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A SURVEY OF THE USE OF GEOGRAPHIC INFORMATION SYSTEMS IN ENGLISH LOCAL AUTHORITY IMPACT ASSESSMENTS

D. RIDDLESDEN, A. D. SINGLETON and T. B. FISCHER*

School of Environmental Sciences, 4imPiAct
University of Liverpool, UK
**fischer@liverpool.ac.uk*

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Across the public sector, Geographic Information Systems (GIS) and spatial analysis are increasingly ubiquitous when making decisions involving people and places. However, historically GIS has not been prevalently applied to the various types of impact assessment. As such, this paper presents findings from a survey conducted in 2011 of 100 local authorities in England to examine how embedded GIS, spatial analysis and visualisation practices are to the process of conducting impact assessments. The results show that despite obvious advantages of applying GIS in these processes, applications employing basic techniques are at best sporadic, and where advanced methods are implemented, these in almost all instances are conducted by external contractors, thus illustrating a significant GIS under capacity within the sampled local authorities studied.

Keywords: Strategic environmental assessment; GIS; impact assessment; transport planning; spatial planning; flood risk assessment.

Introduction

The growing use of GIS in spatial planning relates to their ability to simplify the organisation, presentation and analysis of spatial data relating to environmental and socio-economic processes (Longley *et al.*, 2010). Although there is an already large body of literature on best practice applications for specific examples of GIS

*Corresponding author.

within planning systems (González *et al.*, 2011; Aydin *et al.*, 2010; Herberg, 2008; Al-Adamat, 2008; Balram *et al.*, 2002; Agrawal and Dikshit, 2002), the extent that GIS procedures are utilised systematically in everyday decision making has remained unclear. There have been numerous reviews of the extent that GIS is used within the public sector for impact assessments or planning more generally (see Drummond *et al.*, 2008; Joyce, 2009; González *et al.*, 2011); however, there is a dearth of focus on the English context. As such, this paper establishes the extent to which GIS are used across a range of different types of impact assessments that feature as components of the English local spatial planning system. Assessments considered include: Strategic Flood Risk Assessments (SFRA), Strategic Environmental Assessments (SEA), Sustainability Appraisals (SA), Environmental Impact Assessments (EIA), Flood Risk Management Strategies and Flood and Coastal Defence Strategies.

SEA for plans and programmes and EIA for projects are the most commonly used forms of impact assessment in spatial planning in the UK, as well as elsewhere in Europe, based on the European SEA and EIA directives (Fischer *et al.*, 2008). In England, SEA is frequently applied within the context of SA. Here, SEA inclusive SA is applied to a wide variety of local spatial plan documentation (local development documents — LDDs) prepared within local development frameworks (LDFs), ranging from core strategies to Area Action Plans (AAPs; see Fischer, 2006; 2002).

In addition to establishing the extent of GIS use within the sector, this paper also investigates the types of analyses conducted within the field of impact assessment, establishes which methods are used by the private or public sectors; and finally, identifies what constitutes best practice.

GIS and Impact Assessment

The way in which GIS may be integrated into EIA is well represented by the visual flow diagram featured in Hacklay *et al.* (1998), depicting a possible application in Israel. Figure 1 details the various inputs, outputs and different stages in the analytical process and illustrates how it is possible to draw upon data from numerous sources and combine them within a GIS for comparison, analysis and representation. This multi-level organisation and analysis would be extremely difficult to achieve without a modern GIS software package (Longley *et al.*, 2010). Impact assessment is data intensive, and the use of GIS aids the decision making process through the transformation of spatial data into information. Such benefits have seen similar approaches being developed within public and private sector work more generally, including policy making and consultancy projects.

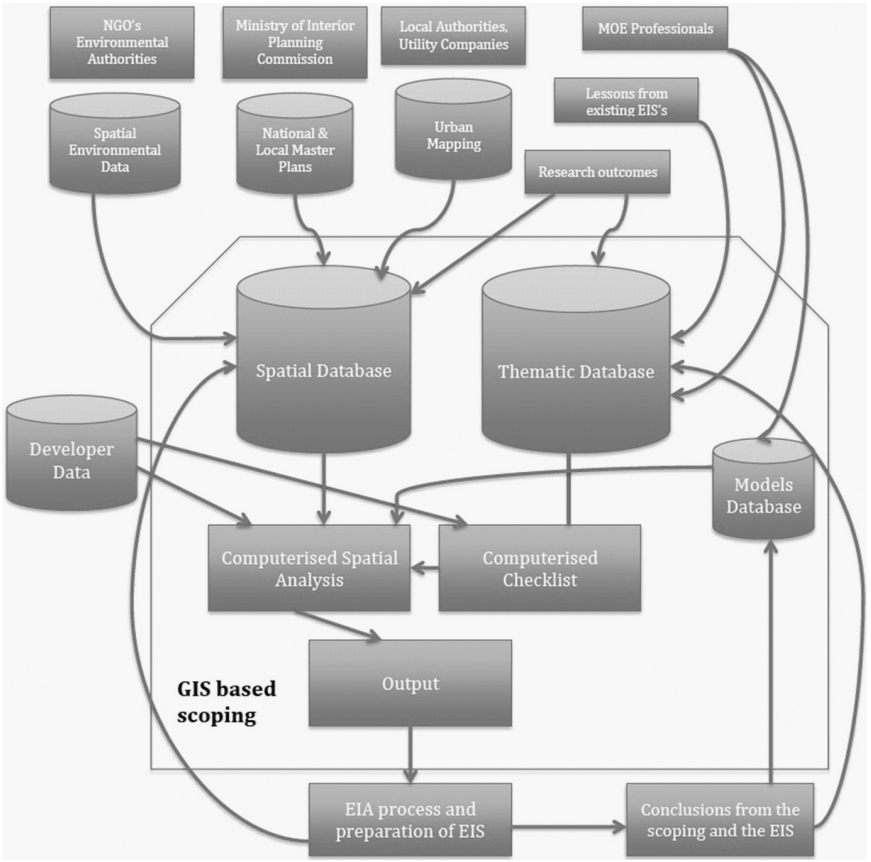

Fig. 1. GIS utilisation within Environmental Impact Assessment (adapted from Hacklay *et al.*, 1998).

The benefits that GIS offers to those analytical tasks required in SEA processes have long been highlighted (Agrawal and Dikshit, 2002) and reiterated more recently by González *et al.* (2011). These include; enhancing aspects of data integration; analytical functionality and manipulation; stakeholder engagement; visualisation and dissemination of results. However, despite these diverse benefits, GIS use has historically been variable. For example, Gunasekera (2004) conducted a search of the GEOBASE[1] bibliographical database which details publications in Earth, Geographical and Ecological Sciences to examine how many references of EIA featured the use of GIS. This analysis found that between January 1990 and February 2003, only fifty-eight (4.2%) incorporated an aspect of GIS. Conversely, Joao (1998) discussed that following those improvements to GIS systems

occurring at the time, these became more widely used in impact assessments. The most common applications were the impact evaluation of roads, pipelines, housing developments, coast and flood protection works, dams, tourism-related projects, ports, and power lines. The variable use, both in absolute terms, but also by levels of analytical sophistication may reflect a lack of spatial literacy by practitioners and the general public alike, a knowledge gap that can only be bridged in the short-term with significant efforts to promote greater development of GIS skills within society (González *et al.*, 2008). Although there is widespread use of online mapping tools such as Google Maps, we differentiate this type of interaction from those skills and knowledge necessary to facilitate analysis in a GIS that would be necessary in environmental assessment/impact assessment. Hacklay *et al.* (1998) suggested that further limitations could include the substantial cost and time required to setup corporate GIS including the compilation of input data, and additionally, conducting, and then analysing derived outputs; constraints which are still applicable today. Furthermore, there is a requirement for specialised personnel, therefore only relatively large organisations may have the capacity to utilise GIS to its fullest potential. Since the late 1990s, the use of GIS within the EIA context has expanded greatly (see Smith, 1993; Joao, 1998; Xiugang *et al.*, 1999; Sahin and Kurum, 2002; Gunasekera, 2004). In spatial planning related SEA/SA, GIS have numerous examples of successful applications (Brown and Affum, 2002; Herberg, 2008; Fischer *et al.*, 2009; Aydin *et al.*, 2010).

A Survey of Local Authority Impact Assessment Use

In the previous section we have outlined the benefits of the use of GIS for impact assessment. We expand on this in the following section by reporting on a survey of local authority impact assessment documents, which was undertaken in 2011 in order to determine how and where GIS are used most commonly within this sector. This survey thus provides a contemporary update to previous reviews.

In line with methods used for similar studies within alternate contexts (González, 2010), a list of all 433 English local authorities was obtained from the Communities and Local Government website[2] and 100 were selected at random and surveyed over the course of four weeks between 4/2/2011 and 3/3/2011 (with the exclusion of London Boroughs). The survey covered all types of local government structure within England including; unitary authorities, borough councils, metropolitan district councils and non-metropolitan district councils. The impact

assessment documents were accessed through the relevant local authority web pages and the documents sourced either through a search query within the local authority web page or by manually scanning the web pages for impact assessment documents within the Local Development Framework. If a search returned more than one relevant document, the first document available for download would be assessed. If no documents were available for download this was noted within the survey tables.

The survey design assessed the local authorities and their impact assessment documents and recorded the following information:

- Publication date
- Consultants used
- Any application of GIS
- Details of specific GIS applications

Detailing the use of private sector consultants in these documents was recorded in order to enable assessment of whether GIS were utilised "in house", or, where GIS implementation was bought in for specific analytical tasks.

Before conducting the survey it was essential to define what criteria constituted the different levels of GIS expertise which were based on qualitative knowledge about the technicalities of producing specific sorts of analysis. Simple visuals, such as maps of administrative boundaries or other map types that only presented one source of information (e.g. Ordnance Survey mapping) were not considered as an application of GIS. Maps and visuals that presented a number of different data types in multiple layers were considered a use of GIS to a basic level, given that data would typically have to be drawn from different locations, manipulated and represented; thus requiring some degree of expertise. In cases where 3-dimentional visuals or more advanced modelling techniques were used, these were considered

Table 1. GIS application criteria.

Example techniques	Consideration
Single-layer Mapping, OS Maps, Aerial Photography	Does not constitute an application of GIS
Multiple-layer Mapping, Overlaying of Aerial Photography (Raster Data)	Constitutes an application of GIS utilising techniques up to a **basic** level
3-Dimentional Visualisations, Projections using GIS, Scenario Modelling, Vulnerability Mapping/ Resource Management Visualisations, Weighted Overlay Methods, Multicriteria Problem Analysis, Spatial Modelling.	Constitutes a GIS application comprising techniques to an **expert** level. These would be considered a best practice example

as expert levels of GIS application. A fuller breakdown of the techniques which were included in the applications are shown in Table 1; and indeed these are ordered into the three tier typology of GIS use.

Results and Analysis

Of the 100 local authorities surveyed, 82% had impact assessment documents available to download through the relevant local authority web pages. The types of impact assessments found are shown in Fig. 2. 18% of the local authorities surveyed did not have any documents available for download.

SFRA documents accounted for one third of all the documents reviewed followed by core strategy SA/SEAs, accounting for a 28% share. Transport based SA/SEAs accounted for 18% of the documents reviewed. Other, less frequently found impact assessment types included those for Area Action Plans (AAPs) and minerals and waste development frameworks (both SA/SEA).

Out of the 82 impact assessment documents located and reviewed, 54% were found to be using GIS techniques in one form or another, whereas 46% did not utilise any GIS techniques at all. Figure 3 shows the share of those impact assessments using GIS by assessment type.

In house documents produced by local authorities with no private sector consultancy work accounted for just 32% of the documents reviewed, making 68% of the impact assessment documents reviewed produced by private sector consultancies, with the "big four" private sector consultancies; Halcrow, Scott Wilson,

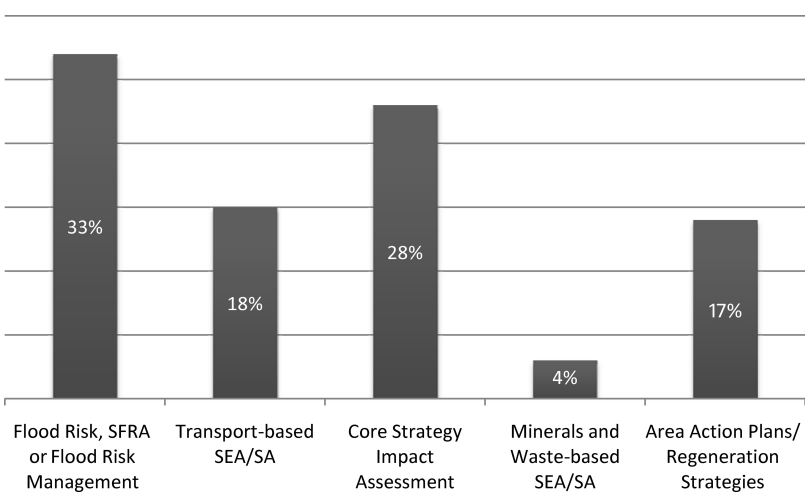

Fig. 2. Impact assessment documents reviewed.

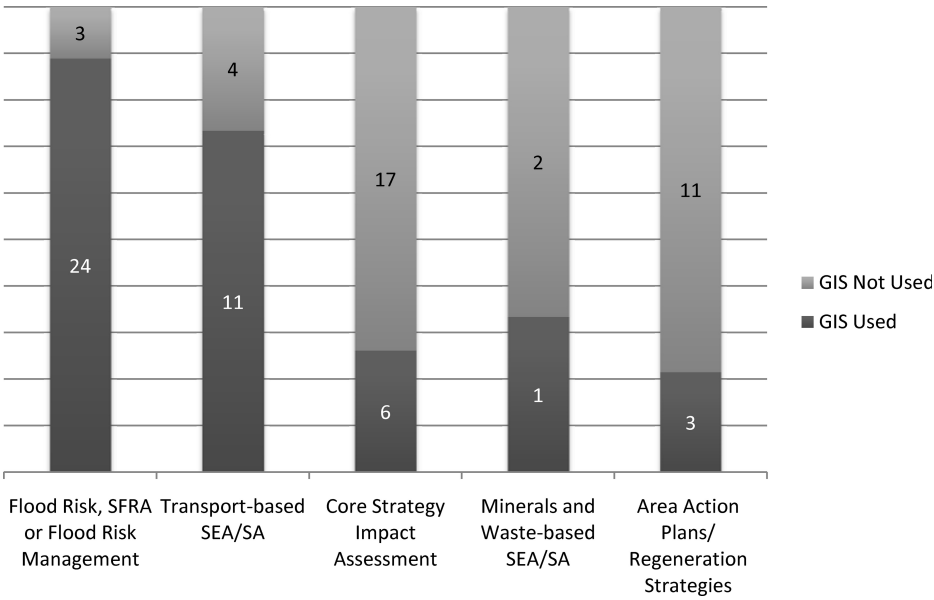

Fig. 3. Use of GIS in the reviewed impact assessment documents.

Atkins and Entec frequently featured throughout the survey (see Fig. 4). As such, it appears that where impact assessment work is required within a local authority, this is often outsourced to private sector consultancies, who in most cases, apply GIS techniques to this type of work.

The following sections present different types of specific IA, and for each application area, the techniques utilised are broken down into those requiring basic and expert levels of expertise. These are summarised in Table 2.

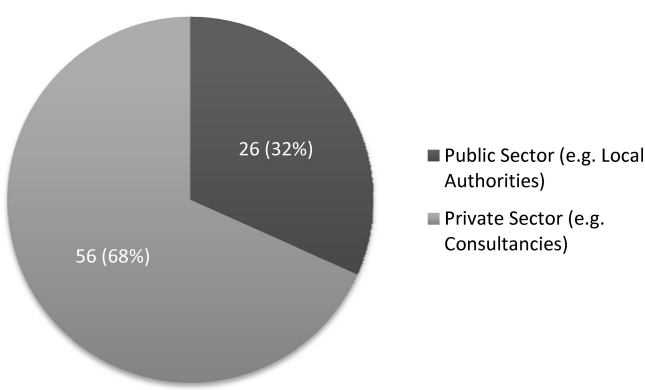

Fig. 4. Impact assessment practitioners.

Table 2. Frequent GIS applications within impact assessment and levels of expertise required for the employed techniques.

Impact assessment sector	Common GIS applications	Basic	Expert
Strategic Flood Risk Assessment (SFRA)	Locating key flood zones, action plan areas and resources	X	
	Flood hazard mapping and ratings	X	
	Historic flood event mapping	X	
	Flood scenario modelling		X
	Identification of potential development sites	X	
	Flood depth projections		X
	3D elevation modelling (in a small number of cases)		X
Transport	Infrastructure mapping	X	
	Identification of environmentally sensitive areas including Sites of Specific Scientific Interest (SSSi) and areas of sensitive habitat	X	
	Service provision (amenities)	X	
	Flood zones and potential impact on infrastructure	X	
	Traffic flow bandwidth and areas of congestion		X
	Transport noise impact and projections		X
Core Strategy of local development framework (LDF)	Eco footprint mapping		X
	Presentation of spatial options	X	
	Designation of protected sites	X	
	Designation of flood risk zones	X	
	Transport infrastructure mapping	X	
	Presentation of socio-economic data (Indices of Multiple Deprivation)	X	
Regeneration Strategy/ Area Action Plans of LDF	Transportation infrastructure mapping	X	
	Presentation of socio-economic data (Indices of Multiple Deprivation)	X	
	Designation of flood risk zones	X	

The use of GIS within flood risk impact assessment, including SFRA and flood risk management documents was of key significance, with 89% of these documents employing GIS methods. The survey identified a number of frequent applications of GIS within this sector, which could be broadly divided within our typology comprising both basic and expert techniques. The majority of documents that presented GIS applications were considered to contain expert level techniques, and in a number of cases 3D elevation modelling and flood projections were

utilised. For example, Kettering Town Centre SFRA[3] demonstrated GIS application to an expert level using hazard mapping (flood risk to people) alongside flood depth projections and velocity mapping, this was one of the most thorough approaches seen within the survey.

73% of transport-based SA/SEA documents reviewed utilised GIS methods which predominantly included techniques that were considered to be basic, and principally included presentation of spatial data rather than those types of more advanced modelling techniques which we would classify as expert. Typically, the applications involved basic overlay mapping of road infrastructure data alongside other attributes such the location of flood zones or areas of environmental sensitivity. Expert techniques included the use of spatial interaction models to model traffic flows between zones and buffer analysis to model hypothetical noise impact scenarios.

Investigating the use of GIS within local authority core strategy SA/SEA, it was found that only 26% of documents reviewed utilised GIS methods. It is clear that the vast majority of documents reviewed did not utilise any GIS methods for this type of impact assessment. For those that did use GIS, these applications only made use of basic mapping techniques. There are a number of reasons why overall GIS use within this area may be low, and where utilised, only basic techniques were employed. This includes that the documents are primarily produced by local authorities themselves and rarely involve the work of private sector consultants. Furthermore, the scope for GIS utilisation within this sector is often limited given that the documents primarily deal with policy assessment and frequently do not require GIS methods.

Only 30% of AAPs and regeneration strategy-based impact assessment documents utilised GIS methods. In the small number of documents that included GIS application, these all comprised of basic techniques only. In many cases, the visual output had been replicated from other local authority impact assessment documents. Typically, transport infrastructure mapping was taken from assessments of Local Transport Plans (LTP's) and mapping of flood risk zones was taken from a SFRA. In instances where GIS was used to present socio-economic data, the techniques used included basic choropleth mapping and overlay functions only. GIS work which was replicated from other sources was not referred to in any great detail; instead, it was used for illustrative purpose to justify area-specific decisions with little explanation of the techniques employed.

Of all the documents reviewed that were produced by local authorities, only 35% had applications of GIS, and this strongly supports the argument that GIS is

not frequently used with English public sector produced impact assessments. However, 64% of private sector-produced impact assessment documents reviewed utilised GIS methods. The evidence collected throughout the survey of impact assessment documents strongly suggests that private sector consultancies appear to have access to a wider range of resources and technical expertise making the application of GIS methods within impact assessment more viable, however, as much of the SA/SEA work required by local authorities is sub-contracted to consultants with appropriate expertise, the requirement for similarly skilled professionals in house is questionable.

The survey also revealed that impact assessment in the fields of minerals and waste and housing (contained within AAPs/Regeneration Strategy) rarely use GIS methods. None of the housing-based impact assessment documents reviewed used any form of GIS and only one out of the three minerals and waste based impact assessments applied GIS methods, although a number of maps were simply lifted from other more detailed impact assessments such as SFRA published by the same local authority.

Within transport-based impact assessment some advanced applications were identified, although many of them featured throughout the majority of impact assessment documents within this sector. A more innovate application was found in the Leeds City Council Aire Valley Leeds Area Action Plan Sustainability Appraisal Report, October 2007. In this report GIS was used to project transport noise contours in areas that are close to sections of the M1 motorway. Noise levels are then mapped in different categories and relevant planning policy is applied to each. This allows for any potential development sites close the motorway to be mapped within the GIS to see if they should be permitted based on noise exposure. The GIS will also inform what noise exposure category the development will fall into and the relevant planning guidance can be passed on. This type of application is considered best practice as it provides a basis for future developments to be modelled.

In general, the application of GIS methods to socio-economic data appeared limited throughout the impact assessment survey, and was surprising, particularly so within the areas of core strategy appraisal, housing and area action plans. Best practice examples of GIS use to present socio-economic data were found in Guildford Borough Council's Strategic Environmental Assessment of the Town Centre Area Action Plan, June 2006[4] and Nottingham City Council's Local Transport Plan 2011–2026 Integrated Impact Assessment, November 2010.[5] Guilford Borough Council uses a GIS to map Indices of Multiple Deprivation

(IMD) within their administrative region. The IMD data include; crime levels, health deprivation and disability, income, and barriers to housing and services. The application of socio-economic data in this way has a number of benefits; it creates a spatially referenced representation of a number of different social conditions and highlights areas that may require policy intervention. This type of data can also inform other sectors within impact assessment, for example housing. Data presented with the aid of GIS includes; household types, locations of black and minority ethnic groups and childhood obesity rates.

GIS is used frequently within SFRA and therefore, there are a number of applications that were deemed to constitute best practice. Digital Elevation Modelling (DEM) was presented in Shepway District Council's Strategic Flood Risk Assessment, June 2009[6] and is used as the basis of a flood model for the district. Digital modelling (as opposed to flood mapping based on historical flooding events) is beneficial within impact assessment although not frequently utilised (Gill *et al.*, 1999). Although flood mapping is informative for the purpose of impact assessment, updateable digital models are far superior and offer greater flexibility as well as opportunity for experimentation and simulation/prediction. Only a small number of local authorities (3 within the review) currently use digital modelling for flood risk assessment, and in all cases this modelling work was completed by private sector consultants.

Conclusions

This paper has provided for an overview of the use of GIS in impact assessment documentation of 100 local authorities (i.e. almost one quarter of all local authorities in England). The use of GIS within impact assessment has been shown to be varied; however, there are a number of frequent application areas within the different types of impact assessment (see previous Table 2); and indeed these span a ranging complexity of techniques. A general conclusion to draw from this is that the use of GIS within the different impact assessment sectors is still relatively basic; and that the standard which constitutes best practice within impact assessment is good but not revolutionary in any way. When compared to GIS applications that appear in the academic literature (González *et al.*, 2011; Aydin *et al.*, 2010; Herberg, 2008; Al-Adamat, 2008; Balram *et al.*, 2002; Agrawal and Dikshit, 2002), which often focus on specific case studies or more general methodological developments, there is a clear disjuncture with practice. This raises an issue of knowledge exchange and training; and it is clear that the public sector could gain

wide benefits from working more closely with the academic sector to benefit from training opportunities. Furthermore, the academic sector could benefit from linking research to live projects within the local authorities, and as such enhance potential impact generated from the results.

Because such a high number of impact assessment documents do not utilise GIS at all, the application of basic GIS methods within impact assessment is close to best practice in itself. In almost all cases where GIS methods were used, this was as an explanatory tool rather than an exploratory method, i.e. creating basic maps of flood zones, as opposed to integrating different data types, for example, population data to investigate how many people may be affected by a particular flood event. Best practice examples were identified to be above and beyond the prevailing standard of use within impact assessment generally, typically encapsulating more advanced representations. Any instances of modelling and the use of 3D GIS were considered to constitute an outstanding application. Such techniques are currently uncommon within impact assessment and demonstrate applications that could be considered "better than best practice".

Innovative uses such as the presentation of housing targets in 3D bars within Bolton Metropolitan Borough Council's Greater Manchester Flood Risk Assessment show GIS software being utilised to a high level for both spatial assessment and visual analysis. The main benefit of GIS use in this way is the easily-understood presentation of otherwise complex datasets. These types of use therefore set the standard for GIS utilisation within this sector. Perhaps what should be of most concern in an era of austerity where local authorities are having their budgets cut in the UK, is the local authority impact assessment survey provided strong evidence to suggest that those impact assessments produced by private sector consultants utilised GIS more frequently than those produced by local authorities (public sector); indicating a substantial lack of skill within the local authorities. It is possible that the potential benefits of GIS methods are, as noted historically (Hacklay *et al.*, 1998), still being currently outweighed by the cost of expertise needed to produce this type of work.

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