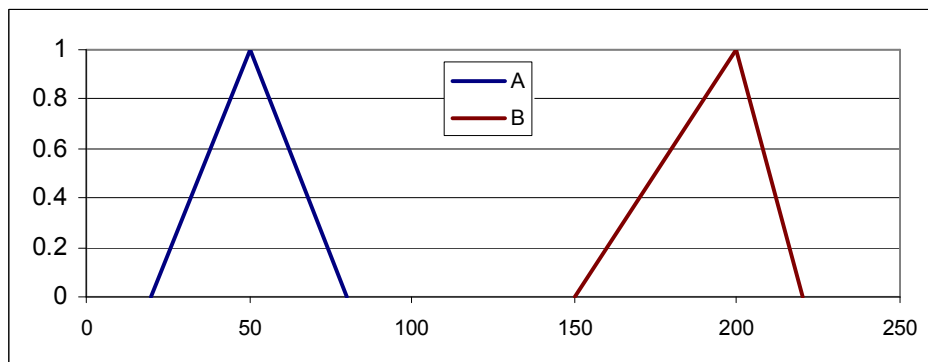


Figure 4. The models of both A and B as fuzzy sets.

The distance can then be determined at each α -cut value of both A and B (Figure 5) and can be represented in graphic form in Figure 6.

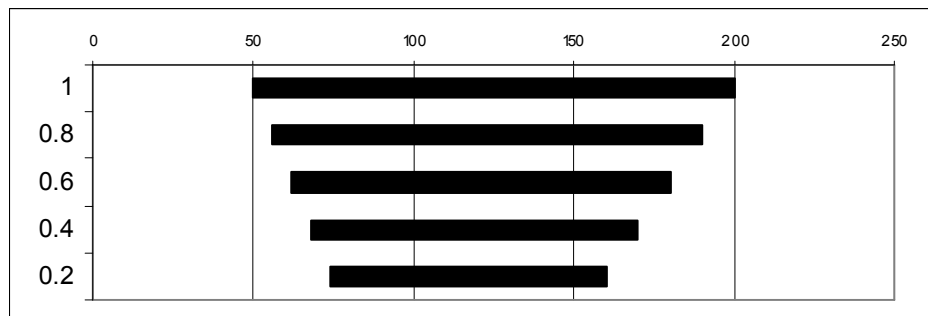


Figure 5. Distances between fuzzy A and fuzzy B as a set of α -cut values.

Table 2. α -cut distances between fuzzy A and fuzzy B

α -cut	Distance
1	150
0.8	134
0.6	118
0.4	102
0.2	86

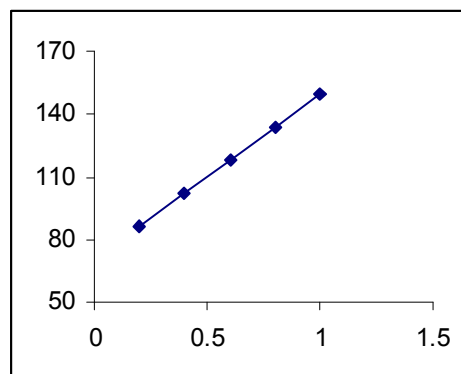


Figure 6. The distance between fuzzy A and fuzzy B as a fuzzy number.

Table 3. The full development of the fuzzy distance between fuzzy A and fuzzy B for α -cut intervals of 0.2.

A \ B	1	0.8	0.6	0.4	0.2
1	150	144	138	132	126
0.8	140	134	128	122	116
0.6	130	124	118	112	106
0.4	120	114	108	102	96
0.2	110	104	98	92	86

However, there is no reason that the distance should be measured from $A(\alpha=0.9)$ to $B(\alpha=0.9)$. Rather, there are a range of possible distances for $A(\alpha=0.9)$ to $B(\alpha=0.1)$, and $A(\alpha=0.1)$ to

$B(\alpha=0.9)$ and all possible distances between. Thus, the fuzzy number can now be approximated as a two dimensional array (Table 3) in which the α -cuts form the two dimensions.

5. Fuzzy distance operators

The Distance Operation available in some raster GIS determines the shortest distance at each grid intersection to a set of target locations. In the interpretation of distance presented here, this distance operation should return not a single number for each grid intersection as in all standard GIS, but rather a fuzzy number for each grid intersection. Because the grid intersection is a clearly defined location, itself infinitesimally small in extent, the interpretation of distance presented here in Figure 2 and 3, and Table 1 is applicable. This can be approximated by determining the distance to all locations for each α -cut of the target fuzzy object, resulting in as many distance maps as there are α -cuts being considered.

A number of spatial statistics are dependent on the determination of the distance between objects, and from this work follows the clear suggestion that when the objects are conceptualized as fuzzy objects the result of spatial statistical analysis should be a fuzzy number. Fuzzy clustering of statistical cases is well established (Bezdek, 1981; Bezdek et al., 1984) in remote sensing applications, based on the idea that observations are Boolean point objects. However, this notion of distance between fuzzy objects is novel in a spatial analytical setting. It is clear that the similarity matrix for such geographical objects, conceptualized as having fuzzy extent within the n-dimensional attribute space, has numerous implications. Future work will explore these implications.

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8. Biography

Peter Fisher is Professor of Geographical Information at the University of Leicester. He has researched many aspects of uncertainty in geographical information.

Firdos Almadani is a post graduate student at the University of Leicester, and a Teaching Assistant in the Geography Department at King Abdul-Aziz University, Jeddah, Saudi Arabia. Work reported here relates to her PhD research.

Claire Jarvis is a Senior Lecturer in GIScience at the University of Leicester. Her current research is mainly concerned with visualization and virtual reality.

Evaluating the Use of Sound to Help Representation of Distance in a Landscape Visualisation Setting

Nick Bearman^{1 (now 2)}, Andrew Lovett¹

¹School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ
Tel: +44 (0)7717 745715 Fax: +44(0)1603 591327

²European Centre for Environment and Human Health, Peninsula College of Medicine and Dentistry, Knowledge Spa, Royal Cornwall Hospital, Truro, Cornwall, TR1 3HD
Email: n.bearman@uea.ac.uk, a.lovett@uea.ac.uk, www.nickbearman.me.uk

Summary: This work evaluates the use of piano notes and bird calls to help represent distance to wind turbines in a landscape visualisation. Visualisations were shown to a variety of Geographic Information professionals (n = 45). Using sound and vision together was significantly more successful than vision alone ($p < 0.001$) and piano notes were generally more successful than bird calls. A binary logistic regression analysis showed that participants who pay attention to sounds and number of attempts were significant factors for most of the methods.

KEYWORDS: sonification, landscape visualisation, distance perception, Geographic Information professionals

1. Introduction

The representation of distance in landscape visualisation is often difficult to understand and use of sound may help users. This work forms the third case study of the authors PhD, following the first two case studies which were also presented at GISRUk evaluating the use of sound to represent uncertainty in ArcGIS (Bearman & Lovett, 2010) and Google Maps (Bearman & Appleton, 2011).

2. Literature Review

Landscape visualisation is increasingly used in planning to assess the potential visual impact of a development (Appleton & Lovett, 2005). In recent years the use of computer based landscape visualisation has come to the forefront, providing many advantages (and some limitations) over traditional physical models and photomontages (Lange, 2011). Perception of landscape visualisations varies due to many characteristics (Appleton & Lovett, 2003) and distance is important interpret correctly. Visual methods of representing distance may detract from and/or obscure parts of the visualisation, whereas sound does not.

Sonification refers to the presentation of information using non-speech audio and covers many fields (Dubus 2011) but is relatively new to GIS. It is a way of representing complex data sets for analysis in a different way to visual methods and also a way of reinforcing data shown visually, resulting in better performance from users (Harrower, 2007). Sonification prototypes of spatial data have been created (Fisher, 1994; MacVeigh & Jacobson, 2007) but with limited user testing.

3. Method

Wind turbines were placed at distances between 800 and 3000m on a series of generated landscape visualisations using Visual Nature Studio 2.85 (3D Nature, 2011), based on literature data (Bishop, 2002) expert advice and a pilot study. All the turbines were 100m tall, based on a turbine located in Swaffham, Norfolk (Ecotricity, 2011) and a field of view of 60 degrees was used, standard for a wide

angle lens (Sevenant & Antrop, 2011). For each visualisation (n = 18), participants were asked to estimate how many turbines were within 2000m. Table 1 lists the different types of visualisations and sounds used.

Evaluation sessions were run in small groups (2 to 8) with participants recruited from UEA, Ordnance Survey, UK Climate Impacts Programme, the Broads Authority and planners from Norfolk County Council (n = 45). A series of questions and visualisations shown on a projector, followed by a group discussion session. Answers were collected using an audience response system (TurningPoint, Reivo 2011) consisting of slides integrated into Microsoft PowerPoint and handheld keypads.



Figure 1. An example of one of the visualisations with five wind turbines.

Table 1. The different methods used and order they were shown in the evaluation. *As shown in Figure 1. #Demonstration of the sound available at http://www.nickbearman.me.uk/academic/bearman_lovett_2012_gisruk/evaluation_demo.pptx (28MB).

Method Name	Visual Element	Sonic Element
Vision Only	Turbine visualisation*	(none)
Vision & Sound (Piano)	Turbine visualisation*	Note for each turbine played in sequence#
Sound Only (Piano)	(none)	Note for each turbine played in sequence#
Vision & Sound (Bird Call)	Turbine visualisation*	Note for each turbine played in sequence#
Sound Only (Bird Call)	(none)	Note for each turbine played in sequence#
Vision with Scale	Turbine visualisation, with turbine at distance of 1000m marked	(none)

4. Results & Analysis

The number of turbines the participants thought were within 2000m was compared to the correct answer for each visualisation, with a value of 0 being correct, a negative value being an underestimation and a positive value being an overestimation.

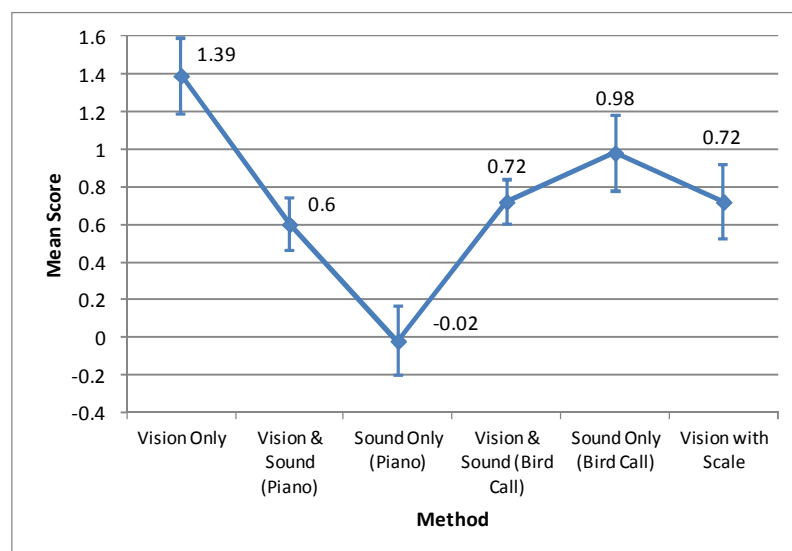


Figure 2. The mean score for each method, with 0 being a perfect score, with error bars (± 2 standard errors). Sound Only (Piano) was the most successful and Vision Only the least successful.

Figure 2 shows the scores for each method for all participants. The most effective method was Sound Only (Piano), significantly better than any other methods ($p < 0.001$) and Vision Only was the worst performer. These results are consistent with the discussion session, with Piano being rated as a more useful sound than Bird Calls.

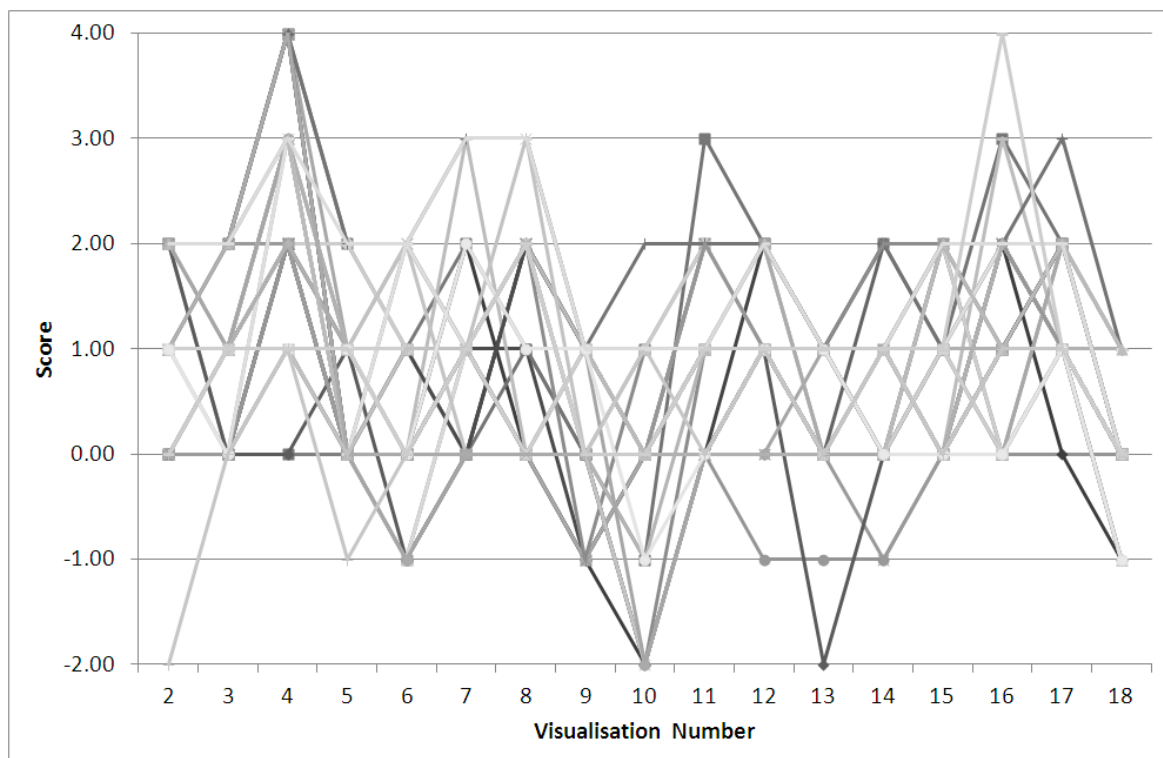


Figure 3. Graph of all responses in the evaluation. The visualisations are in the order completed, where 2-4 = Vision Only, 5-8 = Vision & Sound (Piano), 9-10 = Sound Only (Piano), 11-14 = Vision & Sound (Bird), 15-16 = Sound Only (Bird), 17-18 = Vision with Scale. Some methods overestimate (Sound Only [Bird]) and some underestimate (Sound Only [Piano]).

Figure 3 shows how the individual respondents' answers vary over 18 visualisations, with the majority of answers between +2 and -1 (94.9%). There is a general trend of improvement within each group, particularly Vision & Sound (Bird). Participants were likely to overestimate the number of turbines. There were no significant differences between participants from different organisations or different levels of GIS knowledge.

A logistic regression model was created for each method, to predict if the user would select the correct number of turbines. For all methods using sound, the learning style question 'You pay attention to the sounds of various things' had a significant impact, with people who do pay attention performing less well. Attempt number also had an impact on the bird call methods, with later attempts being more successful than earlier ones. While the pattern seen with attempt number is unsurprising, the 'Pay attention to sounds' pattern is unexpected. An explanation for this is may be that people who do pay attention to sounds were concentrating on the sounds played to them rather than the task, so scored lower. However it is not an obvious finding to interpret and needs further research.

5. Conclusion

Overall the best performing method was Sound Only (Piano) with a mean score of -0.02, and using sound and vision combined was also very successful. Participants with higher GIS knowledge performed better, but this was a non significant. The regression analysis showed that the ability to listen to sounds and attempt number have an impact on the ability to use the sonification. Further research is required to refine the influence of subject knowledge and learning style.

Adding a second labelled turbine at 3000m to the Visual Only method would make the data more comparable to the other methods. The visualisations were not photo-realistic because of time restraints, but a truly photo-realistic visualisation does not necessarily result in better understanding of the landscape. Resources should be focused in the specific areas of the visualisation which have the most impact (Appleton & Lovett, 2003).

This work provides a contribution to the literature as an evaluation of sonification in an area where few have been completed, and shows that Piano notes are more effective than Bird Calls at representing this data. Sonification has wider applications in spatial data representation, where it is useful to present large or complex data sets that cannot be shown visually, and it may be more appropriate for some users than complex visual methods.

Acknowledgements

This research has been conducted as part of ESRC/NERC PhD Studentship No. ES/F012454/1 with additional financial support from Ordnance Survey.

Biography

Nick Bearman is studying for a PhD at UEA in Environmental Science, researching different methods of representing uncertainty using sound in a variety of spatial data environments. As well as the work on using sound in a landscape visualisation setting, the research has also included use of sound to represent uncertainty in address point data and future climate prediction data. He submitted his PhD thesis in January 2012 and has now started a post-doctoral research position at the European Centre for Environment and Human Health (ECEHH, Peninsula College of Medicine & Dentistry, Universities of Exeter & Plymouth).

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Investigation of the use of a SUDS Management Train to reduce flooding in an urban environment

Craig Lashford, Dr Susanne Charlesworth, Dr Matthew Blackett, Frank Warwick

SUDS Applied Research Group, Coventry University, CV1 5LW
Tel: +44. 2476 887688 Fax: +44 2476 888400,
craig.lashford@coventry.ac.uk

Summary: The project aims to examine the possibility for a sustainable drainage system (SUDS) management train at the proposed Canley regeneration plan, Coventry. *WinDes*® drainage software will be used to simulate rainfall to examine areas that would be highly susceptible to flooding or ponding. The software will then be used to input differing SUDS devices into the plan to investigate their benefits for runoff reduction. Multiple combinations of devices will be linked together to assess their use as a management train to ultimately provide a ‘best fit’ scenario for Canley.

KEYWORDS: Canley, *WinDes*®, flooding, SUDS management train, runoff reduction

1. Introduction

This project intends to assess the capabilities of a sustainable drainage system management trains ability to reduce both fluvial (river) and pluvial (rainfall) flood risk. SUDS aim to change the principle that water should be rapidly transported away from towns and cities (Jones and Macdonald, 2007). They mimic the natural hydrological processes associated with water flows which have been lost due to the high rate of urbanisation and impermeable surfaces (Semadeni-Davies *et al*, 2008). A SUDS management train is a process whereby SUDS devices are connected rather than each device being utilised as a standalone unit (Fig 1).

In the last ten years in England flooding has been in the spotlight due to the risk it poses to people and infrastructure. It is estimated that six million people live at risk of flooding (Carter *et al* 2009) with approximately 1.7 million homes at risk (Treby *et al* 2006). The problem is exacerbated by the increasing need for new development, known as urbanisation which has occurred since the 18th century as the industrial revolution saw a need for an increase in housing and development (Wood, 1990).

A change in land use results in an increase in impermeable surfaces, such as roofs and roads (Dale, 2005). A common material used for development is asphalt which has a runoff co-efficient of 0.95, therefore producing large amounts of runoff (Newson, 1994). Additional impacts of urbanisation are that soil becomes compacted and there is a change in vegetation which reduces the land's ability to infiltrate storm water effectively, increasing the amount of overland flow. Furthermore urbanisation results in the implementation of a hydraulically efficient pipe based drainage system (Elliot and Trowsdale, 2007) which creates high peak river flows. Due to the efficient nature of a pipe based system, the lag time between a rainfall event and runoff reaching the river is reduced and results in an estimated increase of 75% of storm water in stream flow (Semademi-Davies *et al*, 2008).

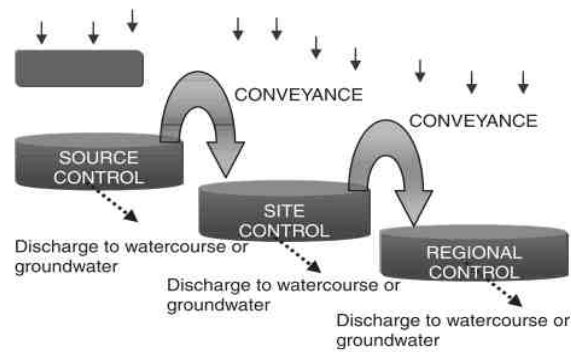


Figure 1: A SUDS management train (Kirby, 2005)

A management train sets out a plan to deal with runoff. A successful management train (Fig 1) starts with source control; SUDS that tackle water directly after precipitation. Runoff is likely to be lost at this point through infiltration to either the water course or the groundwater. What remains would be conveyed to a site control. Site control devices deal with small amounts of runoff but are components that can again allow for infiltration to the surrounding soils and pollutant removal. The remaining water is then again conveyed to another site for regional control. These SUDS components usually deal with high volumes of water and are the last point to deal with runoff. They should allow for moderate levels of pollutant removal, although much should already have been filtered out. Detention basins are an example of a regional control that allow for high volumes of water detention. After this step, it is probable that the water would slowly be released to a water body or would infiltrate out of the system (Kirby, 2005).

A computer program, *WinDes*® will be used to evaluate the capabilities of the SUDS management train. The chosen site is the proposed Canley Regeneration Plan (WSP Environmental Ltd, Coventry City Council, 2008) which consists of a total of 710 new dwellings being developed across parkland and brownfield sites. Development at this scale which reduces green sites therefore reducing infiltration would benefit from SUDS to allow for more natural, slower flows to a water course, reducing the potential for flooding (Charlesworth, 2010).

2. Methodology

2.1 Study Area

The site chosen for the study is a 16 ha site at Canley (Figure 2), an area located approximately 2 miles west of Coventry city centre.



Figure 2: A site location of Canley, Coventry (Ordnance Survey, 2011)

The site is subject to a regeneration proposal (Figure 3) to demolish 30 of the existing houses and replace them with a further 731 dwellings (WSP Environmental Ltd, Coventry City Council, 2008). The main site for change is a local park that will see over 250 houses developed, a public house, a restaurant and a motel. The flood risk assessment (Halcrow Group Limited, 2009) suggested the need for SUDS at the site although gave no indication of which devices or where they can be implemented. The site characteristics and underlying clay lithology (Coventry City Council, 2008) limit the sites ability for infiltration and therefore the effectiveness of infiltration SUDS.



Figure 3 The Canley Regeneration Plan
(WSP Environmental Ltd, Coventry City Council, 2008)

2.2 Method Used

This project adapts the methodology of Viavatenne *et al* (2010) who simulated runoff reduction for individual SUDS devices at a site in Birmingham. Firstly, *WinDes*® is the chosen package as it has a specialist SUDS selection tool allowing for rainfall to be simulated across a site, giving runoff reduction values. Secondly, where Viavatenne *et al* (2010) evaluated each device and their benefits individually, this project will investigate the use of a management train.

To generate the results, 1m resolution light detection and ranging (Lidar) data of Canley will be input into *WinDes*® to ascertain areas that are likely to be susceptible to ponding or flooding. This will give both an indication of where flooding is likely to occur and also the potential volume of runoff. Multiple connected SUDS devices will then be input into the model to determine the probable reductions in runoff which will generate a reduction value for the management train.

3. Expected Results

As the research is at an early stage, no results have been generated yet. However it is possible to predict the results that are likely to be produced and the impacts that they can have.

From a literature review undertaken for the study, it would be expected that certain SUDS devices, as set out by CIRIA's SUDS manual C697 (Woods-Ballard *et al*, 2007) are more successful at reducing the possibility of flooding than others. Although their ability to reduce flows is generally acknowledged, the sites where they would suitably be deployed are not fully understood. It is likely that an effective management train would be able to reduce runoff significantly (Jefferies *et al*, 2009), however their arrangement and suitability for a 'best fit scenario' remains relatively unknown.

Green roofs are a device that involves vegetating a roof to reduce runoff rates and promote infiltration and will be considered at the first stage of the management train. They act successfully to reduce runoff at source level; when precipitation first falls to a surface. CIRIA C697 (Woods-Ballard *et al*, 2007) suggests that they work to a 'medium' level at reducing runoff peaks. If included in the design stage, all roofs could be 'greened'. Green roofs can also remove pollutants from runoff (van Woert *et al*, 2005).

The next step along the 'train' could be permeable paving, another device that act at source level. It is generally implemented in low frequency traffic zones and car parks. Permeable paving allow for water to be directly infiltrated through the voids in their surface to the underlying soil. It has been suggested that as an individual device, they can reduce runoff by up to 75% based on the best value from 150 different storm events (Viavattenne *et al*, 2010). Furthermore, permeable paving can improve runoff water quality (Scholz and Grabowiecki, 2007).

Swales are a vegetated drainage device which aid conveyance of water to another device or outlet structure and also allows for storage and therefore infiltration (Woods, Ballard *et al*, 2007). Swales can be sited next to roads and provide green space for the Canley site.

Detention basins create large stores of water after a runoff event. They allow for the slow release of water to the surrounding soils through infiltration therefore reducing runoff peaks and flow volumes at the water body (Travis and Mays, 2008). For this reason it is likely that they will be implemented at the site.

The project will assess whether, by combining these devices, a near total runoff reduction could occur and will investigate the number of each type of device required to achieve this.

4. Conclusion

The information generated from the project is beneficial for a range of sources. Developers and researchers have limited information currently available regarding the use of a management train for reducing runoff. Furthermore the regeneration plan is expected to commence in the near future and will require a drainage plan which incorporates SUDS. The project will provide a basis to demonstrate the benefits of creating a management train over stand alone devices but also the potential locations and use of SUDS at Canley.

5. Acknowledgments

Thanks go to Micro Drainage for supplying the *WinDes*® software. Further thanks are extended to BWB Consulting for their aid in training in *WinDes*® and for their overall support of the project.

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7. Biography

Craig Lashford is a current MSc by research student at Coventry University, investigating the effectiveness of a SUDS management train for reducing pluvial and fluvial flooding. Craig graduated from Coventry University with a BSc in Geography and Natural Hazards.

Dr. Susanne Charlesworth is a Reader at Coventry University and director of its Sustainable Drainage Applied Research Group. She has particular interests in Sustainable Drainage and urban physical processes.

Dr. Matthew Blackett is a senior lecturer in Geography at Coventry University. After obtaining his PhD from King's College London, he has pursued his main research interests; satellite remote sensing, largely for the monitoring of natural hazard events. Matthew is also becoming involved in studies in the field of SUDS.

Frank Warwick is a PhD student at Coventry University, UK, investigating techniques to determine the feasibility of sustainable drainage devices.

Open Geospatial Data: An Assessment of Global Boundary Datasets

Charles Brigham, Steven Gilbert, and Qiyang Xu

World Bank Institute

1818 H St. NW, Washington, DC

cbrigham@worldbank.org

sgilbert@worldbank.org

qxu1@worldbank.org

1. Introduction to GAUL, GADM, and UNSALB

For the World Bank Annual Meeting on September 26th 2011, the Mapping for Results (M4R) team mapped project locations and development indicators for 142 countries and made these maps and data available through the World Bank's external website (The World Bank, 2011). M4R used publicly available administrative boundaries in order to identify the ADM1¹ and ADM2 in which each project activity is located and to map subnational indicator data. This paper uses our insight gained from these activities to analyze the accuracy in terms of whether boundaries are up to date and the usability of publicly available boundary datasets for mapping on a global scale.

1.2 GAUL

The 2009 edition of Global Administrative Unit Layers (GAUL) is a joint initiative of the Food and Agriculture Organization of the United Nations and the European Commission. As of 2009, the GAUL dataset contains national administrative boundary information of 275 countries and territories, among them thirty-eight countries in Table 1 are copyrighted and published by Second Administrative Level Boundaries (UNSLB) (Food and Agriculture Organization 2008).

Table 1. Countries copyrighted and published by UNSALB used within the GAUL dataset (FAO Geonetwork)

Australia	Belgium	Belize	Bolivia	Botswana
Cambodia	Cameroon	Democratic Republic of the Congo	France	Gabon
Germany	Ghana	Guinea	Guinea-Bissau	Jamaica
Liechtenstein	Luxembourg	Madagascar	Malawi	Maldives
Mali	Malta	Mozambique	Namibia	Nepal
Niger	Norway	Portugal	Saint Kitts and Nevis	Saint Lucia

¹ ADM1 signifies the first-order administrative boundaries such as a state, province, or department. ADM2 signifies second-administrative level boundaries such as district, municipality or county.

Sierra Leone	South Africa	Sri Lanka	Timor-Leste	Togo
Trinidad and Tobago	United States of America	Zambia		

1.3 GADM

Global Administrative Areas (GADM) is a global spatial database of administrative boundaries, including national and lower level administrative areas with boundary information for 217 countries. The GADM database was developed in a partnership between the University of California, Berkeley, Museum of Vertebrate Zoology, and the International Rice Research Institute (Global Administrative Areas 2009).

1.4 UNSALB

In 2001, UNSALB was launched as a working platform for the interoperational global boundary dataset of United Nation Geographic Information Group (UNGIWG). UNSALB contains administrative boundaries for 98 countries with 50 still in the process of validation. These boundaries are officially approved by National Mapping Agencies (NMA) of UN member countries (UN Geographic Information Working Group 2011).

2. Accuracy of Boundary Datasets

Accuracy and precision are of primary concern in data representation, processing and geovisualization. In most circumstances, the number of administrative divisions of a country can be found in official country documents and while there is a lack of official up-to-date information on actual shape and boundary of those administrative divisions. For this reason as well as potential boundary issues with disputed areas between regions and countries, our analysis focused mainly on whether boundaries reflected the correct administrative divisions in a country. As a reference for determining the accuracy of each boundary dataset, we used lists of administrative divisions available through statistics bureaus where available or UNSALB's list of historic changes and codes. For the 142 countries analyzed, Figure 1 below shows the number of countries with correct boundaries by publicly available dataset.

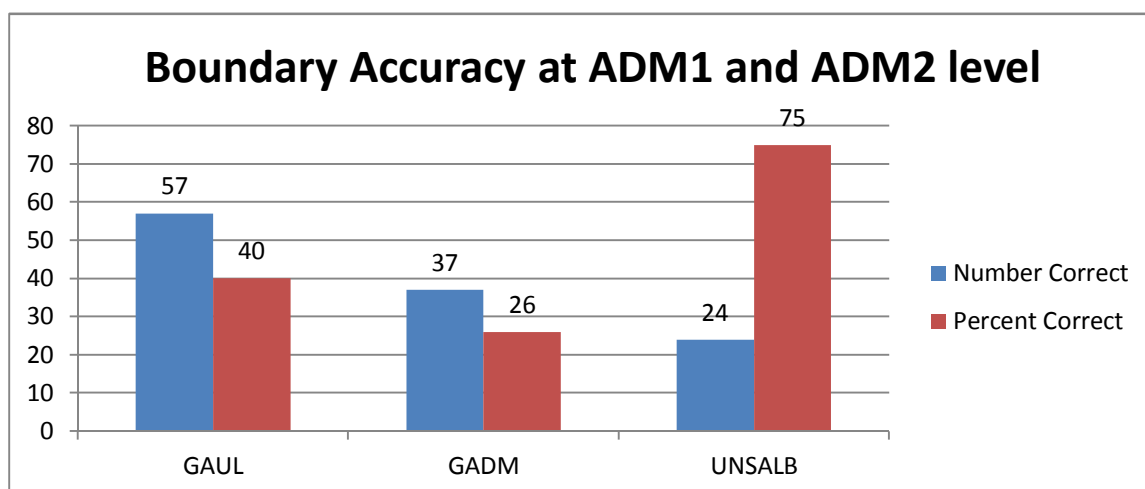


Figure 1. Accuracy of Administrative Boundary Datasets

In terms of accuracy UNSALB consistently contains the most accurate boundaries, most likely due to an update process that involves consultation with national mapping agencies to ensure accuracy. Unfortunately, this strength also inhibits its ability to respond quickly to changes in administrative divisions and to develop boundaries for many countries. During the use of UNSALB by M4R, 75 percent of the boundaries available were found to have the correct administrative divisions, however because UNSALB does not cover many countries, it has fewer correct boundaries than GADM and GAUL. While UNSALB is supposed to represent the ADM2 boundaries of each country, for two countries, Madagascar and Belize, only ADM1 boundaries were included.

The second most accurate of the three boundary sets was GAUL. One obvious reason for this was the inclusion of UNSALB boundaries within the GAUL dataset. However, it should be noted that the GAUL dataset is only updated annually and does not always include the newest boundaries available from UNSALB. For example, Iran GAUL boundaries do not yet include boundaries from UNSALB. Renewal of GAUL dataset as a whole, instead of each individual boundary dataset, may fail to keep pace with frequent changes in ADM boundaries. For example, Rangpur, as a new ADM1 in Bangladesh, is not included in GAUL.

GADM was found to be the least accurate boundary dataset. While GADM lacks the official validation of respective governments, its ability to respond to public feedback makes it possible to rectify problems quickly. However examination of the documentation for the GADM countries indicates little public feedback on data accuracy and no indication whether any provided feedback was incorporated. For example, a user provided feedback that GADM's boundaries for Afghanistan are missing two provinces, Daykundi and Panjshir, and only contained 326 of the country's 398 districts yet these new provinces and districts have not been added to the GADM boundaries. It should be noted that for several countries, we found that the boundaries for GADM contained correct administrative divisions whereas GAUL boundaries were incomplete. For example while GAUL misses most of ADM2 or prefecture level divisions for China, GADM has the correct divisions. Table 2 shows a list of countries where the GADM boundary set contained better boundaries than GAUL.

Table 2. Countries in which GADM boundaries are more accurate than GAUL

<i>At ADM1 level</i>	<i>At ADM2 Level</i>
Albania	Angola
Angola	China
Cape Verde	Honduras
Eritrea	Kosovo
Honduras	Macedonia, FYR
Iran, Islamic Rep.	Nigeria
Korea, Rep.	Tajikistan
Kosovo	Tanzania
Mongolia	Thailand
Myanmar	Uganda
Panama	Ukraine
Paraguay	Yemen, Republic of
Samoa	

Tanzania	
Tonga	
Yemen, Republic of	

Given that the much of the World Bank's projects are located in Africa and Latin America, a regional perspective of boundary accuracy is very useful for development practitioners. In our analysis of boundary accuracy we compared the accuracy of each boundary set from a regional perspective, using the six regions recognized by the World Bank (Figure 2)

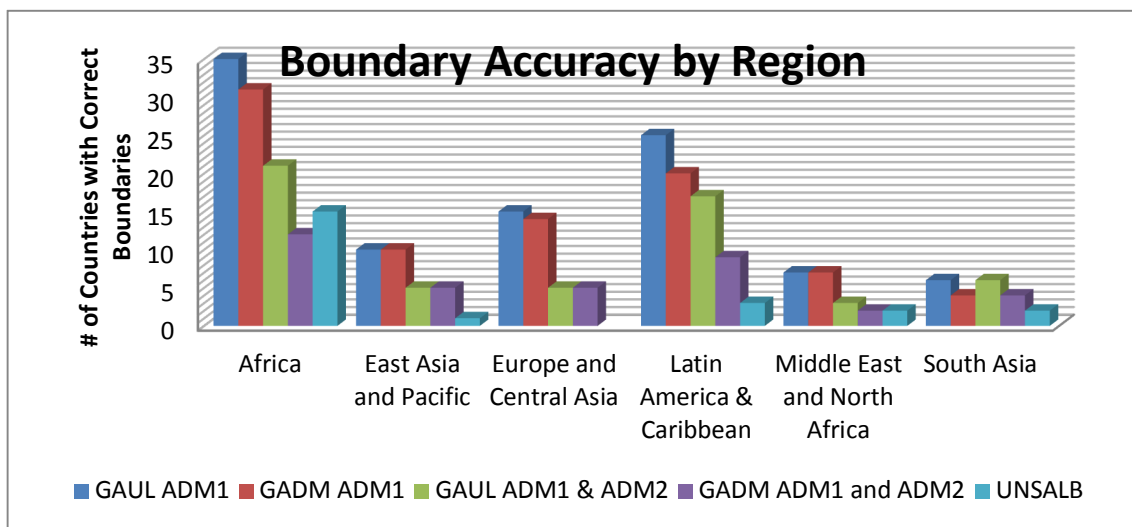


Figure 2. Accuracy of Subnational Boundaries by Region

We found the most profound differences in regional accuracy to be in Latin America and Africa. GAUL was the most accurate in terms of number of countries at both the ADM1 and ADM2 levels in Africa and Latin America & Caribbean regions. In Africa, we found that for 21 countries GAUL had correct boundaries at the ADM1 and ADM2 level, compared with 15 for UNSALB and 12 for GADM. While UNSALB accuracy is highest in Africa, it does not cover many of the countries in the region at all. In Latin America the discrepancy between boundary sets was even greater. GAUL contained correct boundaries for 17 countries, compared to only 9 correct boundaries in GADM and 3 for UNSALB.

For 28 countries in Table 3 none of the publicly available boundary sets had correct boundaries at the ADM1 or ADM2 level. This was often the case with island countries such as Kiribati and the Solomon Islands and with some African countries including Chad, Rwanda, and Sudan.

Table 3. Countries with no accurate boundaries

Afghanistan	Kazakhstan	Moldova	Solomon Islands
Bangladesh	Kiribati	Morocco	St. Lucia
Chad	Kyrgyz Republic	Palau	Sudan
Chile	Libya	Romania	Turkey
Congo, Republic of	Macedonia, FYR	Rwanda	Turkmenistan

Djibouti	Malaysia	Senegal	Uganda
Egypt, Arab Rep.	Mauritius	Seychelles	Vietnam

3. Usability

In addition to boundary accuracy, experience using these boundary datasets provides insight into the usability of each boundary dataset. We found GAUL to be the most usable for mapping on a global scale. Its combination of accuracy and completeness makes it more usable than GADM or UNSALB. A particularly useful aspect of GAUL is the inclusion of unincorporated territories and disputed areas on an individual national-level. For example disputed territories such as Aksai Chin and Arunachal Pradesh on the border between China and India are not excluded from the dataset, but rather included as their own territories giving the user the ability to determine whether to include them or not.

The GADM boundary set is available on a per country basis and as a complete world set without registration, making it easily accessible, but several factors make GADM difficult to use. Unlike the UNSALB and GAUL datasets, historical boundaries are not available through GADM. Additionally, GADM's usability is hindered by inconsistent naming conventions for its administrative divisions that often contrast with official government sources. For example, in Turkmenistan several of the ADM1s are named incorrectly and administrative division names in Albania, Chad, and Uruguay use accents and characters that make joining and processing data difficult. Finally, since the GADM dataset does not support multi-part polygons for countries and administrative divisions consisting of islands or separate areas it make joining disparate sources and geo-processing tasks such as area calculation, and division-based indicator data analysis more difficult to perform.

While UNSALB usually has the most accurate boundaries, it has several pitfalls that affect usability. First, the UNSALB website only provides ADM2 boundaries downloadable on a per country basis, which is inconvenient when boundaries are needed on a global scale. Additionally, while the process of official validation by member countries ensures that boundaries are accurate, it limits the geographic scope of UNSALB, since boundaries for many countries have not yet been validated, are pending, or simply have never been captured.

4. Conclusion

Through comparison of GAUL, GADM and UNSALB boundary datasets we found that each dataset has advantages and drawbacks in terms of accuracy and usability, but overall GAUL was the best dataset due to the accuracy and completeness of the dataset. While UNSALB boundaries have the highest rate of accuracy because of validation with national mapping agencies, it is limited in geographic scope. Although GADM has a global scale, many of the boundaries are outdated and it is unclear whether GADM organizers have utilized public feedback to update boundary sets GADM. For local level mapping exercises boundary selection should be selected on a case by case basis, but given GAUL's superior accuracy and completeness, in particular in the developing countries of Africa and Latin America, makes it best suited for mapping subnational data on a global scale.

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6. Biographies

Charles Brigham has worked in Geography for institutions such as NASA, UN, World Bank, CARICOM, and for many countries. Charles' expertise is in International Development, Census and Statistics, Geospatial Infrastructure, Innovative Geospatial technologies, Imagery Analysis, and Humanitarian affairs. He currently works for the World Bank Institute, Innovation Practice

Steven Gilbert has worked as a GIS and data analyst with the Mapping for Results initiative in the Innovation Practice of the World Bank Institute since May 2010. Prior to joining the World Bank Institute, Steve earned his master's degree in Latin American Studies from Georgetown University.

Qiyang Xu is a GIS Consultant with the Sustainable Development Network Information Services unit at the World Bank. She holds a Master of Arts degree in Geography from University of Maryland, and a Bachelor of Science in Geographic Information Systems from the Zhejiang University, China

Deforestation in the Kayabi Indigenous Territory: Simulating and Predicting Land Use and Land Cover Change in the Brazilian Amazon

Hugo de Alba¹, Joana Barros²

GEDS, Birkbeck, University of London, Malet Street, London WC1E 7HX

Tel +44 (0) 207 079 0644; Fax +44 (0) 20 7631 6498

¹ hugo.dealba@gmail.com, ² j.barros@bbk.ac.uk

Summary: Land use/cover change practices in the Amazon, such as cattle ranching, logging, agriculture, mining, and urbanization are the major contributors to deforestation and have major impacts on ecosystems and environmental processes across scales, such as land fragmentation and degradation, biodiversity loss, alteration in atmospheric composition and climate change. The future landscape for the Kayabi Indigenous Territory in the Brazilian Amazon was simulated using GIS, Remote Sensing and the IDRISI's Land Change Modeler. The model was able to successfully simulate deforestation expansion in the region and identify the main landscape attributes driving anthropogenic disturbance expansion in the studied area.

KEYWORDS: Amazon, deforestation, modelling, remote-sensing, prediction.

1. Introduction

During 2007, over 80% of both clearing and cumulative clearing in Amazon has been concentrated in a band along the eastern and southern edges of the forest, this band is called the 'arc of deforestation' (Fearnside, 2007) - see Figure 1. It seems that is the process of Land use/cover change (LUCC) that is bringing a fast deforestation processes; the most common LUCC practices in the Brazilian Amazon include cattle ranching, logging, agriculture, mining, and urbanization (Asner et al, 2004).

Indigenous lands and different categories of parks and reserves located at the edge of the 'arc of deforestation' serve as a primary defence against deforestation. This is the case of the Kayabi Indigenous Territory located in the states of Mato Grosso and Para, in the Brazilian Amazon. However, since 2000 anthropogenic processes have critically speeded deforestation in the Kayabi Territory. This paper aims to understand the determinants of LUCC by using a modelling approach.

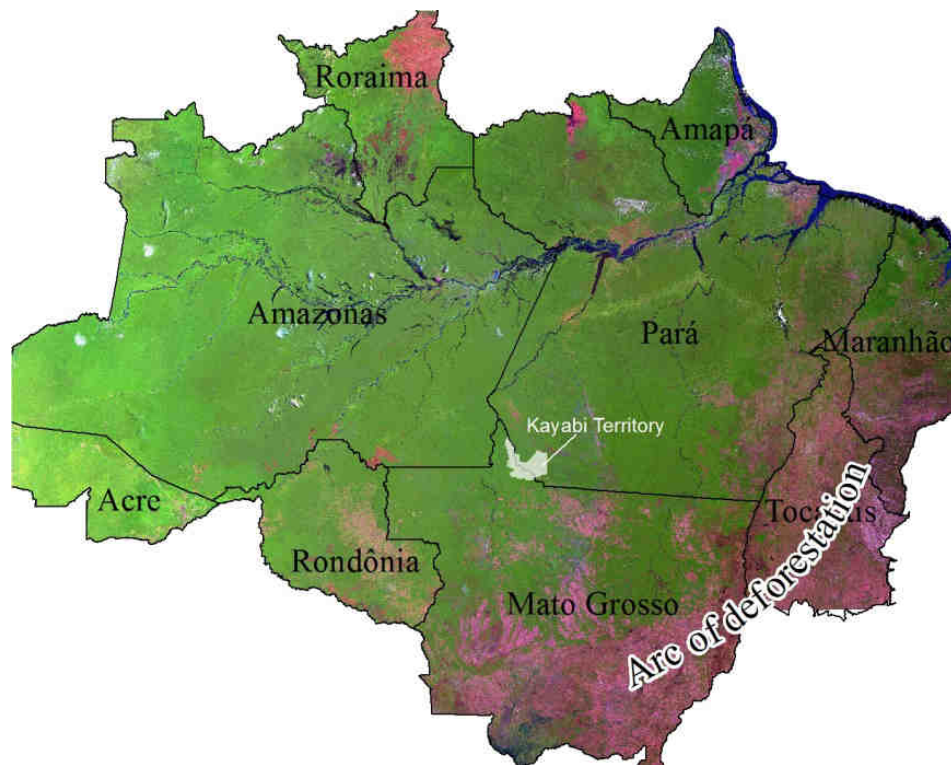


Figure 1. Location of Kayabi Territory within the ‘Arc of deforestation’

2. Modelling LUCC in the Kayabi Indigenous Territory

The prediction of the future landscape was developed using different GIS and IDRISI’s Land Change Modeler and followed five sequential steps, presented as follows.

- (1) Creation of forest land cover maps from 2000, 2006 and 2009 derived from remotely sensed data;
- (2) Land-change cover analysis by cross-tabulating forest land cover maps;
- (3) Calculation of transition potentials from forest to anthropogenic disturbance using a MLP neural network methodology;
- (4) Assessment of the model performance by predicting a 2009 land cover and comparing it with an actual 2009 land cover map; and
- (5) Predicting a 2020 land cover.

Each of these steps will be presented as follow.

Step 1: Creation of land cover maps 2000, 2006 and 2009 derived from remotely sensed data

CLASlite software was utilized to create fractional cover maps for each image shown in Table 1, followed by a supervised classification using ENVI software to create 2 class land cover maps for the years 2000, 2006 and 2009 (forest and anthropogenic disturbance). The result of the classification was a 2 class map: Forest and Anthropogenic Disturbance for each of the analysed years (see Figure 2).

The land change analysis was based on two multi-temporal land cover maps derived from a 2000 Landsat ETM+, a 2006 Landsat TM, a third land cover map, for the purpose validation of the model, was derived from two 2009 SPOT 5 images (see details in Table 1).

Table 1. Characteristics of Satellite data used

<i>Sensor</i>	<i>Spectral Bands</i>	<i>Spectral resolution</i>	<i>Ground pixel Size</i>	<i>Acquisition date</i>
Landsat ETM+	B1: Blue	0.45-0.515 μm	30 m	31/05/2000
	B2: Green	0.525-0.605 μm	30 m	
	B3: Red	0.63-0.69 μm	30 m	
	B4: Near-infrared	0.75-0.90 μm	30 m	
	B5: SWIR	1.55-1.75 μm	30 m	
	B6: Thermal-infrared	10.4-12.5 μm	60 m	
	B7: Mid-Infrared	2.09-2.35 μm	30 m	
	P: Panchromatic	0.52-0.9 μm	15 m	
Landsat TM	B1: Blue	0.45-0.52 μm	30 m	25/06/2006
	B2: Green	0.52-0.6 μm	30 m	
	B3: Red	0.63-0.69 μm	30 m	
	B4: Near-infrared	0.76-0.9 μm	30 m	
	B5: SWIR	1.55-1.75 μm	30 m	
	B6: Thermal-infrared	10.4-12.5 μm	120 m	
	B7: Mid-Infrared	2.08-2.35 μm	30 m	
SPOT 5	B1: Blue	0.50-0.59 μm	10 m	29/05/2009
	B2: Green	0.61-0.68 μm	10 m	12/09/2009
	B3: Near-infrared	0.78-0.89 μm	10 m	
	B4: SWIR	1.58-1.75 μm	10 m	

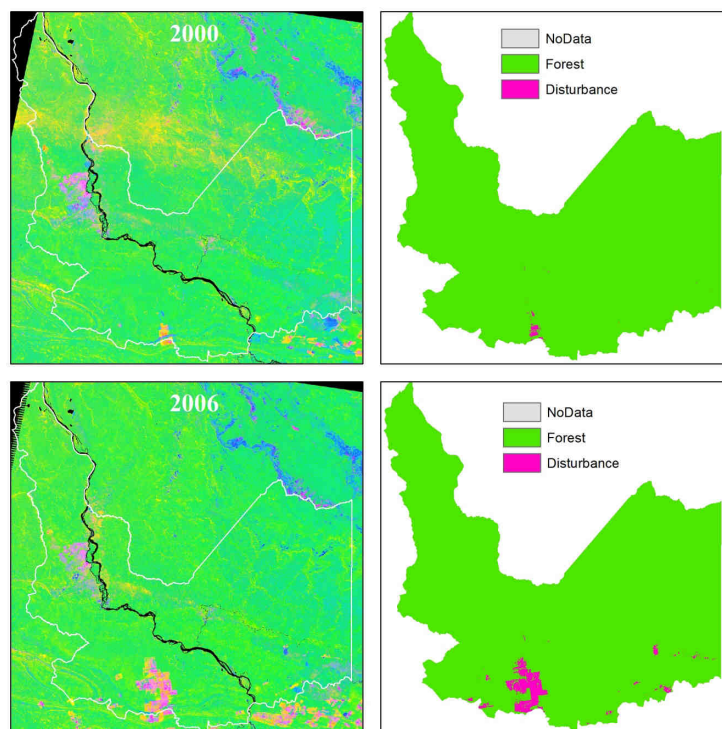


Figure 2. Resulting classification of CLASlite's fractional cover maps.

Step 2: Land Change Cover Analysis by cross-tabulating forest land cover maps

Change from forest class to disturbance between 2000 and 2006 was assessed by using Change Analysis Tab in LCM. LCM analyses each pixel in the earlier land cover map for a transition to a different class in the later land cover image. Since there are only two land cover classes, there are four possible outcomes for each pixel (see Figure 3):

- Case 1. Forest with no change (Forest persistence)
- Case 2. Forest transition to Disturbance (Forest – Disturbance)
- Case 3. Vegetation Re-growth (Disturbance-Forest)
- Case 4. Disturbed area with no change. (Disturbance persistence)

A 3rd order polynomial trend surface was created using LCM to aid interpretation. Spatial trend analysis is an effective way of visualizing the general trend of change based on the observed change between two land cover maps and, as can be seen in Figure 4, makes evident change from forest to disturbance is concentrated in the south part of the image which is consistent with the deforestation tendency observed on the ‘arc of deforestation’.

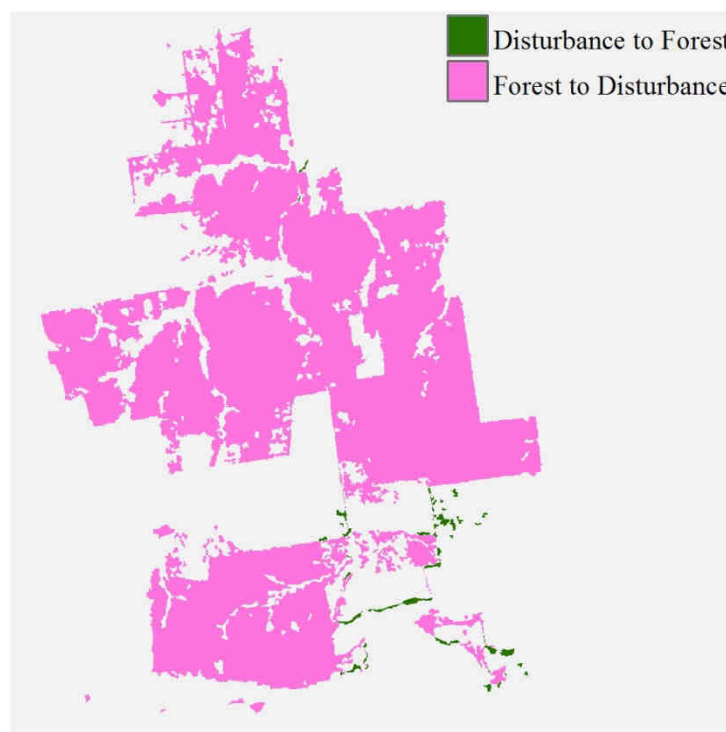


Figure 3. Class transitions calculated by LCM¹

¹ Transitions of less than 500 hectares were ignored in the model as they were produced by a map error in image co registration process.

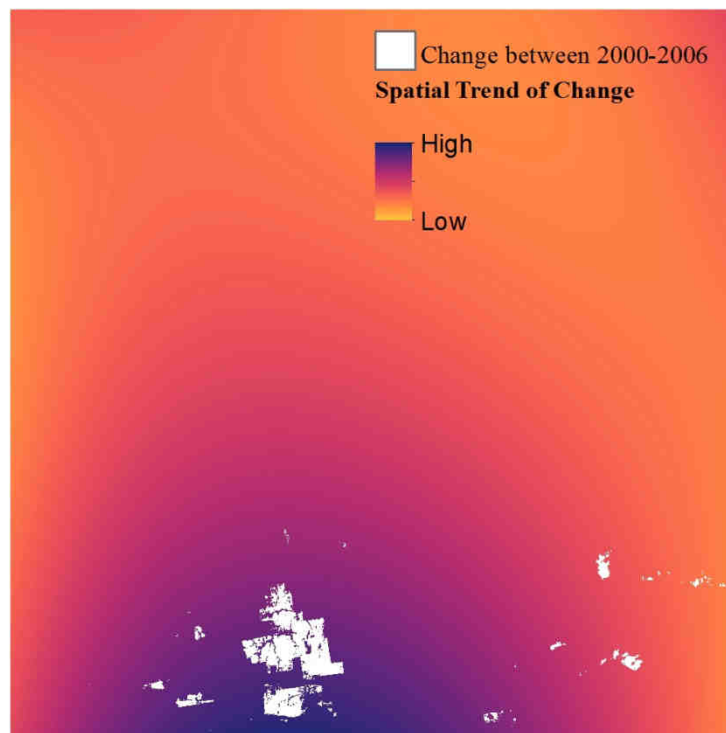


Figure 4. Spatial trend of change

Step 3: Calculation of transition potentials from forest to anthropogenic disturbance using a MLP neural network methodology;

Transition potentials are expressed as the likelihood of one land cover category to another (Paegelow & Camacho Olmedo, 2008). In this case, only transition from forest to anthropogenic disturbance was modelled. A MLP Neural Network approach was used to create transition potential maps. Five factors were identified as major driving forces of change (see Table 1) and were assessed for correlation to deforestation.

Table 2. Explanatory variables in transition sub-model structure

<i>Explanatory Variable</i>	<i>Type</i>
Distance from roads	Dynamic
Distance from disturbance	Dynamic
Terrain (DEM)	Static
Distance from streams	Static
Slope	Static

LCM's Test and Selection of site and driver variable module was used to test the potential power of explanatory variables (see **Table 3**). Only variables with values higher than 0.45 (strong association with change) were kept in the sub-model structure.

Table 3. Cramer's V Test for explanatory variables

<i>Explanatory Variable</i>	<i>Cramer's V</i>
Distance from roads	0.4730
Distance from disturbance	0.4572
Terrain	0.1114
Distance from streams	0.0493
Slope	0.0233

The transition potential from forest to disturbance was modelled using the MLP neural network methodology. The LMC sub model was used to create the transition potential map (MLP achieved an accuracy rate of 94.56 % and a RMS value of 0.20). The outcome of the model is a transition potential map for transition from forest to disturbance (see Figure 5). Each pixel on this map contains the probability value (from 0 to 1) of changing from forest to anthropogenic disturbance.

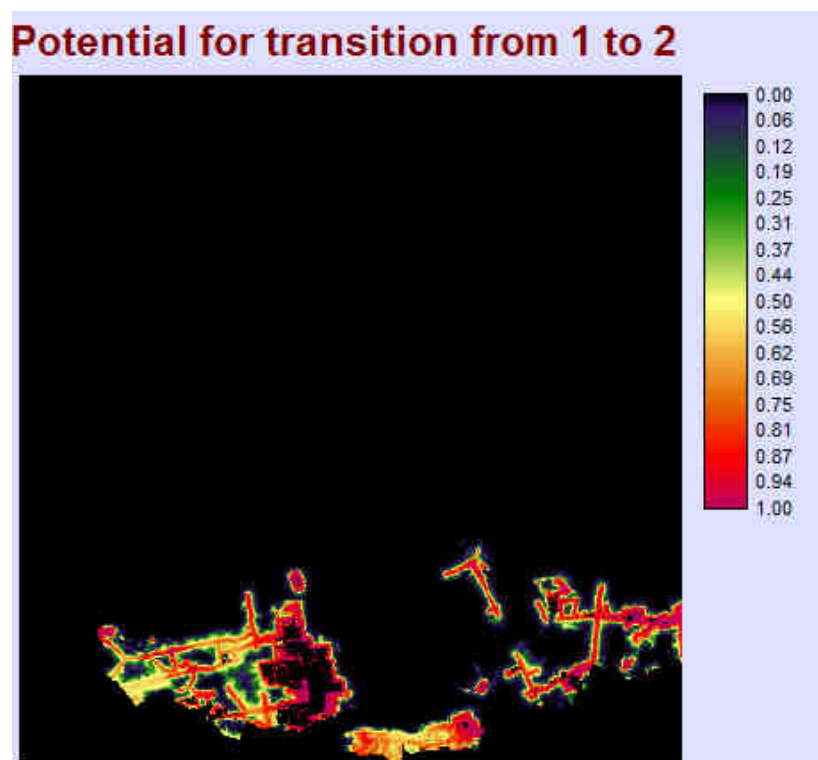


Figure 5. Transition potential from forest to anthropogenic disturbance

Step 4 Assessment of the model performance by predicting a 2009 land cover and comparing it with an actual 2009 land cover map

Markov chain analysis was used to predict the quantity of change in 2009 and then compare to an actual 2009 land cover map. LCM provides two basic models of prediction: a hard prediction model and a soft prediction model.

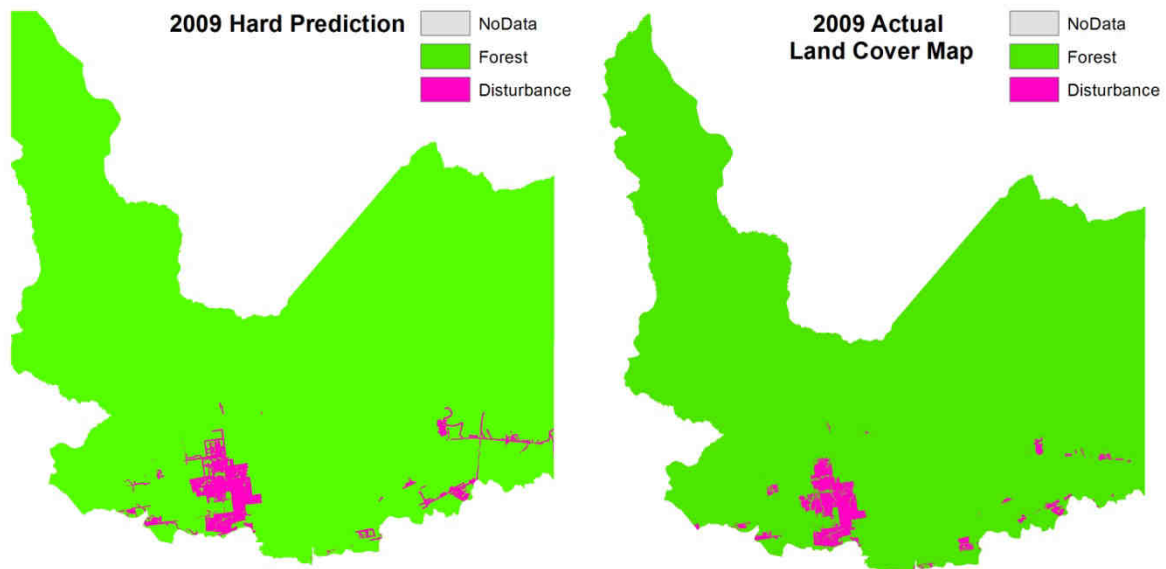


Figure 6. Hard prediction of Kayabi forest condition in 2009 and actual 2009 land cover map.

Figure 6 shows two disagreements in the prediction are either concerned with quantity or with location of change. The assessment of the hard prediction was carried out with the LCM Validate function (see the resulting map in Figure 7 and output of function in Figure 8).

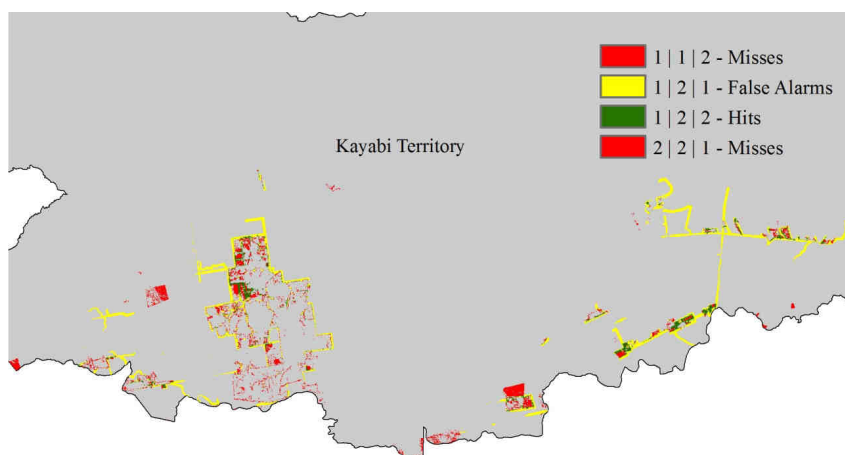


Figure 7. Validation map: hits, false alarms and misses

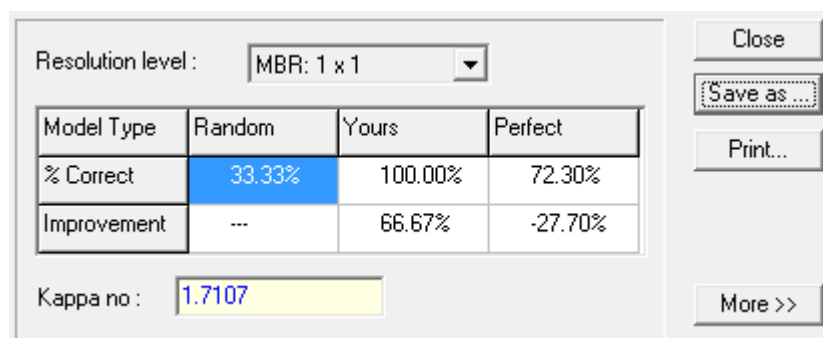


Figure 8. Validation results

As the hard prediction is a single realization of a future scenario chosen from many equally plausible scenarios (Eastman, 2009), it is very difficult to achieve an accurate hard prediction. The soft prediction identifies vulnerability to change, and thus provide a more meaningful map (see Figure 9).

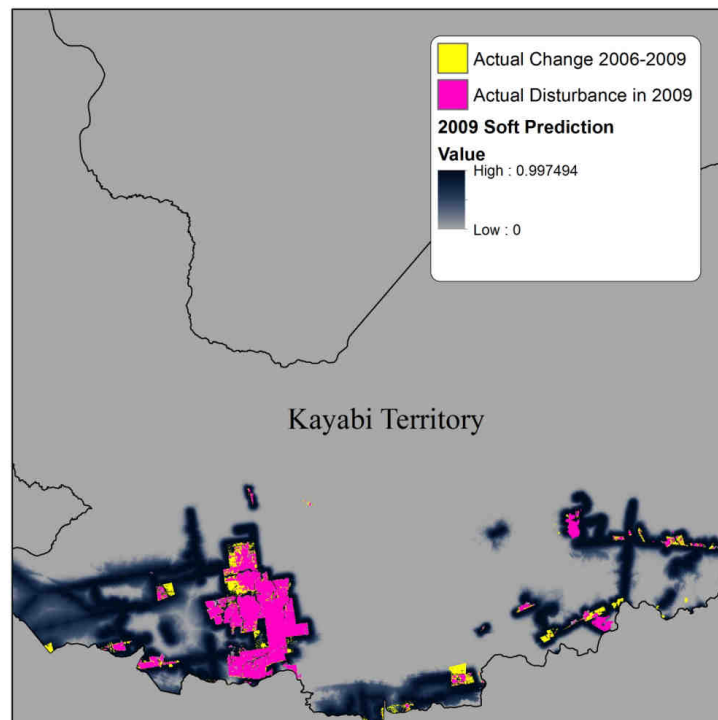


Figure 9. 2009 Soft prediction

A quantitative assessment of the soft prediction was carried out using receiver operating characteristic (ROC) statistics. The result of the ROC statistic was 0.987, which is a very strong value and indicates the soft prediction was very accurate.

Step 5: Predicting the Kayabi Territory forest condition in 2020

Both hard and soft predictions were produced for the year 2020 (see Figure 10).

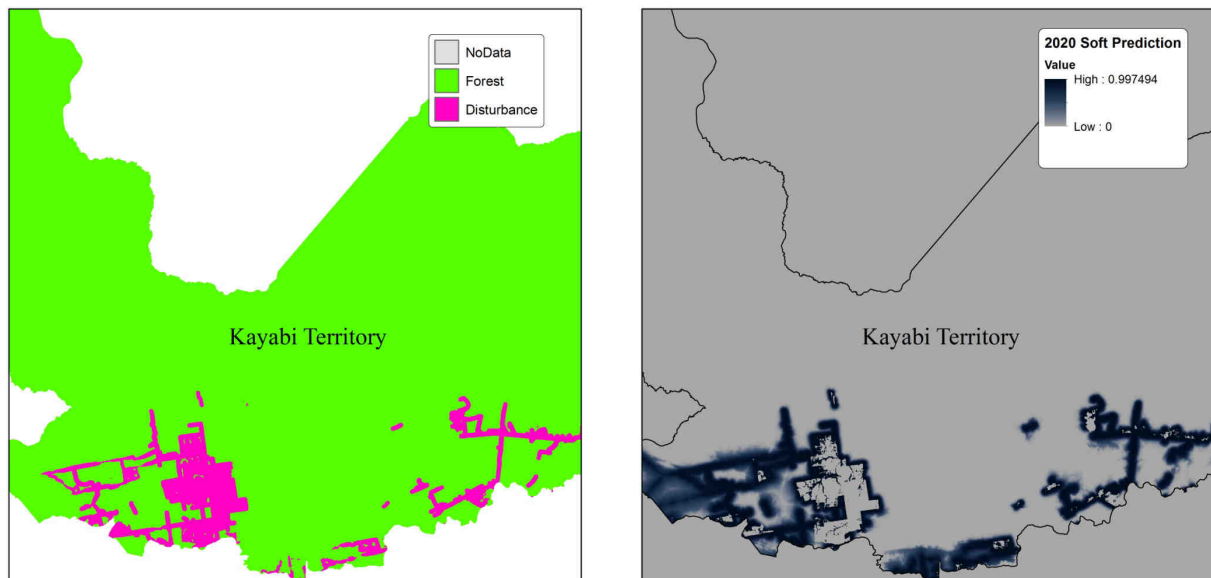


Figure 10. Map Predictions for 2020: hard prediction (left-hand side) and soft prediction (right-hand side).

3. Discussion and Conclusions

The results of the prediction of landscape change in Kayabi Territory for 2020 indicate that by the year 2020, assuming the nature of forest development does not change, an additional 36,000 hectares of forest will be lost in the Kayabi Territory, making a total of 60,645 hectares for the period 2000-2020 (see Table 4).

Table 4. Time Analysis of forest lost in Kayabi Territory

<i>Year</i>	<i>Forest Lost (ha)</i>
2000	1,776
2006	18,018
2009	5,040
2020	35,811
Total	60,645

When comparing to reality, the predicted amount of the deforestation seems high. This can be explained, as the model uses the deforestation rate calculated to train the model. According to the change analysis 16,242 hectares were lost in six years (2000-2006), resulting an average deforestation rate of 2,707 hectares per year. External factors play an important role in interpreting the results. In this case, it is known rates of deforestation were impacted by legal injunction process. Such events are very difficult to incorporate into the model.

Figure 11 shows a time series analysis of land cover maps of the Kayabi Territory, which is consistent with the hypothesis that roads and previous disturbance are the main drivers for deforestation. The analysis also confirmed new disturbed areas serve as seeds for a more intense clearing activity in the future.

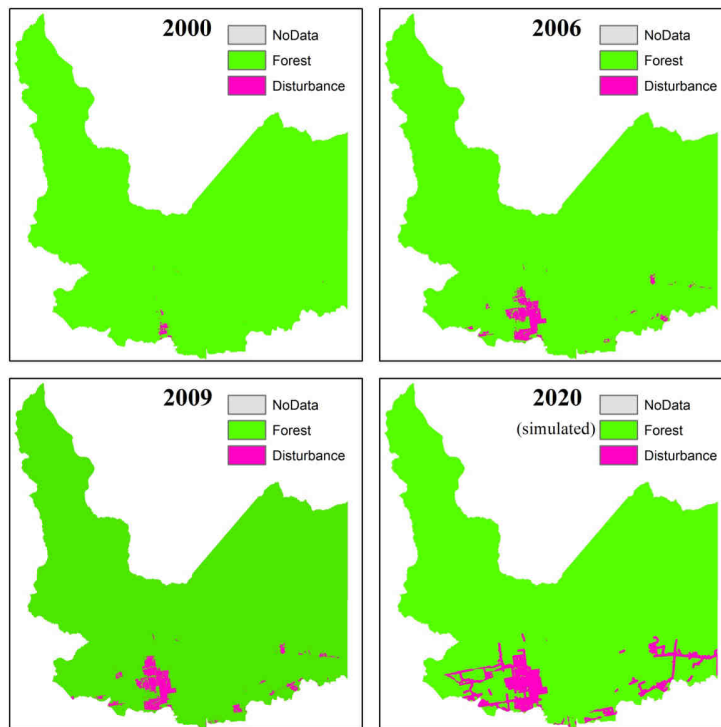


Figure 11. Time series Analysis of deforestation in Kayabi Territory

Based on visual interpretation of the simulation and the ROC criterion, it is clear the soft predictions were produced with a satisfactory level of accuracy. Figure 12 shows the 2020 soft prediction overlaid on a 2011 Landsat image (25/07/2011), where it is clear post 2009 disturbed areas are vulnerable.

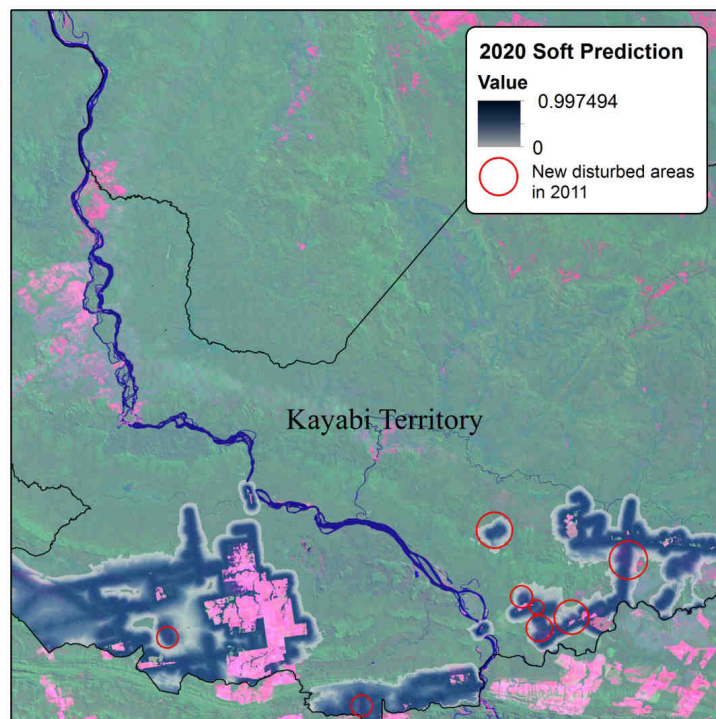


Figure 12. The 2020 soft prediction overlaid on a 2011 Landsat

This study was able to successfully simulate future deforestation expansion in the region and also, identified the main landscape attributes driving deforestation expansion in the Kayabi Territory. Distance from roads and distance from existing disturbance were found as the key factors driving deforestation. Nevertheless, other important aspects have great impact on LUCC. For instance, despite the demarcation of the Kayabi Territory intended conservation of the forest it seems that, far from its purpose of protecting it, it increased the deforestation rates because the uncertainty to the land owners of their land tenure. Single farmers were the most active actors in the deforestation process. However, selective logging activities were found to happen in the territory, it is believed that these activities are product of ‘opportunistic’ land grabbers and loggers that seize existing roads (and develop new ones) to gain access to forest resources. The soft prediction maps simulated in this study provide excellent means for monitoring areas where selective logged has happened and therefore to protect new areas that are susceptible to be disturbed.

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5. Biographies

Hugo de Alba has an MSc in GI Science from Birkbeck, University of London. He has work experience in the environmental assessment field. His research interests include landscape modelling, GI applications in clean energy projects and spatial analysis.

Joana Barros is a lecturer in GI Science at Birkbeck, University of London. Her research interests include computational models of geographical systems, agent-based simulation models of urban systems, as well as urban growth and change in developing countries.

Understanding Landscape Visualisation for Visual Impact Assessments

Lock, David.J.¹

¹LDA Design, Worton Rectory Park, Oxford OX29 4SX

Tel. +44 865 887050 Fax +44 865 887055

David.lock@lda-design.co.uk, web <http://www.lda-design.co.uk/>

Summary: With modern planning policy and the shift to neighbourhood planning through the localism bill understanding the potential visual impacts that may arise from a development is more relevant now than ever before. Whether for 200m high wind turbine developments or to understand how visible a drain culvert will be within a park both planners and developers want to understand where the visibility will be. As part of an environmental statement and in standalone landscape and visual impact assessments, landscape architecture companies undertake analysis of their designs to ensure they understand the potential effects and therefore to inform mitigation strategies.

KEYWORDS: Landscape Visualisation, Zone of Theoretical Visibility, ZTV, Viewshed, Wind Farm LVIA.

1. Introduction

As a well-established tool within most modern GIS, viewshed analysis is often demonstrated as one of the easiest and useful planning and design aids with a GIS. The concept of highlighting areas from which new, or old, objects can be seen and then overlaying this onto mapping is one that most people can understand. In fact for most large planning applications the inclusion of some visual analysis is seen as paramount and the ability to use viewshed analysis often prevents the need for large numbers of photomontages. However the technical aspects behind creating viewsheds are not always as simple as a few clicks of buttons. Instead the design might call for a raised / lowered landform, or questions might be raised as to whether surface models or bare ground assessments should be undertaken. A issue often then arises as most GIS users are introduced to the tools and the outputs without a full understanding of results and how they should be interpreted or even how the inputs need to change in different circumstances. With more bodies, both academic and commercial, adopting GIS for viewshed analysis these accidental misinterpretations are becoming increasingly common. These interpretations are then further compounded by published guidance documents which adopt specific calculations that differ from those built into the commercially available GIS tools making the outputs incorrect to those accepted by the planning bodies. Even without issues of reliability and correct interpretation the GIS analyst is also now faced with questions arising from the commonality of having to interpret multiple viewsheds and how together they cause an “impact” on an area. So what pitfalls should viewshed users ensure are missed? What are some examples of how the guidelines differ from common viewshed tools? And in what ways can other GIS techniques allow for the easier interpretation of multiple viewshed analysis?

2. Following published guidance

In parallel to the development and adoption of GIS there has been numerous papers published which deal with viewshed analysis, indeed the majority of generic GIS guides even explains the viewshed tool and its key concepts. With the publication of papers such as Riggs P D and Dean D J (2007) discussions on issues with viewshed analysis move one stage further but these documents are not as readily recommended to most analysts and so the conclusions are often unheeded. Instead the often publicised viewshed works tend to focus on the implementation of the viewshed and how it aids design. In both Sparkes A and Kidner D (1996) and Foley R (2003) the examples of viewshed analysis on proposed wind farm developments are made. These developments lend themselves to the

tools within viewshed analysis as they tend to contain extremely tall “point” features that have a controversial visual impact and a large study area (often over 30km radii from the proposed developments). To standardise the implementation of viewshed analysis in wind farm planning in 2007 there was the publication of the Scottish Natural Heritage’s Visual Assessment of Windfarms: Best Practice Guidance document (University of Newcastle, 2002). This has helped to develop and standardise best practices within the Wind Farm industry and within most planning authorities has become accepted best practice for the production of all computer generated visualisation techniques (both viewshed and wire framed figures).

3. Understanding errors / differences

With the publishing of guidance for viewshed analysis the GIS specialist then has to become aware of how the algorithms their chosen GIS software differs from the base versions used by the governing body. Although a majority of GIS programmes offer viewshed analysis papers such as Fisher P F (1993) highlight that the outputs can differ completely. Even once the professional has stated which software was used to create a viewshed differences can arise from the extra factors implemented onto the model. As an example the earth curvature model published within the Scottish Natural Heritage’s Visual Assessment of Windfarms: Best Practice Guidance document (University of Newcastle, 2002) is shown as Equation 1 whilst the curvature and diffraction model within ArcGIS is highlighted by Equation 2.

$$h = \frac{C^2 (1 - 2k)}{2r} \quad (1)$$

c : distance to the object in metres
k : is the refraction coefficient (0.075)
r : the radius of the Earth in metres (6,376,000)

$$Z_{\text{actual}} = Z_{\text{surface}} - \left[\frac{\text{Dist}^2}{\text{Diam}_{\text{earth}}} \right] + \left[R_{\text{refr}} * \left[\frac{\text{Dist}^2}{\text{Diam}_{\text{earth}}} \right] \right] \quad (2)$$

Dist : The planimetric distance between the observation feature and the observed location.
Diam : The diameter of the earth (12,740,000 meters)
R_{refr} : The refractivity coefficient of light (0.13).

As both of these equations differ in their representation of both the earths size and refraction due to atmospheric issues and on the exact equation the results are therefore different. Although for a small site with a study area of a few kilometers the curvature of the earth will have minimal affect as the study area increases the effect is increased exponentially. Exploring Table 1 highlights how by a 35km study radius the curve alone would mask a 80m (or 70m) object. Table 1 also highlights however that the difference between the Scottish Natural Heritage’s Visual Assessment of Windfarms: Best Practice Guidance document and that built into ESRI’s ArcGIS product becomes fairly important (with a discrepancy between the two of over 10m at 35km from the site).

Table 1. Earth Curvature Differences

Distance to development (km)	<i>SNH Vertical Correction (m)</i>	<i>ESRI Vertical Correction (m)</i>
5	1.669	1.452
10	6.675	5.808
15	15.019	13.069
20	26.700	23.234
25	41.719	36.303
30	60.705	52.276
35	81.769	71.154

As the viewshed tool within ArcGIS does not allow manipulation of their earth curvature calculation, the creation of a curved surface to which all terrain maps are draped has been the solution to ensure that outputs are to the guidance standards. Additional to this the creation of this curved surface has allowed the export of curved XYZ files to be used in the production of wireframes allowing the photomontages to be a more accurate version of the final development.

Although these mathematical errors occur depending on the software or guidance adopted the greater error with viewshed analysis is with the lack of acknowledgement of the false positive within digital surface viewsheds. When working with a digital surface model the GIS is unaware of the “obstructions” in views (for example a building or woodland) until after it has assessed visibility as if the viewer was standing on top of the obstruction (see Figure 1).

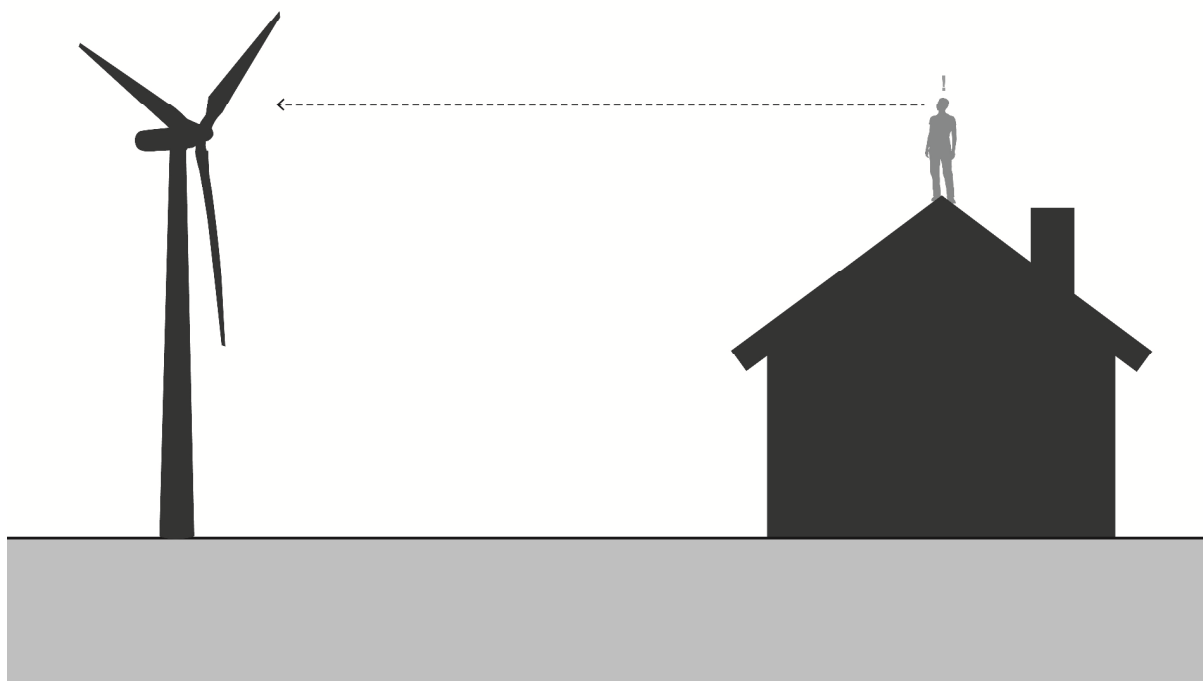


Figure 1. Visibility caused by a surface model viewshed

Obviously from a visual perspective both roof tops and the tops of trees are not likely locations from which the development is visible and instead Figure 2 shows how it should be a negative viewshed response instead of a positive.

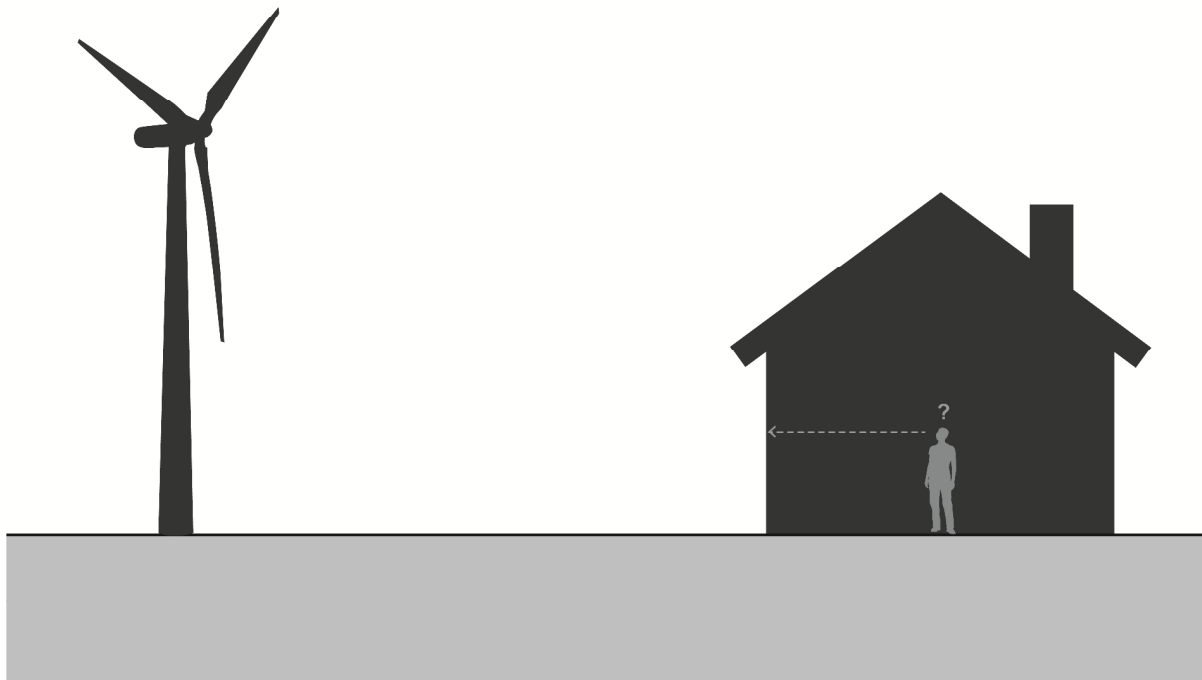


Figure 2. Actual visibility

To enable this, the GIS analyst must therefore be aware of the “False” positives from a surface model viewshed and remove them by questioning surface and bare ground terrain to ascertain where they exist.

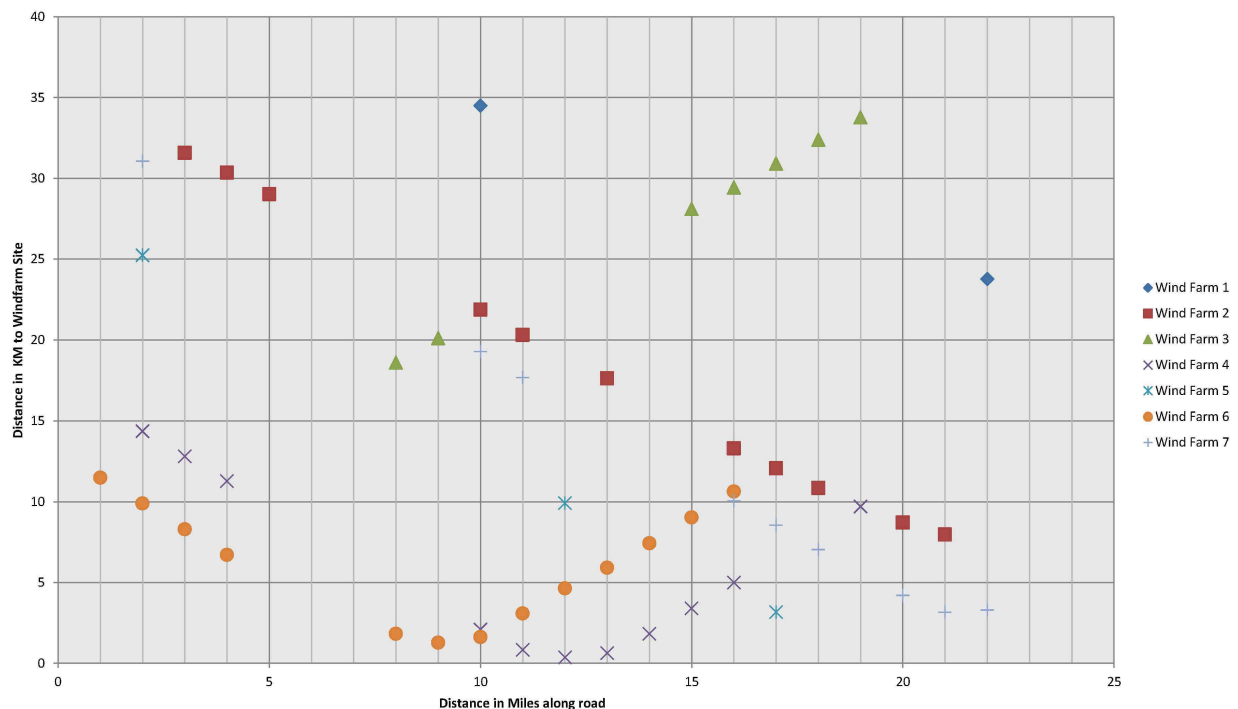
4. Moving viewshed analysis forward

With viewshed analysis common practice within planning applications and users having an understanding of how the tool actually works it becomes possible to find other applications to undertake viewshed work. Although most analysis ends with the production of a plan which provides a yes/no answer to whether a development is visible or not further analytical techniques can give the developer far greater details. For example using the positive results of a viewshed as point locations to run a “reverse” viewshed (with the observer and object attributes switched) it is possible to create a zonal plan showing areas of high visual impact compared to the areas of low visual impact within a development boundary. This tool can then be modified further by ranking different landscapes so that the views from protected landscapes (such as national parks) are more important than those of brownfield sites. Figure 03 shows a reverse viewshed analysis of Peterborough cathedral with the lighter grey areas having a greater visibility and this decreasing to areas of black with no visibility of the Cathedral.



Figure 3. Reverse viewshed of Peterborough Cathedral

Another under used method for using viewshed analysis is to understand the impact of height by applying numerous points at the same location but different heights to get a gradient viewshed to understand at which height the object becomes visible to different locations (for example will the observer only see the wind turbines blades or can they see $\frac{3}{4}$ of the towers as well). With Viewshed analysis also being adopted to understand cumulative impacts from numerous wind farm developments in a small area it also becomes apparent that overlaying numerous viewsheds to understand impact is not always the most feasible analysis. Instead through processing the viewsheds into yes/no information and interpolating this onto points of distance to the turbine and distance along linear features (the often used example is roads) it is possible to graphically show the visibility of different sites as the observer would travel along the road (Figure 4 is one such graph).



Currently this tool has been developed for use on wind farm cumulative impact assessment but with a little modification it could have use within any linear visual projects (for example the visibility of tourism sites along the royal mile, or the visibility of standing stones along the avenue on Salisbury plain).

2. Acknowledgements

Steve Dredge, Applications Manager Associate, LDA Design
LDA Design Consulting LLP

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4. Biography

David's current role is as the GIS Manager for one of the largest landscape architecture firms in the UK (LDA Design) whilst also undertaking an MSc in GIS from Southampton University. David's role includes working across GIS platforms whilst developing spatial analysis, theoretical visibility and master planning solutions.

OSM-CAT: A Java tool for OpenStreetMap Contributor Analysis

Peter Smith and Peter Mooney

Department of Computer Science, National University of Ireland Maynooth,
Co. Kildare, Ireland

Tel. +353-1-708 3847 Fax +353-1-708 3848

Email: peadar81@gmail.com

, peter.mooney@nuim.ie

<http://www.cs.nuim.ie/~pmooney/OSM-CAT>

Summary: In this paper we describe a new Java-based software tool called OSM-CAT (OpenStreetMap Contributor Analysis Tool). OSM-CAT allows GIS researchers to analyse OSM-XML data (for any given area). OSM-CAT produces a large set of output including: breakdown and analysis of who contributed to the OSM data in the chosen area, what types of contributions were made, when these contributions were made, and the accuracy of tagging based on the rules outlined in the OSM Map Features Ontology. It removes the requirement for the user to have any knowledge of handling of OSM-XML data.

KEYWORDS: OpenStreetMap, Quality, Web GIS, VGI

1. Introduction

OpenStreetMap (OSM) is the most famous example of Volunteered Geographic Information (VGI) (Goodchild; 2007) on the Internet today. It hardly requires any introduction to the GIS community. (Sui and Goodchild; 2011). Papers such as Ciepluch et al. (2009), Haklay (2010), Haklay et al. (2010), Girres and Touya (2010), Over et al. (2010), and Mooney and Corcoran (2012) have firmly placed OSM in the research agenda of GIS. However there still appears to be some reluctance amongst GIS researchers to use OSM for “serious geomatics” (Over et al.; 2010) or geographical analysis such as landcover change (Ludwig et al.; 2011). As reported in previous papers by our research group (Mooney et al.; 2010; Mooney and Corcoran; 2011b, 2012) one of the reasons for this reluctance is the availability of raw OSM spatial data in OSM-XML format which many researchers find difficult to work with (Mooney and Corcoran; 2011a) and XML in general (Dunfey et al.; 2006). Other reasons include concerns about the quality of the OSM data, OSM contributor skills and backgrounds, and inhomogeneity of coverage. In this paper we describe the functionality of a new Java-based software tool called OSM-CAT (OpenStreetMap Contributor Analysis Tool). OSM-CAT allows GIS researchers to analyse OSM-XML data (for any given area). OSM-CAT produces a large set of output including: breakdown and analysis of who contributed to the OSM data in the chosen area, what types of contributions were made, when these contributions were made, and the accuracy of tagging. OSM-CAT has been developed as part of an MSc in Computer Science and Engineering with the goal of providing users with a tool to analyse characteristics of contributions to OSM for small areas. OSM-CAT is not intended as a replacement for tools such as OSMOSIS or osm2pgsql or TagInfo and others which are already used widely in the OSM community. Rather this adds to the list of available tools by providing specific application functionality. The software is available to download at <http://www.cs.nuim.ie/~pmooney/OSM-CAT>

2. Overview of the OSM-CAT tool

There are a number of similar tools available which provide information on contributions to OpenStreetMap. AltogetherLost (2011) provides a graphical interface to statistics about the global

OpenStreetMap database with some information on contributors such as number of members who are the last modifier of at least one OSM object (Node, Way or Relation) in the past day. Neis (2011c) allows the comparison between any two OSM contributors on competitions such as “Which OSM contributor edited most nodes?”. How did you contribute to OSM by Neis (2011a) is similar as it displays the summary of edits performed by a single contributor. The OSM Heat Map (Neis; 2011b) overlays a heat map on a web-based map to indicate where a given contributor carried out the most edits. Changesets are an important concept in contributions to OSM. A changeset is a group of edits made within a certain time by one user. A changeset has a maximum capacity (currently 50,000 edits) and maximum lifetime (currently 24 hours). Edits can only be added to a changeset as long as it is still open. A changeset can either be closed explicitly, or it closes itself if no edits are added to it for a period of inactivity (currently one hour). The OpenStreetMap Watch List (OWL) by Amos (2011) shows changes to areas by comparing changesets for that area. While all of these tools are very useful we felt that there was a gap in the available tools in accessing more detailed information about contributions and the data for given OSM area.

2.1. Functionality of OSM-CAT

The functionality provided by OSM-CAT includes:

- ⤴ Summary Information: OSM Primitive Data Overview including total number of edits, nodes, ways, relations, and changesets
- ⤴ Changeset Information: An analysis of the number of changesets produced by each contributor. This information is provided in tabular and graphical formats
- ⤴ Activity in Changesets: This provides a summary of the timespan between changesets (longest and shortest) for each contributor
- ⤴ Overall Contributions: Tabular and graphical summary of the total number of contributions per month since oldest edit in chosen area
- ⤴ Individual Contribution Rates: Number of edits per month from the top N contributors (tabular and graphical)
- ⤴ Map Features and Tag Validity: OSM-CAT provides a summary of the number of valid and invalid assignments to the tag keys for all qualifying objects.
- ⤴ Polygon Validity: Using the Java Topology Suite library OSM-CAT outlines any polygons (ways) which are invalid such as those with self intersections.

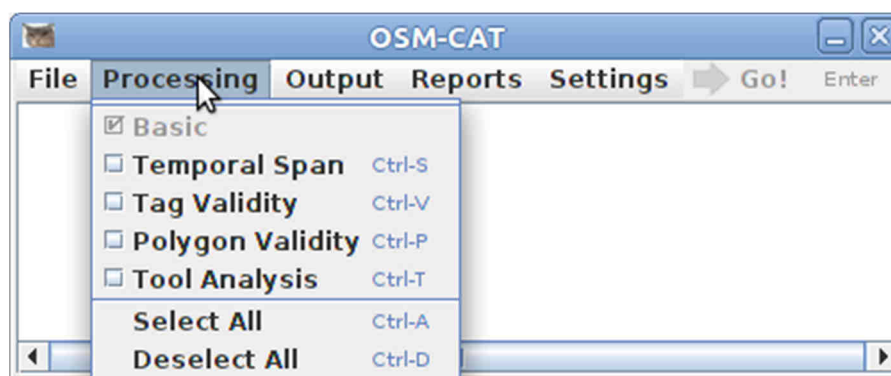


Figure 1: The graphic user interface to OSM with the functionality menu extended to show all options available.

3. Case-study example usage.

In this case-study we used OSM-CAT to perform analysis on OSM-XML data from 60 European cities (3KM square grids). The OSM-XML data was automatically downloaded from the OpenStreetMap servers on November 10th 2011. Cities were chosen to provide a very good distribution of contribution types and spatial coverage to OSM. The purpose of the case-study is to show the types of statistics that can be generated by OSM-CAT, which may otherwise be difficult for those not familiar with OSM-XML to generate. There is no scope in this paper to discuss the implications of the results but we comment on some of the statistics below.

- ▲ The top 10 locations sorted in order of total number of nodes are: 1. Paris 244, 872, 2. Lyon 194, 913, 3. Prague 152, 282, 4. Ruhr-NorthRhine-Westphalia 138, 836, 5. Karlsruhe 115, 992, 6. Bratislava 114, 774, 7. Wien 106, 640, 8. Stuttgart 106, 619, 9. Helsinki 105, 643, and 10. Salamanca 103, 870.
- ▲ The top 10 locations sorted in order of the total number of contributors are as follows. Their ranking overall in terms of number of nodes is provided in brackets. London 553 (16th), Wien 511 (7th), Munich 510 (13th), Berlin 506 (23rd), Paris 322 (1st), Meunster 318 (36th), Stuttgart 293 (8th), Karlsruhe 284 (5th), Moscow 263 (19th), and Zurich 257 (20th).
- ▲ The top 10 locations sorted in order of the total number of Points-of-Interest (POI) nodes (nodes with a "name" attribute): London 5, 072 ,Wien 5, 051 ,Munich 3, 831 ,Paris 2, 998 ,Berlin 2, 699 ,Helsinki 2, 132 ,Zurich 2, 090 ,Prague 1, 823 ,Stuttgart 1, 767 ,Copenhagen 1, 752
- ▲ The top 10 locations sorted in order of the users with the largest number of changesets for that location are provided as follows. In each case the users changesets are expressed as a percentage of the total number of changesets for that location. Birmingham 1817 (69%), Helsinki 1355 (35%), Copenhagen 1355 (34%), Milano 1152 (52%), Zagreb 918 (57%), Paris 833 (26%), Oslo 810 (52%), Dublin 690 (25%), Innsbruck 651 (35%), and Brussels 631 (36%). This analysis can help identify dominant contributors for a given area.
- ▲ OSM-CAT checks tags (key value pairs) against the community agreed ontology of tagging on OSM Map Features Wiki page. There were a number of recurring problems. These are summarized as follows: "railway=platform" has been replaced by "public-transport=platform" and this problem occurs 213times in 43 cities. For mapping fire-hydrants "amenity=fire hydrant" occurs 416 times in 39 cities. This has changed to "emergency=fire hydrant". The tagging for motorcycle parking "amenity=motorcycle parking" occurs in 49 cities on 318 occasions. This tagging is not officially sanctioned in the OSM Map Features ontology. Other frequently occurring problems regarding assignment of objects to the wrong class include: "building=hospital", "building=church", "access=restricted".

3. Summary, conclusions, and future work

The role of contributors to VGI and OpenStreetMap is crucial. Coleman et al. (2009) argue that the participants in the production process of VGI are both users and producers or "prosumers". Assessing the credibility of contributors is important to evaluating the overall reliability of their contribution. OSM-CAT provides a user-friendly means of performing analysis of contributions to OSM for a given area and identifying who the key contributors are, when they have contributed, and how accurate their tagging is (against the OSM ontology). In the case-study example we showed some results of using OSM-CAT to analyse contributions to OpenStreetMap in 60 European cities. OSM-CAT processed, and computed all relevant statistics, for all files (up to 100MB) in less than 3 minutes. OSM-CAT is a fully Java-based tool. Currently OSM-CAT is desktop-based. We will look to extend the functionality to a web-based version of OSM-CAT. This will allow us to build a Web Map interface for geographical area selection. Users will also be offered functionality to upload old

versions of OSM-XML data where the changes in contributions over time can be compared with the current snapshot of the OSM data for that location.

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8. Biography

Peter Smith is an MSc student in Software Engineering at the Department of Computer Science NUI Maynooth. He is currently working as a software developer with Ericsson Research and Development, Athlone, Ireland. Dr. Peter Mooney is a research fellow at the Department of Computer Science NUI Maynooth and he is funded by the Irish Environmental Protection Agency STRIVE programme (grant 2008-FS-DM-14-S4).

Spatially Weighted Geodemographics

*Muhammad Adnan, **Alex Singleton, *Paul Longley

*University College London, Department of Geography, Gower Street, London, WC1E 6BT.

Tel: +44 (0)20 7679 0510 Fax: +44 (0)20 7679 0565

Email m.adnan@ucl.ac.uk, plongley@geog.ucl.ac.uk

** University of Liverpool, Department of Geography.

Email alex.singleton@liverpool.ac.uk

Summary: In their current form, geodemographic classifications are created without the knowledge of the contiguity structure of the geographic units. Spatially weighted geodemographics is created by adding spatial contiguity constraints, in addition to the attribute information, in the geodemographics building process. This paper presents a summary of our research to date in this area and describe a procedure of creating spatially weighted geodemographic classifications.

KEYWORDS: Geodemographics, GIS, Clustering, Spatial Autocorrelation

1. Introduction

Geodemographic classifications are created by the cluster analysis of multidimensional socio-economic data. In their standard form, clustering algorithms do not account for spatial associations of the neighbourhood entities. Thus the final geodemographic classifications produced are not location aware. However, geodemographics gets power from Tobler's First Law of Geography which states "Everything is related to everything else, but near things are more related than those far apart" (Tobler 1970). Thus the socio-economic characteristics of neighbouring areas are expected to be similar than those of the distant areas. Incorporation of the spatial contiguity constraints could result in geodemographics where the two residential neighborhoods that are close to one another are most likely to be similar than the ones that are more geographically separated. Thus the procedure of creating the classifications account for both the socio-economic characteristics and spatial weights of the geographical areas.

K-means clustering algorithm has remained the core algorithm for the computation of geodemographic classifications. In addition to k-means, several other algorithms have been proposed over the last two decades. However, they all deal with the case of independent data. Local measures of spatial autocorrelation, Local Moran's I (Anselin, 1995) and local Getis-Ord statistics (Getis & Ord, 1992), give a basis for assessing the spatial clusters. These measures provide a way to assess univariate variables in the dataset based on the knowledge of geographical entities, whether close to one another or geographically separated. These methods combined with the standard k-means clustering algorithm enable us to create location aware geodemographic classifications. This paper provides preliminary work towards the creation of spatially weighted geodemographic classifications.

2. Measures of Spatial Autocorrelation

Spatial autocorrelation is multidirectional and multi dimensional in nature, and thus it is complex than the normal correlation. (Boots, 2002) describe that there are global and local measures of spatial autocorrelation which can be used according to the problem definition. If a summary of spatial autocorrelation of entire region is required, then global measures are useful. However, local measures are useful to identify hotspots or local clusters in the dataset. A spatial autocorrelation is expected to be positive when similar values occur in two adjacent neighbourhoods, and vice versa.

Moran's I is a well know global measure of spatial autocorrelation. Moran's I is calculated as a ratio of the product of the variable of interest and its spatial lag, with the cross product of the variable of interest, and adjusted for the spatial weights used.

$$I = \frac{n}{\sum_{i=1}^n \sum_{j=1}^n w_{ij}} \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^n \sum_{j=1}^n w_{ij}} \quad (1)$$

Where y_i is the i -th observation, $\bar{y}$ is the mean of the variable of interest, and w_{ij} is the spatial weight of the link between i and j . Centering on the means is equivalent to asserting that the correct model has a constant mean, and that any remaining patterning after centering is caused by the spatial relationships encoded in the spatial weights.

Global measures of spatial autocorrelation are useful when the spatial dependence is uniform over the study region because they emphasize on the average spatial dependence of the study region. If the underlying spatial dependence is not uniform or the size of the study region is large, then global measures may not be quite useful. This is essentially the case in creating geodemographic classifications, where different variables may not be uniformly distributed over all the geographical areas. Also, geodemographic classifications are created at very finest geographical levels e.g. Postcode or Output Area levels in the UK. Hence, global measures of spatial correlation may not be representative in this case. Local measures of spatial correlation are useful in this scenario because these measures aim at identifying patterns of spatial dependence within the study region (Boots, 2002).

There are different version of local measures of spatial autocorrelation. Local Moran's I and Getis-Ord statistics are famous once. Local Moran's I was proposed by Anselin (1995) and it is defined as follows:

$$I_i = \frac{z_i \sum_{j=1}^n w_{ij} z_j}{\sum_{j=1}^n z_j^2 / n} \quad (2)$$

For any $i=1, \dots, n$, large positive I_i values indicate local clustering of data values around the i -th location. However, large negative values indicate that the sign of data value at i -th location is the opposite to those of its neighbours.

Getis-Ord statistics was defined by Getis and Ord (1992). It is based on the definition of a neighbourhood for each location given by those observations that fall within a critical distance.

$$I = \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} x_i x_j}{\sum_{i=1}^n \sum_{j=1}^n x_i x_j} \quad (3)$$

Where w_{ij} is the (i, j) -th element of a symmetric binary matrix of spatial weights, i.e. w_{ij} is 1 for neighbouring locations and 0 elsewhere.

Local measures of spatial autocorrelation provide a basis for assessing and analysing the presence of spatial clusters. However, these measures are univariate in nature i.e. they operate on one variable at a time. But geodemographic classifications are created by the cluster analysis of multiple variables. Therefore, an automatic clustering procedure which optimize some criterion for the identification of clusters of spatial units based on both attribute information and their contiguity structure is required.

The next section builds up a case study of creating a spatially weighted geodemographic classification by using a local measure of spatial autocorrelation i.e. Getis-Ord statistics.

3. Building Spatially Weighted Geodemographics

This section builds up a case study of creating a spatially weighted geodemographic classification by using Getis-Ord statistics. 2001 Census inputs to the National Statistics Output Area Classification (Vickers & Rees, 2007) aggregated at Ward level were used for this purpose. Greater London was used as the study area.

For this case study, two variables "Rent (Public)" and "2+ car household" from 2001 census data, aggregated at Ward level for Greater London, were used. Following figures (1-2) show the distribution of data for these two variables in Greater London.

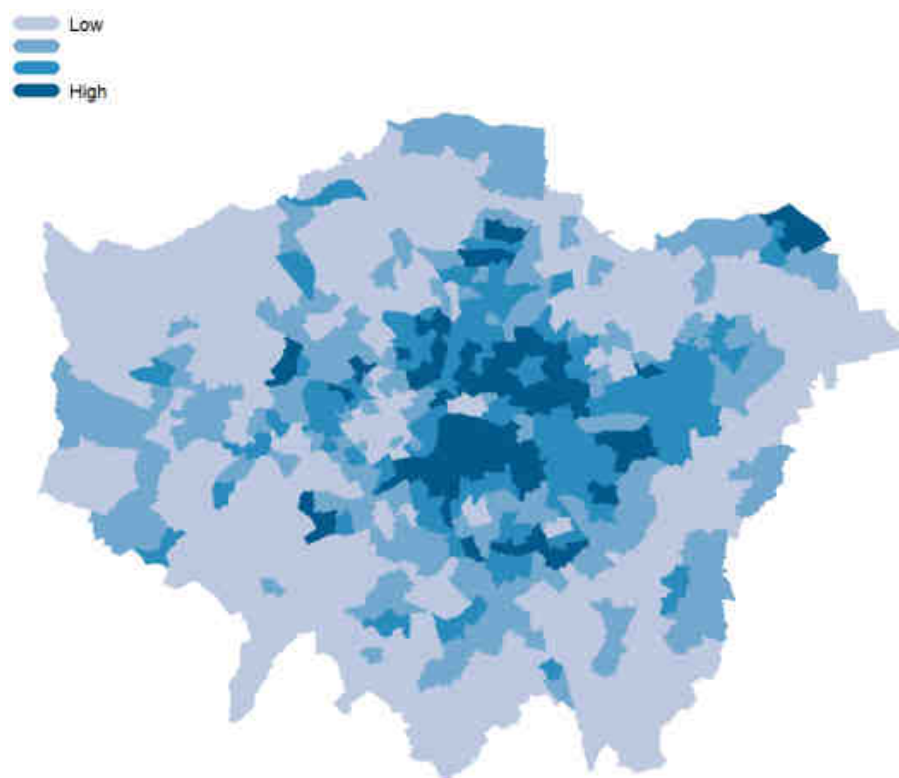


Figure 1: Distribution of data for the variable "Rent (Public)"

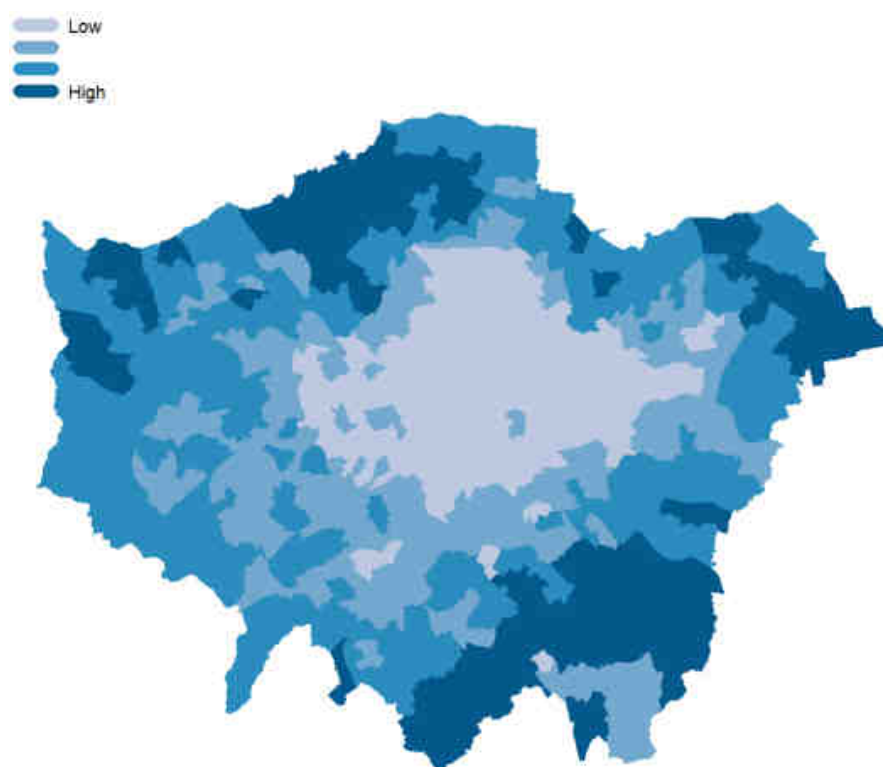


Figure 2: Distribution of data for the variable "2+ cars households"

Our suggested way of computing spatially weighted geodemographics classification has following steps:

- a) Create spatial weights for the geographical areas
- b) Construct new variables by applying local measure of spatial autocorrelation
- c) Find the optimal number of cluster solutions
- d) Perform cluster analysis on the spatially weighted variables

3.1 Create spatial weights for the geographical areas

Creating spatial weights is the first step in performing an autocorrelation analysis. The process determines the set of neighbours for each geographical area and then assigns weights to each neighbourhood relationship.

The following figure (3) shows the use of k -nearest neighbour technique to determine the neighbours of the 633 wards in Greater London. K -nearest neighbours method constructs a neighbourhood matrix by assessing the spatial context of a fixed number of its closed geographical areas. K (the number of neighbours) = 4 was used as the input, and K -nearest neighbour method uses 4 closed neighbours to the target geographical area in the computation.

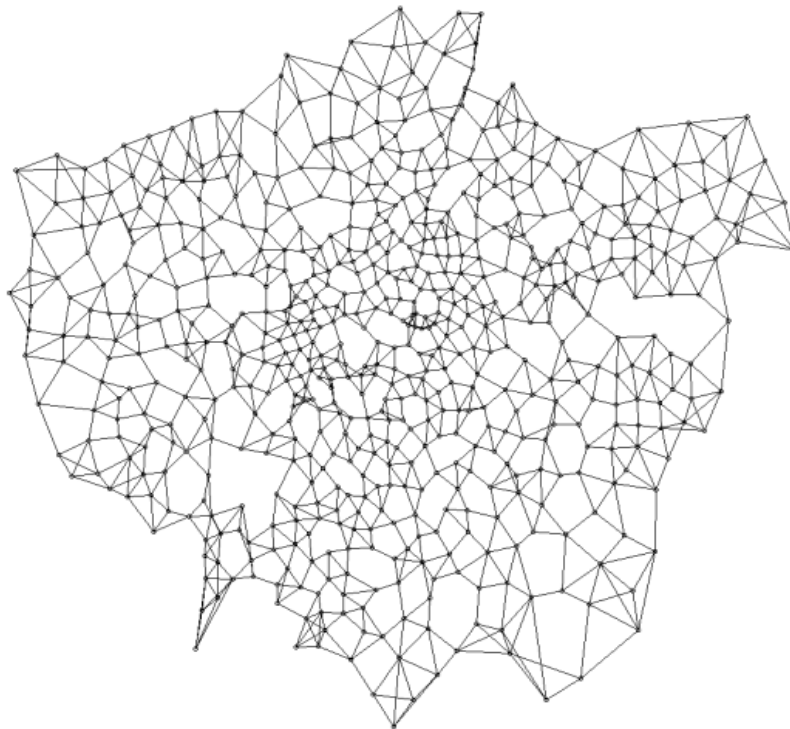


Figure 3: Determining Neighbours of each geographical entity (K=4 neighbours)

After constructing the neighbourhood matrix, a distance constraint was used to construct the final spatial weights.

3.2 Construct new variables by applying local measures of spatial autocorrelation

In this step, Getis-Ord statistics (Getis and Ord, 1992) was used to construct new variables. Getis-Ord statistics is explained in detail in section 2 of this paper. "Rent (Public)" and "2+ car household" variables from 2001 census data, aggregated at Ward level for Greater London, were used. These two variables were used in combination with the spatial weights matrix created in the previous step (3.1). The output of the Getis-Ord statistics are the variables which account for both the socio-economic characteristics and spatial weights of geographical areas.

3.3 Finding the optimal number of clusters

(Vickers & Rees, 2007), citing the reduced average distance to the cluster centre when the number of clusters was incremented, picked seven clusters when building the OAC geodemographic classification for United Kingdom. Bearing this point in mind, following figure (4) plots the change in 'within sum of squares' by incrementing 'number of clusters', obtained by running *k*-means on the two spatial weighted variables created in the previous step (3.2).

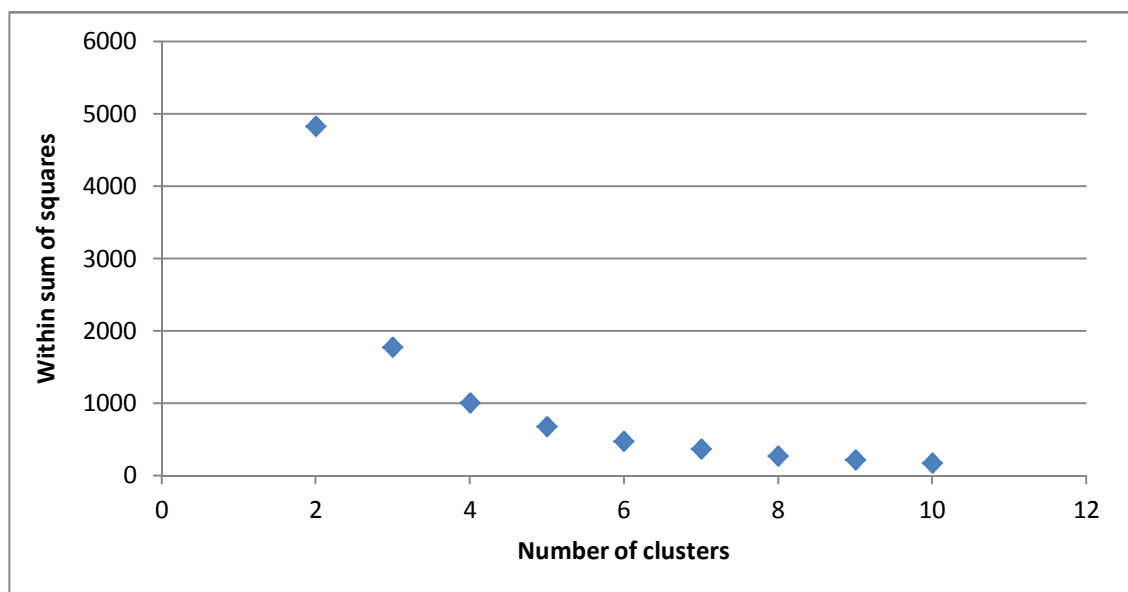


Figure 4: Within sum of squares by number of clusters

K=4 could be taken as a desirable number of clusters. Reductions in the 'within sum of squares' figure are not great from k=4 to k=10.

3.4 Perform cluster analysis on the spatially weighted variables

K-means was used to cluster the two spatial weighted variables variables into homogeneous groups. *K*-means seeks to find a set of cluster centroids that minimises expression (4) below.

$$V = \sum_{x=1}^n \sum_{y=1}^n (z_x - \mu_y)^2 \quad (4)$$

Where n is the number of clusters, μ_y is the mean centroid of all the points z_x in cluster y . The *k*-means algorithm assigns a set of n seeds within the data set and then proceeds by assigning each data point to its nearest seed. Cluster centroids are then created for each cluster, and the data points are assigned to the nearest centroid. The algorithm, then, re-calculates the cluster centroids and repeats these steps until a convergence criterion is met (usually when the switching of data points no longer takes place between the clusters).

The following figure (5) shows the result of the *k*-means applied to the two spatially weighted variables.



Figure 5: Output of the Cluster Analysis

The result shows a clear grouping of areas closer to each other. The final outcome of the cluster analysis incorporates both the attribute information of the variables and the contiguity structure of the neighbourhood areas.

4. Conclusion and future work

This paper has presented preliminary work towards the creation of spatially weighted geodemographic classifications. A series of steps, important for the creation of location aware geodemographics, have been explained. The procedure is the implementation of *k*-means clustering algorithm applied to a set of variables expressing local spatial autocorrelation.

Because this technique was applied to two variables, future work will involve the implementation of the same methodology on large number of variables e.g. 41 census variables (Vickers & Rees, 2007).

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6. Biographies

Muhammad Adnan is working as a Research Associate at the Department of Geography, University College London. His research interests concern the automation of spatial data infrastructures, and the optimization of clustering algorithms.

Alex Singleton is a Lecturer in Urban Planning at the University of Liverpool. Within a framework of Geographic Information Science, his research extends a tradition of area classification in Geography and Planning and has developed an informed critique of the ways in which geodemographic methods can be refined for effective yet ethical use in public resource allocation applications. This research has developed from substantive interests investigating the social, spatial, and temporal dimensions of access inequalities in Higher Education.

*Paul Longley is Professor of Geographic Information Science at University College London. His publications include 14 books and more than 125 refereed journal articles and book chapters. He is a co-editor of the journal **Environment and Planning B** and a member of five other editorial boards. He has held ten externally-funded visiting appointments and given over 150 conference presentations and external seminars.*

An Agent-Based Population Model for Wolverhampton, UK: a spatio-temporal activity based approach to population modelling

Walker, Laura¹, Barros, Joana²

GEDS, Birkbeck, University of London, Malet Street, London WC1E 7HX

Tel +44 (0) 207 079 0644; Fax +44 (0) 20 7631 6498

¹Laura.Walker@atkinsglobal.com, ²j.barros@bbk.ac.uk

Summary: This study presents the development of a prototype model representing the dynamic population across a 24 hour period using an agent-based model, using an activity-based approach by assigning journeys and activities to agents representing different population groups within Wolverhampton, UK. The model simulates dynamic movement of population throughout the day, which provide advantages over comparable traditional static mapping outputs by allowing the exploration of information on the dynamic movement of individuals within the population which cannot be done through static snapshots. Agent-based models, when integrated to geographic information, have potential to develop more advanced and complex representations of the population.

KEYWORDS: population modelling, agent-based, spatio-temporal, dynamic population, movement

1. Introduction

The use of population data has been important for public and private sector organisations in the development of specific policies and plans requiring an understanding of density, distribution and location of the population. Common approaches to representing the distribution of the population through Geographical Information Systems (GIS) often provide only the residential location as a proxy for measurement through a ‘static snapshot’ of time (Martin, Cockings, & Leung, 2009). However, in reality the distribution of the population is dynamic and the location of the population is continually changing throughout time and across space. These changes occur across the day and between different days of the week and also at different times of the year. By using the residential location of the population alone it is argued that we are in effect simply representing the night-time population of a given place (Bhaduri, Bright, Coleman, & Dobson, 2002). The spatio-temporal dynamic nature of the human population can have an impact on where and when certain services should be provided and thus the need to examine the ways in which this dynamic movement can be modelled has attracted interest in the field of Geography over the past 40 years (Kwan, 2004).

Traditional proprietary GIS has limitations in being able to accurately model the population due to their restrictive ability to model temporal changes. In addition, the lack of detailed data at the individual level of a continuous nature is also a contributory factor that has often hindered the development of spatio-temporal modelling (Kwan, 2004; Crooks, Castle, & Batty, 2008). Recent advances in computer modelling have increased the opportunity to use geographic information to model the population through a variety of spatio-temporal modelling techniques, such as agent-based modelling (ABM). ABM provides an appropriate modelling environment in which to examine and to simulate population dynamic movements across space and time with the inclusion of agents representing the population and its interaction with different land use types.

Many difficulties in representing the location of the population in GIS are due to the lack of continuous data that is able to accurately model population over space and time (Heywood, Cornelius, & Carver, 2006). The collection of individual activity data is often a challenge due to the extensive costs and technology required to collect such datasets as well as data confidentiality issues associated with monitoring the daily activities of individuals (Longley & Batty, 2003). This means that aggregated population datasets are the most commonly used data sources for studies of the

population. Census data is the most comprehensive dataset available in terms of population data however in the case of the UK Census this only provides the residential, workplace and daytime (based on workers and residents) location of the population at a particular given point in time.

There are a number of factors which can impact on the population distribution and density of an area at any given time and therefore for the dynamic nature of the population needs to be considered in context of such requirements. Not only day and nighttime populations can be very different but also factors such as day of the week, whether it's the weekend or a holiday, and the season of the year can also have an impact. (Martin, Cockings, & Leung, 2009).

This study focuses on the development of an agent-based model representing the dynamic population across a 24 hour period. It uses data from the UK 2001 Census as well as other publicly available secondary data sources to create a basic prototype spatio-temporal population model of Wolverhampton, UK.

2. Modelling Population Dynamics in Wolverhampton

The prototype model for Wolverhampton population dynamics was developed using NetLogo. The choice for Netlogo was its GIS extension functionality available within the software as well as the basic level of programming skills required.

The table below summarises the data used in the project:

Table 1. Data sets and sources

<i>2001 Census data for England and Wales (Office for National Statistics)</i>	This dataset was used for output-area level data relating to overall resident population (Census table UV01), workplace population (Census table UV37) population by age group (Census table UV04), and data on economic status (economic activity Census table UV28)
<i>National Travel Survey 2009 (Department for Transport)</i>	This information provides statistics on personal travel including modes of travel and trip lengths at a national and regional level. This information was used to develop factors to apply to the local population by type of trip and the distribution of start times of different trip types throughout the day.
<i>Core Accessibility Indicators Database 2009 (Department for Transport)</i>	This is a national database designed to develop the core accessibility indicators for England. It includes geographical location information for education, leisure, and shopping establishments as well as number of jobs available at a Super Output Area level.
<i>Ordnance Survey Digital Mapping (Ordnance Survey) 2011</i>	Output Area boundaries were used to capture Census data at the smallest geographical area available. OS raster based mapping has also been used within this report.

Figure 1 provides a diagram of the main components of the conceptualised model. This shows that the model components consist of; agents representing the population (represented by 'turtles in Netlogo) and the land (represented by 'patches' in Netlogo), and the environment which represents the types of land use or activities.

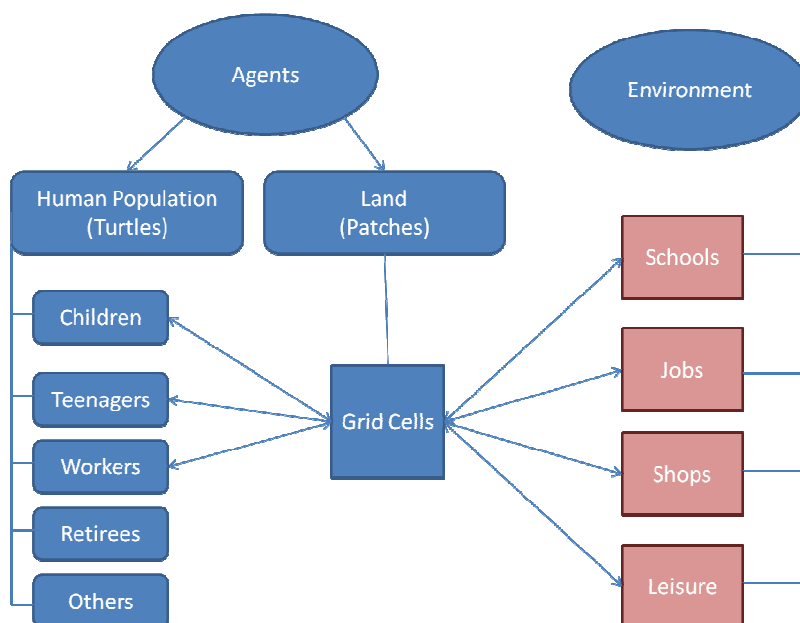


Figure 1. Model Flowchart

The agents in the model represent both the population and the land on which the population move around. The population is represented by of different types of agents which reflect different groups of people within society, each undertaking different travel patterns and activities throughout the day. These groups are described below with a description of their actions within the model.

Table 1. Population Types

<i>Population Types</i>	<i>Definition</i>	<i>% of population</i>	<i>Main activities</i>
<i>Children</i>	People aged 5-10 years old	8%	If no school in output area then will travel to a primary school. The NTS 2009 records that 41% of education trips leave between 8:00 and 8:59 and 32% are made between 15:00 and 15:59. Therefore the main procedure for children will be travel to and from school between these hours and then return to their home patch.
<i>Teenagers</i>	People aged 11-16 years old	8%	If no secondary school home patch then will travel to a secondary school. As with children teenagers will leave their home output area to head to secondary school between 8:00 and 9:00. Therefore the main procedure for teenagers will be to travel to and from school between these hours – and then return to their home patch.
<i>Workers</i>	Population aged 16-64 in full or part time employment	34%	Will travel to town centre or a patch with a minimum number of jobs or to the town centre. The leaving time for commuting trips (NTS0503) associated with workers is distributed across the day. However most trip occur between 7:00 and 8:59 and between 16:00 and 17:59

<i>Retirees</i>	All People aged 65 and over	19%	Involved in leisure and shopping journeys and activities throughout the day. Most shopping trips start and end between 10:00 and 12:59 and as such the main journeys involving this group of the population will take place during these hours.
<i>Others</i>	Includes all people not included within above groups	31%	Involved in leisure and shopping journeys and activities throughout the day. Most shopping trips start and end between 10:00 and 12:59 and as such the main journeys involving this group of the population will take place during these hours.

The environment within the model represents types of land use within the city. The types of land use are represented by variables ‘attached’ to ‘patches’ in the model. Each patch represents a land parcel in Wolverhampton. Census data at the OA level is disaggregated to the grid level in ArcGIS and then this is applied to the patches within the NetLogo model to provide population data. Data from the Core accessibility indicators including location of primary schools, secondary schools, retail and numbers of jobs were disaggregated to patch level.

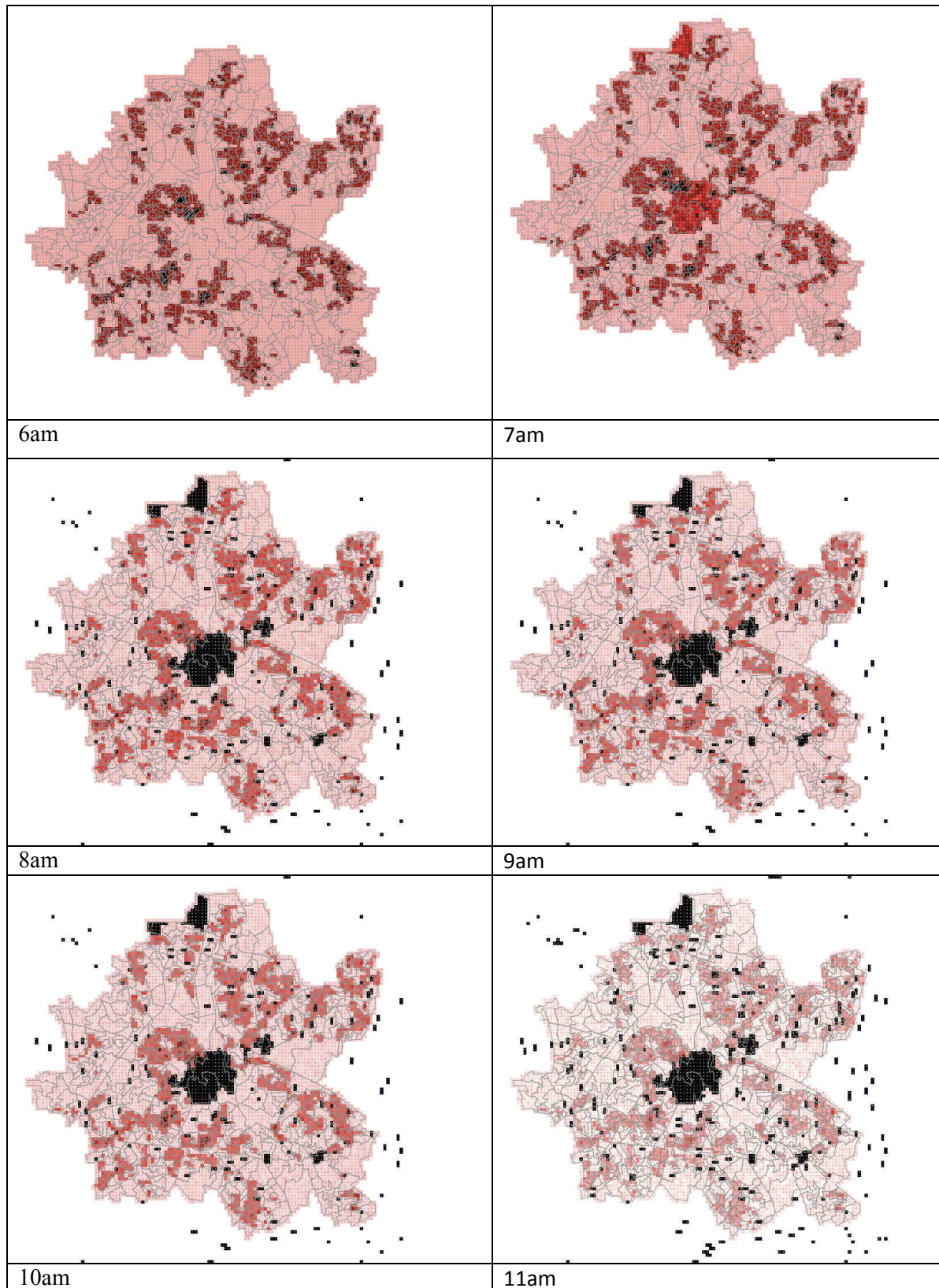
Table 2. Environment Variables within model

<i>Land-Use Type</i>	<i>Comments</i>
Education (Primary Schools & Secondary Schools)	The geographical coordinates of the schools located in Wolverhampton were taken from the Core accessibility indicator dataset from the DfT and verified using the Wolverhampton City Council website ¹ . Each primary school, secondary school and place of further and higher education was plotted in ArcGIS. Information on the number and type of school in the city was to each patch to in the model.
Jobs	The number of jobs at a Super Output Area level is available as collected through the DfT’s Core Accessibility Indicator data set. This data was aggregated to a 100m2 grid level for use at the patch level in NetLogo
Retail (Supermarkets and shops)	The geographical coordinates of supermarkets and shops located in Wolverhampton were taken from the Core accessibility indicator dataset. Information on the number of retail outlets in the city was disaggregated at patch level in the model.

2.1 Model outputs and results

Following the completion of the model development the model was run to simulate population movement over a 24-hour period in Wolverhampton. The outputs from this model included graphical output at each hour of the day showing the density of the population through a sum of all population located at each patch. Figure 2 shows the output views for selected hours of the day, with the darker patches representing denser populated areas and lighter patches reflecting lowest population density. This shows that through the early hours of the morning those population densities are highest in the residential areas especially those built up areas with multi-occupancy buildings. Between 7am and 6pm the most populated areas are within the city centre.

¹ http://www.wolverhampton.gov.uk/education_learning/schools/list/ checked 1/12/2011



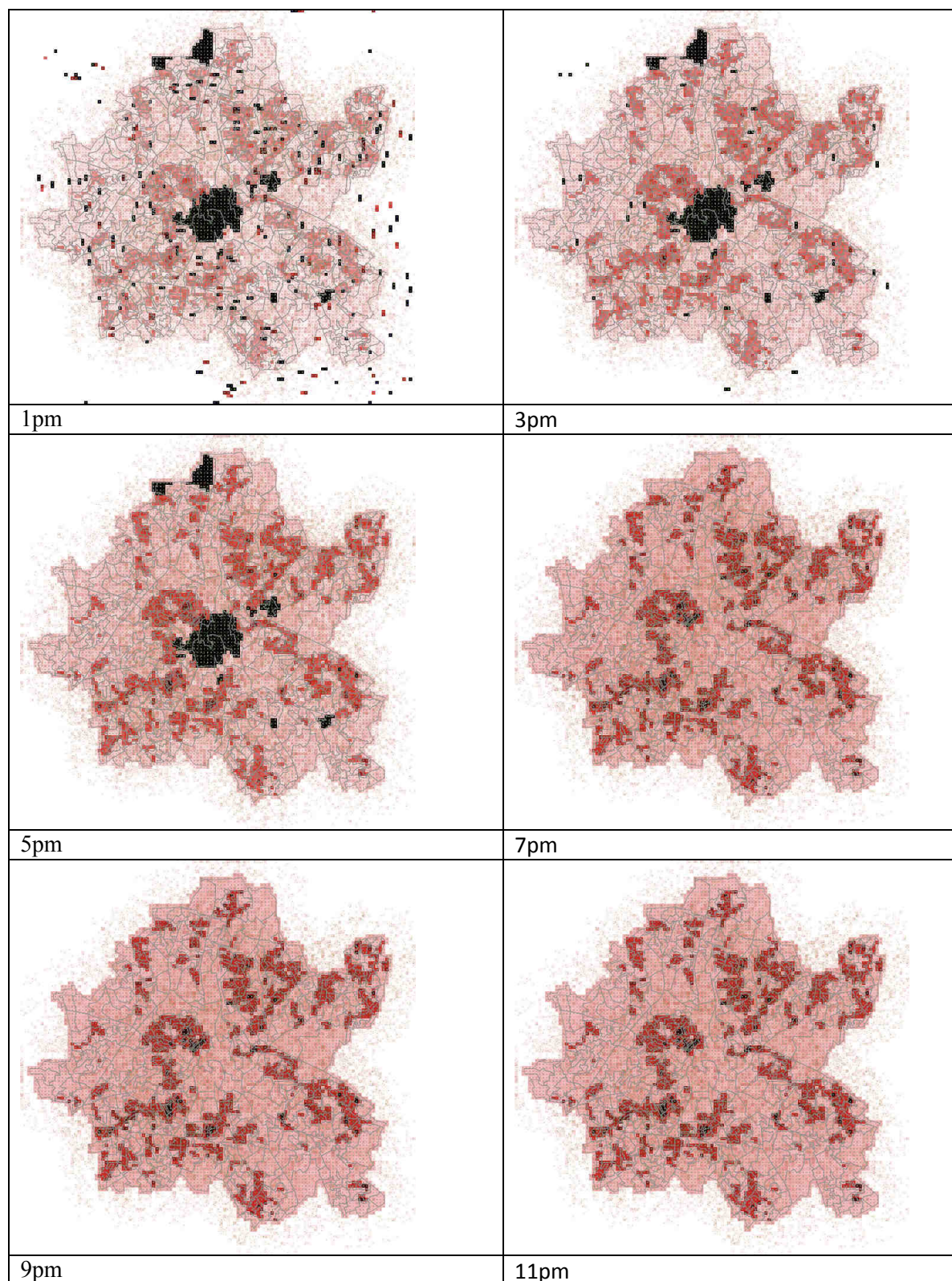


Figure 2. Snapshot sequence of Model Results – by hour of day

The model outputs have been compared with static snapshots of residential and daytime population data from Census to show similarities and differences in population distribution representation (see

Figure 3 and Figure 4). The results show some variation in comparison between the density and distribution of the population throughout the day; however it is clear that the outputs being compared are illustrating different scenarios. The lack of continuous level individual data makes it difficult to validate or accurately evaluate the accuracy of the model outputs and detailed results are difficult to obtain. It is; however, clear that such a model can provide a more detailed representation of individual movements within the population where static maps may conceal the location of particular groups of the population at any given time.

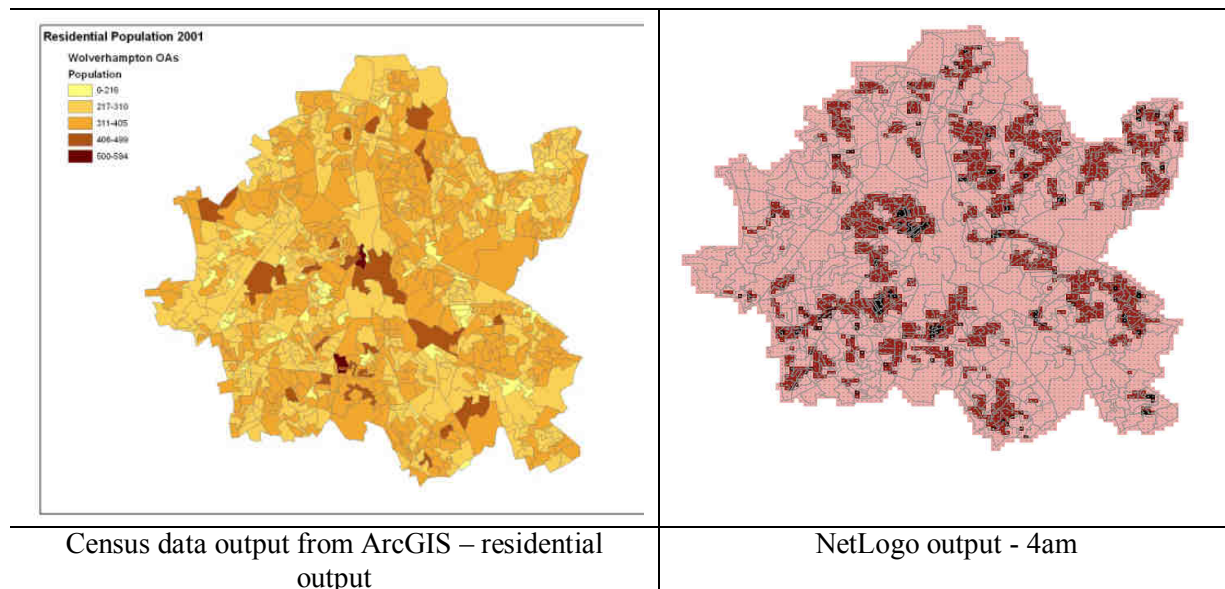


Figure 3. Residential Population of Wolverhampton – representing night time population (Census 2001) choropleth maps from ArcGIS relating to the residential location of the population by output area in terms of number of population. This image reflects the ‘night-time population’. This is compared to the output of the model (image B) showing the population at 4am. Source: 2001 Census Output Areas Boundaries. Crown Copyright material is reproduced with permission of Controller of HMSO.

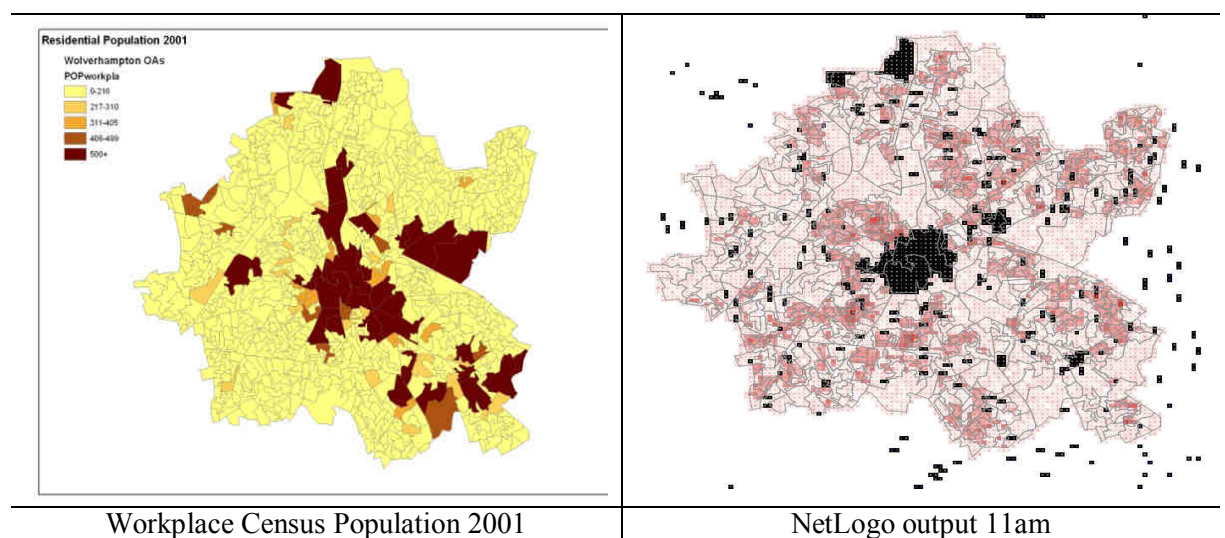


Figure 4. Workplace Population of Wolverhampton choropleth map illustrating the distribution of the ‘workplace population’ for Wolverhampton. This is compared to the output showing the population at 10am from the agent-based model. Source: 2001 Census Output Areas Boundaries. Crown Copyright material is reproduced with permission of Controller of HMSO.

3. Conclusions

This study shows that agent-based modelling can be an appropriate technique for the use of modelling the dynamic of the population across time and space. The use of Census population data can be used as a base for which to understand the residential location of the population and secondary data sources such as the national travel survey can help to create a representation of the dynamic population.

Static snapshots showing residential, workplace and daytime population have been widely using in planning and policy formation and undoubtedly have their uses. However the outputs of the model show the dynamic movement of the population distribution throughout the day and allow the exploration of information on the dynamic movement of individuals within the population which cannot be done through static snapshots.

Limitations in terms of availability of appropriate data, restrictions in development time and programming ability and difficulties in validation and evaluation have all contributed to shortcomings in the model and therefore only a basic outline model has been developed for the purpose of this study. Further development of the model could include more detailed information on the transport network, the physical and psychological barriers impacting on movement as well as choice of destination (ie type of school or employment) and interaction between agents.

Although there are many additional features that could further enhance the developed model, this study has shown that agent-based models integrated with geographic information can be used to develop more advanced and complex representations of the population than traditional GIS methods.

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5. Biographies

Laura Walker is a senior planner at Atkins specialising in socio-demographic analysis and assessment of social and distributional impacts in the context of planning and transport related schemes. She has recently graduated from Birkbeck College with an MSc in Geographic Information Science.

Joana Barros is a lecturer in GI Science at Birkbeck, University of London. Her research interests include computational models of geographical systems, agent-based simulation models of urban systems, as well as urban growth and change in developing countries.

Quantifying Short-term Surface Changes on Recreational Trails – The Use of Topographic Surveys and ‘Digital Elevation Models of Differences’ (DODs)

Aleksandra M. Tomczyk¹, Marek Ewertowski^{2,1}

¹Adam Mickiewicz University, Institute of Geoecology and Geoinformation, ul. Dziegielowa 27, 61-680 Poznan, Poland

Tel. (+48)-61-8296203 Fax (+48)61-829-6271

alto@amu.edu.pl, http://www.geomorfologia.amu.edu.pl/Aleks_Tomczyk.php

²Durham University, Department of Geography, Science Laboratories, South Road, Durham DH1 3LE, UK

Tel. (+44)07999769897 Fax (+44) 01913341801

marek.ewertowski@dur.ac.uk

Summary: The main objectives of this study are: (1) to analyse the spatial aspect of surface changes in microscale; (2) to quantify precisely the short-term rate of soil loss and deposition. Measurements were taken in 12 test fields, located in two protected natural areas in south Poland. The use of precise elevation data provided by the electronic total station and DEMs of Difference allows us to assess the volume of the surface changes. During a two-year period the avenger net volumetric change of the trail surface varied from $-0.037 \text{ m}^3/\text{m}^2$ per year to $+0.005 \text{ m}^3/\text{m}^2$ per year.

KEYWORDS: soil loss; erosion; recreational trail; DEM; trail impact

1. Introduction

Recreational trails are one of the key infrastructure elements which enable visitors to enjoy many of the Protected Natural Areas (PNAs). On the one hand, trails provide an easy access to certain places of interest that usually are not spatially concentrated. On the other hand, they limit recreational penetration to designated routes and prevent the scattering of visitors. In this way, areas which, for environmental reasons, should be excluded from direct human impact, can be isolated. However, the restriction of visitors traffic to certain sites (trails or campsites) brings them far more deterioration through wear and tear than the adjacent areas (e.g. Marion et al., 1993; Hammitt and Cole, 1998; Leung and Marion, 2000; Olive and Marion, 2009).

The size of incision in recreational trails has been studied using mainly three methods. The Cross-Sectional Area (CSA) method is based on the measurement along the tight links across the trail, the depth of which is measured at regular intervals, e.g. every 10 cm (e.g. Cole, 1983; Whinam and Comfort, 1996; Hammitt and Cole, 1998; Yoda and Watanabe, 2000; Kasprzak, 2005; Wałdykowski, 2006). Instead of fixed intervals, measurements can be carried out at the characteristic points of the trail surface – as in the Variable Interval Cross-Sectional Area (Variable CSA) method (Olive and Marion, 2009). An alternative to the two aforementioned methods is measurement only at the point of maximum incision to the trail. Depth is measured from the initial level of the earth's surface, which is determined by pulling across the trail measuring tape, sticks or folding car antenna (Dixon et al., 2004; Cakir, 2005; Hawes et al., 2006).

In this paper, we propose a new workflow which allows us to study the spatial and temporal aspects of trail degradation. The main objectives of this study are:

- to propose a new method for studying recreational trail transformation,
- to analyse the spatial and temporal aspect of surface changes in microscale,
- to quantify precisely the short-term rate of soil loss and deposition.

The study area for this research is two protected natural areas: the Gorce National Park (GNP) and Poprad Landscape Park (PLP), located in south-central Poland.

2. Material and methods

2.1. Precise measurements of elevation changes

Twelve segments of trails were selected for the precise measurement of elevation, so as to ensure representation from different types of use, slopes, exposure, and vegetation cover in the vicinity of the route. Test fields' dimensions were about 5 m in length and from 3 to 4 m wide - depending on the width of the trail. Each test field covered a trail tread and its surroundings.

Elevation surveys were carried out using electronic total station. Each of the measurement sessions consisted of surveys of pickets in scattered points around the test field, taking into account the characteristics of microforms. The density of surveyed points was about 80 pickets/m². At the end of each measurement session, 30 random checkpoints were surveyed – these would be used to verify the accuracy of surveys in later stages. Moreover, re-measuring the reference points was performed to verify whether the stabilization and level of the instrument have been retained.

Five sessions of measurement were carried out for each test field: August/September 2008, June 2009, August/September 2009, June 2010, August/September 2010.

2.2. Analysis of the microrelief transformation

A total of five digital elevation models (DEMs) using inverse distant interpolation methods and cell size 1 x 1 cm were created for each test field. Checkpoints, which were not used when creating the models, were used to assess the accuracy of DEMs. The difference between the measured elevation of the checkpoint, and the elevation obtained from the DEM, made it possible to identify the error. This difference was interpreted as the total error resulting from the inaccurate measurement and method of interpolation. The root mean square error (RMSE) for each set of checkpoints was used to measure the accuracy of mapping relief within each model. The RMSE for the DEMs was less than 1 cm.

Generated DEMs were subtracted from each other, enabling us to obtain a spatial picture of the loss or deposition of soil in each cell of the model from one survey session to another. The subtraction of DEMs from subsequent time periods (DEMs of Differences – DoDs – e.g. Wheaton et al., 2010) gave the amount of soil which was transported within the test fields and showed the spatial distribution of earth-surface changes as well. Then the value of changes was multiplied by cell size, and thus the volume of relocated mineral material was obtained. Cells whose value of changes was within the limits of the RMSE were treated as such, where there has been no change or the transformation of relief was smaller than the model error; in other words, the value 0 was attributed to them.

3. Results and discussion

The examined test fields differ in dimensions. In order to compare them with each other, we used standardized data - the total change in volume of the soil (the loss of soil + deposition) in a given field divided by its surface. The analyzed test fields are characterized by great diversity. There were test fields in which the soil loss in two years was greater than 25,000 cm³/m² (0,025 m³/m²). There were also those where the volume of material removed and deposited was either similar or the deposition slightly dominated. Only on one of the field in two consecutive years, the direction of change was radically different; in the first year a large quantity of material was deposited, in the second year significant loss of material was recorded

In our opinion, soil properties, morphology of the trails (cf. Bryan, 1977; Cakir, 2005) and local geomorphological conditions (especially slope length above the test field) are factors which have the most influence on the amount of soil loss. These three factors are often linked together. Examined sections of the trails whose surfaces are overgrown by tree roots and berries or are covered with numerous fragments of rocks show the least transformation. Roots act as sediments traps and cause the deposition of fine grained material. Similarly, rocks can also harden the soil, which protects against excessive water erosion. When the trail tread is even, the pressure of hikers' boots cause soil compaction as well as soil hardening, which make water erosion difficult. Uneven trail tread can affect trail development in two ways. First, when the trail is hard to walk on, visitors start to bypass the deteriorated section which leads to the trail widening. Moreover, a rough trail tread also favours significant soil erosion. In case of an uneven tread, hikers destroy microforms and cause soil to loose, and in such a way facilitating water erosion and transport. Accelerated soil erosion is also facilitated by being located in the bottom part of the local slope. In such cases, the volume of flowing water after rain is high; this provides greater erosional and transportational power. The impact of soil is also variable and depends on other factors. Clay soil texture is homogenous and compacts tightly which ensures that in dry conditions it is more resistant to trampling. However, in the case of rain, such textures cause greater runoff on steep sections and creation of muddy puddles on gentle sections. Moreover, in humid conditions, boots and tyres easily slide and relocate soil particles. Soils with coarser grains and generally wider range of particle sizes are more prone to soil erosion due to boots and tyres in a dry state. However, in case of light rains, due to greater permeability, they are less prone to creation of muddiness.

3. Conclusions

The main conclusions that can be drawn from this study are the following:

- This study has developed a new method for assessing the dynamic of surface transformation in recreational trails. It incorporates precise topographic surveys and digital elevation modelling to quantify soil loss or deposition from specified areas, and not only profiles. Digital elevation models of differences (DODs) were found to demonstrate a good representation of microrelief features and their transformations. The proposed method was applied to 12 test fields in two PNAs and provided an efficient procedure for assessing soil dynamic on recreational trails.
- The magnitude of recreational trail transformation in the case of studied PNAs can be quite significant. The amount of soil loss was even up to 37,000 cm³/m² per two-year period. This amount of soil loss may be visualized as the equivalent of a half-full average garden wheelbarrow.
- The spatial and temporal aspect of soil loss or deposition is vastly diversified and is for the most part related to local geomorphic conditions. Moreover, those most prone to significant soil erosion are trails with an uneven tread surface.

4. Acknowledgement

Funding for research at Gorce National Park was provided by the Polish Ministry of Science and Higher Education project N N 305 3625 33 and National Science Centre project N N305 066940.

5. Biography

Aleksandra Tomczyk is a Lecturer in the Faculty of Geographical and Geological Sciences, Adam Mickiewicz University, Poznan, Poland. She completed her PhD at June 2011. Her research focuses on human impact in mid-mountain and arctic environment. She uses an approach that links field work, GIS-based modeling and geomorphometry.

Marek Ewertowski is on research fellowship in Durham University founded by PMSHE. He completed his PhD at June 2009. His research focuses on glacial geology and geomorphology with the vast use of GIS and Remote Sensing.

Remote sensing and GIS-based analysis of past frost-wedge polygons

Marek Ewertowski^{1,2}, Andrzej Kijowski², Marcin Słowik²

¹Durham University, Department of Geography, Science Laboratories, South Road, Durham
DH1 3LE, UK

Tel. (+44)07999769897 Fax (+44) 01913341801

marek.ewertowski@dur.ac.uk

²Adam Mickiewicz University, Faculty of Geographical and Geological Sciences, ul. Dziegielowa 27,
61-680 Poznań, Poland

Tel. (+48)-61-8296203 Fax (+48)61-829-6271

evert@amu.edu.pl; kij@amu.edu.pl; slowikgeo@poczta.onet.pl

Summary: The main objective of this study is to propose a multidisciplinary approach (combining remote sensing, GIS, Ground Penetrating Radar soundings and sedimentological analysis) to study the past frost-wedge polygons in lowland settings. Proposed workflow contains four steps: (1) to recognize polygonal-shaped features based on aerial photography analysis; (2) to analyse the geometry of the features and relate them to specific sediments and landforms, (3) to perform GPR soundings to recognise the depth of the features as well as their 3D structures; (4) to make outcrops and sedimentological analysis to confirm the periglacial genesis of studied features.

KEYWORDS: frost-wedge polygons, past permafrost, Remote Sensing, Ground Penetration Radar

1. Introduction

Thermal-contraction cracks are one of the most widespread and convincing features, which are diagnostic of permafrost. The process leads to the development of not only vertically fissures but also horizontal polygons, which can be found on the ground surface in both contemporary and past environments. However, recognition of these polygons is only possible with the use of high detailed aerial photographs, as they are not visible from a ground level.

Several techniques have usually been used to study the past permafrost features. During the middle of the twentieth century, the main emphasis was placed on the sedimentological analysis of the structures that were visible in outcrops (eg. Dylík 1966; Goździk 1970, 1973, 1986, 1995, Harry and Goździk 1988; French and Goździk 1988). During the last two decades of the century, several studies dealing with the use of remote sensing (RS) analysis of frost-wedge patterns occurred (e.g. Svenson 1976, 1988; Walters 1978, 1994; Bogdański and Kijowski 1985; Johnson 1990; Kozarski 1995b; Clayton et al. 2001; Ghysels and Heyse 2006). The use of Ground Penetrating Radar (GPR) soundings to study modern or past permafrost features is probably the newest approach (e.g. Munroe et al. 2007; Doolittle and Nelson 2009).

The main objective of this study is to propose a multidisciplinary approach (combining remote sensing, Geographical Information Systems (GIS), GPR soundings and sedimentological analysis) to study past frost-wedge polygons in lowland settings

2. Methods

In this research, three types of method were used to study the distribution of past frost-wedge polygons:

- 1) Remote sensing. For the study, the special methodology of taking aerial photographs was developed. Photographs were taken during different seasons in order to discover which

vegetation and humidity settings are the best for wedge-polygon recognition. The photographs were taken from different altitudes, from 200m to 400m above ground level (a.g.l.). Hasselblad and RMK Zeiss 15/24 (using visible part of spectra) cameras were used to taken the photographs. Near-vertical photographs were rectified and resultant photographs are scaled 1:500 to 1:2,000.

- 2) GIS-based analysis. Aerial images were analysed with the use of GIS software. Patterns of wedges were recognised and digitized using TNTmips and ArcInfo software. Each of the wedge polygons were treated as a single object with such attributes as: number of edges, dimensions, values of angles. The next step was to add to the database information about elevation, slope and exposition (from Digital Elevation Models), as well as data about geological substratum and type of geomorphological landform. The final step of GIS analysis was to study the spatial relationship between different types of structures and specified terrain attributes, sediments and landforms.
- 3) GPR sounding. Several test sites were selected based on remote sensing analysis. GPR profiles were performed in these sites. Measurements were taken using shielded 100 MHz and 250 MHz antennas. In optimal conditions, the maximum depth range of the antennas is 25m and 8m, respectively (MALA, 2008). Differential GPS (dGPS) were applied to gather detailed information about location and heights of GPR profiles. Data from GPR soundings were processed using ReflexW5.0 application. A subtract-mean (dewow) filter was applied to eliminate low-frequency noise. Divergence compensation and background removal were used to compensate geometrical divergence losses and to make visible near surface signal covered by direct waves' reflections.

3. Study Sites

The proposed methods were tested in the Wielkopolska (Great Poland) region in Central-West Poland. The Last Glacial Maximum (LGM) occurred in the region around 20,000 BP (Kozarski 1995a). After this time the ice sheet started to retreat. Permafrost started to grow on the forefield of the receding ice sheet. Ice wedge polygons are relatively common in Wielkopolska (Kozarski 1993, 1995a, 1995b; Kasprzak 2003). Several hundreds of aerial photograph were taken during different vegetation seasons from 2006 to 2011. Large numbers of polygon structures resembling thermal-contraction cracks were observed and analysed. Several study sites were selected to perform GPR profiles and sedimentological analysis.

4. Results

4.1. Remote Sensing and GIS analysis

Several types of regular features were identified:

- 1) Type A: regular polygons with four to eight edges (Fig. 1A). They are varied in dimension from several to a dozen metres. In some of the structures smaller polygons were identified inside the larger one (Fig. 1B). Thus, they can be interpreted as different generations (older and more recent) of cracks.
- 2) Type B: irregular polygons with irregular edges (Fig. 1C). They are usually founded on slopes. The elongated edges depend on terrain gradient; the shortest ones are perpendicular.
- 3) Type C: other structures, not polygon shaped. These belong to different types of structures. They are usually elongated (Fig. 1D). Sometimes their shape relates to the curvature of slopes.

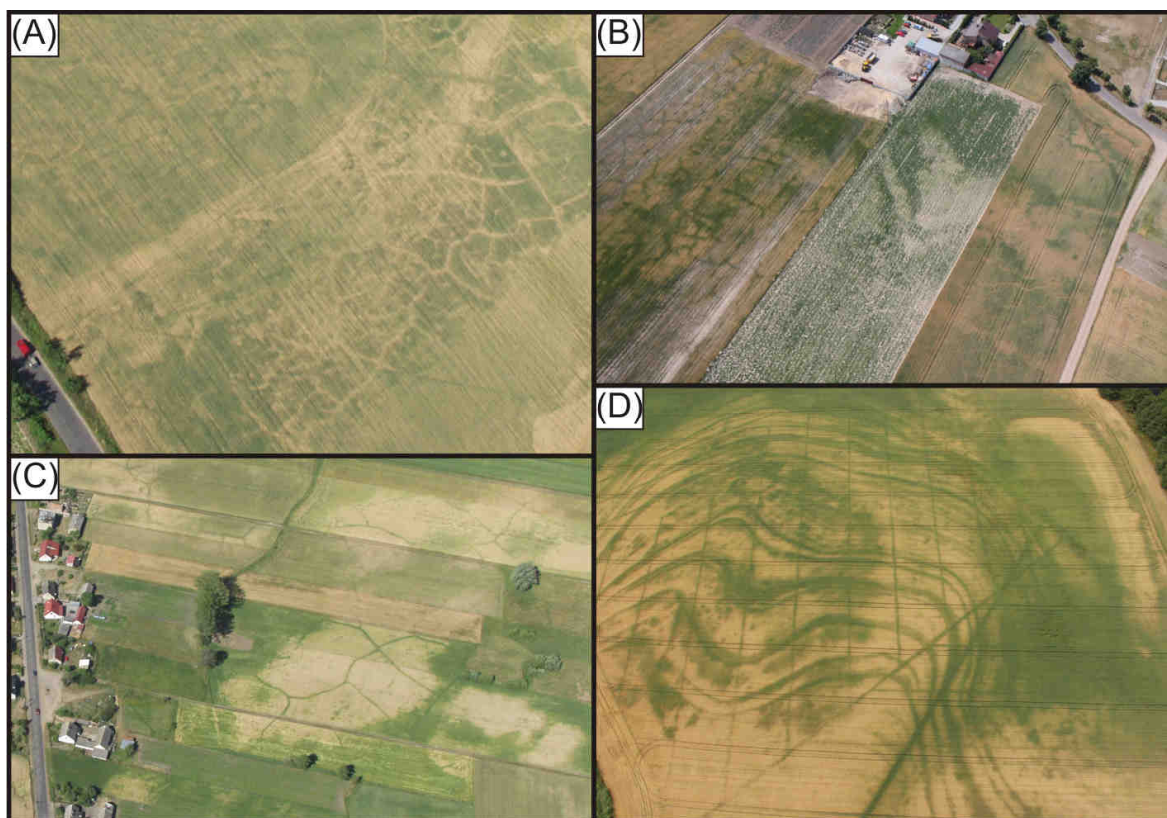


Figure 1. Examples of possible past permafrost features on aerial photographs: networks of regular polygons (A, B, C) and irregular structures (D). Photographs: W. Rączkowski.

4.2. Sample site: Bytkowo

Structures in Bytkowo sites have a regular pattern. Larger polygons have four edges and dimension of c.10m. Smaller polygons were identified within and were c.1–2m in diameter.

GPR surveys were done in one grid to achieve three-dimensional images of frost-wedge structures. Measurements were taken along 6 crosslines (100Mhz antenna) and 7 crosslines (250Mhz antenna), and covered an area of about 27m². The number of crosslines was different in particular surveys because of the antennas' dimensions. The depth scale of the profiles was determined in reference to electromagnetic wave velocity $V=0.05\text{m ns}^{-1}$, on the basis of comparison of depth of frost-wedge structures with GPR reflections. GPR soundings revealed the 3D structures of analysed features.

Structures found in the Bytkowo test site are interpreted as polygons of relict sand wedges. The main proofs are: (1) regular polygonal shape with several generations of the edges; (2) infill of materials distinctly different from host sediments; and (3) characteristic vertical V-shape.

5. Workflow of multidisciplinary approach to study of the frost-wedge polygons

The main aim of this paper was to develop multidisciplinary approach to study past permafrost features, mainly frost-wedge polygons. Techniques that are normally used in such kind of studies are successful only to a certain extent. Each single technique had some limitation:

- 1) RS allowed us to easily distinguish linear or regular features within the soil cover. This analysis within the GIS framework can be used relatively easily for large and remote areas and thus provide information about the spatial distribution of the features. However, there is no possibility to prove the periglacial origin of the features, based only on aerial photography. Moreover, there are several other features (among them those created by past human activity, i.e. archaeological features), that can be easily misinterpreted as periglacial features.

- 2) GPR soundings are useful for the recognition of the vertical dimension of features. They can be used for assessing the dimensions of features as well as their 3D images. However, similar to RS analysis, there is no possibility to prove that structures found in the GPR profile are of periglacial origin.
- 3) Sedimentological analysis, done in the field and in the laboratory, can give the most reliable proof of the origin of selected features. On the other hand, there are large limitations of sedimentological analysis: (1) they are very invasive and damage the soil properties; (2) they are time- and cost-consuming; and (3) they give results only for small areas.

Analyses carried out during this study suggest that there are many advantages when the multidisciplinary approach is used. Proposed workflow is presented on Figure 2. The first step is to recognise the polygonal-shaped features, based on aerial photography analysis. The next step is to analyse the geometry of the features and relate them to sediments and landforms, as well as to existing databases. In the areas where there are suspicions that the polygons are of periglacial origin, GPR soundings should be done, for recognition of the depth of the features as well as their 3D structures. In selected areas, outcrops should be made and sedimentological analysis carried out, to confirm the periglacial genesis of studied features.

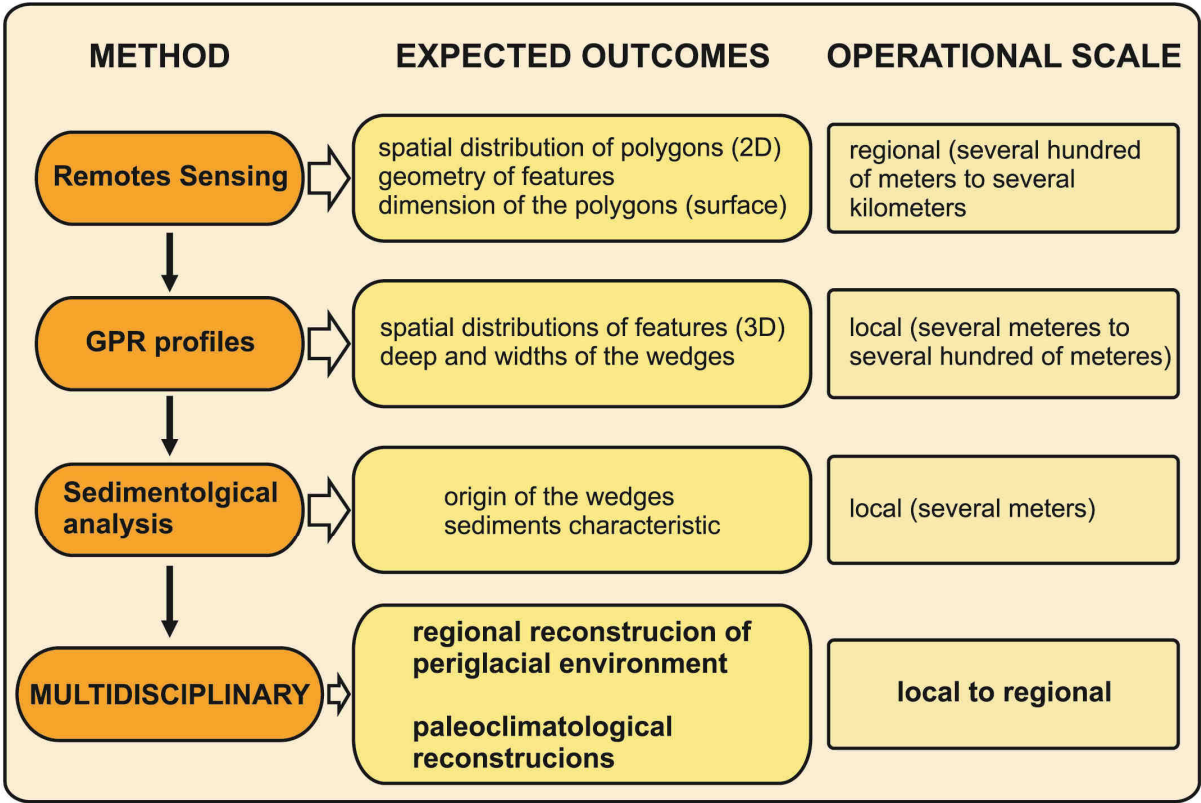


Figure 2. Multidisciplinary approach to study the past frost-wedge polygons

6. Acknowledgements

Funding for research was provided by the National Science Centre as a project: N N306 599640. This research would not have been possible without the field assistance of members of the Association of the Students of Geography from Adam Mickiewicz Univeristy: J. Barabach, A. Barełkowska, M. Saikowska, K. Rymer.

7. Biography

Marek Ewertowski is on research fellowship in Durham University founded by Polish Ministry of Science and Higher Education. He completed his PhD at June 2009. His research focuses on glacial geology and geomorphology with the vast use of GIS and Remote Sensing.

Andrzej Kijowski is senior lecturer in Adam Mickiewicz University, Poznan, Poland. His research focuses on Remote Sensing and its application to environmental studies. He got his PhD at 1982.

Marcin Słowik is a lecturer in Adam Mickiewicz University, Poznan, Poland. His research focuses on implementation of Ground Penetration Radar, human impact and geochemistry

Geovisualization of Household Energy Consumption Characteristics

Sarah Goodwin¹ and Jason Dykes¹

¹giCentre, School of Informatics, City University London, EC1V OHB

Tel. 020 7040 8370

sarah.goodwin.1@city.ac.uk, j.dykes@city.ac.uk

Summary: A vast amount of quantitative data is available within the energy sector, however, there is limited understanding of the relationships between neighbourhoods, demographic characteristics and domestic energy consumption habits. We report upon research that will combine datasets relating to energy consumption, saving and loss with geodemographics to enable better understanding of energy user types. A novel interactive interface is planned to evaluate the performance of these energy-based classifications. The research aims to help local governments and the energy industry in targeting households and populations for new energy saving schemes and in improving efforts to promote sustainable energy consumption. Energy based neighbourhood classifications will also promote consumption awareness amongst domestic users. This poster describes the research methodology, data sources and visualization requirements.

KEYWORDS: Energy Consumption, Classification, Geodemographics, Visualization, Evaluation.

1. Introduction

Energy consumption is of growing interest to individuals, organizations and government due to EU energy consumption and carbon footprint reduction targets set for 2020 and 2050. In 2004 the household sector represented 27% of the UK's total carbon dioxide emissions and approximately 30% of total energy use (HM Government, 2006 in Druckman & Jackson, 2008). Achieving a large reduction at the domestic level is therefore imperative to meeting these targets. Over recent years there has been an increasing amount of research related to energy consumption, carbon reduction and potential energy saving opportunities; however, there is still limited knowledge of the relationship between energy consumption and measurable characteristics of population. Druckman and Jackson (2008) report that domestic fuel consumption in the UK is strongly related to disposable income levels with other highly influential factors being dwelling type, household composition, property tenure and rural/urban location. This work indicates that energy consumption patterns correlate to socio-economic and geographic characteristics and continued research in this field is needed in order to better target new low-carbon policies.

Within the energy industry there is a substantial amount of energy consumption data and the introduction of modern smart meters will increase this data quantity exponentially (Computer Weekly, 2009). Smart meter technology allows for consumption to be recorded at frequent intervals and communicates this information to both consumer and energy supplier allowing for near real-time feedback of energy use. Smart meters form a major component of 'Smart Grids', which are estimated to reduce annual EU household energy consumption by 10% and carbon dioxide emissions by 9% (European Commission, 2011). Many EU countries have started to introduce smart meter technology into households, with Italy reaching 85% household coverage in 2010 (Clastres, 2011). In 2009 the UK Government announced the intention to introduce smart meters into all households by 2020 (Faruqui *et al.*, 2010).

Smart meters are expected to greatly improve user awareness and allow for the regulation of energy consumption at the household level (Darby, 2010). A study of early adopters (Hargreaves *et al.*, 2010) reports improved awareness, but further studies are needed to identify whether changes in behaviour are long term and to understand the differences across household types. Traditionally household energy consumption feedback is provided through standard utility bills, which are usually vague,

uninformative and do not invite householders to think about their consumption patterns. It is rare for utility suppliers to provide benchmarks or comparison target groups for improving consumer awareness (Ehrhardt-Martinez *et al.*, 2010). Räsänen *et al.* (2008) acknowledge the need for neighbourhood level comparisons to provide consumers with understandable and concrete reasoning for saving energy as well as to encourage discussion of energy saving techniques amongst neighbours. Energy usage profiling and online visualization tools are now available for individuals to track their consumption over time, with some of these allowing for comparison at the neighbourhood or community level - such as iMeasure (Environmental Change Institute, 2011). While providing the opportunity to explore household energy consumption patterns in greater detail than the standard utility bill, these profiling tools are often time consuming and require some technical understanding in order to achieve a reduction in energy consumption. Ehrhardt-Martinez *et al.* (2010) review recent research and compare the success of different usage feedback schemes.

Electricity distribution deregulation has enabled electricity providers to formulate dedicated tariff types based on customer characteristics (Stephenson *et al.*, 2001). Energy providers and market analysts would benefit from consumption classifications as this would enable tariffs to be targeted based on typical consumer traits. Chicco *et al.* (2006, p.933) describe the need for electricity customer classifications for service providers:

“For the purpose of defining suitable tariff structures, the existing customer classifications based on the type of activity are scarcely correlated to the actual evolution of the electrical consumption and, as such, give poor information to the distribution providers”.

A new geographical clustering of energy characteristics at the neighbourhood level is necessary for energy companies, local governments and residents to allow realistic comparisons, understand complex consumption variations and enable better targeting of services and schemes to encourage more sustainable energy use.

2. Geodemographics and Energy Consumption

There is a body of relevant research correlating energy consumption with household or population variables (Semenik *et al.*, 1982); however, little research directly investigates the classification and evaluation of energy related variables with geodemographics. Druckman and Jackson (2008) compare energy consumption with the seven ONS Output Area Classification (OAC) Super Groups showing clear correlations with household disposable income and property tenancy. This draws parallels with other literature (Dillahunty & Mankoff, 2011; Dillahunty *et al.*, 2009) indicating that low-income families and tenant households have difficulties and additional barriers to reducing energy consumption.

Large multivariate dataset classification is ideal for residential energy consumption as previous research shows that human populations with similar characteristics and behaviours tend to cluster together. Some topical research by Chicco *et al.* (2003, 2006) evaluates techniques and methods for classifying characteristics of non-residential electricity use. In 2008, Experian introduced a data product ‘GreenAware’ (Experian, 2008) responding to demand to characterise populations based on energy behaviour. A case study of the use of this data by Haq and Owen (2009) demonstrates the potential for using population classifications to understand the geographical variations in energy consumption, however, the thematic map examples offered also highlight the difficulty in visualizing such abstract classified datasets. In classic thematic maps the areas of interest with the largest populations are frequently least visually salient due to the limited geographical area of the most densely populated areal units. Slingsby *et al.* (2011; 2010) show that well designed and novel visualization methods can be used to effectively visualize local and national multivariate datasets to overcome some of the problems associated with the kinds of thematic maps that are more routinely used.

3. Data Visualization and Energy Consumption

While data classification radically reduces data volumes and enables trends and clusters in large datasets to be identified with greater ease, they can be misinterpreted (Harris *et al.*, 2005). Data visualization can be both useful in helping gain access to and traction with such abstract but potentially informative information as well as providing insight into some of the detail lost during the classification process. OAC Explorer (Slingsby *et al.*, 2010; Slingsby *et al.*, 2011) shows that exploratory visualization methods can be effective in helping organizations understand local populations and their characteristics through geodemographic classifications. The public-facing *placeSurvey* application (LSR, 2011) and related means of providing timely information for citizens demonstrate how visualization can be used to engage the public in exploratory analysis of information about local issues.

Technological advances in data visualization offer real opportunities for research into energy consumption awareness with techniques that may provide personal views and interactive exploration of energy data – potentially in real time. Recent research highlights new ideas to encourage awareness and behavioural changes through tools and visualizations designed to make the user aware of their current energy use through non-intrusive and subtle visual stimuli (Jönsson *et al.*, 2010; Rodgers *et al.*, 2011).

4. Research Plan and Status

The academic literature in the field highlights a continued need to classify UK energy user groups as well as provide the ability to explore such a classification through interactive visualization techniques. Our research therefore has two objectives:

- a. To create neighbourhood energy consumption classifications by combining datasets such as energy consumption, energy loss and saving potential with geodemographic variables
- b. To provide user groups such as energy suppliers, local government and citizens with the possibility to visualize this information through innovative and interactive geovisualization techniques that enable the data to be explored, understood, evaluated and acted upon.

The proposed classification and visualization of energy consumption related data will enable the private household energy market to be better understood, allow for energy profiles at the neighbourhood level and give local government and the energy industry better targets for potential energy saving schemes.

Having established a need for geodemographic energy profile geovisualization we are currently in the process of defining the classification system to be used, collecting datasets that may contribute to it and establishing visualization requirements. Our poster presents a description of our classifier and some initial visualization requirements that form the first stage in moving us towards our research objectives.

5. Acknowledgements

This work is funded by a Vice Chancellor's Scholarship from City University London and Betternest Ltd UK.

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7. Biography

Sarah Goodwin is a first-year PhD candidate at the giCentre, City University London. She has an academic and professional background in Geographical Information Science. After being awarded a distinction for her MSc at City University in 2007 and presenting her findings at GISRUK 2008 she was employed in Germany to analyse and map geographical variations in energy use characteristics.

Dr. Jason Dykes is Professor of Visualization at the giCentre, City University London undertaking applied and theoretical research in, around and between information visualization, interactive analytical cartography and human-centred design.

Future fusion of VGI and sensor-based information sources

Błażej Ciepluch and Peter Mooney

Department of Computer Science, National University of Ireland Maynooth,
Maynooth, Co. Kildare. Ireland.

email b.ciepluch@cs.nuim.ie, peter.mooney@nuim.ie

Tel: 353 (1) 2680100, Fax: 353 (1) 2680199

Summary: VGI is not restricted to spatial data which has been explicitly collected by citizens and contributed to OSM or similar projects. Through the use of sensors, sometimes paired with mobile phones, citizens are empowered to participate in collecting and sharing measurements of their everyday environment that matter to them. In this paper we summarise our proposal for a model for the integration of sensor and non-sensor based information where data from these sources are linked to VGI projects such as OpenStreetMap and GeoNames.

KEYWORDS: OpenStreetMap, Quality, Web GIS, VGI

1. Introduction

Goodchild (2007) presents the vision of the potential of “six billion citizens” sensing their environment. Goodchild’s vision does not necessarily mean that all of the world’s citizens will be collection geospatial data specifically for the purposes of contribution to some geospatial database (such as OpenStreetMap). The vision is not restricted to spatial data which has been explicitly collected by citizens and contributed to OSM or similar projects. Through the use of sensors, sometimes paired with mobile phones, citizens are empowered to participate in collecting and sharing measurements of their everyday environment that matter to them. As Diaz et al. (2011) remarks this user-generated content is growing at unprecedented rates. In this paper we present a unified model of VGI (Volunteered Geographic Information) data collection, management, access, and visualisation from fixed and mobile sensors as presented in Figure 1. We have created a high-level organisation of potential sources of VGI from fixed and mobile sensors. We classify sensors into four groups: fixed autonomous sensors, mobile autonomous sensors, fixed user operated sensors, and mobile user operated sensors. Our unified model is restricted to individual sensors rather than large networks of sensors deployed over a large geographical area. At the top of Figure 1 the temporal axis indicates the rate of data capture of these sensors. Capture rates can range from: every x seconds (for example ODBII, electricity metering and power consumption), minutes (geocoded photographs, Twitter feeds), hourly (air quality measurement, humidity, etc), or daily (GPS loggers, geocoded photographs, UAV captured aerial imagery). The bottom of Figure 1 shows the means by which other applications and researchers can access the information produced by the sensors. In the next section we will outline examples of each class of sensors.

2. Sensors as a future source of VGI

Goodchild (2007) states that if VGI can attract the attention of citizens then it is very feasible that they will contribute to VGI projects. Elwood (2008) describe how and why citizens contribute to VGI projects like OpenStreetMap. We feel that it is very likely that in near future citizens will voluntarily contribute not only their GPX lines from data loggers and smart-phones or geocoded photographs but VGI in a much broader sense. This data and information will be generated by a broad range of devices with and without our personal involvement. In some cases the human role will only be to sometimes assist (accept or refuse permission, accept security protocols, etc) for sending the sensed data and information to some server on the Internet. In the next four sections we briefly outlined examples from each of the sensor classes in Figure 1.

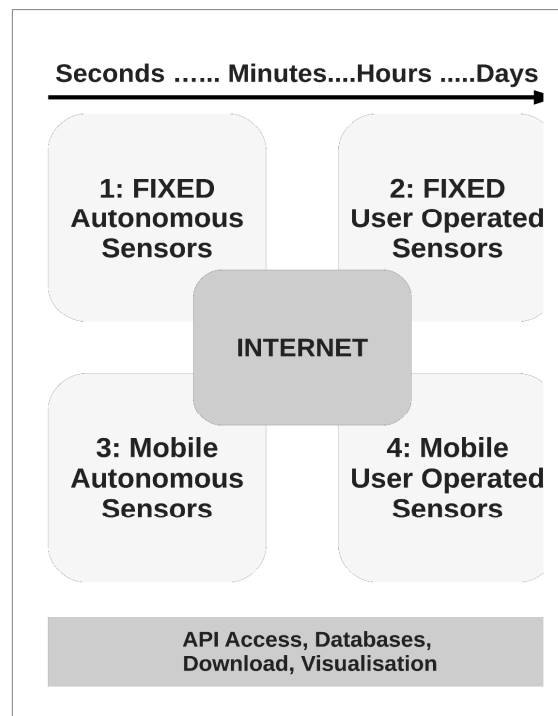


Figure 1: A unified model of VGI data collection, management, access, and visualisation from fixed and mobile sensors

2.1 Mobile User Operated Sensors

The rapid growth in mobile sensor devices today will continue as we expect the cost of these devices to drop in the future (Lin et al., 2011).

Example: Quadrocopter

A good example of a mobile sensor operated by users is the Quadrocopter based on the Paparazzi project (Paparazzi, 2011). Equipping this remote controlled helicopter with a digital camera aerial surveying of locations can be performed. Quadrocopter can hover on a preprogrammed path. From safety reasons it is still required to maintain radio control connection in case of an emergency situation. The landing and starting procedure need attention from the user side, even if they are executed autonomously. The price of these devices is a barrier (around 1000 Euro). As these types of devices become cheaper citizens will be able to perform surveying (subject to security and privacy conditions) and then use this data for tracing features and visualisation of temporal changes to an environment. The OSM community could benefit greatly from these sensors but will have to provide easy methods for users to upload, store and then access to the imagery.

2.2 Autonomous Mobile Sensors

Autonomous mobile sensors do not require very intense interactions from the users. In some cases they can operate without user interaction with the exception of start-up and shut-down.

Example: On-board Diagnostics

Is there potential for using data captured by On-board Diagnostics OBDII in cars as a VGI source? All the cars manufactured after 1996 in USA and 2001 in Europe are equipped in interface called OBDII which is standard for all manufacturers. This create a common way to access provided by car on-board computer. This interface is commonly used by technicians during car systems inspection. With use of this connector is possible to gather a data about the vehicle's real time parameters (engine speed, fuel consumption, environmental parameters, etc.). At the end of the journey the stored data in the OBDII system could then be contributed to a VGI project. If close to real-time contribution over the Internet was possible then OBDII could provide very useful information about a fast changing

environment. Information about engine speed could provide input for analysis of real-time traffic information (Cohen et al., 2008; Li and Ouyang, 2011). Lin et al. (2009) uses OBDII for real-time monitoring of a fleet of vehicles. Data about position from GPS together with OBDII data such as speed, RPM, voltage, and temperature of engine are sent to a central fleet management server. Checkoway et al. (2011) considers the OBDII interface with in-vehicle entertainment systems with USB ports, iPods connectors, bluetooth, remote keyless entry, etc. Barry and Stockton (2011) speculates that the cars of the near future will feature more additional features in terms of software rather than hardware. Authors such as Koscher et al. (2010) warn of security and privacy implications of these approaches. Storage and visualisation is the key challenge here. As Checkoway et al. (2011) speculates in the near future vehicles will be equipped with more sensors and possibility to upload our own software applications to the OBDII operating system.

2.3 Fixed Autonomous Sensors

Fixed autonomous sensors are “installed” into a fixed position and usually run completely independent of user input. These include: electricity consumption meters, humidity and temperature measurements, water flow measurements, data about the status of home appliances (water consumption, heating appliances)

Example: Power meter consumption monitoring

Electricity power meter measurements is a potentially very popular application for citizens as it has a direct connection to making financial savings. Potential benefits from storing such data in VGI systems was already noted by Godbole and Gurney (2011). An example device is manufactured by Current Cost Ltd. Their device has output ports in RS-232 allowing transmission to an Arduino device with a network card. The power consumption data can then be transmitted and stored in a database. Arduino (Arduino, 2011) is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It is intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Pachube (2011) provide an implementation of this concept with a MySQL database and different visualisations components are available for users with mapping output to Google Maps. We have implemented a demonstration of these power meters for measurement of power consumptions in the Undergraduate computing laboratories in our department. Sensed data is sent over the network to a database and then displayed on a map of the building. Power consumption, on a large scale of thousands of citizens, will require a storage environment capable of storing millions of records every day. Visualisation will have to aggregate this information into temporal clusters (morning, rush-hour, midday, etc.). Power consumption for an area could then be visualised on VGI mapping such as OSM.

2.4 Fixed Sensors operated by user

Fixed user operated autonomous sensors include sensors which are sensors installed in a fixed location but require a user to “switch-on”. The “switch on” can be performed over to web using a simple web interface or using some physical switch on a micro-controller. Data logger sensors without permanent connection to the Internet must store their captured data on-board until the user connects them to the Internet to upload their captured data.

Example: Home Entertainment System monitoring

Even your TV together with MCE PC can contribute some data to systems such like OpenStreetMap. Example for that may be a TV adapted version of Linux called Linux MCE (2011) this version of entertain system has build in function to follow a user through rooms when he switch the place where he view his favourite TV program. TV receivers are connected to thin client terminals which are driven by server. If presence of user will be detected in another room system may simple redirect video stream to different destination. This type of functionality may be also used to generate map of area where our curious person will be able to see in real time which channels are most popular in his part of the town and also which places are use for viewing living room or kitchens. Of course data will must be anonymous in some way that we can see most popular TV programs in our estates but not in

specific home that will be to big intrusion into privacy. The option to contribute or not data to VGI and also what contribute should be a part of settings in our entertain system to easy switch off if we change our mind about. Similar functionality may be implemented in washing machines that we will be able observe options in washing programs or how much water we consume in our house during washing and if we decide that we do like to reveal something we should be able. This choices maybe use by VGI systems to create a maps which will show real time but also past choices in washing programmes in our estate - town - country. Or in the same way reveal on maps how looks habits in our town related with watching TV when we look what we prefers and where we prefers to watch.

3 Conclusions and Outlook

A current realisation of our concept is Pachube (2011) which is a software platform that “connects people to devices, applications, and the Internet of Things”. As a web-based service built to manage the world’s real-time data, Pachube gives people the power to share, collaborate, and make use of information generated from the world around them. Future VGI contributors will be very different to the current sources of information: gpx tracks, photographs, messaging, etc. We personally believe that this type of data may create totally new types of maps and mashups which will be able to visualise and answer on very basic questions like how many sinks of water is used in may town daily. This data are already captured and stored by various companies and governmental agencies but probably none has full prospect from macro-scale to micro-scale. Some of this type data are already collected by companies lets mention for example sending by some software some statistical data to manufacturer. Unfortunately they can be also gather in stealthy way lets mention Iphone location scam recently. We just think that the best way will be show in devices all the variables gathered during operation and allow him to decide what he do like to do with them store , delete or contribute to VGI. We also think that will be necessary to create some unified schematics which will allow different brands products send the data in unified form to OpenStreetMap

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4 Biography

Blazej Ciepluch is a PhD student at the Department of Computer Science NUI Maynooth. His PhD is focused on the integration of sensor and non-sensor based information in an extended model of Volunteered Geographic Information (VGI) which includes OpenStreetMap as a core component. Dr. Peter Mooney is a research fellow at the Department of Computer Science NUI Maynooth. Both Blazej and Peter are funded by the Irish Environmental Protection Agency STRIVE programme (grant 2008-FS-DM-14-S4).

UK Location an INSPIREing Resource

Andrew Newman

UK Location Programme, Defra, Area 1D, Ergon House, Horseferry Road, London SW1P 2AL
Tel. +44 300 060 1779
andrew.newman@defra.gsi.gov.uk

Summary: Following the publication of the UK Location Strategy in 2008 and transposition of INSPIRE in to UK legislation in 2009 a UK Location Programme was established within Defra to deliver both initiatives. This paper will provide delegates with an overview of UK Location and the policy drivers for its establishment. The paper will then explore the range of data that has been made available and challenge researchers to exploit this new resource.

KEYWORDS: INSPIRE; Government; Open Data; UK Location, Challenge

1. What is UK Location?

UK Location is the spatial data infrastructure for the UK. Established to enable the wider use of public sector location data UK Location is made up of a series of technical and business services with a robust governance framework. Figure 1 provides an overview of UK Location.

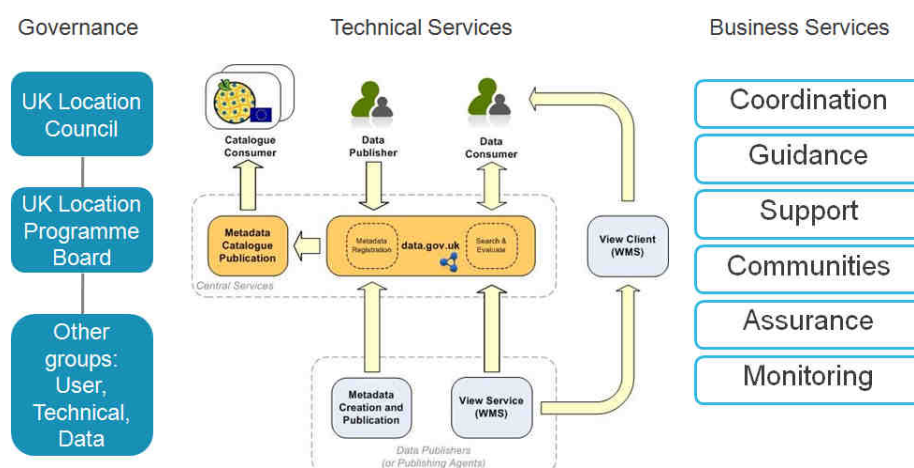


Figure 1 - The UK Spatial Data Infrastructure (UK Location).

Implementing UK Location will enable the UK to meet the requirements of INSPIRE (Directive 2007/2/EC) and the UK Location Strategy (GI Panel, 2008). It is now also a key vehicle for public bodies to publish data for reuse in response to the current government's transparency and open data agendas.

To deliver UK Location government established the UK Location Council and the UK Location Programme (UKLP) both lead by Defra. The Council is government's strategic advisor on location information policy; it is made up of around 20 senior civil servants.

2. Policy Drivers

2.1 The UK Location Strategy

The strategy was published in 2008 in response to a challenge from government to make better use of location data. It recognises the value of location data to the public sector and wider economy and sets out 5 strategic objectives to make more effective use of location data public sector. Figure 2 sets out these objectives and progress to date.

Objective	Progress
We know what data we have and avoid duplicating it	Currently over 900 datasets have been registered with the UK Location Discovery Metadata Service (data.gov.uk). View services are available for a significant number of these datasets.
We use common reference data so we know we are talking about the same places	By focusing on publication of data for INSPIRE Annex I & II themes several key reference datasets have been published, including addressing, a cadastral index, transport networks and geological data.
We share location-related information through a common infrastructure of standards, technology and business relationships	UK Location has been established. The UK Location Programme is developing: a suite of standards for example UK GEMINI 2.1 for discovery metadata; open source software and; a programme of business engagement
We have appropriate skills, both among geographic professionals and amongst other professional groups who use location info or support its use	The Location Council has identified that there is a skills gap and is considering how best to address this. More work is required in this area.
We have strong leadership and governance to drive through change including the implementation of this strategy and INSPIRE	The UK Location Council and Programme have been established. The UK has made good progress in meeting the first round of INSPIRE deadlines.

Figure 2- Progress in delivering the UK Location Strategy

2.2 INSPIRE

The EU INSPIRE Directive was introduced in 2007 and transposed into UK legislation in 2009 (SI 2009 No 3157 & SSI 2009 No 440). INSPIRE's principal aim is to improve environmental policy making in Europe. Implementing the Directive will also enable better delivery and monitoring of public services and improve access to public sector information.

Under INSPIRE member states must make spatial datasets available in a consistent formats and create services for accessing these datasets. INSPIRE specifies deadlines for delivering conformant data and services. The UK is making good progress in delivering INSPIRE.

2.3 The Right to Data

"From July 2010, government departments and agencies should ensure that any information published includes the underlying data in an open standardised format."

Prime Minister, David Cameron

When elected in 2010 the coalition government committed to being the most open government ever. The Coalition Agreement included a transparency agenda with a commitment to publish public data in reusable forms to enable economic growth and government accountability. Subsequently there have been a number of key developments:

- Establishment a Transparency Board to lead on transparency including opening up public data.
- Delivery of a public data portal (data.gov.uk).
- Publication of large quantities of public sector information including spend and pay data.
- Development of a series of Public Data Principles.
- Development of the Open Government Licence.
- Movement of OS, Met Office and Land registry to BIS with a view to establishing a Public Data Corporation (PDC).
- Consultations on Open Data and the PDC.
- Establishment of a single government agreement for access to OS data.
- OS OpenData providing free access for all to a number of key OS datasets.
- The announcement of a Public Data Group and governing Data Sharing Board in the chancellors Autumn Statement 2011.

In light of the changing policy landscape Council reviewed its role and the Location Strategy in 2011 and concluded that it continues to be relevant and compelling. The Transparency Board has acknowledged the role Council can play and the importance of UK Location and INSPIRE.

3. The Data

UK Location provides a rich catalogue of public sector location data, from a wide variety of public bodies. The data is discoverable at data.gov.uk, which provides textual search, map search and preview tools as well as catalogue services developers can integrate into applications. Delivering UK Location with data.gov.uk supports the government's policy of a single point of access to public data.

The INSPIRE Directive requires the publication of data for 34 themes (figure 3) covering a broad range of environmental data. The UK has published over 230 datasets for the INSPIRE Annex I & II themes. Figure 4 illustrates the quantity of data published at 9 November 2011, the deadline for INSPIRE Annex I & II datasets to be made discoverable with view services. Figure 5 shows the key organisations this data is sourced from.

Annex I	Annex II	Annex III	
Geographical names Administrative units Addresses Cadastral parcels Transport networks Hydrography Protected sites Coordinate reference systems Geographical grid systems	Elevation Land cover Ortho-imagery Geology	Statistical units Mineral resources Natural risk zones Soils Species distribution Environmental monitoring facilities Population distribution & demography Meteorological features Agriculture and aquaculture facilities Oceanographic features Area management restriction / regulation zones & reporting units	Buildings Sea regions Land use Energy resources Habitats and biotopes Human health and safety Utility and government services Atmospheric conditions Bio-geographical regions Production and industrial facilities
Deadlines Existing Data: Discovery & view 2011 Download 2012 Compliant Data: New 2012 Transformed 2017	2011 2012 2015 2017	2013 2013 2015 2020	

Figure 3- INSPIRE Data Themes & Deadlines

	9 November published (in progress)	December 2013 estimates
INSPIRE		
Datasets	216 (18)	1000+
Datasets with view services	172 (62)	100%
Organisations	31 (4)	100+
TOTAL		
Datasets	873	3000+
Organisations	34	100+
% of data.gov.uk records	13%	Likely to rise

Figure 4- Number of datasets & services available at 9/11/11 INSPIRE Deadline and 2013 Forecast



Figure 5- Current UK Location data providers

While the focus has been on the publication of data for INSPIRE UKLP is also working to facilitate the publication of a broader range of location data, this is illustrated by figure 4 which shows that at over 750 datasets not mandated by INSPIRE have also been published. UKLP is also investigating the publication of location data for health and infrastructure and it is considering its links with other initiatives including GMES, GEO and EOF.

To register data to UK Location providers must also provide web services to enable users to easily consume the data. View services (WMS) allow users to draw snapshots of data into their applications, whilst download services (WFS) enable users to undertake more complex analysis and data processing. UK Location is adopting INSPIRE specifications for these services for all data.

4. Opportunities

The delivery of UK Location presents users of location data with new opportunities. It is expected that implementing UK Location will deliver a range of benefits summarised, with examples, in Table 1.

Delivering more for less	
<ul style="list-style-type: none"> Reducing costs of delivery while providing more value Cutting duplication and promoting reuse 	<p>Newport City Council has improved the services it provides to its citizen by implementing a single addressing service across its business systems.</p> <p>The service uses the authorities Local Land and Property Gazetteer (LLPG) which is produced and maintained to national standards.</p> <p>Updating the central service instead of 17 separate systems has yielded an estimated annual net benefit of approximately £57,000 per annum.</p>
Better services	
<ul style="list-style-type: none"> More effective and responsive public services Better cross organisational coordination 	<p>The East Sussex Partnership, which includes local authorities and police, has a shared web GIS based fault reporting service for citizens. This shared service has enabled:</p> <ul style="list-style-type: none"> More cost effective contact and feedback from citizen A reduction in service costs, with 18,800 fault incidents logged over 5 years with an approximate net saving of £60,000 Reduced remedial action costs
Enabling innovative new services and economic growth	
<ul style="list-style-type: none"> Providing services which have been impractical or not cost effective Unanticipated reuse - new knowledge from different combination of data / data sets Increased commercial innovation and exploitation of location data Improved capacity and capability for use of location data 	<p>Natural England has a requirement to monitor moorland burning to ensure upland habitats are being properly managed. Natural England and the British National Space Centre sponsored research to investigate if burns could be successfully monitored using earth observation, remote sensing, automated image classification and GIS. The pilot projects were successful and the methodology is being used on a site by site basis leading to a reduction in field work and reduced costs.</p>
Better informed policy development and decision making	
<ul style="list-style-type: none"> Providing an improved evidence base Better preparation for and response to emergencies 	<p>In anticipation of possible flu pandemics the NHS established a network of local collection points for antiviral drugs.</p> <p>An analysis of potential sites using data on public buildings, accessibility, security and other factors such as homelessness and vulnerable people was undertaken.</p> <p>Data was sourced from multiple organisations and integrated and analysed in GIS reducing the time required to develop the network to 3 days.</p>

More open government	
<ul style="list-style-type: none"> • Making government information more accessible 	<p>The Environment Agency has undertaken a pilot to publish Bathing Water data in Linked Data form.</p> <p>Both water quality sampling points and water quality observation data are available in RDF enabling further data to be linked.</p> <p>Linking to other data offers the potential for users to see the relationship between a range of social economic and environmental factors such as bathing water quality and tourist visitor numbers and meteorological events like storms.</p>

Table 1 - UK Location Benefits

Once the culture of data sharing is widely embedded and standards are applied, less time and effort needs to be spent searching for, procuring, licensing, manipulating and transforming data and more time can be spent adding value to data through research, analysis and interpretation.

UK LP believes that UK Location provides an opportunity for academics and researchers to find new ways to exploit location data and services. The UK Location Campus Competition challenges the sector to use UK Location to deliver solutions in innovative ways but this is only the start, UKLP would like to work with researchers to find new ways to use the services provided by UK Location – **any ideas?**

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6. Biography

Andrew Newman is the UK Location Programme's Engagement Manger. Andrew is a GI expert with a degree in Geography and IT from the University of Northampton. He has developed GIS and GI data standards, managed teams, established communities of practice and is a member of professional groups including AGI. @andnewmangeo.

Studying the Persistence of Urban Segregation in the city of Cape Town through agent-based modelling

Jacobus M. van Rooyen

Department of Geography, Environment and Development Studies,
Birkbeck, University of London,
Malet Street, London, WC1E 7HX
Tel. (+440) 207 079 0644 Fax (+44) 207 6316 498
Email: hvanr01@mail.bbk.ac.uk

Summary: The history of the South African city was shaped more by a turbulent political past than by the inherent dynamics of urban growth. Since the initial emergence of colonization in South Africa racial prejudice and cultural segregation was evident and to date this phenomenon is still apparent in the major cities. This paper considers the idea of studying segregation and the potential promotion of future integrated development by the application of agent-based modelling to social and cultural interaction in the urban environment.

KEYWORDS: segregation, agent-based modelling, complexity, integration

1. Introduction

“In the absence of an indigenous urban tradition, South African cities were established by white settlers, who regarded the cities as their cultural domain.” (Lemon, 1991).

To date, many researchers have pursued and deliberated the tumultuous past of the South African city and much has been published on the colonial occupation of Southern Africa and the consequences of racial and social segregation.

The main objective of this paper is to provide an outline of my research – a study of the complex dynamics of cultural interaction within the residential environment of Cape Town by the application of agent-based modelling. Firstly, background to the historical urban development and segregation of Cape Town is provided, followed by a brief discussion on the concept of segregation modelling and the possibilities it presents. Finally, a brief outline is presented of the methodology applied and the initial and simplified conceptual model constructed for studying the nature of segregation in the case study area.

2. Context

2.1 Cape Town: A brief urban history

Urban development practice and related policy formation in South Africa has undergone much transformation in the past and Davies (1981) identified three predominant policy phases.

Initially, the colonial and settler period spanned from the start of white settlement development at the Cape in 1652, until the early years after the Act of Union was signed in 1910, followed by the start of progressive nationwide urban segregation. This phase was marked by the implementation of the Native Urban Areas Act of 1923, which stipulated that South African urban areas are “white” and prohibited access to “blacks”. This was superseded by the third phase when an act was created by the apartheid government of South Africa in 1950, known as the Group Areas Act. This extensive

legislation assigned “racial groups” to different residential and business quarters in urban areas, as seen in Figure 1. This act had a devastating effect in Cape Town and led to the forced removal and relocation of well-established communities to newly developed housing estates.

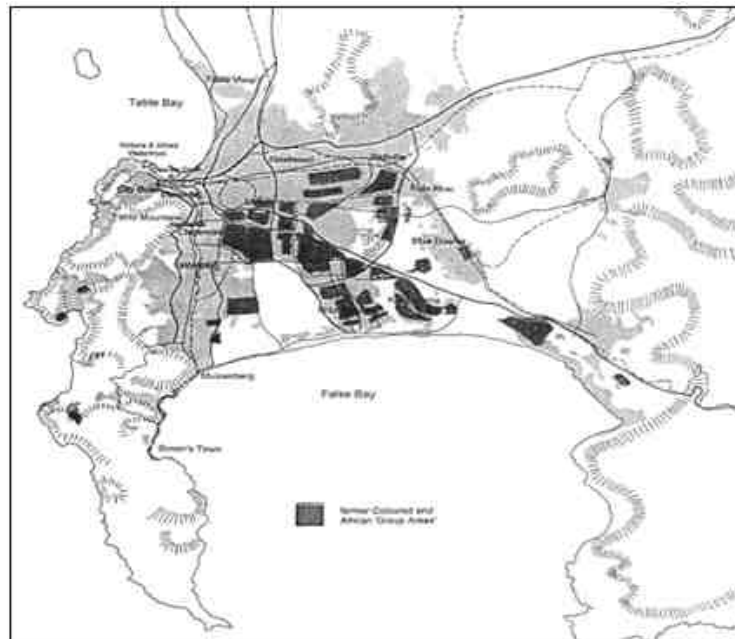


Figure 1. Location of Designated “Group Areas”
(source: City of Cape Town council)

The post-Apartheid government had to deal with an inherited spatial planning structure reflecting an illogical and fragmented planning system on a national scale. Hence, new legislation and initiatives were established to address these shortcomings. Watson (2002) highlights the concept of integrated development planning.

However, in the current post-apartheid era segregation remains evident within the urban environment (see figure 2) and spatial patterns of racial inequality and limited access to economic opportunities persist (Christopher, 2001a).

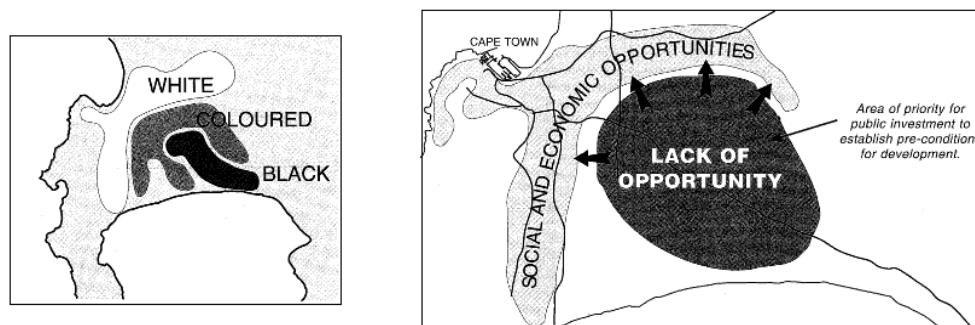


Figure 2. Segregation Emphasized by the Metropolitan Spatial Development Framework of the City of Cape Town (source: City of Cape Town council)

The complex nature of the segregated city of Cape Town provides a boundless challenge for the spatial planners involved to find an optimum solution to the question of social division and racial disparity in opportunity.

2.2 Segregation and Modeling

Although Reardon and O’Sullivan (2004) provide the means of quantifying the degree of segregation with neighbourhoods, there is little to be learnt from such analysis with regards to the behaviour or dynamics that lead to the outcome of segregation. The initial and general tendency is to view segregation as a predominantly negative phenomenon. Indeed this notion is also reinforced by the historical legislative process of enforcing racial segregation on the indigenous population of Cape Town. Communities were forcefully removed from the city and re-established away from opportunities and amenities enjoyed by others.

However, segregation can also be the result of preferential separation by culture or nationality. Goldberg (1998) stated the following: “Thus while the old segregation was ‘activist’ and for the most part monolithic, the new segregation is ‘conservationist’, preference driven, and class differentiated.” The fundamental basis of residential preference remains the subject of ongoing debate. Nevertheless, in the case of Cape Town and effectively most South African cities it is essential to preserve the distinction between preference and discrimination. Residential choice may be guided by preference as opposed to involuntary segregation by discrimination and economic constraint. Even so, comprehensive review of the issues is beyond the scope of this discussion.

In summary, preferential segregation is complex in nature and emerges predominantly from social psychology, group dynamics and also the history of racial and ethnic relations (Clark and Fossett, 2008). Hence, the rationale for ever-increasing interest in social simulation and segregation modelling is quite evident.

The economist, Thomas Schelling (1971, 1978), produced a series of papers in which he proposed a remarkable model exhibiting the self-formation of neighbourhoods based on the preference of people to live with “their own type”. In these models the micro-level preferences of individuals provide for a phenomenal outcome on a macro level.

The following section provides a brief layout of the proposed methodology behind the conceptual model, with Schelling’s concept as underlying basis.

3. Methodology

The objective of the study is to explore the complex dynamics of racial and cultural segregation within the city of Cape Town. The intention is to apply Schelling’s idea of “preferential” segregation modelling to the case study area and provide possible research expansion by considering in addition the phenomenon of segregation by constraint, as is evident in the case of Cape Town.

The screenshot presented by Figure 3 shows an example of segregation modelling undertaken by Crooks (2008). It exemplifies the fact that agent-based modelling allows for the capturing of a fairly large range of agent types and behaviour and also explores non-linear interaction between these agents. Furthermore, Crooks, Castle and Batty (2008) emphasized that models should be based on theory and be able to provide ‘what-if’ scenarios as a translation of theory into a testable format.

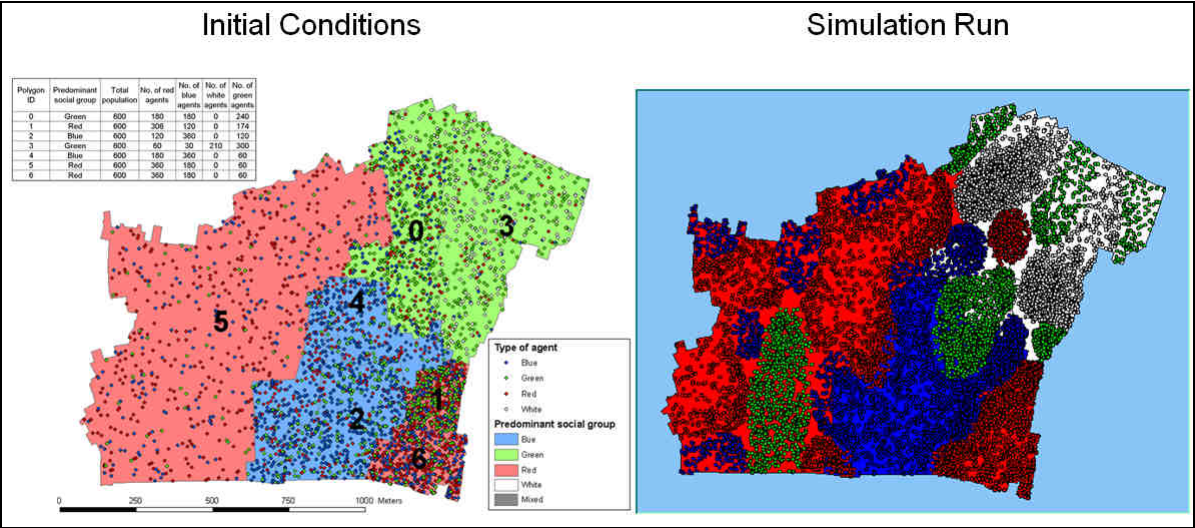


Figure 3. Residential Segregation Model
(source: Dr Andrew Crooks, George Mason University)

It was decided to utilize NetLogo (Wilensky, 1999) as modelling environment for the study, due to its suitability for modelling complex systems developing over time. The environment for the conceptual stage of the model will represent reality at a micro level and vector GIS data will be applied at a neighbourhood scale. Figure 4 provides an example of the GIS data that was obtained from the Cape Town city council. However, the neighbourhood structure in this report is presented in a more abstract form for the purpose of simplicity.

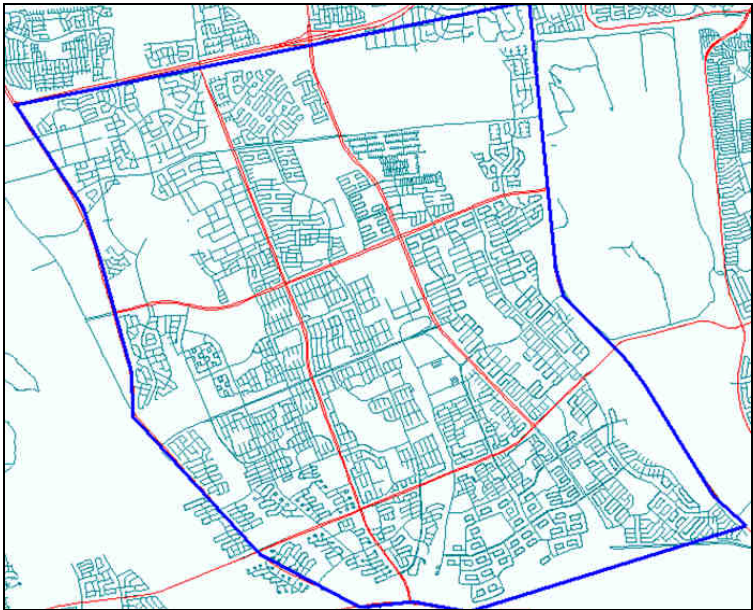


Figure 4. Neighbourhood Example in GIS
(source: City of Cape Town council)

For this particular study two different cultural groups of agents are constructed. Figure 5 shows two neighbourhoods (red and blue) for these cultural groups, divided by undeveloped land (purple). The movement of these two groups of people will be simulated and preference included at a later stage. The figure also indicates two existing train stations, which will play a role in the basic simulation of movement towards transport nodes.



Figure 5. Abstract Neighbourhood Areas in Netlogo

Behaviour and movement patterns for the agents of both groups will be determined predominantly by their cultural background. Figure 6 shows how agents are set up at an initial stage where they only move around in their own neighbourhoods and towards the stations in their own neighbourhoods.

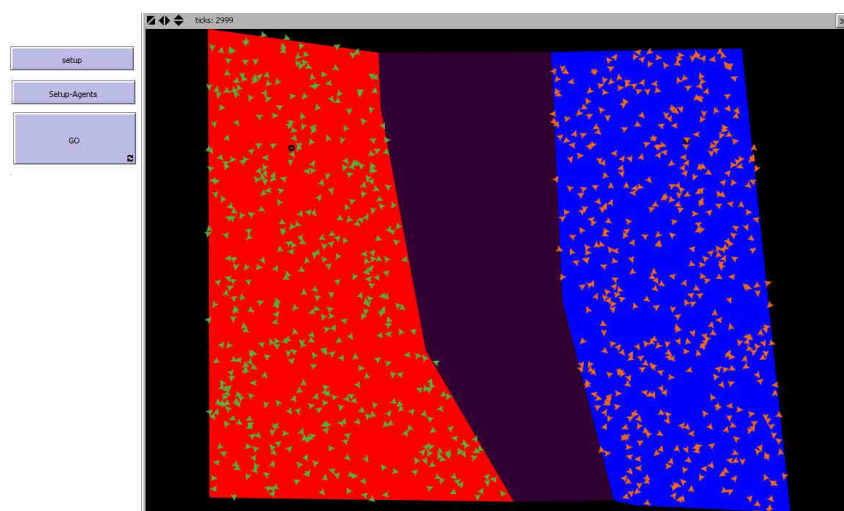


Figure 6. Agent Movement within Neighbourhood

The next step was the addition of a third station to present possible future development within the undeveloped area. Figure 7 indicates how agents choose to move to the closest station, regardless of the fact that they might need to leave their own areas to reach the new station. The model also allows for counters to be added keeping track of the number of people entering each station.

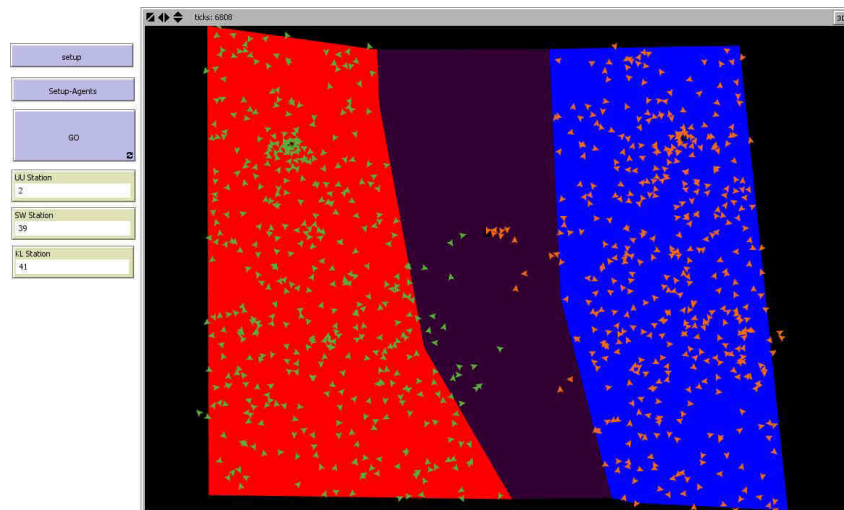


Figure 7. Agent Movement by Rules of Distance

The simulation process is now enhanced by the addition of the preference of each agent to stay in the vicinity of his or her own culture and use local transport services rather than approach the new station where interaction with other cultural groups might be experienced. Figure 8 indicates a slider (in green), which indicates the degree of preference of an agent for interaction with his or her own culture. The preference in this figure is set to high and in the counter for the new station (UU Station) it is evident that only two people entered the station.

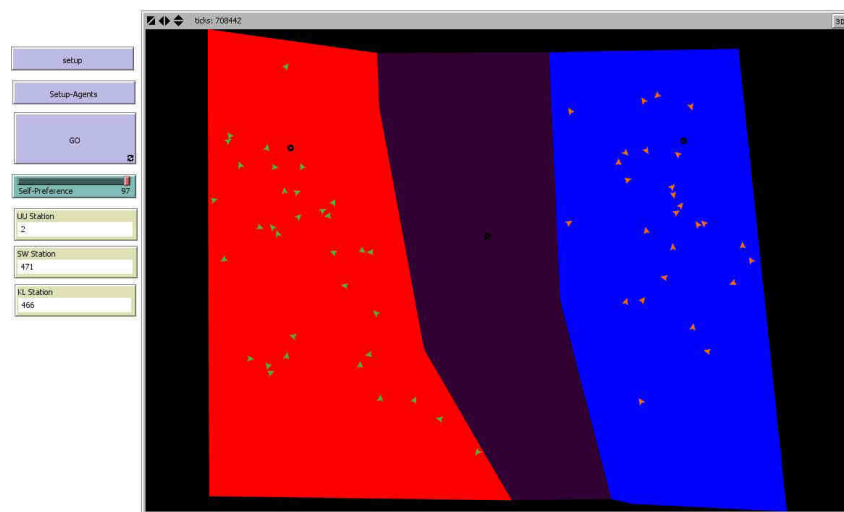


Figure 8. Agent Movement – High Degree of Preference to Own Culture

In contrast to this phenomenon, the slider in Figure 9 is set to a very low preference and it is evident that more than a 100 agents from both cultural groups used the new station, as they have less preference in remaining within their own cultural group.

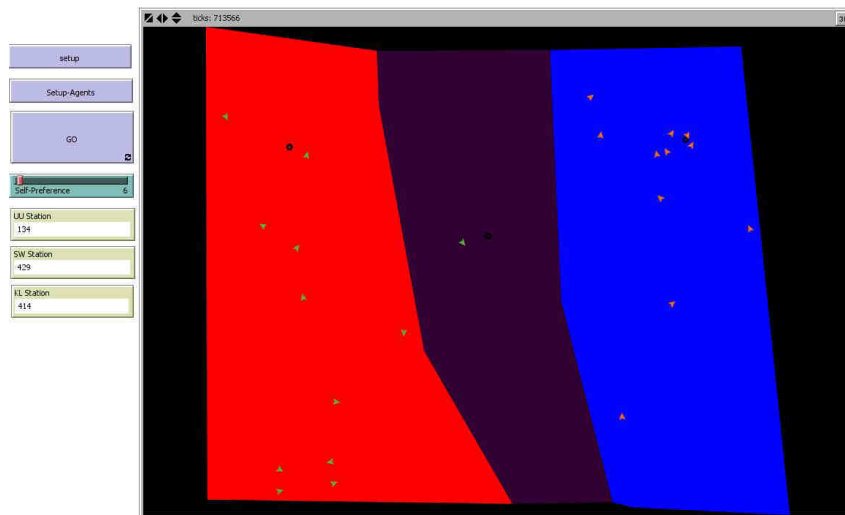


Figure 9. Agent Movement – Low Degree of Preference to Own Culture

It is intended for this conceptual model to prove that specific rules determine that the agents of each cultural group will move and interact in accordance with their preference and also constraints.

4. Conclusion

The intention of this study is to explore the dynamics of urban segregation within the city of Cape Town, by modelling social behaviour and interaction at a local scale and specifying what emergent patterns might be present at a larger scale. Agent-based modelling was identified as the most appropriate method for conducting this “bottom-up” approach in social simulation. The collective preferences of different cultural groups may provide better insight for integrated development decision-making.

5. Acknowledgements

**Department of Geography, Environment and Development Studies.
Birkbeck, University of London.**

Funding body
Joana Barros, PhD supervisor and mentor

City of Cape Town council.

Provision of census, statistical and GIS data.

MIT Media Lab

Daniel Wendel, advisor on modeling techniques

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Biography

Jacobus van Rooyen is currently a PhD researcher at Birkbeck, University of London. His research focuses on the application of agent-based modelling concepts to explore complex urban dynamics. Further interest involves the study of ancient cities and the phenomena of urban emergence and evolution.

Simple Maps – A Concept of Plain Cartography within a Mobile Context for Elderly Users

Kovanen J., Oksanen J., Sarjakoski L. T. and T. Sarjakoski

Finnish Geodetic Institute,
P.O. Box 15, 02431 Masala, Finland
firstname.lastname@fgi.fi

Summary: Ageing reflects the way in which people read maps. Maps should be designed to take deficiencies such as presbyopia into account for better map accessibility. Map design should also consider other vision-related weaknesses, such as colour vision deficiency. We present a plain cartography concept for creating simple maps that the elderly can also read. The concept is realized on a Web server and iteratively developed for use on mobile devices.

KEYWORDS: Plain cartography, mobile cartography, presbyopia, colour vision deficiency

1. Introduction

The population is ageing and a growing number of elderly people have some kind of restriction on their ability to read maps, notably mobile maps on small displays. However, neither current research studies nor map specifications provide specific cartographic rules for how to create usable maps that the elderly can read while still being aesthetically pleasing.

An example of a disability that affects the elderly pertains to changes in their vision, such as presbyopia. Presbyopia occurs as a result of a hardening of the crystalline lens. However, presbyopia can be corrected by using reading glasses, but when untreated, presbyopia makes reading traditional outdoor maps difficult. Another type of disability, one that not only affects elderly map readers, is colour vision deficiency. Requirements for suitable colour schemes and palettes have been studied in different contexts, such as digital displays (Meyer and Greenberg, 1988), digital maps (Olson and Brewer, 1997) and car navigation (Pugliesi and Decanini, 2011). These colour schemes only contain colours that can be distinguished; that is to say, the colours are outside confusion lines. One option is to replace colours with patterns.

From the linguistic perspective, the problem of creating legible contents has been addressed through plain language (e.g. Cutts, 2004). The target audience of such a plain-language solution is not only users with decreased cognitive abilities; the theoretical framework can also be used to address the concerns of other user groups, such as the elderly. In a broader context, the principles of plain language could improve the efficiency of communication with the general public when the circumstances for communication are non-optimal, for example in a mobile context. The concept of plain language defines rules for how to create or convert the vocabulary, structure and content of a language into a more understandable and readable form. In addition, guides for plain language include design principles for efficient communication. In this paper we introduce the concept of *simple maps*, which represents an example maps that have been made by adopting the rules of *plain language* for *plain cartography*.

2. Realization of plain cartography

The simple maps concept arose as part of a requirement to simplify the maps that had been designed for the general public and for outdoor leisure activities in the MenoMaps project (Oksanen et al., 2011). The maps did not take the vision-related disabilities of users into account (Figure 1), and the elderly found them to be too complex and overloaded with information. During the HaptiMap project, map accessibility became a central aim and, therefore, the map design needed to be recreated.

One possibility to take the elderly into account is to design entirely separate maps for them, which is nowadays feasible on digital platforms. For example, presbyopia can be taken into account in map design by increasing the contrast between objects, and by emphasizing the important features more than traditional cartography does. Also, the typography of map labels, such as their typeface design and print size, has to be adjusted for the users and for the desired reading range (Legge and Bigelow, 2011). Our aim was to make the maps usable not only for the elderly users that visit national parks, but also, to a certain extent, for other user groups. Hence, we addressed vision-related problems in a mobile context by first deriving the principles of plain cartography and then utilizing them to develop a simple map (Figure 2).



Figure 1. Original outdoor map created for the general public.



Figure 2. A simple map created for the elderly.

The aim in creating principles for plain cartography was to strike a balance between visual clarity, information density and the necessity of including particular map elements from the perspective of the accessibility of the terrain. By using this approach, only indispensable information from the earlier maps (Figure 1) was preserved; redundant information was removed and the symbology for the features was simplified and clarified. Thus, the selection of the map elements, the degree of generalization and the classification and symbology of the features reflect the principles of plain cartography.

We first ranked the map elements according to their importance within the context of outdoor activities. We gave the highest ranking to a road and path network and to lakes and rivers, cliffs, swamps and other land use features, as well as to buildings. Examples of map elements with the lowest ranking included power lines, forest-type symbols and polygons representing bedrock outcrops, all of which were left out from the simple map. In between the highest and lowest rankings we ranked the surface forms. For the simple map, we left out the contour lines and placed relief shading behind all of the other map elements to decrease the information density of the map.

Secondly, we combined road classes, showed fewer details of buildings and removed redundant and unnecessary labels. Thirdly, we simplified the symbology, for example by leaving out the outlines of road symbols. In addition, we replaced the colour of swamps with a line pattern to increase their visual differentiation. The primary colour of the text elements was still black, but we added a white halo to increase the contrast between the text and the background. We chose to colour the labels for bodies of water with dark gray to distinguish them from other places, and we used italics for labels denoting nature-related features. Finally, we validated that all of the colours were easier for those with poor vision to read by using an application (Vischeck, 2011) that simulates the colour appearance of dichromats (Figures 3 and 4).



Figure 3. Simulation of the colour appearance of a simple map as seen by protanopes.



Figure 4. Simulation of the colour appearance of a simple map as seen by Deuteranopes.

We implemented the simple maps for six different design scales (Figure 5). The maps were rasterized and tiled to be suitable for small, high-resolution displays. This required two different sets of tiles. One set was created for displays with a resolution of approximately 150 points-per-inch and another targeting the displays with a resolution of approximately 300 points-per-inch. To reduce data download sizes, we chose PNG8 as the default data format; this also affected the colour palettes. Next, the tiles were made available through a Web Map Service interface. Finally, the maps were iteratively reviewed on an in-house built mobile application.

3. Conclusions and future work

In this paper we have presented the concept of plain cartography, which we consider a viable alternative to general cartography. The simplification and selection required for plain cartography creates maps that should be easier to understand by non-cartographers and especially by the elderly. The mobile context introduces another set of challenges, such as the limited view size and restricted network connection. An example of the effects of the latter has to do with the maximum size of the colour palettes.

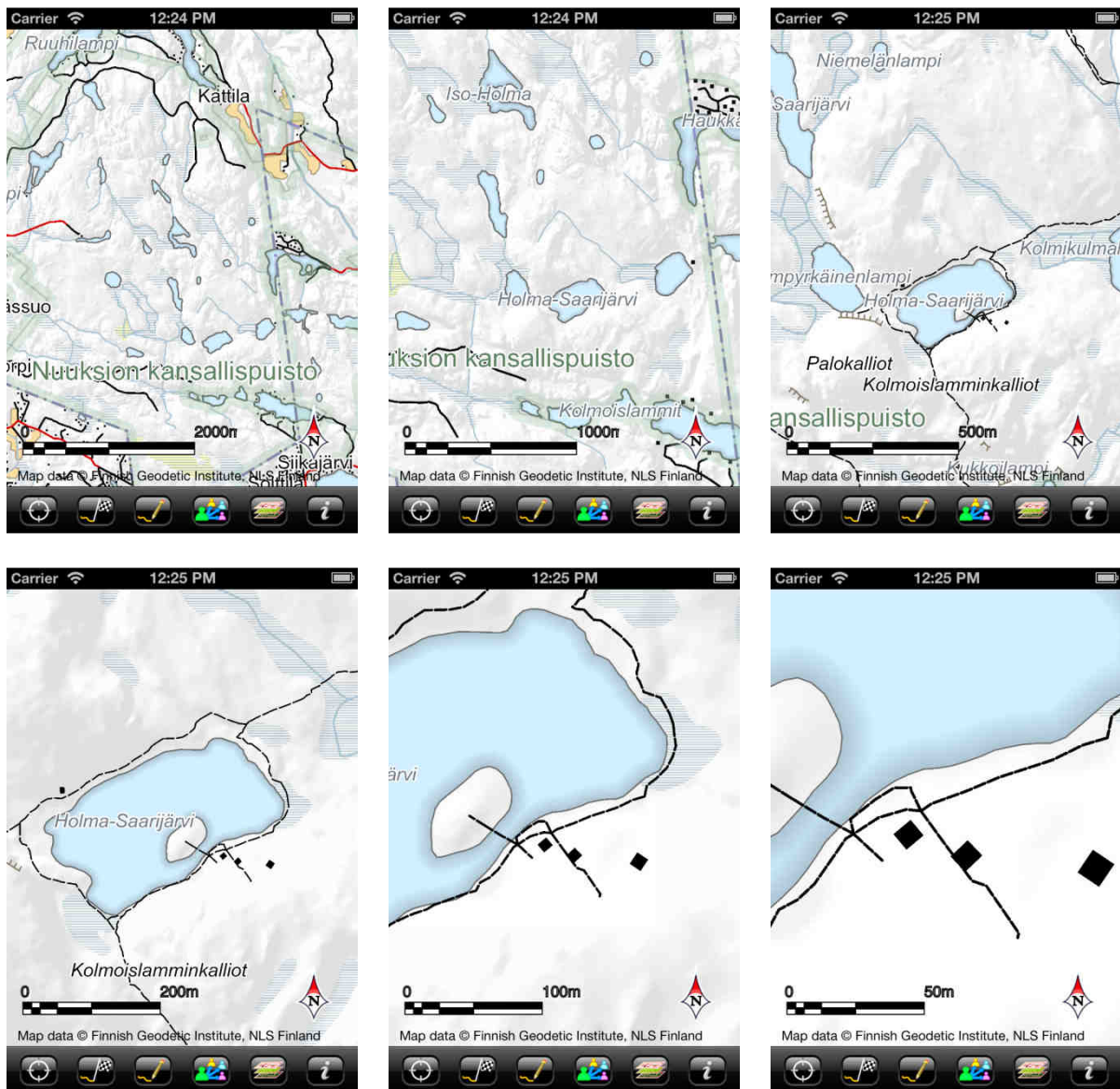


Figure 5. The simple maps on six scale levels, as seen on an in-house built client.

The presented study will continue with an expert evaluation. The results of the evaluation will be used as input for our next iteration, in which elderly users in real outdoor conditions validate the maps. In addition, we have not yet tested combining the simple maps as background maps with selectable themes especially important for the elderly, like the accessibility or steepness of paths. An important part of this research will involve finding a symbology and set of good colour schemes that could be used in these overlay layers.

4. Acknowledgements

This survey is part of three research projects. The European Commission supported HaptiMap project (FPT-ICT-224675) is coordinated by the Lund University. The MenoMaps project funded by Tekes is a joint venture of the FGI and Aalto University of Helsinki. The UbiMap project is funded by the Academy of Finland, Motive programme and is carried out in co-operation with the FGI and the University of Helsinki.

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6. Biography

M.Sc. Janne Kovanen has a position in the Dept. of Geoinformatics and Cartography at the Finnish Geodetic Institute as a senior research scientist. His field of expertise includes the development process of geographical information systems. Currently his focus is in the development of mobile mapping applications and the use of ubiquitous computing.

Dr. Juha Oksanen is a specialist research scientist in the Dept. of Geoinformatics and Cartography at the Finnish Geodetic Institute. In 2006, he received his Ph.D. degree in Geography from the Helsinki University. His focus area of research is cartography, geovisualisation and uncertainty-aware geospatial analysis.

Dr. Lea Tiina Sarjakoski acts as a research manger in the Dept. of Geoinformatics and Cartography at the Finnish Geodetic Institute. She has published in the field of knowledge-based methods for GI, usability of mobile topographic maps, visualisation and generalisation for network processing and mobile map services.

Professor, Dr. Tapani Sarjakoski is the Head of the Dept. of Geoinformatics and Cartography at the Finnish Geodetic Institute. He is also a docent in geoinformatics at the University of Helsinki and as a docent in photogrammetry at the Aalto University.

Climate Change & Solent Coastal Vulnerability: Mapping Impacts on at-risk Assets and Vulnerable Sectors of Society

Sarah Percival¹, Richard Teeuw²

¹Centre for Applied Geosciences, School of Earth and Environment Sciences,
University of Portsmouth, Burnaby Building, Burnaby Road, Portsmouth, PO1 3QL
Tel. +44 2392842418
Sarah.Percival@port.ac.uk
Tel. +44 2392842267
Richard.Teeuw@port.ac.uk

Summary: Climate change is expected to increase the frequency and magnitude of flood events. Society's vulnerability to flooding has increased, due to urbanisation, extension of infrastructure and other land-use changes in flood-prone areas. This project will concentrate on coastal flood vulnerability, and aims to produce an integrated GIS database that will facilitate the modeling of coastal flood vulnerability maps, which will identify at-risk assets and vulnerable sectors of society. The Solent region will be used to test this methodology, particularly the island city of Portsmouth and the Havant coastal district.

KEYWORDS: Vulnerability, Assets, Flooding, Mapping, Solent

1. Introduction

Coastal zones have social, economic and environmental importance: they attract settlements and economic activity. Coastal activities are vulnerable to climate changes. Sea-level rise and more intense storms could raise flood risk, increase coastal erosion and adversely affect ecosystem structure and functioning, especially on low-lying coasts (Nicholls et al, 2008). Coupled with natural risks, the problems associated with our ever changing human environment on the coastline have increased the risk of coastal flooding. According to the Environment Agency (2011), there are around 490,000 properties today in England that face a 1 in 75 chance, in a given year, of flooding from rivers and the sea. The Environment Agency have also predicted within their Investing for the Future Report (2009) that if overall investment remains at 2009 levels and if there is no additional development in the areas at risk, by 2035 there will be an additional 350,000 properties (280,000 residential) in areas with a 1 in 75 or greater annual chance of being flooded. The expected annual damages to residential and non-residential properties in England at risk of flooding from rivers and the sea is estimated at more than £1 billion. Floods can also cause serious indirect impacts, including damage to important energy, water, communications and transport infrastructure. They can also interfere with basic public services such as schools and hospitals (Environment Agency, 2009). According to the latest Environment Agency reports (2011), 55% of water and sewage pumping stations/treatment works, 20% of railways, 10% of major roads, 14% of electricity and 28% of gas infrastructure are located in areas at risk from flooding.

Population change, development and land management, will also affect risk to coastal flooding. For example, in England the population is predicted to increase by 10 million by 2030 (Hughes, 2009), which will increase the need for homes and infrastructure. Planning must be carried out correctly, otherwise more people and properties could be placed in areas at risk from flooding. Land cover type and land management can also have significant effects on the movement of surface water, with a likely increase in impacts from fluvial flooding and urban flash-floods (The Environment Agency, 2011). Sea level rise and regional subsidence will also affect water tables, with a probable increase in groundwater flooding.

This study examines the effects of climate change on coastal businesses and communities in the Solent (Figure 1), focusing on the island city of Portsmouth and the coastal zone of Havant Borough (highlighted in Figure 1). The main research questions are:

- How can at-risk social, environmental and economic assets be classified and analysed?
- Can socio-economic vulnerability analysis be interlinked with land cover/ land use analysis?
- Can improvements be made to frameworks for coastal flood vulnerability analysis?

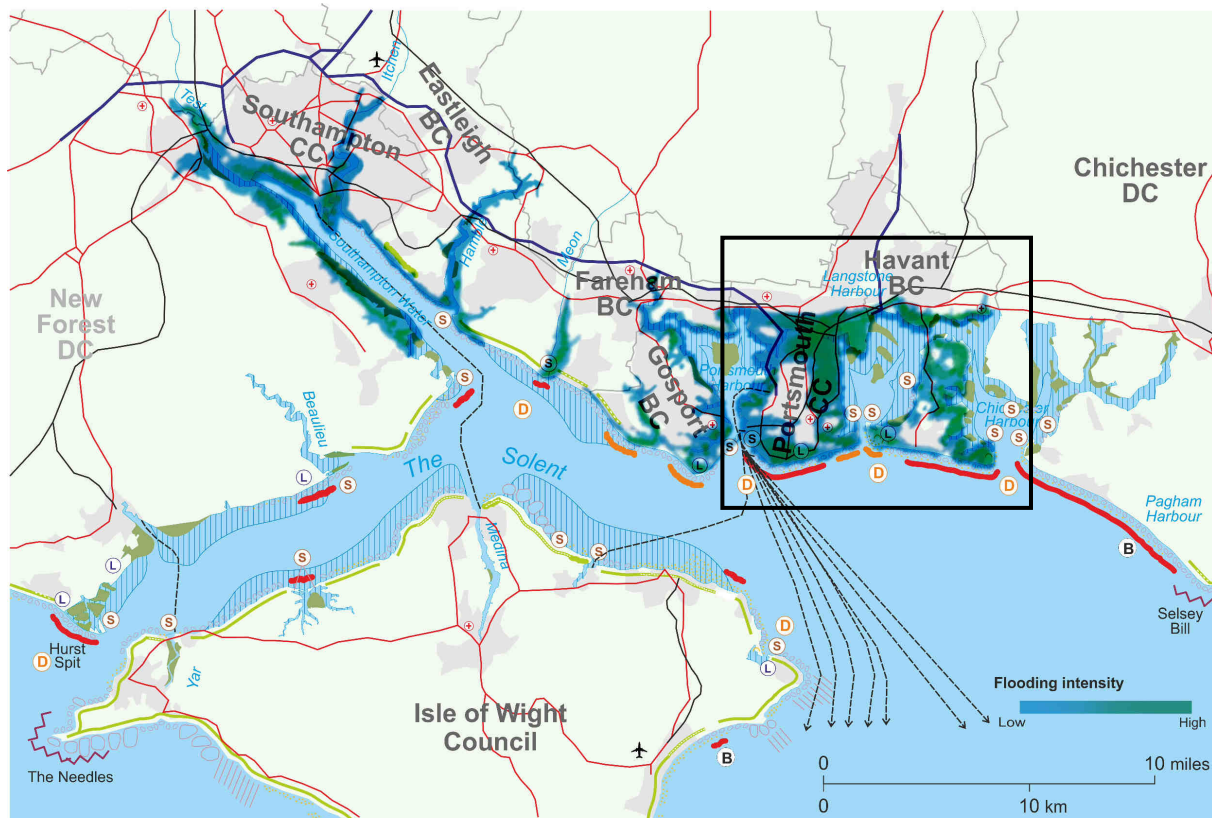


Figure 1. This map incorporates data from Standing Conference on problems associated with the Coastline (SCOPAC), The Solent Forum and Google Maps, it includes coastal landforms, urban distribution, important points of infrastructure and expected flooding for 2115 (based upon the Partnership for Urban South Hampshire (PUSH) Strategic Flood Risk Assessment)

1.1 Case Study areas – The Solent, Portsmouth and Havant Borough

The Solent is the body of water that lies between the central south coast of England and the Isle of Wight (Figure 1). It is a low energy, sediment dominated estuarine complex, consisting of 12 separately defined estuaries and harbours, draining a catchment of approximately 3000 km² (Fletcher et al., 2007). Expected predictive flooding from the PUSH analysis, indicated that the city of Portsmouth and Havant Borough, had the greatest risk to future high intensity coastal flooding (see figure 1). These two areas are also socio-economically different, one being a major city, the other more rural and suburban. Therefore, analysing coastal vulnerability in different socio-economic settings, but under the same environmental conditions.

The city of Portsmouth (Figure 1) is a low-lying maritime island city and one of the most densely populated areas in Britain (Portsmouth City Council, 2009). It is also of major economic importance for industry, commerce and, tourism, as well as being the primary naval port of Britain. The area of Portsmouth is approximately 40 km², split between Portsea Island and the mainland. The city has 45 km of open coastal frontage. At present, the Strategic Flood Risk Assessment (SFRA) for Portsmouth

has shown that the primary source of flood risk is from the sea: approximately 47% of the city's land area is designated as within the Environment Agency's Flood Zones 2 and 3. The SFRA has predicted that the areas most vulnerable to rising sea levels, are Southsea and Eastney (Atkins, 2007). Portsmouth has a mix of average and high social vulnerability to flooding. However, Flood zones 2 and 3 generally have a high social vulnerability to flooding on the east of Portsea Island and the north-eastern part of the mainland, while the remaining areas mostly have an average social vulnerability to flooding (Atkins, 2007).

The Borough of Havant has a coastline of 48 km, mostly around Hayling Island (Figure 1). Havant Borough Council maintain the coastline, with the assistance of land owners whose land adjoins the shoreline (Havant Borough Council, 2008). Hayling Island has an area around 30km², and is a low lying coastal plain island, separated from the mainland by shallow tidal harbours. The maximum height is about 5 m Above Ordnance Datum (Hampshire County Council, 2010). At present, approximately 22% of the Borough's land area is within the Environment Agency's Flood Zones 2 and 3. The primary source of flood risk to Havant is from the sea (Atkins, 2007), with Hayling Island the most sensitive area to sea level rise, particularly the southern half of the island. Havant Borough has a mix of average and high social vulnerability to flooding. However, within flood zones 2 and 3 there is a high social vulnerability to flooding on the mainland and average social vulnerability to flooding on Hayling Island Atkins (2007).

2. Preliminary Findings

This study has utilised maps from the Ordnance Survey, historical flood data from the British Geological Survey, and data on expected flooding to 2115 from the SRFA. Combining these datasets identified 'assets' that were affected by past flooding and the areas for potential future flooding. Coastal flood risk maps for the Solent lack detail with regard to socio-economic and asset data. For instance, Figure 2 is the most detailed Environment Agency map, in which, 'asset' and land use data have been identified. Furthermore, the National Flood Risk Assessment shows areas at risk of land flooding, but does not show which specific properties are at risk. This project will produce an integrated GIS database based on Ordnance Survey data sets (Mastermap, Integrated Transport Network, Points of Interest, Address layers 1 & 2, and a Digital Surface Model), Environment Agency Flood Hazard Zones (2 & 3) and socio-economic data (UK national census (2001) and economic). These datasets will be used to develop a methodology for a vulnerability and resilience analysis which will facilitate the production of flood vulnerability maps for the UK coastal zone.

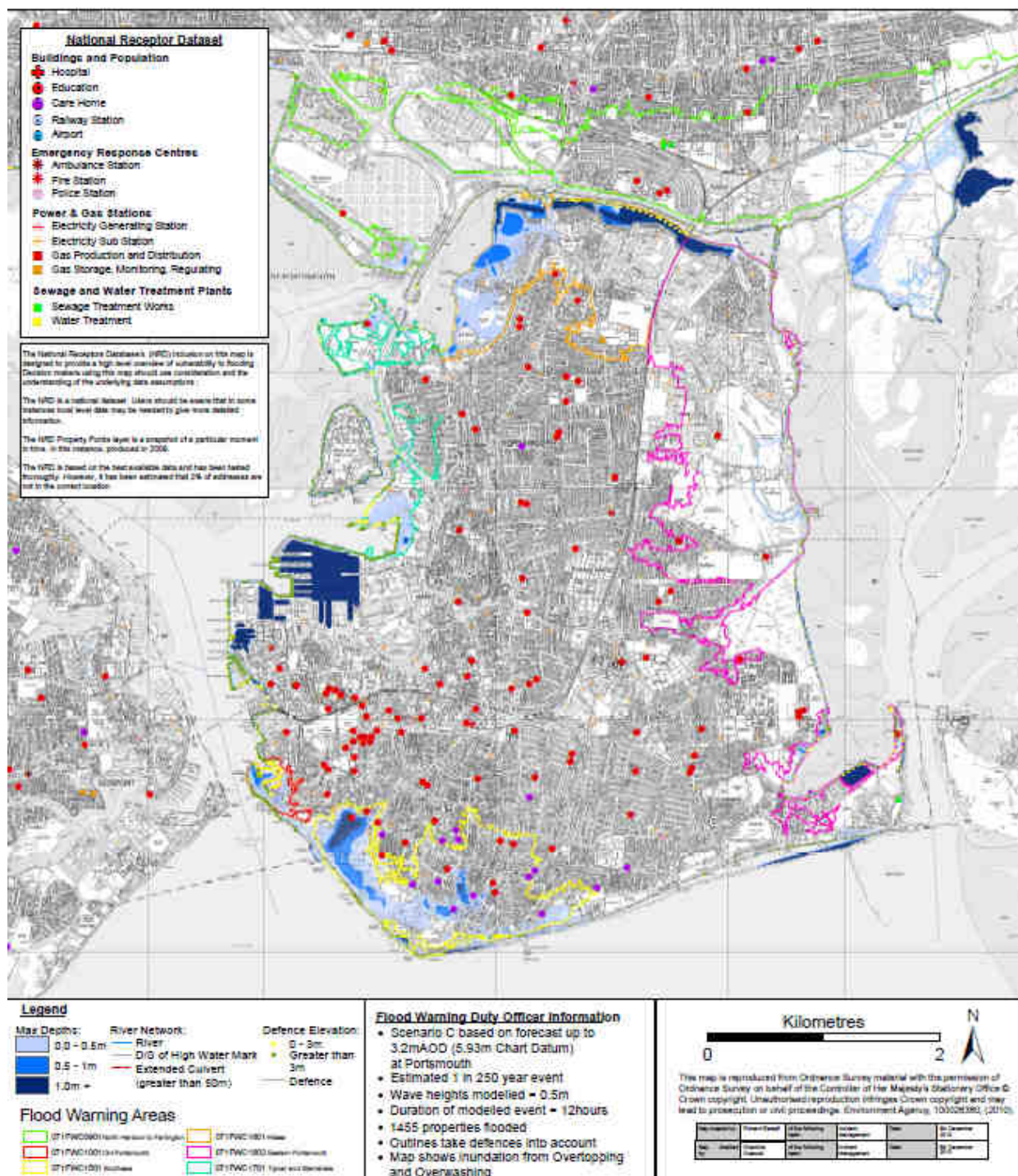


Figure 2. Portsea Island – Flood Inundation Scenario C (Environment Agency, 2010)

3. Methodology

The methodology follows six stages to produce Coastal Flood Vulnerability maps (Figure 3). They include different social, environmental and economic ‘asset’ datasets, which have been split into three stages within the methodology, and are explained in more detail in sections 3.1, 3.2 and 3.3. This mapping methodology can be re-applied around the UK coastline and will result in a social, economic and environmental vulnerability analysis for coastal flood hazards that can be used by local authorities, private organisations, government agencies, developers and emergency planners.

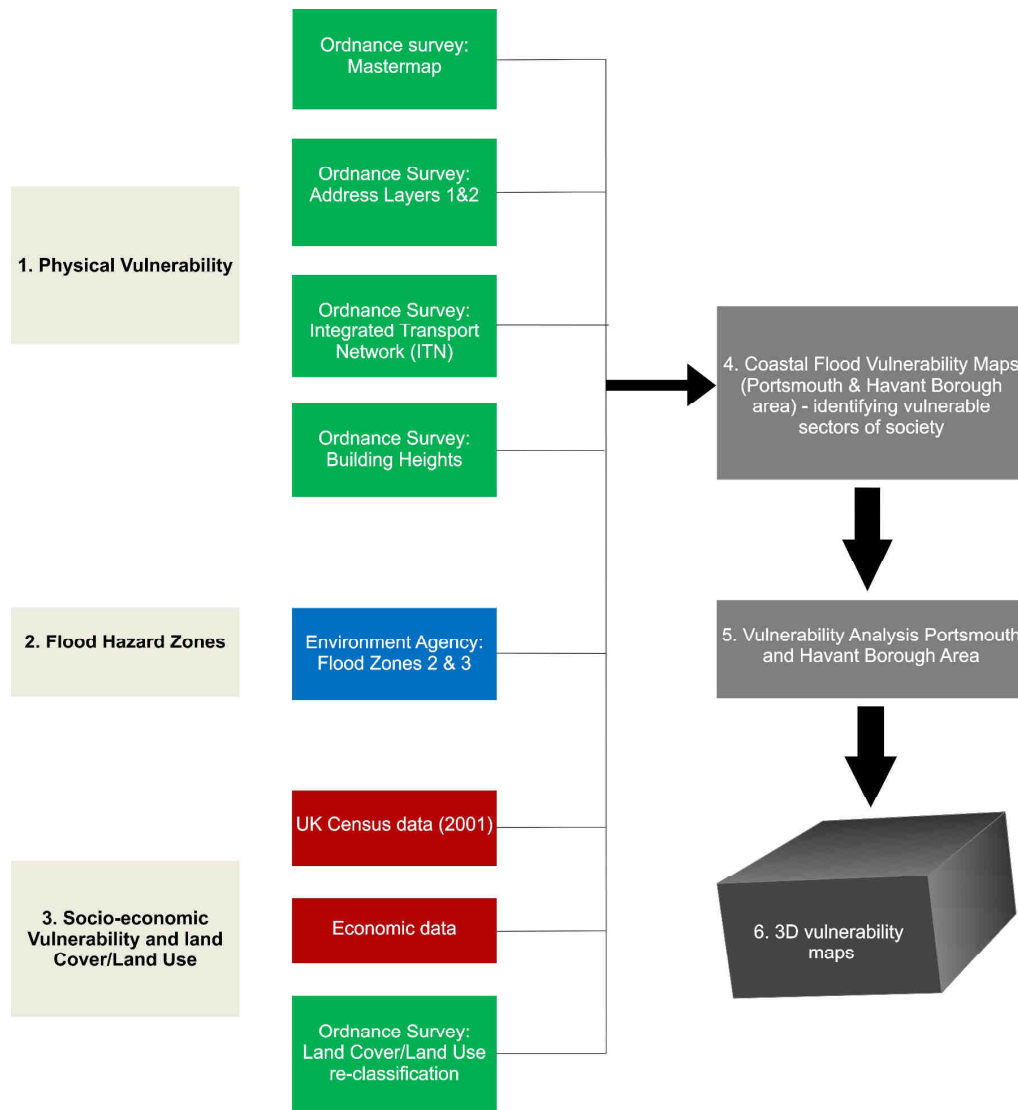


Figure 3. Mapping methodology

3.1 Stage 1 - Physical Vulnerability

Ordnance Survey data layers have been processed using ArcGIS. The O.S. datasets include; Mastermap, Address Layers (1 & 2), Integrated Transport Network, and building heights. The layers have been clipped and split into electoral ward size polygons. The Land cover/Land use data was separated using a classification system (ontology) already present within the O.S. Mastermap datasets. These steps have produced ward size maps that give a detailed, manageable view of the area, at a local scale (e.g. Figure 4).

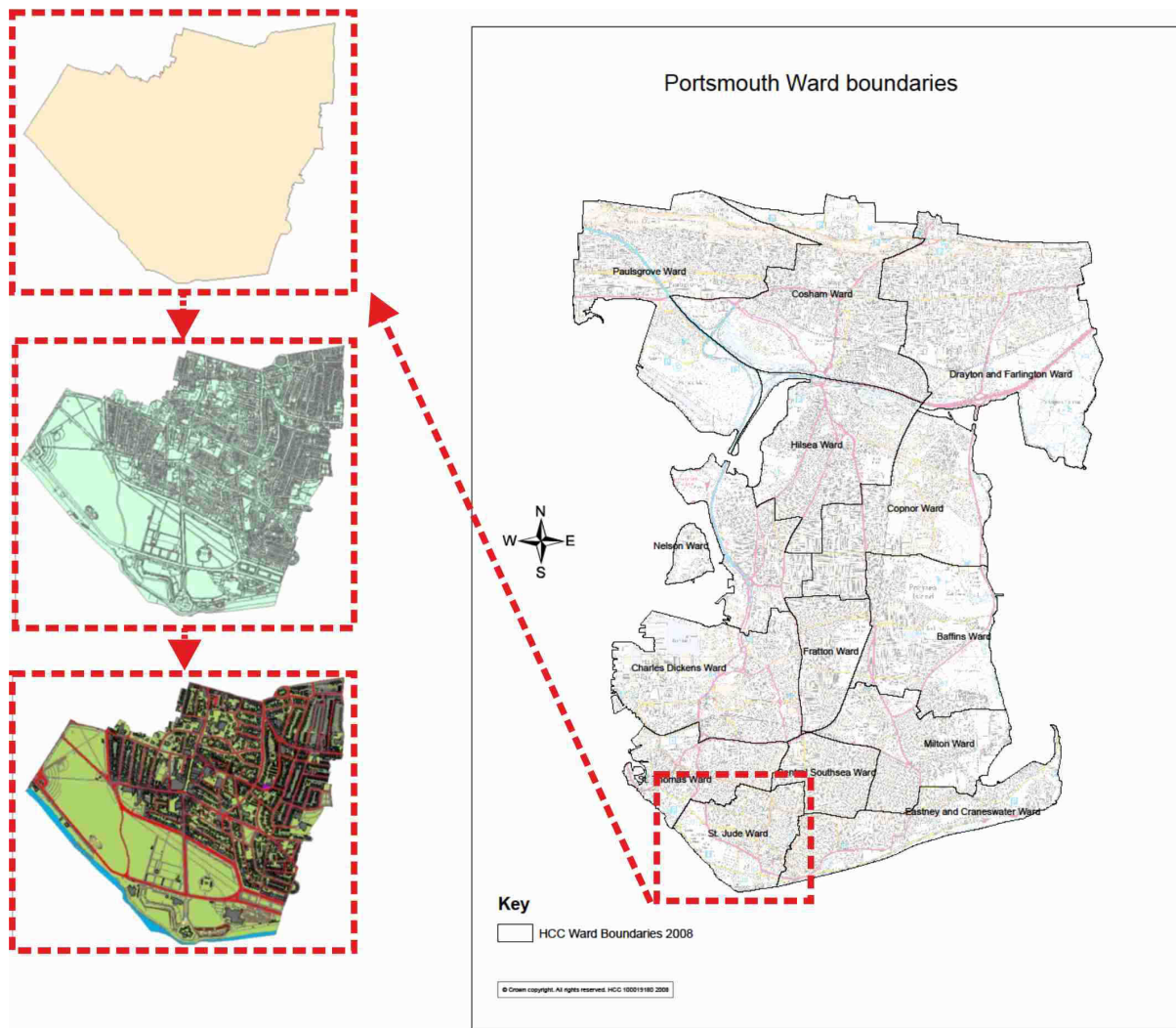


Figure 4. Adding all Ordnance Survey Mastermap data layers; split into electoral ward size polygons

3.2 Stage 2 - Flood Hazard Zones

The flood hazard zones used within this research are provided by the Environment Agency (Figure 5). The production of these flood hazard zones in England followed the publication of the Planning Policy Statement (PPS) 25 and pressure from the Government to provide Local Planning Authorities with quality-assured flood risk data. Combined with this, is the commitment the Environment Agency has given to improving information on flood risk (Environment Agency, 2011). The flood zones used within this research are:

Zone 2 - areas where the chance of flooding in any one year is between 0.1% and 0.5% (i.e. between a 1000 to 1 and a 200 to 1 chance). The outer edge of this zone is the 'Extreme Flood Outline' (EFO).

Zone 3 - areas with the highest probability of flooding. The chance of flooding in any one year is greater than or equal to 0.5% (i.e. a 200 to 1 chance).

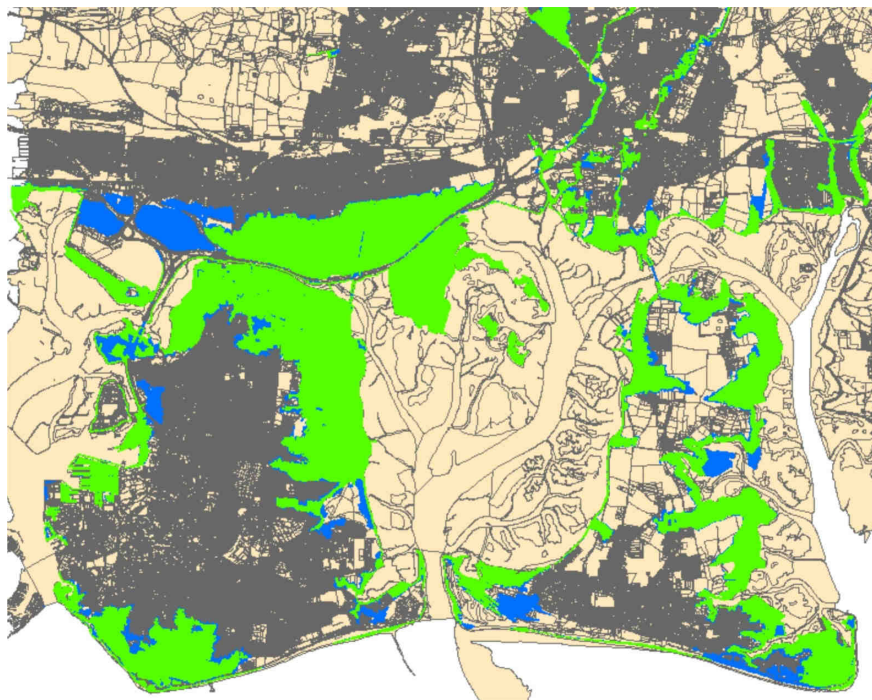


Figure 5. Environment Agency Flood Zones 2 (blue) and 3 (green) added over Ordnance Survey area polygons

The flood zone data has now been clipped to individual ward size (to continue with stage 1) and added to the physical vulnerability data layers (Figure 6). Orthorectified photography of the area has been used to provide a more easily recognisable background to the maps.



Figure 6. Environment Agency Flood zones 2 and 3 added to ward size physical vulnerability polygons.

3.3. Stage 3 and Beyond

The research is now at the beginning of Stage 3. Work has started for the last point (visualisation techniques) this can be seen in Figures 8a and b:

1. Frameworks will be established for (i) socio-economic vulnerability analysis and (ii) for land cover/use analysis; interactions between land use and socio-economic vulnerability will be examined (for instance, Figures 7a and 7b show examples of other studies and their results for land cover/use re-classification).
2. The end-product will be Coastal Flood Vulnerability Maps: identifying vulnerable infrastructure and sectors of society. The final stage of the project will investigate innovative visualisation techniques for flood risk mapping, as illustrated in Figures 8a and 8b which show preliminary results when combining ward coastal vulnerability maps in 3D.



Figure 7a. Re-classifying land cover and land use data sets and adding 3D structures (Kinley, 2010)

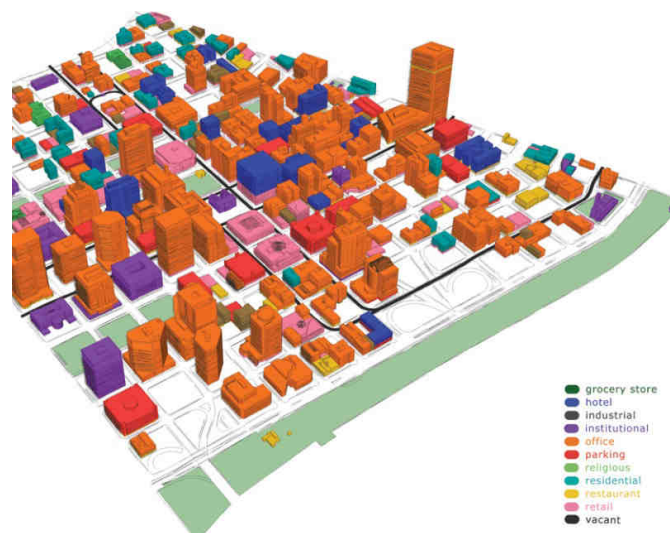


Figure 7b. More examples of a re-classified land cover and land use data set, with the addition of 3D structures, but for a section of the City of Portland (City of Portland Bureau, 2002)

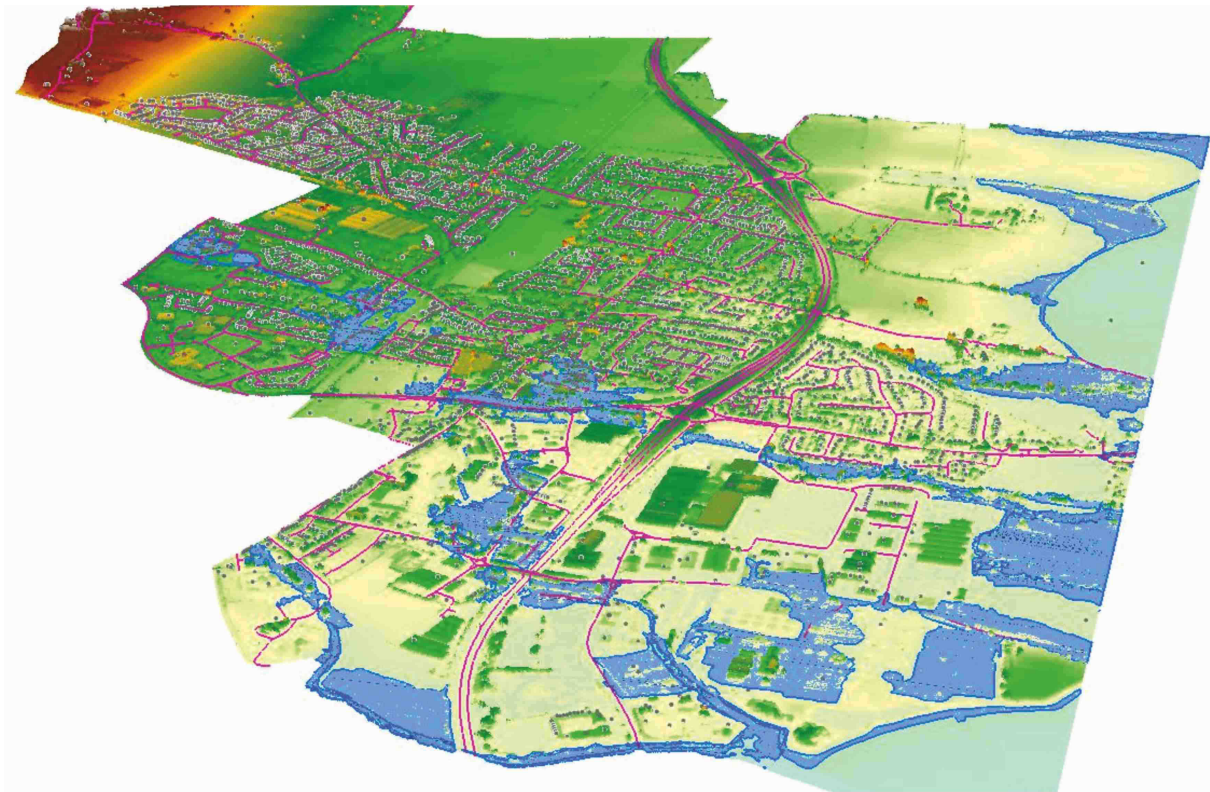


Figure 8a. 3D Coastal flood vulnerability maps at ward level. This map is clipped to an OS DEM and an OS digital boundary for St Faiths ward which is within the Havant Borough area. Within this clipped polygon are the OS Mastermap data layers; ITN and Address Layer. The final clipped layer, is the Environment Agency Flood Zone 2 layer.

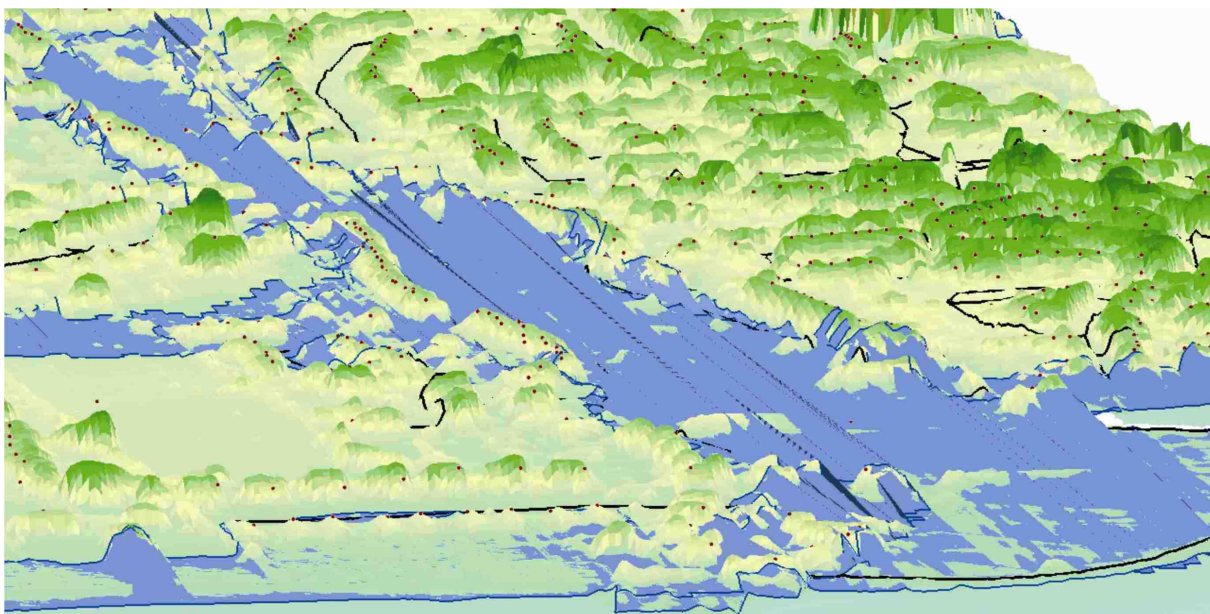


Figure 8b. Zoomed in section of St Faith's ward coastal vulnerability map.

4. Conclusion.

Coastal flood risk maps lack detail with regard to socio-economic and asset data. This research will produce coastal flooding vulnerability maps for Portsmouth and Havant Borough. These maps will incorporate new visuals and socio-economic and land cover/use analysis. These maps will be part of a social, economic and environmental vulnerability analysis for UK coastal flood hazard zones that can be used by local authorities, private organisations, government agencies, developers and emergency planners.

5. Acknowledgements

Thanks to the Ordnance Survey for their support and data, as well as to the University of Portsmouth, for logistical support.

Acknowledgement should be made of any funding bodies who have supported the work reported in the paper, of those who have given permission for their work to be reproduced or of individuals whose particular assistance is due recognition. Acknowledge data providers here where appropriate.

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7. Biography

Sarah Percival is a PhD student in the School of Earth and Environmental Sciences at Portsmouth University, using GIS to assess climate change impacts within coastal areas of the UK. Current research is focused on vulnerability mapping.

Richard Teeuw is a Principal Lecturer in the School of Earth & Environmental Sciences at Portsmouth University, using remote sensing and GIS to assess geohazards and Earth resources. Current research is focused on uses of low-cost geoinformatics for disaster risk reduction and vulnerability mapping.

Dung Beetles of the UK Uplands: Predicting Responses to Future Environmental Change

Ali J. Birkett¹, Blackburn, G. A.¹, Bardgett, R. D.¹ and Menendez, Rosa¹

¹ Lancaster Environment Centre, Lancaster University, Lancaster, Lancashire, UK. LA1 4YQ

Tel. : +44 (0) 1524 593508

Email: a.birkett1@lancaster.ac.uk

Summary: Studies considering the cumulative impacts of both climate and land use change on species distributions are relatively uncommon. This study contributes to this area using the dung beetles of the UK's Peak District National Park as a study system. A GIS is being used to assemble environmental variables into a consistent spatial framework and model the current and future distributions of dung beetle species. Work is ongoing at the time of abstract submission, but current results predict distributional responses to warming air temperatures in five species, including the potential regional extinction of one by 2050.

KEYWORDS: British uplands; distribution modelling; dung beetles; environmental change; spatial ecology

1. Introduction

Future environmental changes in terms of climate and land-use changes are both predicted to have significant impacts on the distribution of species worldwide (e.g. Thomas et al., 2004, and Kremen et al., 2007). Studies considering the cumulative impacts of both types of change are, however, relatively uncommon. The aim of this study is to contribute to this area, using the dung beetles of the uplands of the Peak District National Park as a study system.

Dung beetles are known to provide a wide range of ecological functions through their movement and consumption of mammalian dung. These functions include the physical breakdown of dung pats; contributing to nutrient cycling processes and controlling parasite populations (Hutton and Giller, 2003, Gardner et al., 2008, and Nichols et al., 2008). Given the importance of these functions, there is concern over how such a crucial group as the dung beetles will respond to climate (Menendez and Gutierrez, 2004) and land use change (Hutton and Giller, 2003, Vessby and Wikteliuss, 2003, Gardner et al., 2008) in the future.

2. Methods

2.1. Field Survey

This was the first known dung beetle survey of the UK's Peak District National Park. 32 field survey sites were selected across the moorland, heathland and upland acid grasslands of the National Park between 240 and 600 metres a.s.l. The dung beetle community was surveyed at each site in summer (August 2010) and spring (May 2011) using dung-baited pitfall traps and hand-sorting of naturally occurring sheep dung. For each site, environmental data were also collected, or are currently being sought. This includes air temperature data (two hour intervals for whole year) collected using onsite dataloggers.

2.2. Distribution Modelling

To date, species distributions in terms of presence and absence have been modelled at the landscape scale in relation to elevation using binary logistic regression and the digital elevation model (DEM). By relating elevation to air temperature, predictions have then been generated regarding the effect that the anticipated future rise in air temperature may have on these distributions. By the time of GISRUUK 2012 it is expected that similar work will have been completed for variables such as precipitation, grazing density and habitat change, using data derived from GIS maps and remote sensing imagery. This abstract, however, presents the results for the distribution models based only on elevation.

3. Current Results

3.1. Dung Beetles of the Peak District

6,640 individuals of 15 species were recorded in the Peak District during the 2010-2011 survey. This represents 20% of the total number of dung beetle species recorded in Britain.

3.2. Modelling Distributions

For the analysis, only species present at more than three sites and absent from more than three sites were considered. Two species, *Melinopterus prodromus* and *M. sphacelatus* are difficult to separate, so have also been omitted from the analysis. As a result, the distributions of 9 of the 15 recorded species were modelled (Table 1).

Table 1. Dung beetle species (and abundance) in the Peak District National Park. The number of sites where the species was present (32 surveyed in total) and the results from binary logistic regression of occupancy against elevation are also included in the table.

Species	Total abundance	Sites present	χ^2	p-value	Model coefficient	
<i>A. depressus</i>	551	29				
<i>A. ater</i>	3683	30				
<i>A. stercorosus</i>	2	2				
<i>G. puncticollis</i>	3	2				
<i>Melinopterus species</i>	54	13				
Included in analysis	<i>A. rufipes</i>	336	16	11.007	0.001 *	-0.016
	<i>A. lapponum</i>	998	27	4.521	0.033 *	0.013
	<i>A. rufus</i>	73	7	4.456	0.035 *	-0.011
	<i>A. fimetarius</i>	46	18	0.667	0.414	
	<i>N. contaminatus</i>	750	15	0.322	0.571	
	<i>O. haemorrhoidalis</i>	14	4	7.395	0.006 *	-0.022
	<i>P. uliginosus</i>	50	10	1.774	0.183	
	<i>T. fossor</i>	26	5	0.986	0.321	
	<i>G. stercorarius</i>	6	4	7.618	0.006 *	-0.023

Five species showed a significant relationship between occupancy and elevation (Table 1). The relationship was negative for all except one species (*Agoliinus lapponum*). Using Equation 1 adapted from the linear equation, the current probability of occupancy for each species at each elevation was calculated (Table 2).

Probability of occupancy = binary logistic model coefficient * elevation + intercept coefficient (1)

Table 2. Current distribution of dung beetle species across elevation gradient in Peak District. Given as elevation range at which modelling predicts each species is < 20%, ≥ 20%, ≥ 50 %, and ≥ 80 % likely to occur.

Species	Probability of Occupancy			
	<0.2	≥0.2	≥0.5	≥0.8
<i>A. rufipes</i>	635 – 405 m	404 – 386 m	385 – 366 m	365 – 0 m
<i>A. lapponum</i>	0 – 270 m	271 – 293 m	294 – 315 m	316 – 635 m
<i>A. rufus</i>	635 – 261 m	260 – 234 m	233 – 207 m	206 – 0 m
<i>O. haemorrhoidalis</i>	635 – 268 m	267 – 254 m	253 – 241 m	240 – 0 m
<i>G. stercorarius</i>	635 – 269 m	268 – 256 m	255 – 243 m	242 – 0 m

3.3. Future Climate Change

A significant linear relationship between air temperature (recorded by dataloggers at each site) and elevation ($R^2 = 0.241$, $F_{1,24} = 7.634$, $p = 0.011$) was identified, indicating 0.59 °C decrease in temperature per 100 m ascent. According to the medium emissions scenario, summer temperatures in the region are predicted to increase by 2.5 °C by 2050 (Defra, 2010) which equates to a 425 m uphill isotherm shift.

3.4. Responding to Climate Change: Two Example Species

This isotherm shift was factored into binary logistic regression modelling of species distributions to predict distributional response of species to climate change.

Acrossus rufipes (L. 1758) is widespread and common in Britain. It was found to have a negative relationship with elevation in the Peak District (Table 1) and is therefore expected to increase its range to higher elevations as the climate warms.

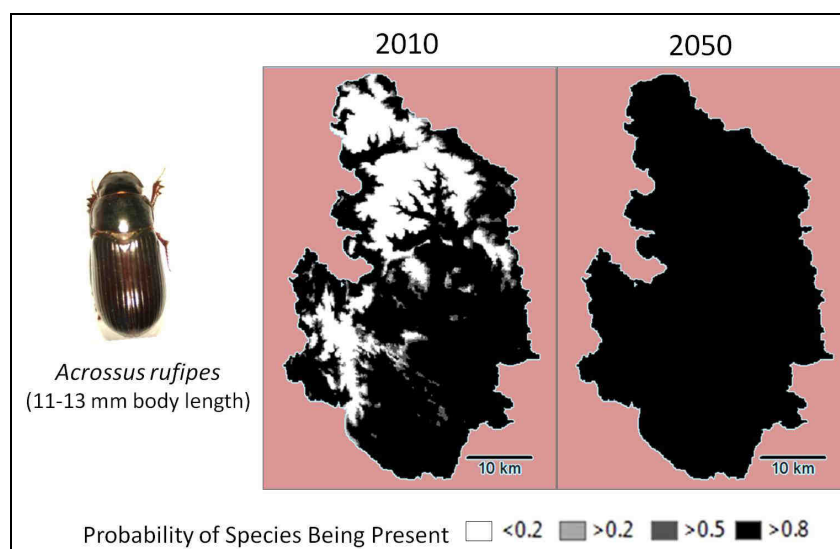


Figure 1. Predicted distribution of *Acrossus rufipes* in the Peak District with the 2.5 °C increase in temperature in 2010 and in 2050 (assuming 2.5 °C increase in temperature (Defra, 2010)).

Agoliinus lapponum (G. 1808), on the other hand, is a northern species reaching its southern limit in the Peak District. It was found to have a positive relationship with elevation in the Peak District (Table 1) and is therefore expected to see a dramatic reduction in available habitat with a warming climate. This may lead to a regional extinction of the species.

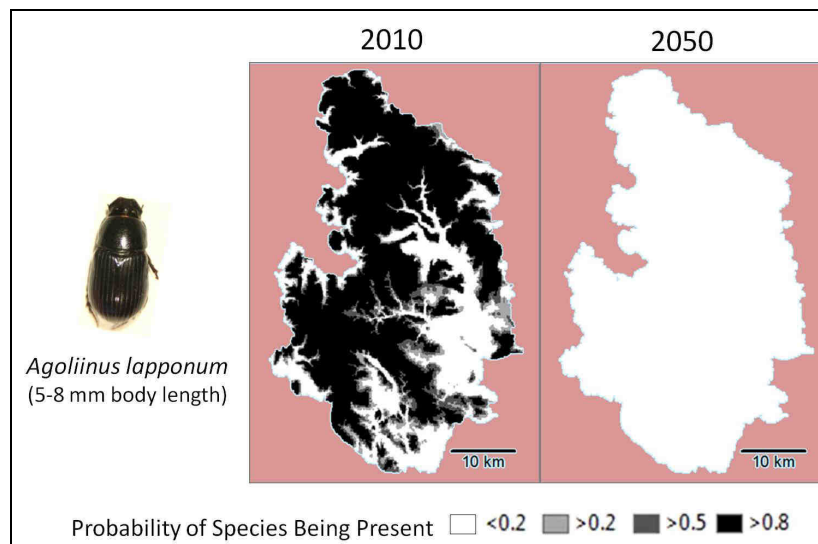


Figure 2. Predicted distribution of *Agoliinus lapponum* in 2010 and in 2050 (assuming 2.5 °C increase in temperature (Defra, 2010)).

4. Discussion

The level of species diversity recorded in the Peak District survey is in line with that recorded in other British uplands (Snowdonia, North Pennines) (Birkett et al., in prep.). In line with documented evidence for many other montane species (e.g. Menendez, 2007, and Chen et al., 2011) the results presented here suggest that most dung beetle species in the Peak District are likely to see an uphill expansion in habitat available to them as the air temperature warms. *Agoliinus lapponum*, however, is predicted to suffer an uphill contraction, possibly to the point of regional extinction by 2050. This will result in community composition change at individual sites, with potential implications for ecosystem function provision. Ongoing work will investigate discover how future changes in precipitation, grazing density and habitat may affect species distributions.

5. Acknowledgements

We thank the landowners of the Peak District National Park for allowing sampling to occur on their properties. We also thank Jonathan Walker and Rachael Maskill of Moors for the Future Partnership for securing these permits and providing the DEM, and Ellie Rickman and Georgina Whittaker for their assistance in the field. This work has been funded by NERC and Moors for the Future Partnership.

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7. Biographies

Ali Birkett is a PhD student at Lancaster University interested in understanding temperate species distributions and responses to environmental change with, in recent years, a particular focus on terrestrial insects.

Dr. Alan Blackburn is a senior lecturer at Lancaster University who focuses on developing remote sensing and GIS techniques for ecological and environmental applications.

Prof. Richard Bardgett is Professor of Ecology at Lancaster. His research focuses on biological interactions in soil and how they influence ecosystem processes, such as plant growth, nutrient and carbon cycling.

Dr. Rosa Menendez is a lecturer at Lancaster University and her main research interest focus on understanding the effects of environmental change (climate change and habitat fragmentation) on insect communities.

Distribution Pattern Analysis of Green space in Al-Madinah Using GIS

Haifaa Al-Ballaa¹, Alexis Comber², Claire Smith³

¹Department of Geography, University of Leicester, Leicester LE1 7RH, UK

Tel. (00441162523823) Fax (00441162523854)

Email, ha169@le.ac.uk¹, ajc36@le.ac.uk², cls53@le.ac.uk³

Summary: parks and green spaces provide important services to individuals and communities in terms of recreation, exercise and sport. This study will examine the population distribution in the province of Madinah and accessibility to green spaces using GIS. In addition, an exploration will be made of alternative solutions for ensuring fair distribution and accessibility.

KEYWORDS: Green space; GIS; accessibility; Spatial Analysis

1. Introduction

Green spaces and parks are of great importance both for ecological balance and for the health of individuals. They play a fundamental role in providing opportunities for rest and relaxation and enjoying the beauty of nature for the urban population. Hence, this study will examine the distribution and analysis of ease of access to public parks for all categories of the population using (GIS). When there is a significant increase in population and urban growth in a region, the need for public places of recreation increases. For example, in Britain, the area dedicated to national parks and green areas is in the region of 10,000 square miles or 17% of the total area of England and Wales (Cullingworth, 1972). Increasing rates of urbanisation in Madinah have led to increased pressure on many of the services and facilities, especially green spaces and gardens which are a key requirement for high density neighbourhoods.

This study will evaluate the equity of the distribution of public green spaces and their accessibility. In this way this research will consider problems that some public parks are experiencing which relate to location, size or suitability for their local population.

2. Background and Literature Review

Many studies have addressed the subject of green spaces, their accessibility, and economic importance (Comber, et al, 2008). These show the relationship between the distribution of green spaces and the road systems linking them with residential neighbourhoods, as well as how ease of access to a particular site can be measured by the cost of the trip or its duration. Green spaces are important for improving air quality and reducing levels of carbon dioxide and other pollutants; they also beautify the environment, create a soothing atmosphere, and protect people from the glare and heat of the sun (Kiichiro, 2011). In another study, Chang & Liao (2011) focused on assessing the spatial distributions of public parks and their accessibility.

Access to urban green space is important. According to Hillsdon et al (2009), a relationship exists between access to urban green space and the recreational and physical activity levels of local inhabitants. (Hackney, 2004) indicated the importance of the distribution of, and admission to, public parks, in relation to the need to identify population density when assessing access to public parks.

Many studies have focused on ease of access to green spaces, including de Vries et al, (2000) research which examined residents' needs and their selection of a neighbourhood which is close to services for easy access.

Recently, the benefits of green infrastructure (GI) have been widely promoted, and interest in the potential ecosystem services they provide has stimulated GI research in a range of environments . Comber, et al. (2008) analysed green spaces in England using GIS; introducing a general method to measure the differences occurring in society and to provide the services that are available to them. They described the actual use of services within various recreational parks in references to available services; highlighting the importance of spatial analysis in providing easy access to the best methods available (Comber et al, 2011).. In the case presented in this research the theoretical basis for the initial distribution of parks in the study area can be based on spatial distribution and the use of geographic information systems. According to Hillsdon et al. (2009) there is a relationship between access to urban green space, recreational and physical activity levels of individual and the relationship between them This research will be discovering if there distribute fair or not in Al-Madinah of Green space

3. Method

Study area

Al-Madinah is located in the north western part of central Saudi Arabia. Its position is: longitude 39°, 36; latitude 24°, 28 (figure 1). It has a population of approximately 1.6 million (Department of Statistics in Riyadh, 2008).

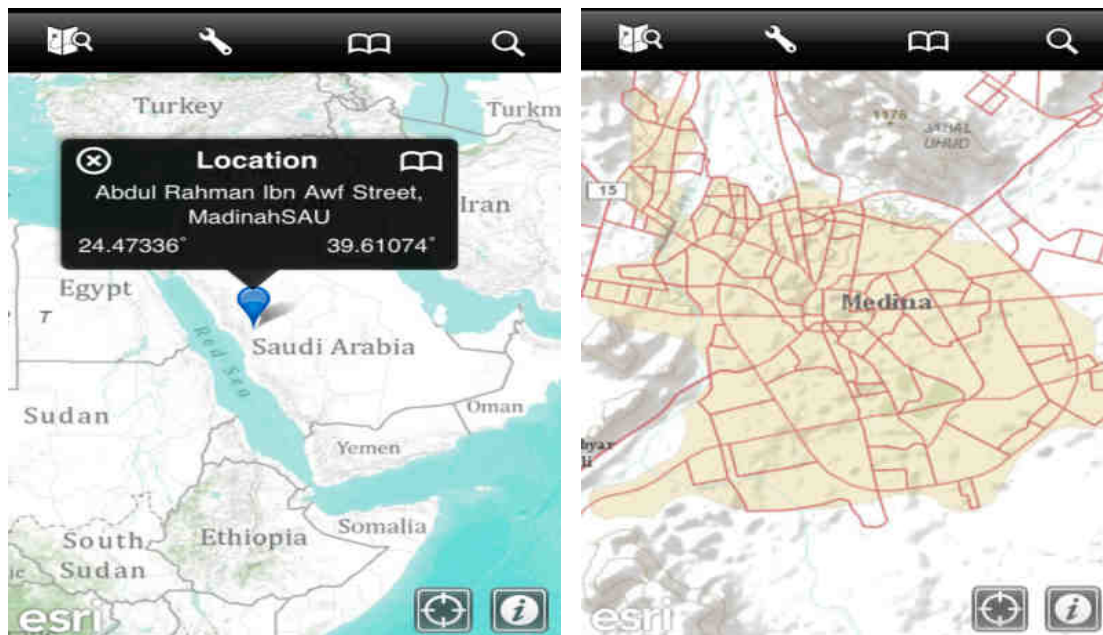


Figure 1. Location of Madinah for the Saudi Arabia *ArcGIS Mobile*

The Data Sources and Network Analysis

The data for this study was collected from the following sources:

Table1. The data sources

Data & maps	shapes	sources
Road maps	Shape file (line)	Al-Madinah Municipality
Neighborhoods' maps	Shape file (polygon)	Al-Madinah Municipality
Green space maps	Shape file (point)	Al-Madinah Municipality
population data	Excel file	Al-Madinah Municipality
Location Al-Madinah	Photos	Geo Mobile & ArcGIS Mobile

There are a number of parks in AL-Madinah almost 47 distributed to 102 on neighborhoods, based on the analysis of data collected from many sources, using the map of the road network and the distribution of the neighborhoods and Greenspaces. It has located them using the results of the analysis OD. It is connected with the polygons for the analysis of people accessibility in the following format:

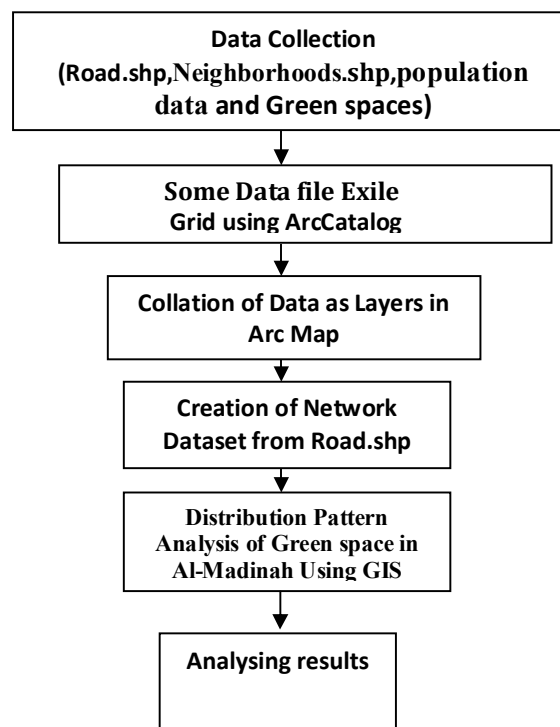


Figure 2 shows the network of roads in the study area serving all neighbourhoods. Figure 3 illustrates the distribution of 102 neighbourhoods in the study area. Figure 4, shows the distribution of population. Based on the it is clear that the population is largely concentrated in the central region, while a smaller proportion of the population l in the periphery, as shown in figure 4 .

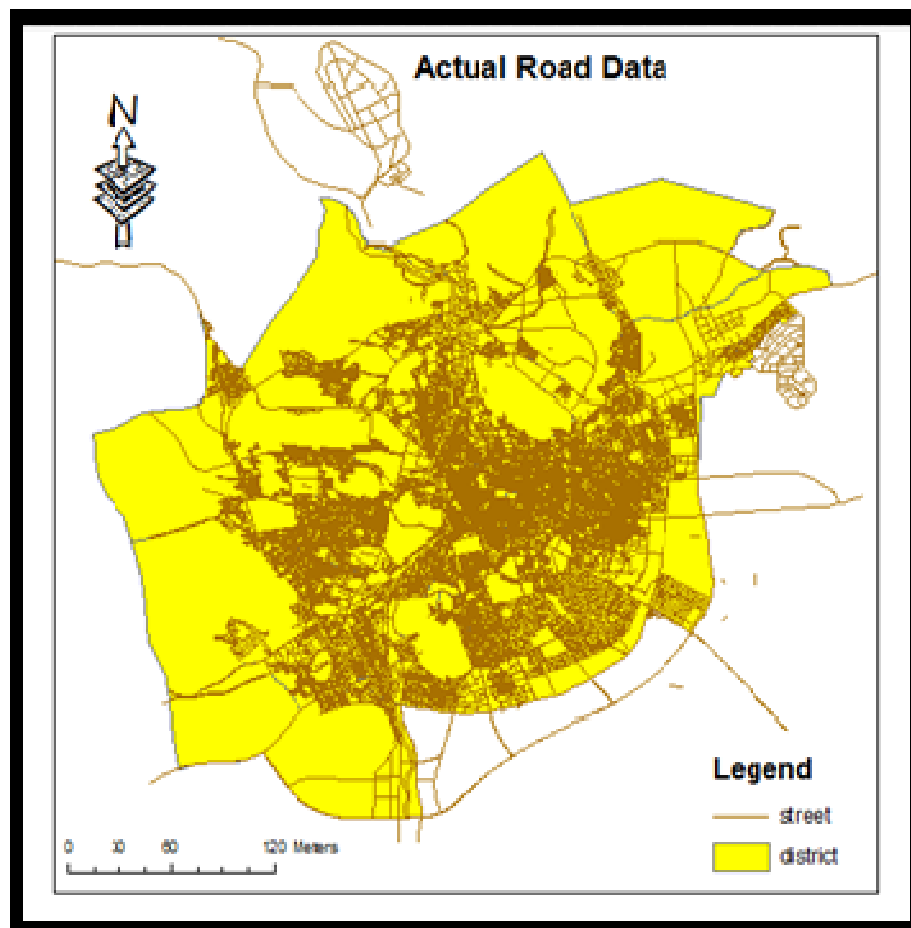


Figure 2. Actual Road in Al- Madinah

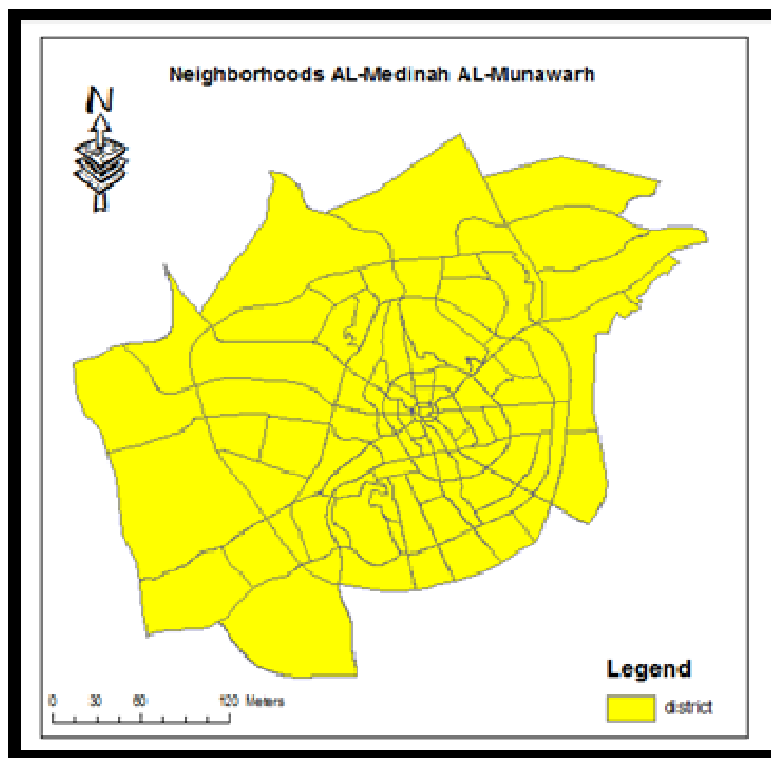


Figure 3. Neighborhoods in Al-Madinah

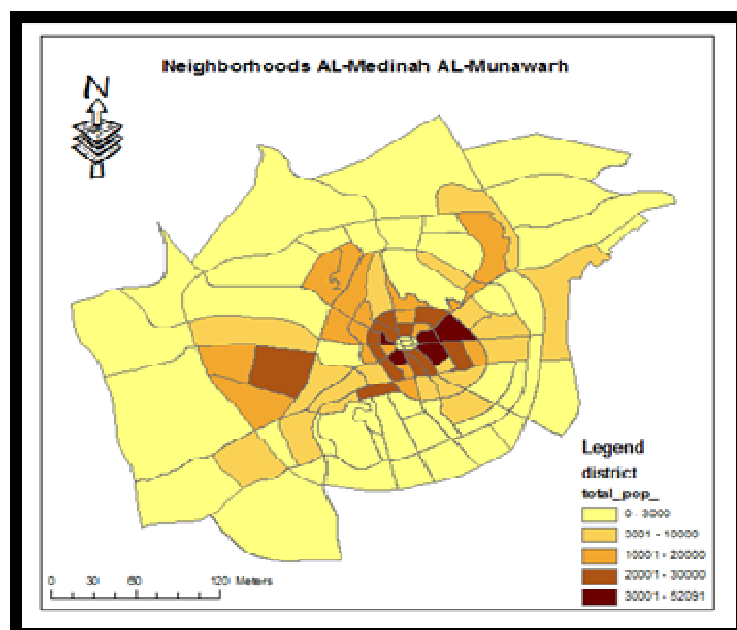


Figure 4. Total Population in AL-Madinah

4. Results

Visual analysis and result from GIS spatial query from greenspace map (see Figure 6 and 7) indicate that distribution of green spaces in the neighbourhoods is uneven. For example, the gardens of King Fahd have a dense concentration of green spaces Square kilometers almost (79%), while other neighbourhoods are completely deprived of any.. Furthermore, transport is very cheap compared with Europe.

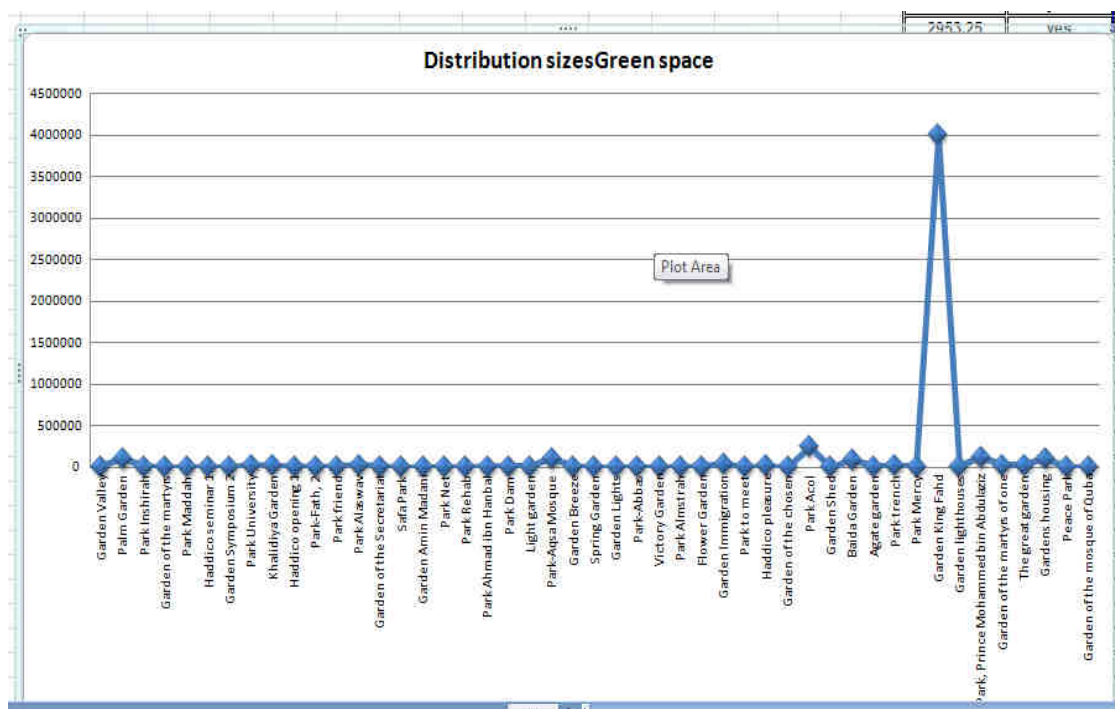


Figure 5. Percentage distribution of green spaces within each park

As illustrated in Figure 5, the King Fahd district includes several gardens in close concentration, which indicates the uneven distribution of parks in the area. According to the Municipality of Madinah (2010), the number of public parks is 47; in addition, more than 90 green spaces are distributed throughout the city. Arc GIS were used to analyse the distribution of gardens and green spaces (figure 6). The results of analysing the spatial distribution of green spaces indicate gaps in the provision of green space, and potential locations that may have low levels of that accessibility. Ongoing research is seeking to quantify inequalities in green space accessibility and will suggest spatial planning strategies that specifically address .

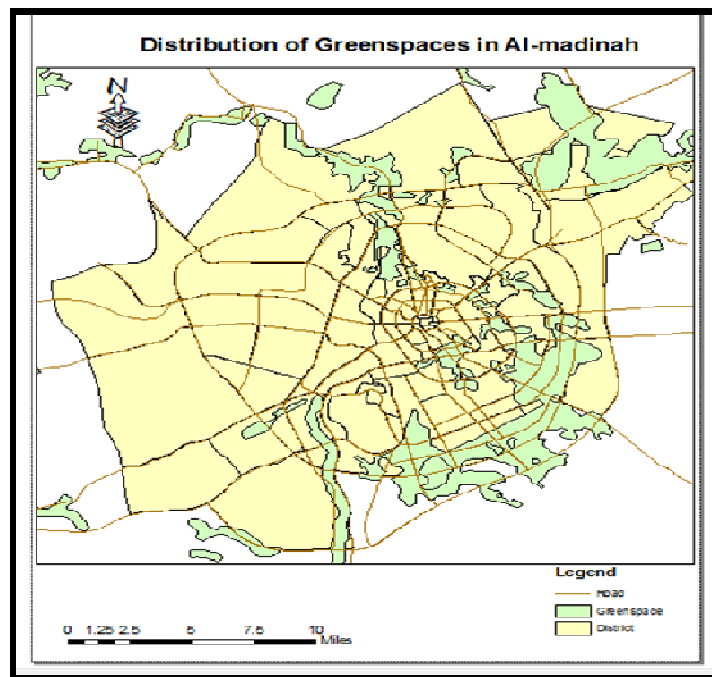


Figure 6. Distribution of green space

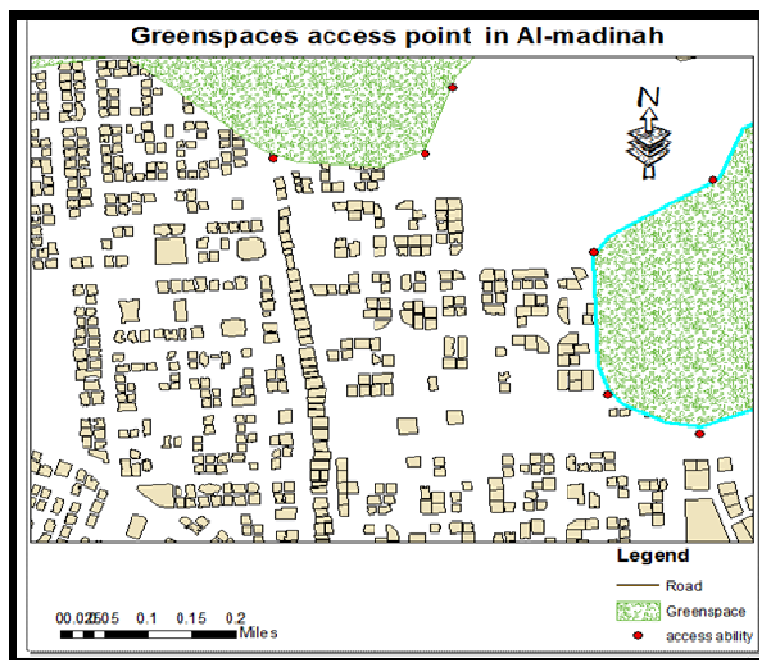


Figure 7. Greenspace access points

5. Acknowledgements

The author of this study would like to thank the General Secretariat of Municipalities in Al-Madinah and for the data they provided.

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7. Biography

Haifaa Al-Ballaa ¹: PhD student in Human Geography & GIS, Department of Geography, University of Leicester. Research interests in the distribution pattern analysis of public parks in Al-Madinah using GIS techniques.

Alexis Comber ²: Senior Lecturer in Geographic Information, Department of Geography, University of Leicester. Research interests in two primary areas: issues associated with uncertainty and representation in spatial data and the use of spatial analyses to evaluate policy.

Claire Smith³: Lecturer in Climate Change Adaption, Department of Geography, University of Leicester. Research interests primarily associated with the interaction between atmospheric change and the local environment.

Towards improving spatial literacy for non-specialists: Developing Interactive, Integrated Geospatial Learning and Understanding (IIGLU)

Jones, C.E.¹, Weber, P.W², Ellul, C.³

¹University of Portsmouth, kate.jones@port.ac.uk

^{2,3} University College London, p.weber@ucl.ac.uk; c.ellul@ucl.ac.uk
www.iiglu.com ; <http://jiscg3.blogspot.com>

Summary: This paper discusses the user-centred design approach for developing an end to end framework for Interactive, Integrated, Geospatial, Learning and Understanding (IIGLU). Based on the premise that GIS are hard to use, IIGLU makes them easier by presenting learning and understanding of geospatial concepts embedded within discipline specific scenarios relevant to new learners outside the field of GIS. This paper explores a qualitative approach using semi-structured interviews and transcript analysis to define user stories which were turned into user storyboards for recording learning scenarios within our custom developed e-learning tool.

KEYWORDS: GIS in Education, GI Pedagogy, Geoweb, User Stories, Users

1. Background

Geographical Information Systems (GIS) can solve problems ranging from finding the shortest route between two locations to modelling the change over time of an archaeological site; mapping the area where dialects of a language are spoken or examining factors affecting the spread of disease. GIS are, however, under-utilised across a wide range of disciplines. In the literature, two main issues emerge as the front runners to their lack of use and poor rates of adoption: (1) the perceived (and real) complexity of Geographical Information Systems (GIS) desktop software packages) and (2) a lack of understanding as to what a GIS can do within the context of specific disciplines (Downs, 2006; Davies and Medyckyj-Scott, 1996; Clarke et al, 2007; Koch and Denike 2007; Klein, 2003).

Proprietary GIS software are notoriously difficult to use and the concept of simplicity has been neglected in preference for complex functionality; on first use they are often daunting, unwieldy and require significant user training (Davies and Medyckyj-Scott, 1996). Students find software packages such as ArcGIS and MapInfo unintuitive, and they require a lot of time, patience and regular practice to build up mental models of how the particular software systems work. Often there is a mismatch between the software designer's perception of ease of use and the real experience of the user interface as experienced by users. As a consequence, users waste time grappling with the software interface, instead of focusing on the actual task - such as engaging with and understanding geographical data and processes for problem-solving. In these circumstances, the development of mental models for understanding geographic concepts takes second place to concerns of trying to understand how to interact with the software.

Observations from the authors' teaching experience provide further evidence in support of the issues. A recent experiment conducted at University College London (UCL) asked twenty students on an MSc in GIS to perform a series of ten tasks using three unfamiliar GIS packages (MapInfo Professional, Geomedia Professional and Quantum GIS). The students had a theoretical understanding of the spatial concepts that underlie GIS and had previous experience with ArcGIS. They also had access to tutorials and online help and could ask their classmates for assistance. Despite this, comments such as "*very different functionality than that found in ArcGIS*", "*It is very frustrating using a new software. I didn't realise how much I had learned in ArcGIS*" indicate that

their understanding of GIS was linked to a specific software interface, rather than the underlying geographic mental model – they struggled to link concepts to functionality. In 4 cases out of 36, students did not manage to complete all ten tasks in on time, and all three packages were rated “difficult to use”. These observations highlight the difficulties faced by users having some familiarity with GIS software and concepts. How much more difficult, then, is the learning situation faced by students outside the realm of specialist GIS courses, who do not have a basic understanding of GIS concepts and their application to their specialist domain?

The complexity of desktop GIS interactions is a stark contrast to the widespread familiarity with simple online reference mapping solutions such as Google or Bing Maps. Many students and staff in Higher Education are now unconsciously regular users of “GIS” in the form of online or smart phone applications. Tasks such as ‘click on a point to find information’ are common and well understood. This paper builds upon this commonality between online mapping and GIS, through the gradual introduction of users to geographic concepts via the development of an interactive, integrated geospatial framework for learning and understanding (IIGLU), enabling active learning.

The IIGLU framework comprises two components, one for teachers the other for learners. Within the framework is an e-learning environment, with two components: (a) a facility for teachers to record discipline specific geospatial tutorials and (b) to provide a facility for learners to playback and interact with discipline specific tutorials based on predefined relevant scenarios. Central to the success of the framework is first the notion of embedding the learning and understanding of geographic concepts within discipline specific scenarios that users outside of GIS can relate to. Secondly, learning material for geographic concepts is presented in an easy to use, interactive environment that does not distract users with complex interaction. Consequently, this paper will discuss the process behind developing the discipline specific scenarios and focuses on user-centred design.

2 Development of discipline specific scenarios

At the project’s conception a panel of user experts was formed (see table 1), motivated by the need to continually engage with future end users and inform the development of IIGLU’s functionality and interface. The engagement of users was critical to the creation of the domain specific-scenarios in which the geographic concepts could be embedded and to characterise their perceptions of geographical information tools within their disciplines. The creation of the scenarios comprised of five activities based upon a qualitative research methodology. (1) Plan and define semi-structured interviews (2) conduct interviews (3) code and identify themes in interviews (4) create background narratives to describe students (user stories) and then (5) develop and record scenario storyboards.

Table 1. Academic background of user panel

ID	<i>Academic Discipline of user expert panel</i>
1	Urban Historian
2	Urban Anthropologist
3	Urban Designer
4	Environmental Geographer

The semi-structured approach to the interviews enabled relevant discussions to emerge, allowing for the development of potential scenarios. Interview participants were provided with background data describing the project aims and objectives and each participant was informed that the results of the interviews would be used to formulate problem scenarios relevant to their discipline. The themes of the interview questions were as follows:

- GIS knowledge and map making experience
- Use of maps in their research
- Types of students, their computer experience
- Typical discipline specific issues that students encounter

Each interviewee was asked to describe their background and academic experience and to identify whether they used a particular reoccurring problem or situation to illustrate concepts to new learners in their field. Analysis of the interview transcripts revealed insights valuable to the IIGLU development process

2.1 Themes emerging from the interviews

Transcript analysis proved useful for a number of reasons. Firstly, themes associated with perception and use of digital mapping technologies emerged: (i) inherent use of maps or location specific information (ii) general IT literacy and software use and (iii) awareness and knowledge of digital mapping technology (GIS) / geographic data. Secondly, discipline specific problems informed the design of our discipline specific scenarios (see section 2.2). Figure 1 shows a summary of the interview with the user design expert.

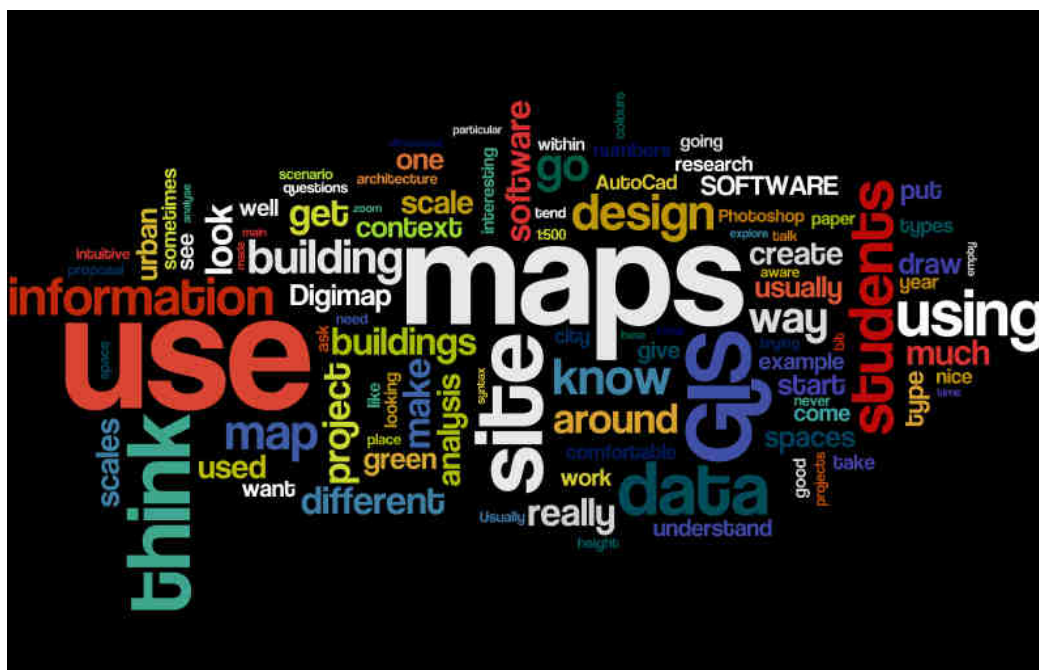


Figure 1. Summary of User interview with Urban Design Expert

2.2 Development of User Case/User Stories – background narratives

The transcript analysis enabled user stories to emerge. These stories act as a tool to summarise the user scenarios identified during the interviews. They characterise user needs, from which functional requirements of the IIGLU framework were then developed. For example, the following quote describes the user story of a student specialising in environmental management:

“Megan is an Environmental Manager who is responsible for organising Participatory Workshops which involve a range of stakeholders in the planning and management of water catchments (this is in accordance with the EU water Framework Directive). She has no prior mapping experience and is not very technical but is confident with desktop office software. She would like to identify low-income neighbourhoods from which participants can be invited to a workshop, in a suitable location. She would like to use a mapping application to do this but is not sure how to start making a map or what data are available to her.”

3. Summary

The final step was to create a storyboard, a scenario comprising of a series of tutorials and tutorial steps to explain introductory geographic concepts such as (layers, symbology, map projections, scale). For the student of environmental management the scenario topic was focussed on rivers and river catchments. The final step in the learning framework was to record the scenarios using the specifically designed and developed software, see screen shots in figure 2. Where essential mapping concepts such as knowing why location is useful, modeling the world using points, lines, areas and the basics of layers could be introduced using river data (obtained from ShareGeo).

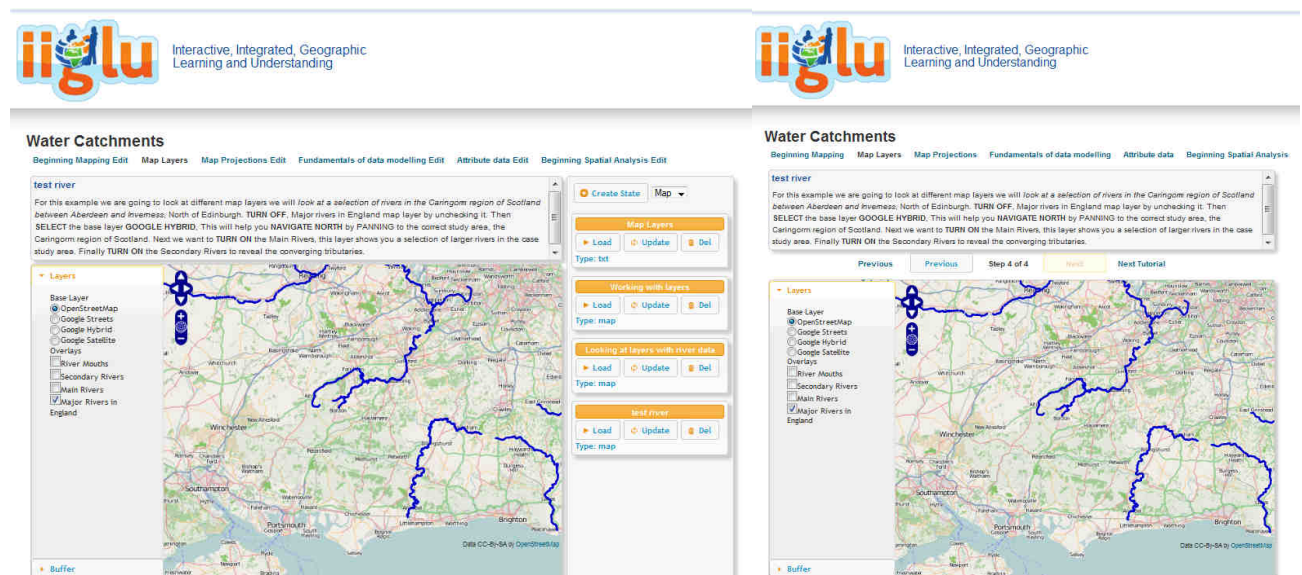


Figure 2: (a) Teacher recording and (b) Student play back of user scenarios

The IIGLU framework was developed as an entry-level tool for introducing geospatial concepts to new learners from outside the discipline of GIS. By bridging the gap between desktop GIS and geoweb mapping applications, the IIGLU framework developed a user centric approach placing the learner at the centre of the learning experience instead of the software. In the pedagogical literature, teaching GIS is strongly influenced through the channels in which geographic information is presented to learners (Fargher, 2007). By embedding user stories into the development process, IIGLU facilitates self and active learning of geographic concepts by reducing the interaction effort required at the point of entry into the discipline.

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5. Biography

Dr Catherine (Kate) Jones is a lecturer in Human Geography in the department of Geography at the University of Portsmouth with 8 years expertise in delivering GIS projects. Having been awarded her MSc in GIS in 2003, she completed her PhD in 2008 and worked as a post-doc, leading the GIS development of an interdisciplinary project (2007-2009) - all at UCL. She is an expert within the field of cartography, usability analysis and useful and useable GIS for enabling and developing spatial capabilities for non-domain experts. <http://jiscg3.blogspot.com/>

Dr Patrick Weber is a postdoc researcher /teaching fellow and geo-application developer consultant with 8 years experience in GIS, spatial analysis research and product development. He is a geography graduate with an MSc in GIS from UCL, and was awarded an Engineering Doctorate sponsored by the LDA's FDI investment promotion body in 2010. His research is looking at FDI business site selection in London. Apart from his knowledge in the analysis and support of business location decision making, and user requirements specification using Personas and AGILE approaches, Patrick has extensive experience in the creation and delivery of GIS projects. He is the application developer on the #JISCG3 / IIGLU project.

Dr Claire Ellul is a Lecturer in Geographical Information Science (GIS) at University College London. Having graduated in Electrical Engineering, she worked for ten years internationally as a GIS, specialising in systems architecture design, data management, programming and integration of GIS software. Claire completed a PhD in GIS at UCL in 3D topology and worked as a post-doctoral researcher at UCL and London Metropolitan University. She designed and programmed the Mapping for Change software and now lectures on the MSc in GIS course, with specific responsibility for the *Spatial Structures and Representations* and *Databases and Spatial Databases* modules.

Reducing Critical Service Loss through Coordinated Resilience Planning

Julian Watts¹

¹ Gutteridge Haskins & Davey Limited (GHD), Horton House, Exchange Flags,
Liverpool, L2 3PF, United Kingdom
Tel. (+44) (0) 755 445 1698 Fax (+44) (0) 151 244 5041
Email, julian.watts@ghd.com Web www.ghd.com

Summary: In the modern economy, the drive to manage assets efficiently and effectively is stronger than ever. Recent catastrophic events affecting people and assets have resulted in a surge of Business Continuity Planning requirements on the boardroom agenda. This paper outlines a process to identify potentially vulnerable critical infrastructure during emergency events that would require detailed response plans. It summarises observations from traditional disaster planning methods and compares outputs from vulnerability analysis and Geographical Information Systems modeling undertaken for a Local Authority in New Zealand. These outputs illustrate the benefits of coordinated analysis across local roads, water services and wastewater services.

KEYWORDS: Critical Vulnerability, Resilience Planning, Business Continuity, Cross-Network Infrastructure, Rena

1. Introduction

Requirements to undertake risk and analysis for lifelines and critical infrastructure protection have been in place and publicised for many years as seen in Crimp (2008). Likewise, recognised concepts of Plan-Do-Check-Act (PDCA) have been embedded in asset management standards like BSI PAS-55 (2008) and Optimised Renewal Decision Making (ODRM) is part of our everyday manuals such as the International Infrastructure Management Manual (2011). Why then, is resilience planning focussed on protection of a single asset class and so easily overlooked for a set of crossing but unconnected networks? Possibly because ODRM is only applied on assets that custodians have direct influence on. Possibly because there are no agreed guidelines that outline the scope of impact analysis that should be undertaken. Several lifeline studies have been completed in the Bay of Plenty region in New Zealand, however these generally focus on one location, asset or scenario at a time. This paper does not seek to recommend modeling of every scenario, however it demonstrates how a broader planning approach can identify mitigation options for unaccounted for eventualities, such as the Rena (2011) oil spill that was not a considered scenario however benefited from an accelerated response.

1.1 The Compounding Impact

Recent catastrophic events, exhibit compounding effects of disasters that impact simultaneously on multiple services. These include mobility, electricity, potable water, haulage of goods and availability of community centres. These compounding effects can have devastating impacts on the economy, driving communities and businesses out of city centres, causing lasting changes to regions. A recent report on climate change by the Commonwealth of Australia (2009) stated "even if the cost of protection was AUD\$10 billion for Melbourne alone, it would still be a lower cost alternative to losing low-lying infrastructure, building assets and the cost of disruption to the local economy and society". Business Continuity Planning (BCP) assists in dealing with the ensuing aftermath from events like these however they do not address the ability to build resilience into the infrastructure to standard procedures.

1.2 Aspects to Combine

A paper on lifecycle analysis of existing infrastructure by Magnuson and Amador (2010) looks at coordinating renewals and reducing the long term cost of replacing essential services. This

methodology aligns with good practice asset management however only considers time of optimised renewal, not optimising the replaced asset. Another promising paper by Bruneau et al. (2003) looks at performance indicators to identify resilient communities and has a conceptual framework that could be applied in a regulatory context. This model would work best for measuring resilience using a coordinated approach. It does not utilise the feedback cycle ORDM to build resilience into core infrastructure. The International Standard on Business Continuity ISO/PAS-22399 (2007) covers multidisciplinary resilience planning. However this is only for one organisation and it is not designed to set procedures for post disaster recovery.

2. Case Study: Cross Asset Vulnerability Analysis

Tauranga City Council (TCC) engaged GHD New Zealand Ltd. to lead the development of a vulnerability assessment for City Transportation and City Waters to be delivered to the Bay of Plenty Lifelines Advisory Group (BOPLAG), a member of the New Zealand Engineering Lifeline Groups. During the project it was identified that different results were captured if analysis was undertaken on a single network than when undertaken in a combined spatial environment. Therefore the results of the individual studies have been combined to illustrate a more complete output.

The purpose was to identify potential high risk areas within communities that are susceptible to damage during natural disaster events or service outages, in order to capture region-wide mitigation planning. The objective was to review asset criticality in the transportation, water and wastewater networks, assess their vulnerability under 27 different severe climate scenarios and deliver optimum outputs to the BOPLAG as set out in Table 1.

Table 1. Natural Event Scenarios

Code	Scenario	Event
FL	Flooding	Flash Flood
		Inundation
		Landslide
GE	Geothermal	Chemical Action
		Ground Settlement
		Ground Shaking
IL	Infrastructure Local Authority	Sewerage
		Stormwater
		Water
IP	Infrastructure Private	Electricity
		Gas
		Telecoms
SE	Seismic	Fault Displacement
		Ground Settlement
		Ground Shaking
		Landslide
		Liquefaction
SS	Storm Surge	Coastal Erosion
		Inundation
TS	Tsunami	Coastal Erosion
		Inundation
		Velocity Damage
VO	Volcanic	Ash Fall
		Lahar
		Water
WF	Wind Fire	Fire
		Wind

The locations of critical assets across different networks were modelled in a Geographical Information System (GIS), ESRI ArcGIS. This assisted in identifying areas of high risk with a dependency on other infrastructure networks. Critical assets were overlaid with soil maps to identify drainage issues, contour maps to identify tsunami impacts and liquefaction maps to identify earthquake-prone areas. Under each scenario, assets identified as 'vulnerable' had potential risk mitigation techniques documented so that these actions could be combined where vulnerable hot-spots emerged.

2.1 Process Undertaken

Critical assets were defined through meetings with Transportation, Water and Wastewater network managers and asset managers. The process used to identify the vulnerable assets was explained and is illustrated in Figure 1.

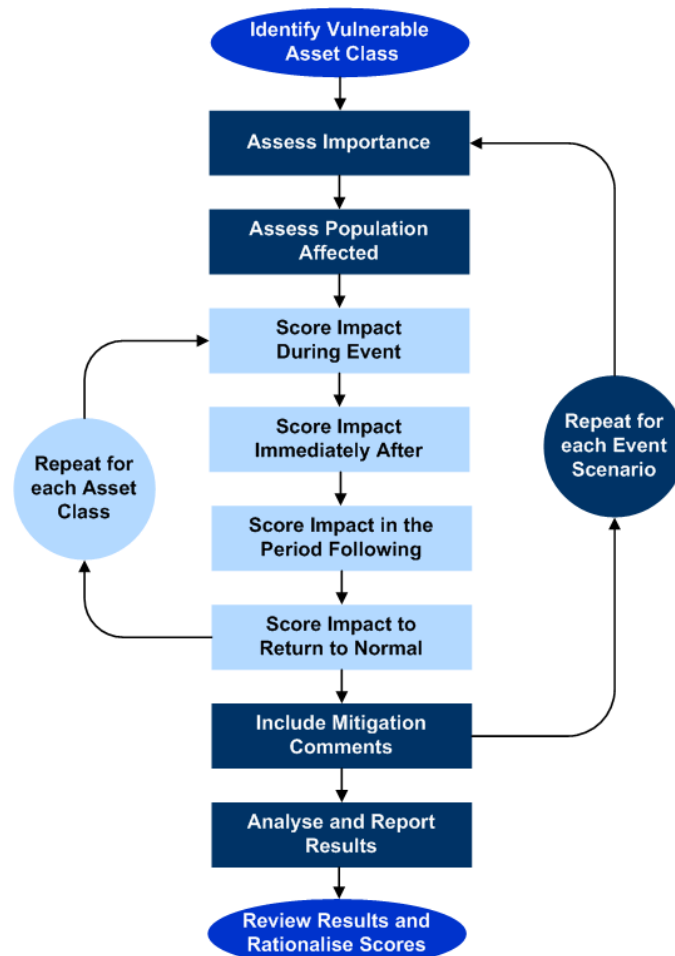


Figure 1. Process to Assess Vulnerability

Under each scenario, critical assets were scored on three dimensions; importance to the network, population affected if service was disrupted and likelihood of being affected by the scenario. The impact or consequence was then scored at four stages during the event. This resulted in an understanding of when an asset becomes vulnerable and aids prioritisation. This process allowed all critical assets to be ranked by vulnerability across the entire city.

2.2 Risk Score Definitions

Asset classes were scored across three dimensions using definitions provided by BOPLAG (Table 2):

Table 2. Risk Definitions

Ranking	Importance (population or people served)	Vulnerability (likelihood)	Impact (consequence)
5	Extremely important	Almost certain	Catastrophic
4	Very important	Likely	Major
3	Important	Possible	Moderate
2	Some importance	Unlikely	Minor
1	Not important	Rare	Insignificant

2.3 Risk Time Factor

Each event's impact is scored with a time factor to indicate when the most severe damage would occur. The descriptions below are used to define each time period that should be scored.

Table 3. Chronological Assessment of Impact Codes

Chronological Code	Description
DE	During Event
IA	Immediately After
PF	Period Following
RN	Return to Normal
RT	Return Time (Weeks)

2.4 Data Sources Utilised to Define Asset Classes

The Transportation (RAMM), Water and Wastewater (Hansen) Asset Management Systems (AMS), and GIS databases were reviewed to collate the set of asset classes. The soil maps were sourced from the Western Bay of Plenty Lifelines Study : Microzoning for Earthquake Hazards (2002) report. The asset classes identified are as follows:

Table 4. Asset Classes Reviewed

Network	Type
Transportation	Bridges
	Retaining Walls
	Embankments
	Arterial Pavements
Wastewater	Pump Stations
	Reticulation - Gravity
	Rising Mains
	Treatment Plant
Water Supply	Booster Pump Stations
	Intakes
	Interchange
	Pipe Bridges
	Processing Plants
	Reservoirs
	Reticulation - Distribution
	Reticulation - Raw

2.5 GIS Features Used to Map the Asset Classes

The asset attributes from TCC were filtered to extract only the critical assets that are essential for the network to operate. The resulting GIS layers are as follows.

Table 5. GIS Features Utilised

Feature	Description
TCC Road Centreline	All local roads used as a basis for selecting critical linear assets
State Highways	Define NZTA responsibility
Critical Asset Point	Roads that are potentially vulnerable
Critical Asset Line	Bridges, Embankments and Retaining Walls that are potentially vulnerable
NZ Power Transmission Lines	High Voltage Lines
NZ Railways	Rail network for critical access
Relic Slips Database	Slips database maintained since 2004
Contour and TIN	20m contours used to define low lying areas
Liquefaction ground damage	Based on soil maps
Soil Drainage	Based on soil maps
Earthquakes in 2009	NZ Earthquakes for 12 month period in 2009
Treatment Plants	Location of wastewater treatment facilities
Reticulation - Rising	Extent of pumped rising mains to treatment facilities
Reticulation - Gravity	Extent of gravity fed mains to treatment facilities
Processing Plants	Location of water processing plants
Raw Water Intakes	Location of raw water intakes
Reticulation - Distribution	Extent of trunk distribution of treated water
Reticulation - Raw	Extent of raw water trunk lines to processing plants
Eastern Boundary	Area assumed for defining assets in Tauranga East
Western Boundary	Area assumed for defining assets in Tauranga West

2.6 Resulting Map Outputs of Vulnerable Assets

The maps, Figure 2 to Figure 10, show how the identified critical assets in the Transportation and Waters networks are affected by the surrounding environment.

This extent shows the entire road network by hierarchy. It also notes railway lines and high voltage power lines. All state highways are considered critical however were excluded as assessed by the New Zealand Transport Agency (NZTA).



Figure 2. Extent of Study

The extent below shows the critical assets only. This includes the point assets (bridges, embankments and retaining walls) and the line assets (pavement).

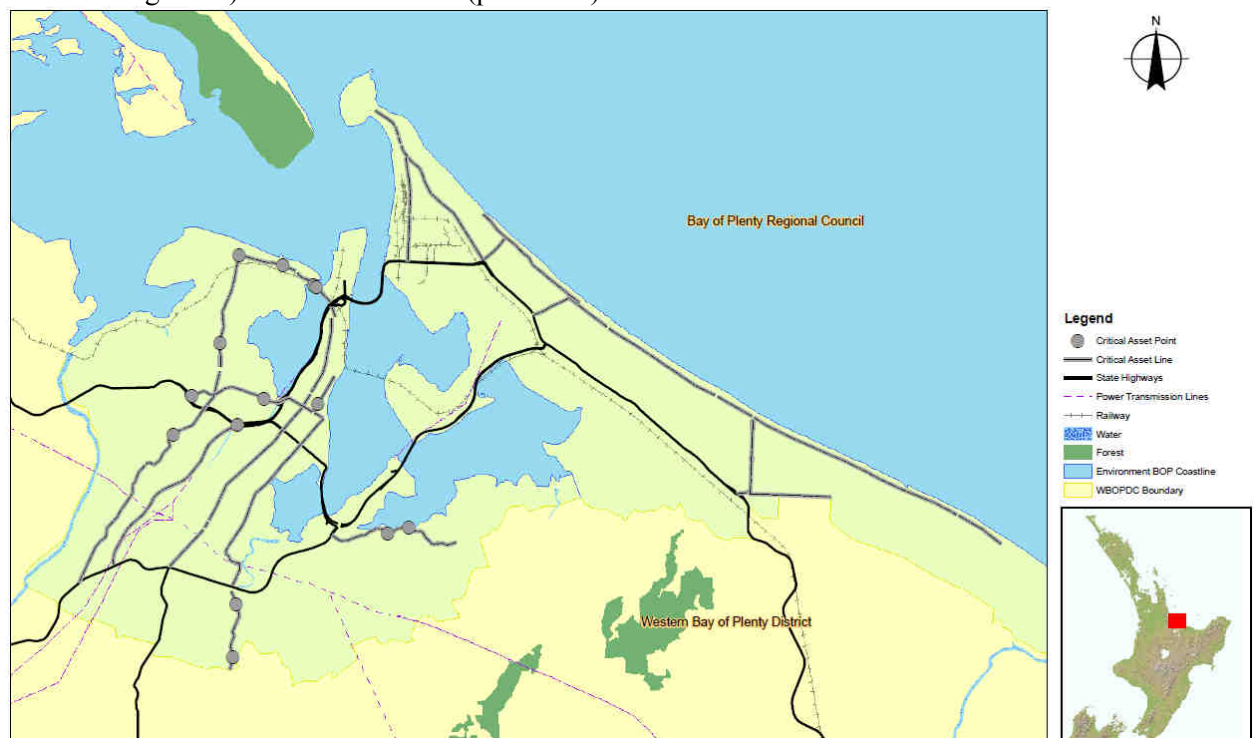


Figure 3. Critical Transportation Assets

This extent shows critical water assets with treatments plants, pump stations, reservoirs and intakes.

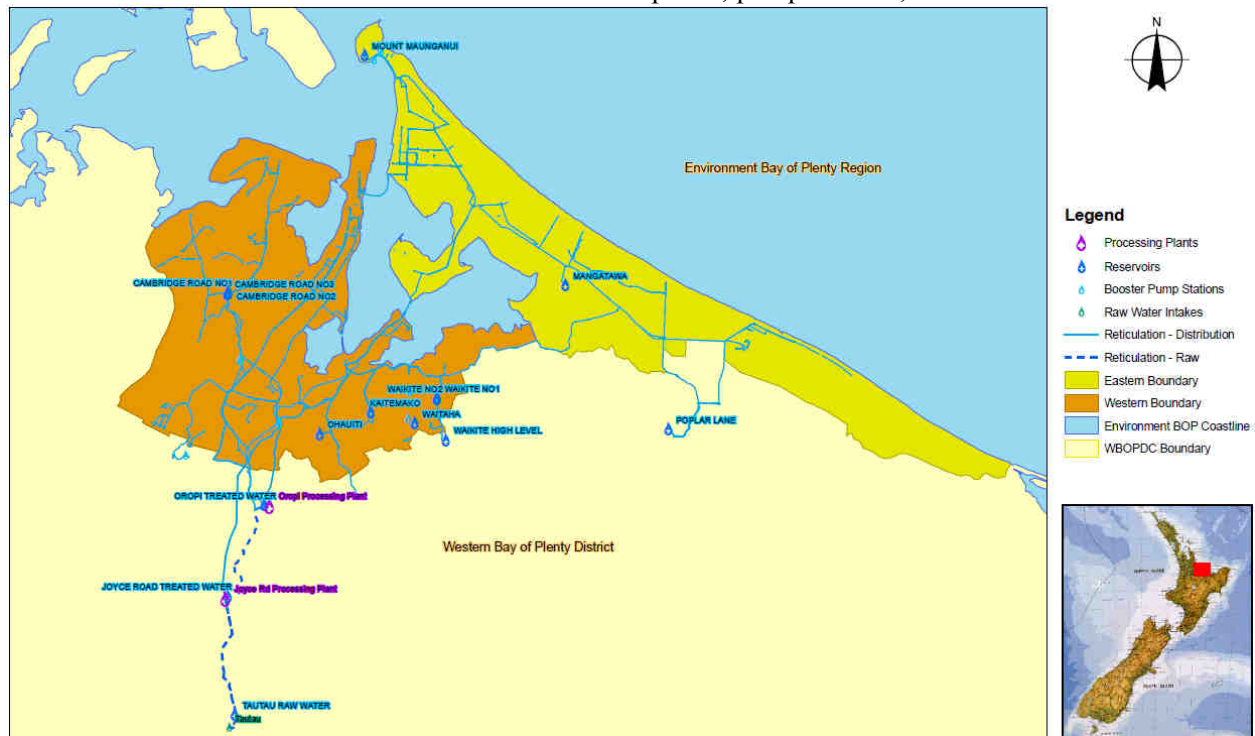


Figure 4. Critical Water Assets

This extent shows critical wastewater assets with treatments plants, pump stations and ocean outfalls.

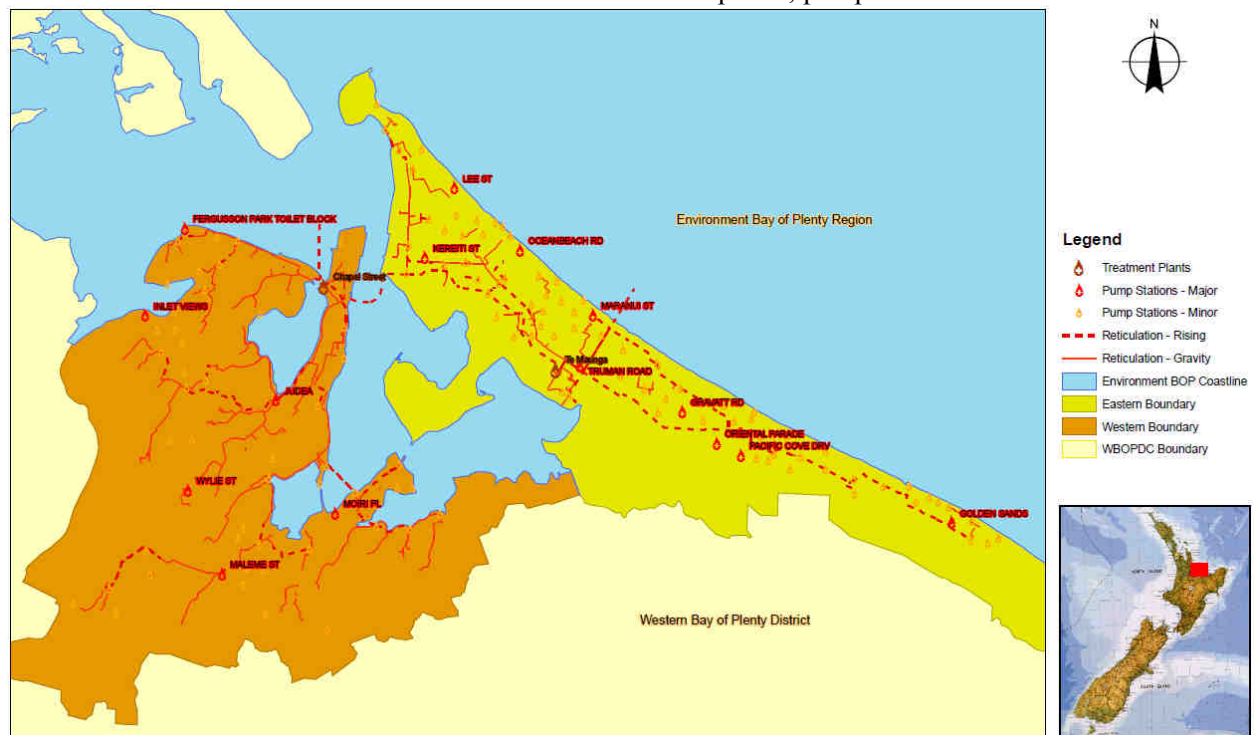


Figure 5. Critical Wastewater Assets

This extent illustrates the ground shaking events recorded in the previous year. It shows that the Bay of Plenty is on a fault band, however TCC is not as active as Matata to the southeast.

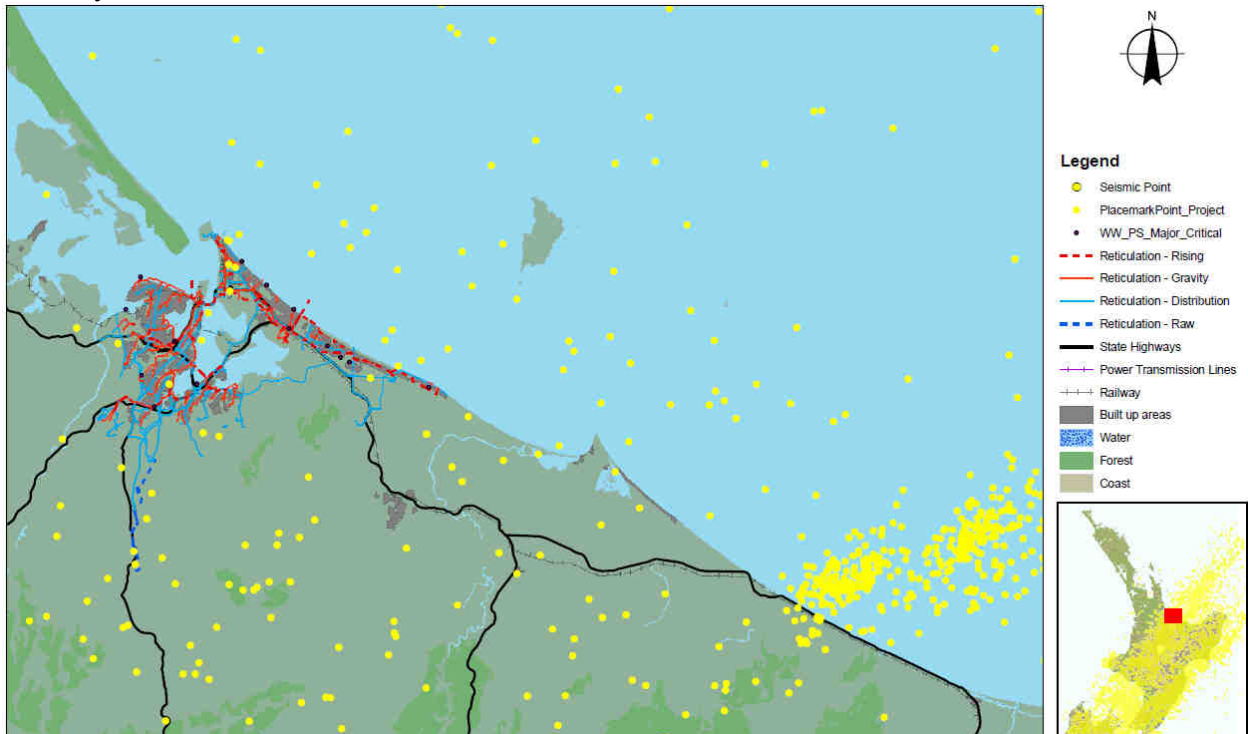


Figure 6. Seismic Activity across 12 Months

This extent shows the soils that are susceptible to flooding and ponding. This has an impact on surface runoff, damage to road basecourse and debris lodging in drains.

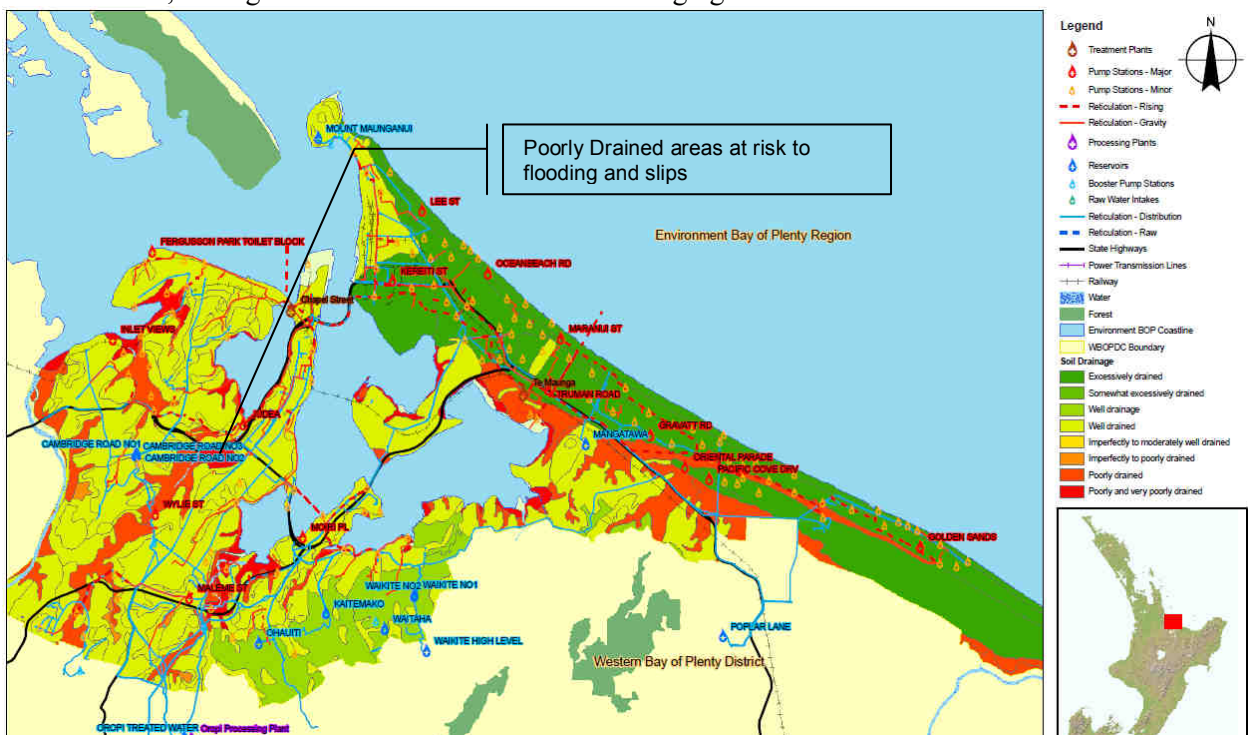


Figure 7. Soil Drainage

This extent shows the soils that are susceptible to liquefaction. It also uses a colour coded scale to illustrate which areas are affected by this.

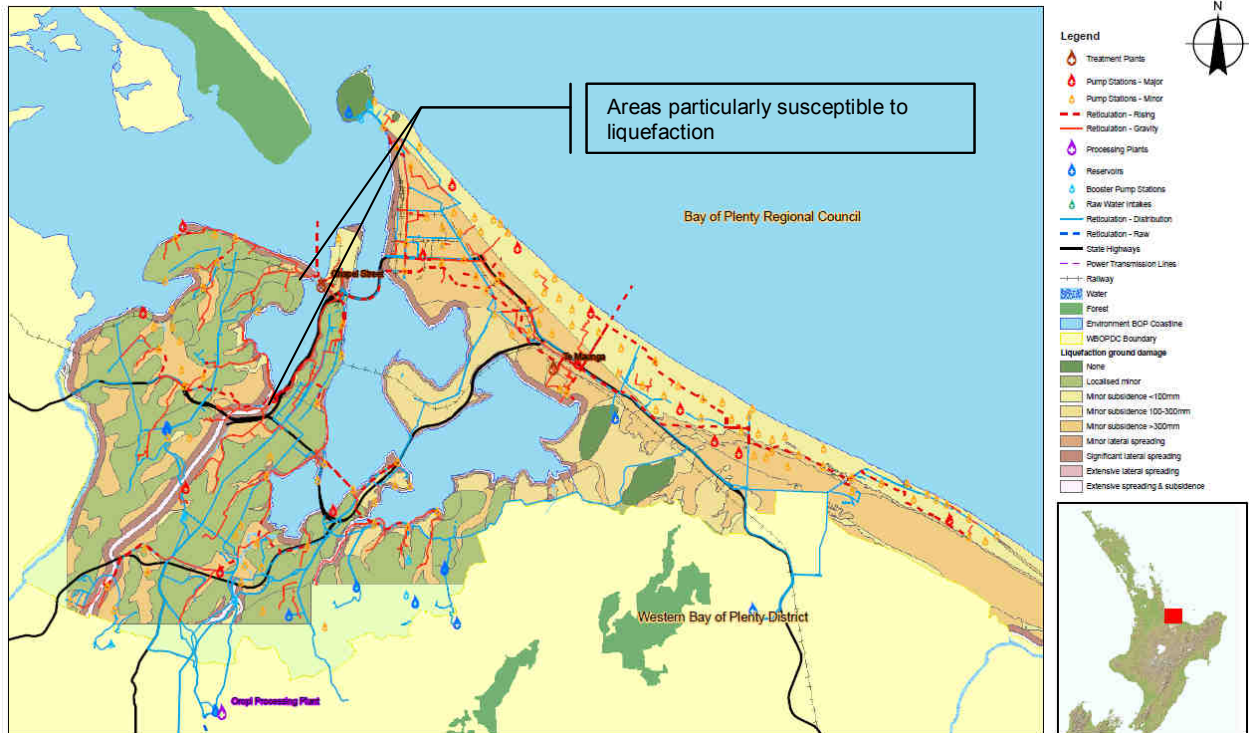


Figure 8. Liquefaction Ground Damage

This extent shows the topology of the coastal region and the risk of tsunami impact. It also shows where water naturally drains from the hill sides.

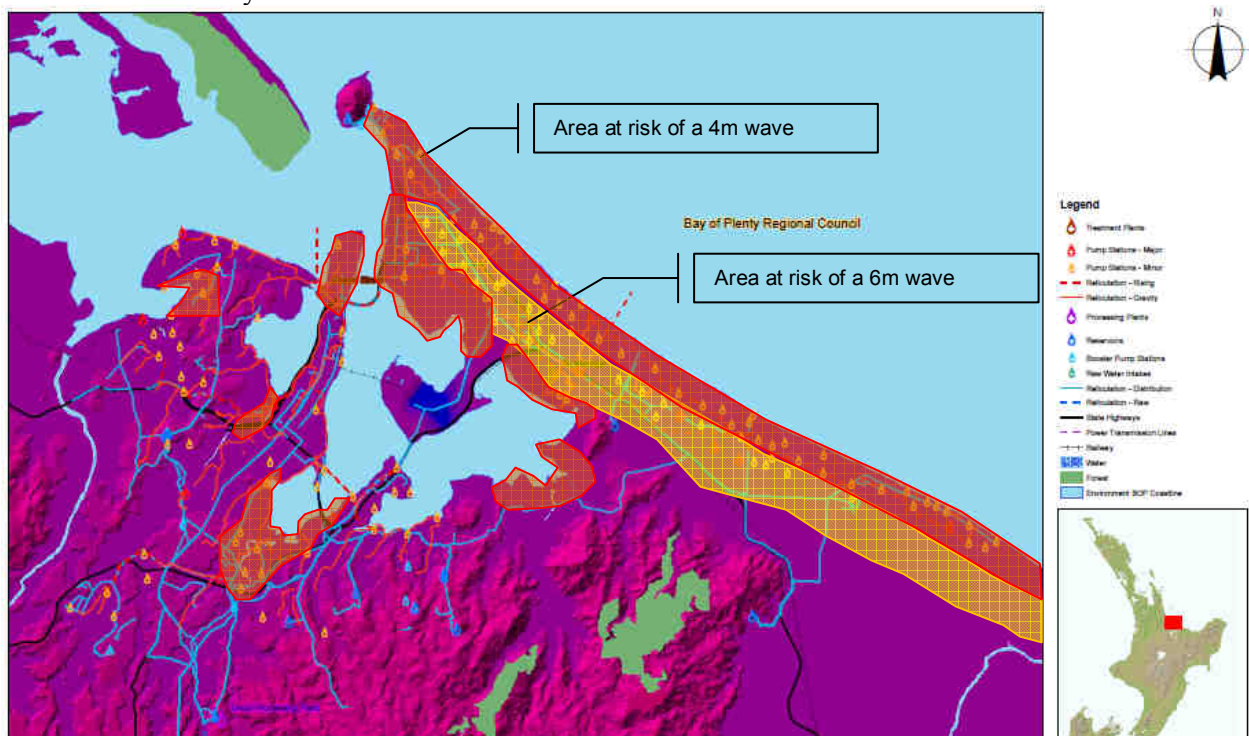


Figure 9. Elevation and Tsunami Impact

This extent shows the intersections between critical roads, water and wastewater mains. It utilised proximity and intersection analysis tools to highlight the critical areas in pink of (A) the Chapel St bridge and the Chapel St treatment plant and (B) the Welcome Bay bridge as a bottleneck access to critical reservoirs and pump stations.



Figure 10. Comparison Map Local Roads, Water and Wastewater

2.7 Overall Summary of Impact Scores

All asset classes were scored against the vulnerability criteria. This enabled further analysis of the results for the purpose of rationalising the scores and identifying the most critical assets. Table 6 below ranks the top 10 asset classes from most critical by the sum of each score given for each event. This method does not follow the traditional risk matrix. Currently the model sums all scenarios for the asset impact (consequence) score and vulnerability (likelihood). It also shows which critical assets remain critical for longer indicated by having a larger score in the Period Following and Return to Normal columns.

Table 6. Critical Asset Class Impact Ranking

Network	Type	Component	During Event	Immediately After	Period Following	Return to Normal	Total Score
Transportation	Arterial Pavements	Welcome Bay Rd	82	60	44	34	220
Transportation	Arterial Pavements	Chapel Street	73	54	43	34	204
Transportation	Arterial Pavements	Papamoa Beach Road 2	66	49	39	32	186
Wastewater	Treatment Plant	Chapel St - Overload	57	49	44	33	183
Wastewater	Reticulation - Gravity	Trunk Main Overload	53	54	45	30	182
Wastewater	Treatment Plant	Te Manga - Overload	56	49	44	33	182
Transportation	Bridges	Chapel Street Bridge	61	51	39	30	181
Transportation	Arterial Pavements	Papamoa Beach Road 1	64	47	37	31	179
Wastewater	Pump Stations	Pump Stations - Western Major L	61	47	40	29	177
Transportation	Arterial Pavements	Maunganui Road	62	45	35	30	172
Etc.							

2.8 Limitations in Identifying Disaster Event Scenarios

Since the study above it has been noted that although a coordinated analysis of site vulnerability has taken place and critical response plans have been identified, there are still events that have not been planned for. This is evident in the event of 5 October 2011 where the container ship, Rena, ran aground on the Astrolabe Reef in the Bay of Plenty posing a threat of spilling its cargo including 1,700 tonnes of oil.

Although this event was not part of the vulnerability analysis, the resulting emergency response plans provided the thought processes for organising clean-up and support teams. At the height of the response approximately 600–800 people were involved in the oil spill response team including those that produced refreshable GIS maps of the disaster location and hazard areas as seen below.

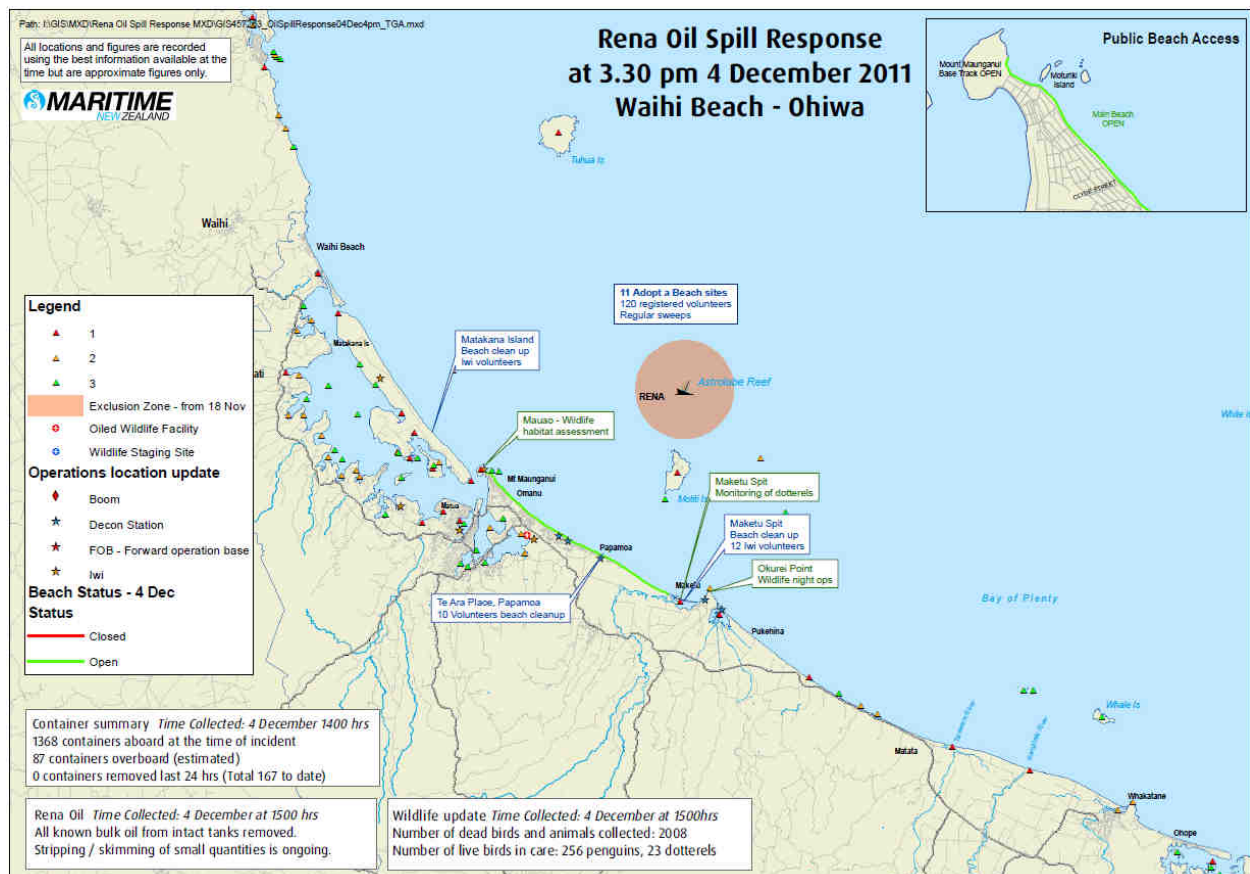


Figure 11. Rena Oil Spill Disaster Location

3. Conclusion

With the majority of the world's population living in urban environments dependency on our built infrastructure will continue to escalate, along with the consequences of major failures. In order to meet this challenge, there needs to be a new approach and new responsibilities to address the resilience of the integrated infrastructure.

This represents a major change over current autonomy practices in that resilience should be a combined assessment across all types of infrastructure. Nor is this confined to the provision of new infrastructure but needs to address the ongoing maintenance and replacement of existing infrastructure, such that fundamental weaknesses from an integrated perspective are not perpetuated simply because they are inherited.

It is evident that a collective responsibility will have to be applied and possibly achieved through an overseeing authority, one that can regulate the interests of the stakeholders with the sustainability imperatives for the community.

4. Acknowledgements

The author would like to thank Tauranga City Council for supplying historic and spatial data that enabled these results to be realised.

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6. Biography

Julian moved to the UK from GHD New Zealand with 10 years spatial sciences experience and eight years focused on holistic asset management across multiple portfolios. Julian's emphasis is on improvement planning to link strategy to people, knowledge, data and system enablers, optimising service delivery processes and cross-network geospatial modelling.

The application of augmented reality as a landscape visualisation tool: a proposed research study

Sarah Taigel¹, Andrew Lovett, Katy Appleton

School of Environmental Sciences, University of East Anglia, Norwich, UK, NR4 7TJ

¹Tel. +44 (0)1603 597411 s.taigel@uea.ac.uk

Summary: The benefits that the landscape gives us (ecosystem services) are often taken for granted and inadequately considered in decision making. The recently published National Ecosystem Assessment has highlighted growing individual consumerism as one source of pressure on ecosystem services. It is therefore important to communicate to people the link between personal behaviour and pressures on the ecosystem services in the landscape, supporting the need for behavioural change. Visualisations have been successfully used in the past to engage people with the landscape around them. This research explores the use of augmented reality as a visualisation tool to communicate information about ecosystem services and encourage behaviour change.

KEYWORDS: Augmented Reality, Ecosystem Services, Public Participation

1. Introduction

Traditionally rural landscapes have had agriculture and forestry central to the strategies used to manage them. However the landscape provides a wealth of other functions (ecosystem services) to human kind, some obvious such as food and fresh water, and some so subtle they do not feature in the public consciousness (National Ecosystem Assessment, 2011). The rural landscape around us is changing rapidly due to a range of economic and climate driven factors, putting some ecosystem services at risk (Hawkins & Selman, 2002). With a shift towards bottom-up (as opposed to top-down) management approaches, stakeholders are playing an increasing role in decision making (Lange and Lange, 2010). Increased awareness is needed amongst the general public about ecosystem services, including why it is important to manage the rural landscape at a landscape scale, and the link between individual actions and local level issues (Nicholson-Cole, 2005).

Lange (2011) suggests that there is a great deal of potential in the use of mobile visualisations to increase public participation in the environment around us. Communicating information while in the field enables the non-visual senses to be engaged, and a sense of interaction impossible within a building to be stimulated.

This paper briefly outlines an engagement event to be held in the spring of 2012 in King's Lynn, Norfolk, UK, where augmented reality on mobile devices will be used to show the location of ecosystem services within the Gaywood catchment. The project will involve the Gaywood Valley Project, an INTERREG project aimed at engaging the community with their rural fringe.

2. Study Area

The Gaywood Valley is a small chalk valley of just 4,000 ha which is located to the east of King's Lynn in Norfolk, UK see Figure 1. The land use of the valley is predominantly agriculture and heathland and it contains a variety of different protected areas and a mosaic of habitats. The source of the Gaywood River is from a chalk fed aquifer; the river itself is just 10km long, and is not visible by the general public for most of its length leading to a sense of community disengagement with the river and its catchment.

The valley has in the past been intensively managed with flood management as the prime objective. There has been more recently been a drive to restore the meanders of the river channel which has led to increased populations of species such as the otter and water vole. In addition, the large coniferous

plantations have been logged by Norfolk Wildlife Trust, who bought the site intending to return the upper slopes of the valley back to heath which supports a diverse range of wildlife. The Norfolk Wildlife Trust hope that engaging with local communities and stakeholders will increase support for restoration of the valley along its entire length.

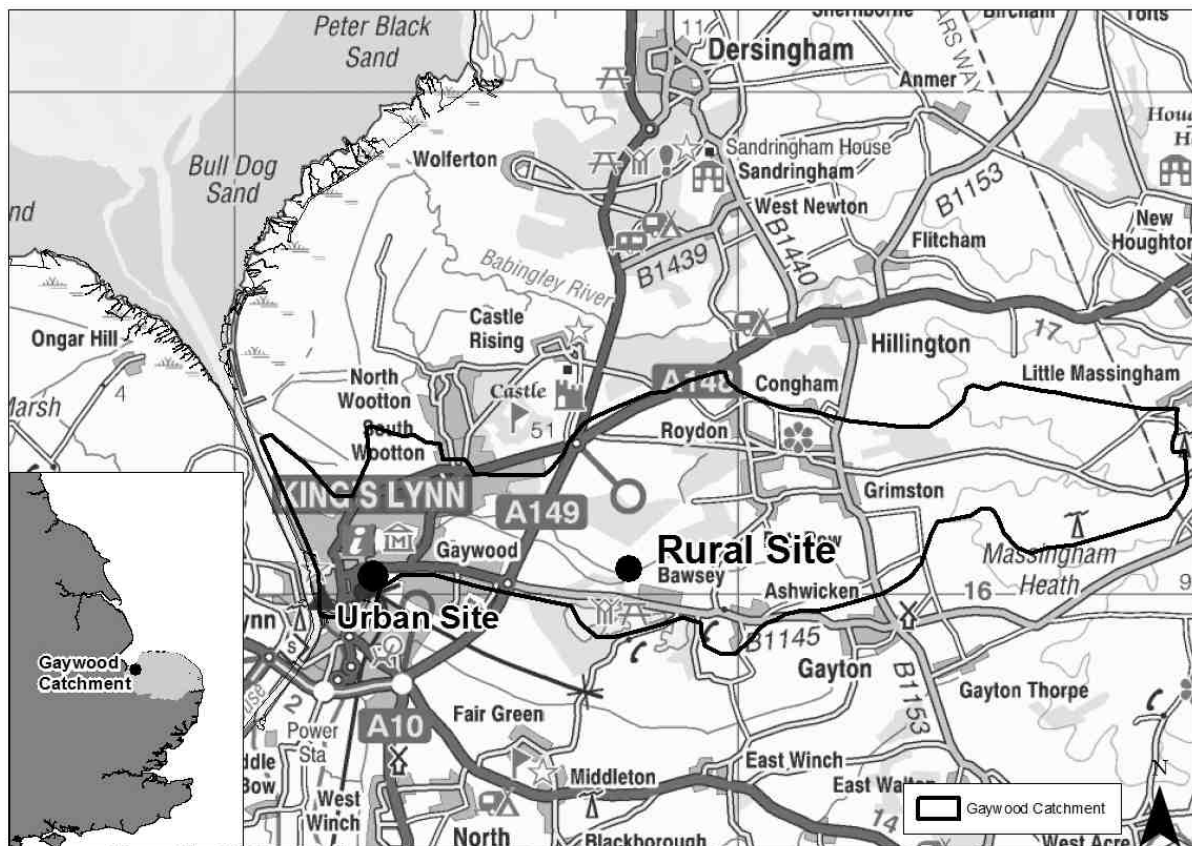


Figure 1 - The location of the Gaywood catchment and the two sites to be used in the evaluation, the rural site at Church Farm, Bawsey and the urban site in King's Lynn

3. Development of the augmented reality application

The augmented reality application VesAR (Visualising ecosystem services using Augmented Reality) has been developed using a suite of internet based applications including the Hoppala web service (Hoppala, 2011) and the LayAR augmented reality provider (LayAR, 2011a). The National Ecosystem Assessment (2011) and the Millennium Ecosystem Assessment (2006) have been used to describe the types of ecosystem services in the catchment which were identified during a field visit to the sites in September 2011.

VesAR utilises a combination of camera, GPS, compass, accelerometer and an Internet connection: GPS determines the exact location of the device (within a few meters) and the compass and accelerometer determine the field of view. The person using the device sees the world via the camera image which is displayed on the screen (Figure 2); additional digital information such as text, images and animations are augmented on top of the camera view via mobile Internet (LayAR, 2011b).



Figure 2 - VesAR on an HTC Android phone

To date the applications of augmented reality on smartphones (Android, iPhone) have been targeted at gaming, marketing and advertising, and as yet their application to landscape visualisation has been limited. Lange (2011) highlights the potential use of augmented reality for viewing planning proposals live on site or visualising 3D models of proposed building aligned to the existing viewpoints.

4. Survey Methodology

A series of engagement events, taking the form of a ramble, will take place in the spring of 2012 in conjunction with the Gaywood Valley project. A number of participants will be shown the ecosystem services within the Gaywood catchment on both a rural and an urban site (Figure 1), using two tools: a paper handout and an augmented reality phone/tablet application. The aim is to examine the potential of augmented reality for communicating information about features within the landscape and engaging people with the importance of ecosystem services which these features offer.

After the tours, participants will be surveyed to establish which tool was most effective and which was preferred, along with demographic information to examine any differences in responses due to age, technological familiarity, and other factors. Details of the engagement event are yet to be finalized but the data collection will most likely use face to face paper-based questionnaires.

5. Next Steps

VesAR has been developed as part of a PhD based at the UEA to develop tools to enable the visioning of future catchment landscapes. It is intended that by bringing together a group of interested stakeholders the future of Gaywood Valley landscape at the rural site can be explored in further workshops using 3D visualisation tools, the results being used by conservation and community groups. In turn the outcome from the visualisation strand of research will feed into an interactive What If? decision-based management tool.

6. Acknowledgements

Sarah Taigel's research is being conducted as part of ESRC PhD Studentship No. ES/I022139/1. Ordnance Survey digital data is © Crown Copyright 2011. An Ordnance Survey/EDINA supplied service.

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8. Biography

The author has a background in GIS in industry, an MSc with Distinction from the University of Southampton in 2008 and an RGS award for her Masters project on modelling tranquillity in ELA using GIS. She is currently funded by ESRC on a PhD researching innovative uses of visualisation and spatial technologies for visioning river catchment futures.

Pedestrian navigation using haptic feedback: Results from a field study to test spatial abilities and memory recall

Ricky Jacob¹, Adam Winstanley¹, Naomi Togher², Richard Roche²

¹Department of Computer Science, National University of Ireland Maynooth, Co. Kildare, Ireland
Tel: 353-1-708 3847 Fax: 353-1-708 3848

Email: rjacob@cs.nuim.ie Web: <http://www.cs.nuim.ie/~rjacob/>

²Department of Psychology, National University of Ireland Maynooth, Co. Kildare, Ireland

Summary: Haptic feedback (using the sense of touch) or 'haptics' is a technology that provides forced feedback, vibrations, and/or motions to haptic-enabled user devices. The mobile haptic interaction model for a point to destination pedestrian navigation system is described. The importance of eyes-free, subtle feedback has been highlighted in previous work. This paper reports on the initial findings from the tests carried out to evaluate the user's spatial abilities, navigations skills and memory recall of features seen along the way. Initial results show that the user walks faster to the destination on the second attempt and builds a good mental map of the features seen along the route as haptic feedback ensures heads-up navigation and no interaction with the mobile device (a GPS enabled smart phone) while walking towards the destination.

KEYWORDS: haptics, pedestrian navigation, orientation, spatial ability, mental map

1. Introduction

The word *haptics* is derived from the Greek word *haptesthai*, which means 'of or related to the sense of touch'. In the psychology and neuroscience literature, haptics is the study of human touch sensing, specifically via kinesthetic (force/position) and cutaneous (tactile) receptors, associated with perception and manipulation. The benefit of using the human sense of touch is that it is faster than vision, it is the first sense one develops when born and the last sense to fade at death. Consequently haptic interaction we believe has a much longer 'use life' than traditional interaction methods. Another important feature of this kind of communication is that unlike visual or audio based interaction, this overcomes the language barrier and can thus be extended to other geographies with ease. The use of a non-visual system like this means that the user can query about features by performing pointing and/or scanning gestures and not having to look into the mobile device. Thus such operations can be performed privately by having the phone in the jacket/loose pant pocket and by pointing and waiting for feedback. This insures that the people around are not aware that the user is a stranger to the area and thus serves as a good feature to ensure the user is 'one among the crowd'. In this paper we discuss the results from the haptics based navigation tests carried out to test the spatial abilities (orientation skills and memory recall) of users.

2. Related work

We have seen in Jacob et al (2010), the uses and importance of haptic feedback as a way to convey spatial information to the user. A point to query Haptic Geowand was described in Jacob et al (2011) where distance to point of interest and density of point of interest information was defined using varying vibration patterns. In our previous work in Jacob et al (2011a) we defined the four pedestrian navigation prototypes and the haptic interaction models for them. The authors in Waller et al (2002) examines the degree to which knowledge about the body's orientation affects transformations in spatial memory and whether memories are accessed with a preferred orientation. The participants learned large paths from a single viewpoint and were later asked to make judgments of relative directions from imagined positions on the path. Experiments were later carried out to test their

memory recall and spatial orientation skills. In Hegarty et al (2006), we see the various tests like mental rotation and spatial learning has been carried out to measure the spatial ability of the user. In this we paper we test the spatial abilities of the user based on both the navigation performance and also the memory recall of the user to recreate a map of the test region.

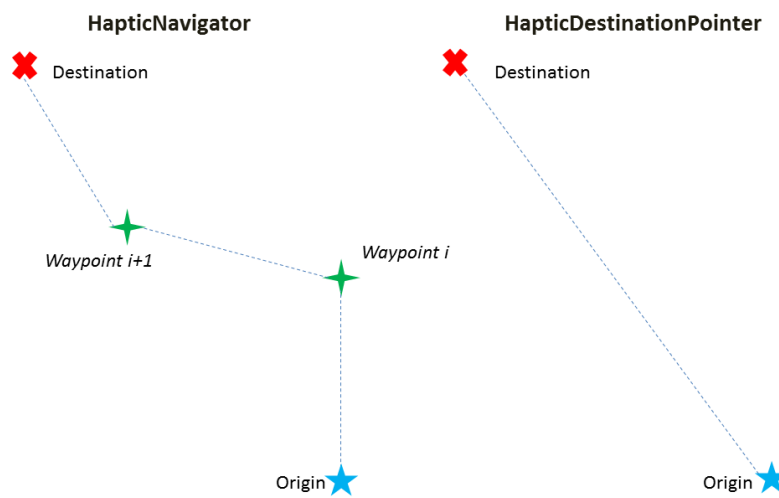


Figure 1. Haptic feedback for HapticNavigator and HapticDestinationPointer

3. Haptic interaction model

The haptic interaction for *HapticNavigator* and the *HapticDestinationPointer* described in our previous work in Jacob et al (2011a) is shown in Figure 1. The *HapticNavigator* provides waypoint by waypoint navigation along the shortest path. The *HapticDestinationPointer* provides haptic feedback when the user points in the direction of the destination. The distance from origin to destination is calculated and divided into three parts as shown in Figure 2. The querying angle is dependent on this distance information of the user from the destination where the angle decreases to a much smaller range as the user is nearing the destination.

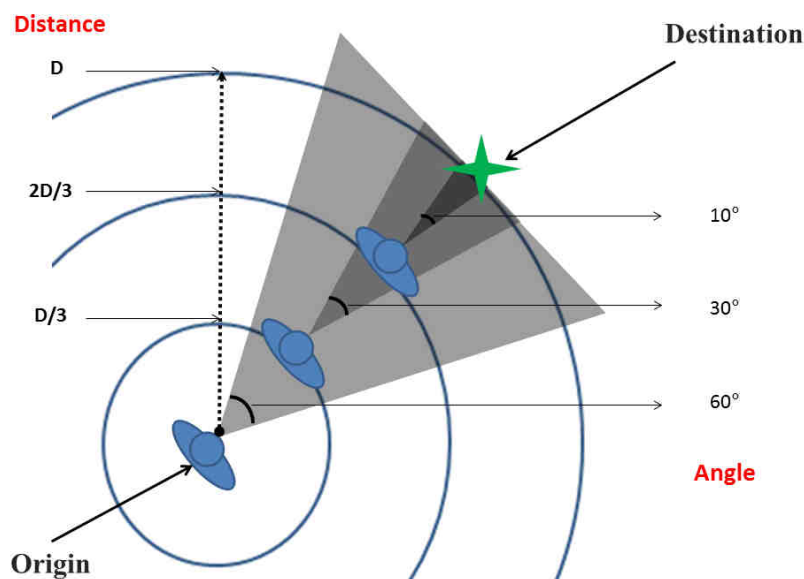


Figure 2. Variation in querying angle based on distance from destination

For any origin, O to the destination, P the straight line distance is set as D. This distance is divided into three parts which form the three main parts of the user's travel. For the walk from the origin to the point D/3 from the origin, the angle range for querying is 60°. The querying angle range for the second part of the walk from distance D/3 to 2D/3 is set to 30°. The last part of the trip when the user is closer to the destination which is between 2D/3 and D, the angle range is decreased to 10°. The user performs the 'scan function' where they hold the mobile device parallel to the ground and move it around them slowly to be alerted of the direction they need to start walking. The user is alerted with a unique continuous vibration feedback when the user reaches within 10 metres of the destination point.

4. Experiments

The experiments were carried out between the three user groups to test spatial abilities of the user. To ensure that all users are at the same level and navigation performance is not biased by better IQ or spatial intelligence, a few tests were carried out before the experiments. The tests carried out before the navigation tasks were – National Adult Reading Test (NART), Trail Making task, Mental Rotation Task and a Cognitive Failures Questionnaire (CFQ). We selected a destination location P and two origin points, A and B. Users were divided into three groups of 10 each. The average age of the users was 22 yrs. The map of the study area is shown in Figure 3 with all the important points marked for the navigation tasks. Memory recall of the users was tested once the users completed the navigation tasks.



Figure 3. The map of the area with the destination and the two origin points along with the waypoints

4.1 User trials

User group 1 were provided with panoramic images of the destination (P) before they started from the origin A. Once they reached the destination they were taken to origin B and were asked to again make their way to the destination P. User group 2 were provided with the mobile device running the

HapticDestinationPointer application. A 5 minute briefing about the working of the haptic system was provided to the user. The user had to walk from origin A to the destination P using haptic feedback. Once the user reached destination P, the user was taken to the origin point B and the user had to perform the same task by walking to the destination P. User group 3 were provided with the mobile device running the *HapticNavigator* application. After a quick briefing about the working of the waypoint-by-waypoint navigation system, the users were asked to go from the origin A to the destination P. Once the user reached the destination P, they were taken to the origin point B and were asked to again find their way to the destination (P). Information about the distance walked and time taken along with the chosen path for all the users were recorded.

For all the three user groups, once the users reach the destination, they were provided with a sheet with just the main road around the study area drawn. The final task for the users now was to mark on this map the two origins and destinations and all the features (buildings, bins, lamp posts, etc.) that they remember seeing along their path. The users were not informed about this final task at the beginning of the experiment so as to ensure that the user doesn't memorise the features while doing the tests before reaching the destination but rather try to recall what they remember seeing. The steps for the user trials are described in Figure 4.

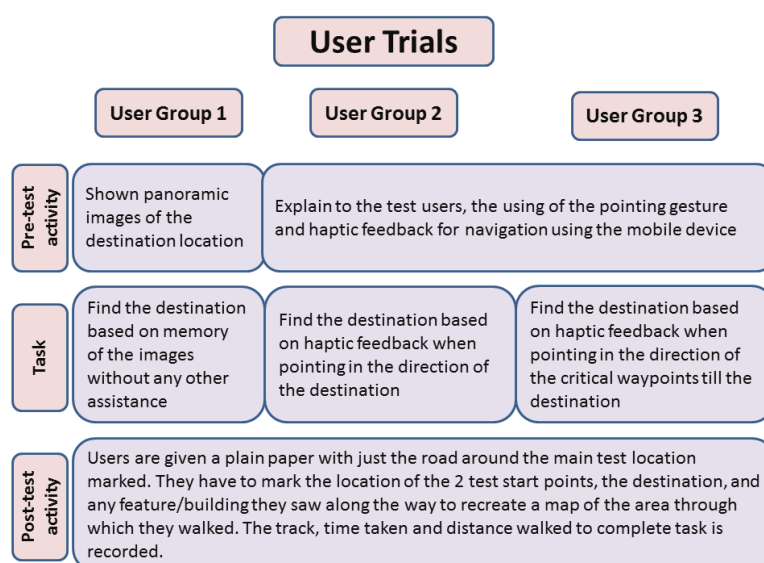


Figure 4. User trials for three different groups

4.2 Results

The users of all the three groups successfully reached their destination. While walking to the destination from the origin point B, almost all the users walked faster and with more certainty as they now had a better understanding of the environment. On reaching the destination the users marked features what they saw along their way. The users were given points based on the features marked, especially building polygons.

4.2.1 User group 1

All the users in the group 1 reached the destination successfully. The navigation performances of the users are shown in Table 1. All users excluding user 4 chose the same route (route 1) to get from origin A to destination P. User 1 chose route 3 and took longer time and walked a longer distance to get to the destination from origin B. The routes taken by the users are shown in Figure 5.

Table 1. User group 1 navigation performance results

User	From Origin A to Destination		From Origin B to Destination	
	Route taken	Time taken (in minutes)	Route Taken	Time taken (in minutes)
1	1	2.37	3	4.16
2	1	2.39	4	2.55
3	1	2.49	4	3.57
4	2	2.16	4	2.55
5	1	2.34	4	3.22

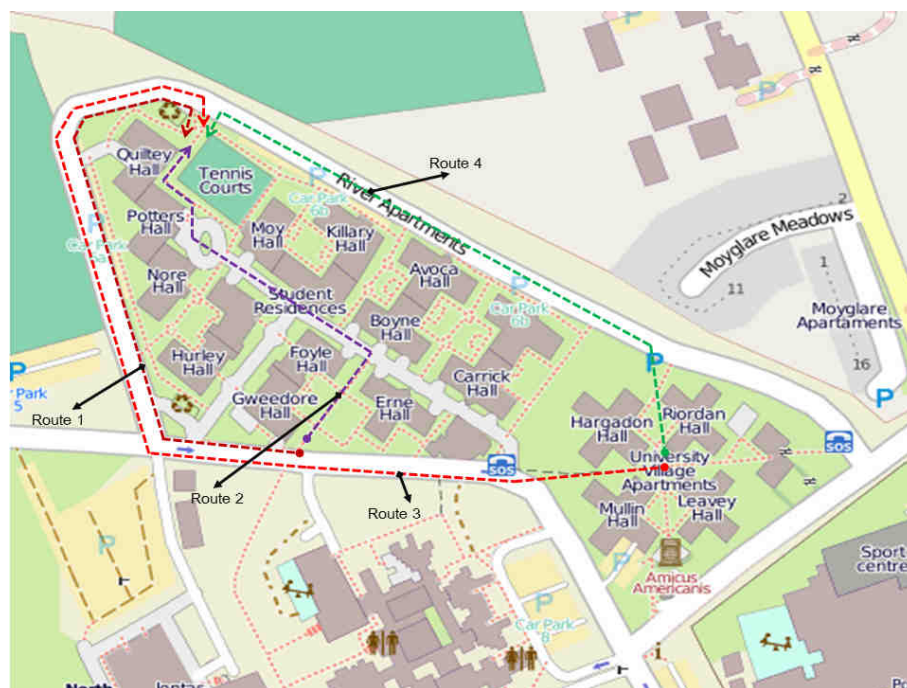


Figure 5. The 4 distinct routes taken by the *User Group 1* during the tests

4.2.2 Haptic user trials

User groups 2 and 3 used the pointing gestures on the phone and were provided with haptic feedback to get to the destination. All users of group 3 took the same routes to get to the destination from both origin A and origin B as they were guided by haptic feedback towards the waypoints till they reach the destination. The paths are shown in Figure 6. All users in group 2 chose the same route to get to the destination from origin B like group 3. The group 2 users choose an alternative route to the waypoint by waypoint route to get from origin A to the destination P as shown in Figure 6.



Figure 6. The routes taken by the *User Group 2* and *User Group 3* during the tests

4.3 Key findings

All the users marked the destination point and the points of origin. All the users walked faster while going from origin point B to the destination. Some users marked buildings and bins. Most users marked the tennis court near the destination location. The map drawn by one of the user soon after the user completed the navigation task is shown in Figure 7. The user has marked the destination and the origin points and included buildings, tennis court and bins. Based on the time recorded, it is seen that users who were provided with the panoramic images of the destination (group 1), reached the destination faster as compared to the users of group 2 and group 3. Since the participants of group 1 knew what the destination point looked like, they were able to quickly walk to the destination when they reached within sight of destination P. Group 2 and group 3 users did not have any idea where the destination point was and how it looked and thus took time to get to the exact spot although they were within sight of the destination P. But it has been noted that users of group 2 produced the best maps once they completed the navigation tasks.



Figure 7. The map of the area on OpenStreetMap versus the map drawn by one of the user after completion of the trials

5. Conclusion

Haptics ensures eye-free interaction as there was no visual display which the user was dependant on while performing these navigation tasks. The users of group 1 who were provided with panoramic images of the destination completed the navigation task the quickest. We tested the memory recall after the user has carried out navigation tests by having the user map the area based on memory from the navigation experiments. Most users marked the origin and destination points well. Some users remembered the buildings and bins along the way and included them in the map when asked to draw. We find that the users of group 2 produced the best maps suggesting they were able to look around and see features around them as the device would guide them to the destination. Thus we notice that the users are able to interact with the real-world and remember features along the way when they were provided with subtle feedback guiding them towards the destination. In future tests we wish to compare the user navigation and memory recall performances by comparing haptics with map based systems on mobile devices. We believe that haptics can be an added modality by integrating it with vision based systems for pedestrian navigation. Thus during conditions when navigation using vision based systems cannot be used, haptics can be used for the same tasks.

6. Acknowledgements

Research presented in this paper was funded by a Strategic Research Cluster grant (07/SRC/I1168) by Science Foundation Ireland under the National Development Plan. We thank all the students who took part in the user trials. We acknowledge the inputs from our colleagues at the Department of Psychology. The authors gratefully acknowledge this support.

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8. Biography

Ricky Jacob is a 3rd year PhD student at the Department of Computer Science at NUI Maynooth. He is part of the StratAG project working on Geo-spatial technologies. His primary focus is on integrating non-visual interaction techniques using mobile devices to pedestrian navigation systems.

Adam C Winstanley is Professor and Head of Department Computer Science at NUI Maynooth. He is one of the PI of the StratAG project. His primary research interests include pedestrian navigation, real-time bus tracking, and location based services for environmental monitoring.

Naomi Togher is a 2nd year Undergrad student at the Department of Psychology at NUI Maynooth. Her research interests include spatial abilities, memory recall and spatial navigation skills.

Richard Roche is a Lecturer in Psychology at the Department of Psychology at NUI Maynooth. His research interests include the neurocognitive processes underlying human spatial navigation and representation, and the neurocognitive mechanisms underlying memory consolidation.

Participatory map-making after brain injury: a case-based feasibility study

O'Brien J¹

¹University College London, Gower Street, London, WC1E 6BT
Tel. (+44) 0207 679 3734
jamie.o'brien@ucl.ac.uk

Summary: This paper outlines a participatory map-making collaboration with members of a charity supporting people experiencing difficulties following brain injury. The map-making involved members describing their experience of everyday life after brain injury. The study sought to assess how map-making may provide modes of individual, group web-based expression after brain injury.

KEYWORDS: Map-making, brain injury, web-sharing, community participation, advocacy

1. Introduction

Headway is a charity that supports people after brain injury. The project sought to assess whether map-making is a tractable and accessible way for members to describe their experiences, and whether a web-sharing platform could help produce a community map. Map-making compliments Headway's engagement and advocacy agendas¹. Standard searches² have revealed no similar examples of participatory GIS relating to neurological impairment in a community setting. The study outlined in the present paper is a 'public' collaboration (PPGIS) as we sought to achieve a shared understanding of the participants' knowledge (c.f. Jankowski, 2011:349).

Ten maps were produced during a five-month period. Seven were produced individually and three in a group. The participants (see *Table 1*) represent a representative sample of the day-centre community in terms of sex and age. Each had suffered a brain injury and continue to experience related impairments, including to memory, attention and communication, as well as difficulties such as fatigue, confusion and low self-esteem. Suitable participants were pre-selected Headway's by psychologist. The investigator imposed no formal schema on participants' modes of expression.

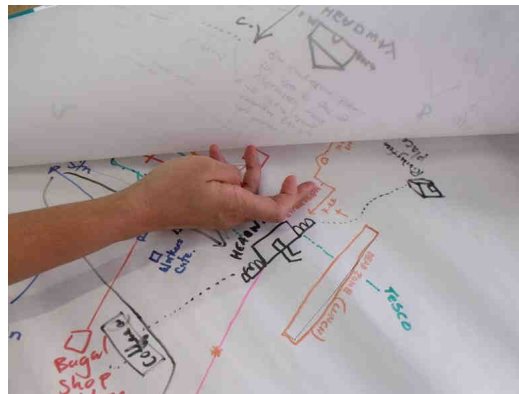
The initial map-making sessions were led by the investigator and Headway psychologist, after which two Headway members led individual and group sessions. Participants were requested to draw and annotate a map of their routine life. Map-making involved drawing on A3 sheets with coloured marker pens and ball-point pens. A similar map-making exercise was undertaken with a group of members. The pen-and-paper map-making was developed to support the production of a digital map of Headway members' experiences using a web-based image sharing platform. *Figure 1* provides an illustration of the map-making sessions³.

¹ Details are provided via <http://www.headwayeastlondon.org/services/discovery-programme/> [accessed February 2012]

² Including Google Scholar, Microsoft Academic Search, institutional library search

³ The investigator is not able to provide full illustrations due to participant privacy

Figure 1 An illustration of the Headway map-making sessions



1.2 Individual map-making

TR's map is complex and detailed, representing a network of routes and places weighted around his neighbourhood. There are two layers to the map: one 'written large layer' (the main routes and places) and the 'commentary layer' (thoughts, feelings and stories). Written large on Map One are places of interest: football stadia, retails areas and leisure destinations. Drawn around a tight cluster of activities is a ring labelled 'confident area safe zone'. His maps describe how his injury impacted negatively on his activities. For example, under a football stadium is written 'used to be an [Club A] fan but now difficult to get to the stadium so has switched to [Club B]; next to clothes shop (and intensified with 'fright' marks and capital letters) 'lost 18 months ago scared; [...] confused about which side of road shop was on. Walked up and down for 45 minutes'.

Table 1. Breakdown of participants

Name	gender	Age	yrs since injury	Cause	Impairments
TR	M	mid-20s	7	traffic accident	memory, vision
OH	M	male mid-40s	8	traffic accident	fatigue
PD	M	male mid-40s	5	trauma	memory, fatigue, navigation
Anon.*	M				
MM	M	male mid-40s	3	trauma	memory, hearing
FC	F	mid-20s	2	asthma	memory, fatigue, navigation
TR	M	late-20s	7	traffic accident	memory, fatigue, navigation

*no details collected as this map-making session was member-led

OH's map shows a major cluster of routes and places, featuring 'Home' at its centre. The routes and places are arranged by salience. Hence, the cluster that represents his everyday activities within a five-mile radius is disproportionate in size to a 40-mile journey he undertakes once a week. Routes are colour-coded and reveal his chief mode of transit to be his bicycle. OH has annotated his map according to activity rather than experience (eg 'shopping', 'seeing friend'). The phrase 'pass through' is written under every place not associated with everyday life, including a place demarcated as, 'repairing friend's bike pass through', meaning that this place bears personal and social salience but is no longer visited.

PD's map includes a circle drawn around the region comprising home, pub, nearby shops, nearby family, football and Headway. PD's map shows his interest in football and how disabilities have affected his engagement in the sport: 'really misses football'. PD notes that he watches football in the nearby pub, but has had to leave the venue due to the noise and crowds. PD reveals that he is able to travel to Headway twice weekly during the morning's rush hour, but habitually picks up a newspaper and 'puts his head in it and tries to ignore other people'.

Anon.'s map is unique among the materials in that it shows only places, not routes. Some but not all London's markets are depicted, and only one football stadium is shown; more places in north-west London are shown than places elsewhere in the city. The map also shows London's major airports, plus a major music venue. Hence, landmarks are simply geographic but also salient. Anon.'s sole annotation on the map is a single asterisk that appends a football stadium.

MM's map shows places and routes in London's west end, encircled and annotated with 'anxiety zone ... crowds!'. Shops are situated in a 'very disorientating' underground complex, and the major transport interchange was 'horrible, being noisy and difficult to navigate'. MM symbolised this by a sketch of an ear surrounded by alarm marks.

FC's map reveals that she travelled widely and regularly by bus before her injury, but now avoids this for several reasons: they are too busy, 'awkward to stand on', the drivers are 'mad', 'park too far from the kerb', 'the passengers use the same doors to entry and exit'.

1.2 Group map-making

Group maps were produced using several sheets of paper in various formats, taped together asymmetrically and rendered in a variety of vividly coloured felt-tip pens. Each map shows a region surrounding the Headway day centre. While the focus of interest was on the surrounding streets and resources, one map included some locations on the south coast of England.

The group-work maps combine different viewpoints and perspectives and bear conflicting scales of description, for example a pet cat is rendered the same size as a supermarket. The marks of several participants are evident, revealing differing modes and capabilities of expression.

1.3 Web-sharing

Participant OH led a map-making session using a popular web-based, image sharing platform with participant MM. OH shadowed MM on a regular trip, and used an iPhone to take pictures of him *en route*. The images were geo-tagged, uploaded to the web-sharing platform and annotated with additional prompts. The intention was for MM to log in to the site on his mobile phone, and use the sequence as an aid to memory. The author has requested MM to use this platform as he sees fit for a period of months, and assess the potential use of web-sharing platforms.

2. Discussion

The study demonstrated that map-making is a tractable and accessible mode of expression following brain injury. More critically, the participatory map-making was shown to involve *ideational* activities, meaning that everyday experiences were brought to presence as a *thinking-space* (c.f. Rosenberg in Garner, 2007: 110). Hence, the maps may be viewed as creative and authored surfaces. Developments in web science currently afford to the map-maker a broader modal and dimensional scope, including platforms for rapid authorship. Hence, ‘semantic web’ knowledge-modelling tools may also allow the participant to ‘think on the web’⁴.

Expanding on these technical themes, we may consider John Urry’s critique of current descriptions of social arrangements as networks of people, places, materials and mobilities; also observing how web platforms may represent such rapidly evolving landscapes (Urry, 2004). These social networks bear a kind of conceptual proximity – for example of ‘friendliness’ or ‘strangeness’ – which were instantiated in the map-making sessions, for example in the delineations of ‘safe zones’.

For those experiencing impairments as a result of brain injury, everyday life may involve deliberately managed activities. Their maps of everyday life (including social arrangements and phenomenal encounters) must be reconfigured rapidly and constantly, with minimal cognitive load. The task ahead is to explore how semantic web tools may provide agile support for map-making as a *thinking-space* activity.

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⁴ c.f. Alesso et al (2009) *Thinking on the Web*, London: Wiley Publishing.

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