The Importance of Scale Issues in Environmental Impact Assessment and the Need for Scale Guidelines

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Contents

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List of acronyms and definitions

AONB - Areas of Outstanding Natural Beauty - The primary purpose of AONB designation is to conserve natural beauty. Since 1949, 14% of countryside of England and Wales has now been given AONB status.

CEA - Cumulative Effects Assessment – type of assessment that seeks to identify and communicate the consequences of more than one impact from a single development or combination of impacts from multiple developments.

EIA - Environmental Impact Assessments - are carried out to discover the future potential impacts of projects (e.g. road building) and policies such as regional transport plans. Their ultimate aim is to design ways of minimising damage to the environment. In this report the term 'EIA' encompasses both SEA and Project-EIA.

EIS - Environmental Impact Statements – the reports written after the EIA are carried out.

GIS - Geographical Information Systems – a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes.

IAIA - International Association for Impact Assessment – the premier organisation in the field of EIA was organised in 1980 to bring together researchers, practitioners, and users of various types of impact assessment from all parts of the world (http://www.iaia.org/).

Project-EIA – In this report the EIA of projects is called 'Project-EIA' to distinguish it from SEA.

SEA - Strategic Environmental Assessment – the EIA of higher level policies, plans and programmes.

SSSI - Sites of Special Scientific Interest - the finest sites for wildlife and natural features in England (covering approximately 8% of England), supporting many characteristic, rare and endangered species, habitats and natural features.

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Elsa João

Abstract

This paper summarises the main findings of a research project that investigated the importance of scale issues on Environmental Impact Assessment (EIA), financed by the ESRC Global Environmental Change Programme. An empirical study, using data from a real EIA for a proposed road bypass, was carried out in order to measure the effects of different scales on the analysis. Scale effects were measured separately for spatial extent and detail, and were measured both *quantitatively* using a Geographical Information System (GIS) and *qualitatively* using EIA experts. The empirical study found that changes in scale, in terms of detail and spatial extent, affected the results of EIA. Scale choice can therefore have important repercussions for the accuracy of an EIA study. This situation can be made more serious when the scale used is not clearly stated.

This paper therefore proposes that new scale guidelines need to be developed. The concept of scale guidelines was strongly supported by the practitioners who took part in the two 'Scale issues and EIA workshops' specifically organised for this research project. The consensus was that there was no need for *specific* scale guidelines *per se* but what was required was that scale issues were brought into *existing guidelines*. This paper recommends that the crucial stage to determine scale is the scoping study, and that scoping should be mandatory and involve key stakeholders. However, it is recognised that the choice of an appropriate scale is very circumstantial and depends on many factors such as the type and size of project or plan, the social and ecological processes being studied, and how heterogeneous or homogeneous the spatial setting is. This means that many of the scale guidelines to be included within the scoping guidelines will be procedural rather than prescriptive. Three types of guidelines are proposed: a) general guidelines or recommendations; b) specific guidelines linked to processes, c) what not to do or 'scale warnings'.

The discussion on the need, design and implementation of new scale guidelines is still on-going and it is one of the aims of this research paper to promote further discussion on the subject.

Introduction

Scale has two key meanings in EIA: firstly, scale as the extent of the assessment (e.g. size of area studied, distance from activity causing the impact); and secondly, scale in terms of the amount of detail or granularity (e.g. map scales, rate of sampling) used. Extent determines the size of the 'window' to view the world, while the amount of detail is related to the level of resolution and determines the smallest entities that can be seen in the study. The concepts of extent and detail are however inter-related – for example, if an assessment is being carried out for a very large area it is likely that, for reasons of cost, it will be done in less detail than if a similar study was done for a much smaller area. By definition the scale of the study is the interaction of extent and detail. The notion of scale can be applied both to temporal and spatial aspects, and both are important to EIA. This research project however concentrated on studying the spatial scale.

Due to the diverse nature of the EIA process, ranging from EIA of small projects to large projects, cumulative effects assessment (CEA), through to strategic environmental assessment (SEA), assessments are carried out for a wide range of spatial extents and detail. This is one reason why scale issues are such an important aspect of impact assessment. Figure 1 proposes the relationship between extent and detail for different types of EIA. The assumption is that as the spatial extent of an assessment increases, it will be done in less detail. This suggests the existence of a 'ratio' between extent and detail that constrain the cost and the data volume that is reasonable to analyse for a particular project (Goodchild and Quattrochi, 1997). Figure 1 is only an approximation as there will be variations depending on the circumstances of each EIA, and in some cases it is even difficult to pinpoint a geographical area (such as in the case of certain SEA).

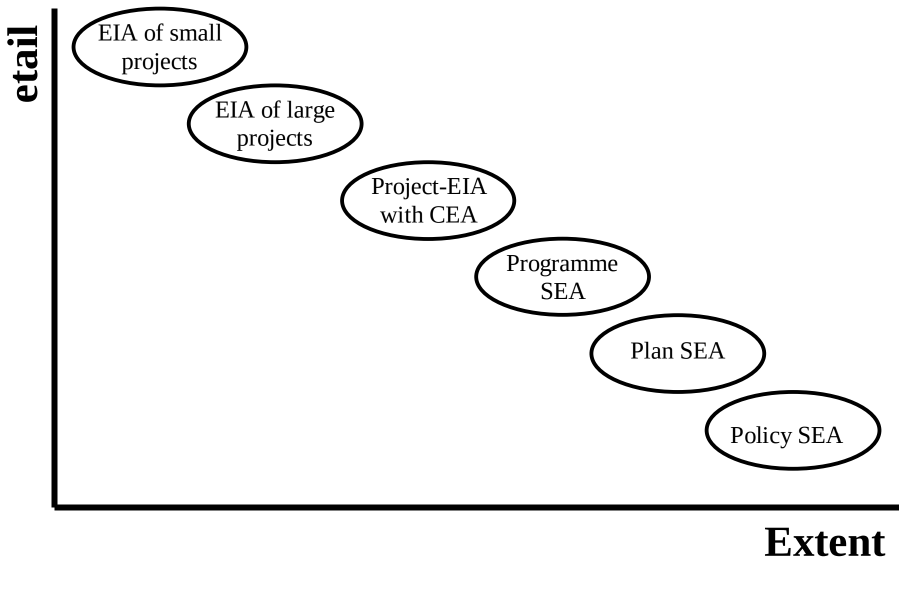

Figure 1 The relationship between extent and detail and how it relates to different types of environmental assessments.

Scale is increasingly being recognised as a key research topic in many areas of application: ‘Scale is undoubtedly one of the most fundamental aspects of any research’ (Goodchild and Quattrochi, 1997, p. 1). But at the same time it remains a complex issue. ‘Scale is one of the most fundamental yet poorly understood and confusing concepts underlying research involving geographic information’ (Montello and Golledge, 1999, p. 3). The importance of scale issues has led researchers to propose a ‘science of scale’. Goodchild and Quattrochi (1997) suggest that a full science of scale would study which measures or properties are invariant with respect to scale, methods to change scale, measures of the impact of scale change, scale as a parameter in process models, and implementation of multiscale approaches. In this research project the emphasis is on measuring the impact of scale *change*.

Despite the importance of scale, currently scale has been a neglected issue in EIA. Firstly, no EIA literature has addressed the issue of scale and how it can affect the outcomes of impact assessment. Secondly, EIA studies, although they cannot escape dealing with scale, do not state the scale used explicitly. This has been found by analysing EIA literature and a sample of forty environmental impact statements (EIS). This last problem has also been noted in ecology. Allen and Starr (1982) observed that despite the large body of ecological literature which involves scale, few papers directly address scale in their own right. ‘Since scale is not generally explicitly included in ecological models, the reader of a communication must guess and arbitrarily apply a scale of his own’ (Allen and Starr, 1982, p. 237). As a consequence, and because different scaled models define entities differently, results of ecological studies using apparently identical models will appear inconsistent.

There is however literature on scale effects in disciplines related to EIA, such as water quality (Osterkamp, 1995), landscape studies (Meentemeyer and Box, 1987), ecology (Fernandes *et al.*, 1999), hydrology (Sposito, 1998), archaeology (Stein and Linse, 1993), land degradation (Gray, 1999). Gray (1999, p. 330), for example, found that ‘one’s conclusions about whether land is degraded are influenced by the scope and scale of the analysis. For example, if we examined changes at the local or regional scale using aerial photographs, we would most likely arrive at a different conclusion than if we examined soils at the farm scale. The scale at which studies are undertaken affects the conclusion because processes and parameters important at one scale may not be important or predictive at another scale’.

It therefore seems unlikely that EIA would be immune from the effects of scale, making it all the more important to study. This is especially the case, given that most EIA are done under strict budgetary and time constraints:

> In practice, budgets and schedules often get in the way of using sufficient detail. (Ron Bass, Jones & Stokes Associates, USA, 1998, personal communication)

> Unfortunately, scale is often directly related to funding. Although the overall boundary of investigation may be less affected, the detail of investigation will be. (Tim Huntington, MacAlister Elliott & Partners Ltd, UK, 1999, personal communication)

If budget and time allow, studies are done with more detail or for larger spatial extent (ironically this often happens for smaller projects with probably less impacts – see Figure 1). This begs the question of how many projects are done without sufficient detail and large enough spatial extent, and how this is affecting the quality of EIA work.

The potential effect that scale issues might have on the outcomes of EIA (e.g. by influencing the type of impacts found, their magnitude and significance, the type of mitigation measures recommended, and ultimately the end decision regarding the proposal) calls for two important initiatives. Firstly, it is necessary to try and quantify scale effects in EIA and secondly, it is necessary to find out if guidelines on the use of scale in EIA are needed. Both of these are tackled in this paper. The paper starts by describing the methods used in the empirical study on the effects of scale on EIA and this is followed by the results of the empirical study. The paper then presents the case for scale guidelines in environmental impact assessment.

Methods used in the empirical study on the effects of scale on EIA

The empirical study consisted of two different complementary approaches: one study based on measurements using a GIS and a parallel study based on analysis by EIA experts. One of the most common EIA methodologies for evaluating impacts is 'expert opinion'. An exclusively quantitative study of the effects of scale therefore would have only offered a limited view of how scale affects EIA. To measure scale effects in EIA, parts of an existing EIA of a road bypass project were re-done using data at different scales to discover how the results differed. In order to measure changes due to the amount of detail, areas of the same size but different detail were compared, while to measure scale effects due to changes in spatial extent, areas with the same detail but different spatial extent were used.

There were three main reasons why a road bypass project, rather than another type of development such as a new factory, was selected. The first reason had to do with the spatial aspects of road projects. Due to their linear nature, and potential long lengths, roads pose interesting challenges related to the choice of the spatial extent and detail of the study. The second reason was because roads exert impacts at a range of scales: from localised direct impacts on particular areas, through to impacts affecting whole regions due, for example, to habitat fragmentation and severance of human and wildlife communities. The final reason had to do with the availability of EIA guidelines. Road projects are one of the few types of EIA where guidelines exist to advise on the scale to use. These include the UK Design Manual for Roads and Bridges (Highways Agency, 1998), and the World Bank publication on roads and the environment (Tsunokawa and Hoban, 1997).

Through a preliminary investigation of possible UK case studies involving road projects, seven controversial road EIA were shortlisted. Of these, the A259 Hastings Eastern Bypass (6.2 km), was selected. The other two proposed schemes which are related to the Hastings Eastern Bypass are the Bexhill and Hastings Western Bypass (14.7 km) and the Pevensey to Bexhill

Improvement (4 km). Together these three projects are nearly 25 km long, which makes them one of the longest road projects in the UK at present (see Appendix A for their location in Southeast England). The three road projects are linked but at same time can be built independently of each other. This means that it is possible to look at the EIA of one single scheme or all three as a whole and so bring to the fore interesting issues of scale.

Data for the Hastings Eastern Bypass case study was obtained by digitising different source-scale maps and by obtaining data directly from the Ordnance Survey. Table 1 summarises the different data sources used for this research. Project-EIA is usually done using very detailed map data, and often culminates with fieldwork. For this reason very detailed source scales were chosen: 1:10 000 and 1:25 000. Data from both scales was digitised by the grant holder directly from the information provided by the EIS of the road bypass. In addition, Ordnance Survey Land-Line data and Address-Point was used for the air pollution impacts. Using ARC/INFO and ArcView this digitised data was then used to measure scale effects in EIA. The measurements looked at changes in the number of features, differences in measured lengths and areas, and displacement in the position of features.

Table 1

Data sources for the empirical study on measuring scale effects on EIA.

Data	Source and Scale
Major environmental features (e.g. ancient woodland, ponds with nature conservation value, etc.)	1:25 000 source scale Digitised by the grant holder directly from the information contained in the Environmental Impact Statement (EIS) of the Hastings Eastern Bypass. (1)
	1:10 000 source scale (complemented by fieldwork carried out for the EIA) Digitised by the grant holder directly from the information contained in the EIS of the Hastings Eastern Bypass. (1)
No. of buildings within 200m and 1000m of the Hastings Eastern Bypass (2)	1:25 000 Ordnance Survey paper map (1997)
No. of buildings within 200m, 1000m and 2000m of the Hastings Eastern Bypass	Land-Line Digital Data from the Ordnance Survey (Feb 1999) (based on 1:1 250, 1:2 500 and 1:10 000 source scales)
No. of addresses within 200m, 1000m and 2000m of the Hastings Eastern Bypass	Address-Point Dataset from the Ordnance Survey (Oct 1999)

Notes:
(1) Date of publication of the EIS is September 1994.
(2) For the Ordnance Survey paper map, buildings had to be counted by hand. Because this was so time consuming, it was not done for the 2000 metres buffer.

Coupled with the above quantitative analysis, EIA experts were asked to determine how their impact evaluation changed when an area was looked at in more detail or when a larger area was considered. So as not to bias their analysis, the experts were not told that it was the Hastings Eastern Bypass until after the study. Experts were first given a map of the major environmental features for a corridor of 100 metres from the road centreline (where most construction impacts are felt). For this first map, data was taken from the 1:25 000 scale source map. They were then shown a map of the major environmental features for the same spatial extent but using the more detailed 1:10 000 scale map. These two maps were followed by: a 500 metres road buffer zone of the 1:25 000 scale map; a 500 metres road buffer zone of the 1:10 000 scale map; a 1500 metres road buffer zone of the 1:25 000 scale map (see Appendix B for the five maps shown to the experts). Finally, they were told where and what the road project was. Twenty one experts from various consultancies were interviewed.

Results of the empirical study that measured scale effects on EIA

Scale effects were measured separately for spatial extent and amount of geographical detail. In this section, results of the scale effects due to changes in the amount of detail from the quantitative measurements using a GIS are presented first. The results of the scale effects due to changes in spatial extent then follow. Finally, the results from the study that used human experts to evaluate the effects of scale on EIA are presented.

Scale effects due to changes in the amount of detail

Scale effects due to changes in the amount of detail were found to fall into four different categories: a) changes in the number of features; b) difference in measured lengths and areas; c) displacement in the position of features; and d) failure to find relationships that matter. These findings corroborate the map generalisation work done by the author using topographic maps with scales ranging from 1:50 000 to 1:625 000 (João, 1998).

Changes in the number of features can be illustrated by the assessment of air quality impacts. According to the UK Highways Agency (1998, section 3, part 1, page 6/1) in order to assess air quality ‘mark on a map of a scale in the range 1:25 000 to 1:10 000 all buildings or areas where people might possibly be subjected to a change in air quality. Only properties or areas within 200 metres of the route or corridor need to be considered.’ This method advocated by the Highways Agency, and used by environmental consultancies when doing EIA of road projects, requires that the number of properties is used as a surrogate for population. It is assumed that beyond 200 metres the contribution of vehicle emissions is not significant because it returns to background levels. Table 2 shows the results of counting the number of buildings for these two map scales. In addition the table shows the results with postcode addresses. Although this last data source is not mentioned in the above reference, and is not used routinely by the consultancies, it is considered to be a more accurate indicator of population (Raper *et al.*, 1992).

Table 2

Number of buildings for different scales when measuring air pollution within 200m of the Hastings Eastern Bypass (6.2 km long).

Source data	**1:25 000 paper map**	**OS Land-Line Digital Data** (based on 1:1 250, 1:2 500 and 1:10 000)	**Address-Point seeds**
No. of buildings within 200m of the Hastings Eastern Bypass	56	160	58

Surprisingly, the number of address point seeds is much less than the number of buildings in the Land-Line data. Because there are multiple addresses in high-rise buildings, the opposite was expected, i.e. that there would be more addresses than there were buildings. This unexpected result was due to the way ‘building seeds’ are classified in the Land-Line digital data. It covers all buildings with a minimum dimension of 5 metres but this includes uninhabited buildings such as greenhouses, detached monuments, cooling towers and water tanks! Counter-intuitively, the less detailed 1:25 000 scale map (where less important buildings have been eliminated or amalgamated) was therefore a better source for calculating the population exposed to air pollution from the new road.

In relation to the second type of scale effect - the difference in measured lengths and areas – it was found that on the whole lengths got longer for more detailed scales but areas would get smaller as the outline of areas got more convoluted (see Figure 2). For example, the area of ancient woodland for the 500 metres road buffer using the 1:25 000 scale map is 91.2 hectares while for the 1:10 000 source scale is 87.5 hectares. This means that the impacts of the destruction of ancient woodland for the proposed Hastings road bypass would be found to be slightly more serious when measured using the 1:25 000 scale map.

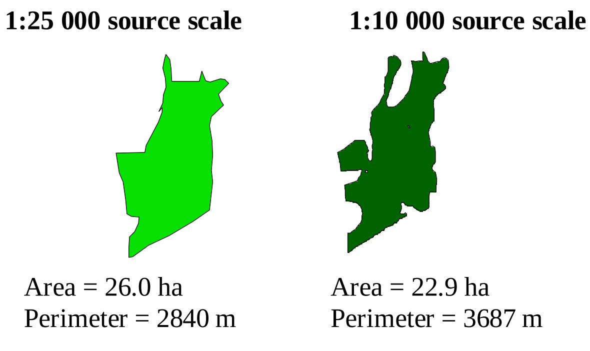

Figure 2 An area of ancient woodland measured using different source scale maps (although displayed here at the same scale).

There were several instances when displacement in the position of features was observed between the two scales. Besides introducing errors of positional accuracy and affecting any subsequent spatial analysis, displacement also caused a failure to find relationships that matter. In one case, because of the displacement of some listed buildings and a Roman road an environmental consultant found a relationship between the buildings and the Roman road in the 1:25 000. However, that relationship was no longer observed at the 1:10 000 scale due to a change in the relative position of the buildings and the Roman road. This meant that at the scale 1:25 000 the area was considered more important archaeologically and as a consequence any impacts would be found to be more serious then if the study was done at the 1:10 000 scale.

Scale effects due to changes in spatial extent

In order to measure scale effects due to changes in spatial extent, areas with the same detail but different spatial extent were compared. The main effect on EIA is how it influences the determination of the level of impact significance, i.e. how important the impact is deemed to be. If only a small spatial extent is considered, and a particular resource is widely available within that small extent, then it would be assumed that losing part of that locally-abundant resource is not very important. If however, a wider area is studied and it is found that this resource is rare at a national level, then the same amount of resource loss would have a relatively greater importance and the impact significance is deemed to be high.

This can be expressed quantitatively using the example in Table 3. In this case, as the extent increases and more urban areas are included, the percentage of population affected by air pollution decreases, and the impacts therefore take on less importance. The opposite would happen, i.e. the impacts would look more serious, if less urban areas were included when the area looked at was increased.

Table 3

Percentage of addresses, of different sized study areas, affected by air pollution caused by the Hastings Eastern Bypass.

	No. of Address-Point seeds	% affected by air pollution
Area within 200 metres of road centreline	58	100%
Area within 1000 metres of road centreline	1653	3.5%
Area within 2000 metres of road centreline	7101	0.8%

Note: It is assumed that only addresses within 200 metres of the road centreline are affected by air pollution.

This relationship means that it is possible to manipulate the results according to the size of the area studied. Ross (1998, p.271) notes this in relation to cumulative effects assessment (CEA):

> The greater the area assessed for CEA, the smaller will be the percentage of impacts caused by the project, because more other sources of impact get captured in the analysis. While I would not suggest this happens on purpose (a proponent wishing to have it appear that a project causes only a small portion of the impact), it is an interesting feature of this and other regionally based CEAs.

This is why guidelines and standardisation are so important, as discussed later in the paper.

Study on the effects of scale on EIA using human experts

Coupled with the above measurements, EIA experts were asked to evaluate road impacts by looking at different maps (see Appendix B) to see how their evaluation changed for different size areas and areas with different detail. As more detail and more extent were provided a wider range of features and issues appeared. Most experts felt that the impacts looked more serious both with increased detail and with increased extent. The new features that appear with each new map can be seen in Table 4. With the exception of the 500 metres buffer zone using the 1:10 000 source scale map, all maps presented the expert with some new information. Particularly noteworthy, as observed by most experts are: the hedges, footpaths and features of conservation interest that only appear in the 1:10 000 scale map; the southern boundary of the Area of Outstanding Natural Beauty (AONB) that only appears with the 500 metres buffer; and the two Sites of Special Scientific Interest (SSSI) that only appear with the 1500 metres buffer zone.

Overall the experts felt that it was the lack of extent, rather than lack of detail, that affected their judgement the most. ‘In terms of EIA, context is everything’ (Ruth Kelly, Environmental Resources Management Ltd, UK, 1999, personal communication). As the consultants explained, they are accustomed to evaluate sites with very little data – ‘you can sort the detail in your mind very quickly but what you can’t do is form any view of where it is and what is the context you’re dealing with’ (Jon Grantham, Land Use Consultants, UK, 2000, personal communication). It was even suggested that extent could be used to complement detail. For example, the existence of archaeological sites within a wider extent (as wide as a one kilometre buffer zone) can be used to conjecture whether there are archaeologically significant areas within the narrow corridor of 100 metres. This finding indicates that it is necessary to study Project-EIA with sufficient extent, otherwise the real importance of the site might be disguised. Widening the study area supports the recommendation by English Nature to have all proposed roads evaluated with a minimum of 500 and a maximum of 2000 metres buffer on each side of the road (Bina *et al*., 1995). An area this size is considerably larger than the recommendation by the UK Highways Agency of using a 100 metres buffer zone as the maximum distance to calculate disruption due to construction (see Appendix C for a table which summarises the wide range of different road-buffer zones recommended by the literature).

Table 4
New features that appear when more detail and more extent is given to the EIA experts.

Sequence of maps given to experts	Initial features	New features that had not appeared before in any of the maps
Map 1: 100m buffer zone, 1:25 000 source scale map	1. Ancient woodland 2. Recent woodland 3. Copses and shaws - possible ancient woodland 4. Conjectured Roman road	
Map 2: 100m buffer zone, 1:10 000 source scale map		1. Grassland of nature conservation interest 2. Pond of nature conservation interest 3. Archaeological find-scatter, identified from field walking 4. Line of trees 5. Hedges 6. Public footpath 7. Archaeological earthworks 8. Archaeological site 9. Archaeological find-spot
Map 3: 500m buffer zone, 1:25 000 source scale map		1. Public open space/Recreation area 2. Archaeological significant area 3. Southern boundary of the Area of Outstanding Natural Beauty (AONB) 4. Listed building 5. Sites from 'Sites and Monuments Record'
Map 4: 500m buffer zone, 1:10 000 source scale map		
Map 5: 1500m buffer zone, 1:25 000 source scale map		1. Sites of Special Scientific Interest (SSSI) 2. Scheduled ancient monument

Presented with the 100m buffer most experts felt very uncomfortable and stated that they could not do a fair judgement with such a narrow extent. Some expressed how it was problematic to evaluate the significance of the impacts. For example, it was not possible to determine the percentage of woodland areas affected. It was also difficult to know if the road was passing through the middle of an area of ancient woodland or if the road was only cutting an edge of it. It was also not possible to evaluate alternatives with such a narrow corridor. 'Can't do any evaluation with just 100 metres buffer - woodlands might only be 100 metres wide – if so then you could go around them' (Philip Cumming, Dames & Moore, UK, 2000, personal communication).

Although less so than in relation to lack of extent, a few experts felt uncomfortable with the lack of the detail. With more detail the majority of experts felt that the impacts looked more problematic than before. 'A key issue in EIA is that the more you look, the more you find. This means that a site that is looked at in more detail might appear more precious than other sites' (Jon Grantham, Land Use Consultants, UK, 2000, personal communication). With increasing detail it looked as if the road would have potential impacts along its whole route while previously only the west area seemed problematic. 'My first impressions were wrong. I originally assumed that only the first two kilometres of the road were vulnerable to impacts. With the extra detail it became obvious that the whole length of road was an issue' (Ana Teresa Chinita, PROCESL, Portugal, 1999, personal communication).

The case for scale guidelines in environmental impact assessment

This research project has found that there are 'double standards' regarding scale choice in EIA depending of the size of the project. If a consultant can afford it for smaller-size projects (in terms of budget and time) studies are done with more detail and for larger extents – which implies that large studies are sometimes not done with enough detail and extent. 'The larger the project, the relatively lower the level of detail paid to various aspects of it' (Richard Grassetti, Environmental Planning Consultant and Adjunct Faculty of the California State University, USA, 1998, personal communication). 'In cultural heritage studies, for single sites such as a power station, you have more luxury and can afford to widen a detailed study area to 3km. But with a linear development like a road (which could be as much as 100km long) you have to stick with the 1km detailed study buffer after your regional overview' (Ruth Kelly, Environmental Resources Management Ltd, UK, 1999, personal communication). 'One of the most worrying things about what is happening at the moment is that the larger the project, the smaller the percentage of the budget is given to the EIA. It should be the other way around, because the larger the project, the more likely it is to have difficult distant impacts, as well as purely local' (Doug Cross, Environmental Consultant, UK, 1999, personal communication).

Limited budgets therefore can be an important constraint in the choice of scale. More seriously however is the possibility that a certain scale is deliberately chosen to bias the results. 'The temptation is there for unscrupulous proponents to consider adverse impacts in the national context and positive impacts locally' (Chris Dalgliesh, African Environmental Solutions, South Africa, 1998, personal communication). Luis Miglino (Inter-American Development Bank, USA, 1998, personal communication) reported, for example, the case of corrupt enterprises in Brazil that were using maps of poor detail to help them get work commissioned (bearing in mind that the criteria of selection is often to minimise cost and producing a geologic map at the 1:50 000 scale is more expensive that at 1:500 000). More seriously this was also allowing these enterprises to escape being penalised afterwards due to the lack of definition of the scales used. For this reason the Inter-American Development Bank started to demand the use of particular scales in the terms of reference both for analysis and for presentation of the results. As a consequence a significant improvement in the quality of the EIA work was reported.

It is also possible that scale is given too little thought, too late. ‘Spatial scale is a last consideration in many studies, yet scale often selects the nature of the results’ (Meentemeyer and Box, 1987, p. 22). ‘Scale choice in EIA falls prey to “lazy thinking” – seeing (and analysing) only the scale that is most apparent or easiest to deal with’ (Lance McCold, Oak Ridge National Laboratory, USA, 1998, personal communication). There is even the suggestion that size of the sheet of paper used in the EIS might determine the spatial extent being studied for a particular detail level - as one consultant put it ‘one can only fit so much on an 8.5x11" or 11x17" piece of paper’. Finally, and most easily correctable of all, scale is rarely made explicit in the EIS. For example, in their review of EIS of proposed road developments, Treweek *et al.* (1993, p. 298) found that the width of the road corridor studied was not accurately defined, ‘making it difficult to determine whether the land-use types mentioned were to be affected directly, or whether they were described simply to give a subjective feel for the landscape types in the area of interest’.

All of the above suggest that scale guidelines are required. The need for scale guidelines was strongly supported by the practitioners that took part in the two scale issues and EIA workshops. The consensus was that there was no need for specific scale guidelines per se but what was really needed was that scale issues were brought into existing guidelines. There was also a strong agreement among the workshops’ participants on where in the existing EIA guidelines scale issues should be included: the scoping study. Scoping is an important early step in the EIA process that establishes the key issues to be addressed and usually results in the preparation of the ‘terms of reference’ for the preparation of the EIA study. However, scale would only be universally addressed within the scoping stage if scoping was made mandatory. There are many countries, including the UK, where scoping is not compulsory although it is recommended as good practice.

A review of the EIA legislation for over thirty different countries and organisations found that issues related to scale are rarely mentioned. The few that do, include the UK Highways Agency guidelines regarding the EIA of air pollution mentioned earlier in page 7 (Highways Agency, 1998) or the recommendation by the US Department of Housing and Urban Development to use of the USGS (US Geological Survey) 1:24 000 scale topographic map as a readily available map resource for the EIA of housing projects (US Department of Housing and Urban Development, 1985). However, these are the exception and the guidelines are usually defined in the vaguest of terms. For example, guidelines might only mention that ‘the geographical boundaries for the study should be determined’. Guidelines could be more concrete and require, for example, that the areal extent of an EIA should include the water catchment basins and airsheds of all project components, as recommended by Goodland (1997). More guidance on the appropriate extent and level of detail for different situations needs therefore to be included in existing guidelines.

However, designing scale guidelines is not straightforward. The choice of an appropriate scale is very circumstantial and depends on many factors such as the type and size of project or plan, the social and ecological processes being studied, and how heterogeneous or homogeneous the spatial setting is. Forman and Debblinger (1998), for example, found that a ‘road-effect zone’, over which significant ecological effects extended outward from a road, was strongly asymmetrical and had convoluted margins. The asymmetry was due to ‘nature’s directional patterns and processes on the landscape, specifically wind movement, water flow downhill, and differing habitat suitability on opposite sides of the road’ (Forman and Debblinger, 1998, p.78).

In most circumstances, therefore, it would not be sensible to impose strict rules like ‘100 metres either side of a project’. This means that many of the scale guidelines to be included within the scoping guidelines will be procedural rather than prescriptive. The proposed solution for making scale guidelines possible in practice (first suggested by João, 1999) is to have three types of guidelines:

a) General guidelines or recommendations – these could be qualitative – e.g. ‘Terms of reference should consider scale issues explicitly’.
b) Specific guidelines linked to processes – these would be quantitative as much as possible and based in empirical studies – e.g. ‘In reporting landscape pattern, grain should be 2 to 5 times smaller than the spatial features of interest’ (O’Neill *et al.*, 1996, p. 169).
c) What not to do or ‘scale warnings’ – these could indicate which scales should not be used rather than the ones to use – e.g. ‘Map scales of less detail than 1:250 000 should be avoided for baseline studies of project EIA.’

Further work on the development of the general guidelines and scale warnings, and also the compilation of specific guidelines linked to processes, is being carried out by the author.

Conclusions

This research has carried out for the first time an empirical study to determine whether scale affects the accuracy of impact prediction. Parts of an existing EIA of a road project (the Hastings Eastern Bypass in Southeast England) were re-done at different scales to discover how the results differed. Two different complementary approaches were used: one study based on measurements using a GIS and a parallel study based on analysis by EIA experts. Both aspects of the empirical study found that changes in scale, in terms of detail and spatial extent, have important repercussions on the EIA results.

It may be argued that for Project-EIA, *fieldwork* might complement and correct any incomplete or wrong information given in mapped data, and that in this case scale effects might not manifest themselves. For example, the number of houses within 200 metres of a road might be counted in the field. However scale effects are still relevant in that: a) the field study might not cover all areas; b) scale influences the desk study which in turn affects the design of fieldwork; c) scale will always affect assessments which rely solely on mapped information, e.g. very large projects, cumulative effects assessment and Strategic Environmental Assessment (SEA).

Despite the importance of scale, currently scale has been a neglected issue in EIA. No previous EIA literature has addressed the issue of scale and how it can affect the outcomes of impact assessment. More fundamentally, EIA studies, although they cannot escape dealing with spatial scales, very rarely state the scale used explicitly. Because scale is such a serious issue that has been neglected in terms of both detail and extent, it is necessary to devise ways of improving existing environmental assessments by taking scale into account. This paper proposes that it is necessary to create new EIA guidelines on scale. Three types of guidelines are being investigated: a) general guidelines or recommendations; b) specific guidelines linked to processes; and c) what not to do or 'scale warnings'.

Detailed guidelines will be proposed to the EIA community and the final draft is planned to be presented during the International Association for Impact Assessment (IAIA)' 2001 conference. This guidance could later be expanded and be included in an overall quality certification scheme, in other words, scale issues should be part of the wider context of quality issues. Coupled with the guidelines, a compilation of a set of case studies that reflect the importance of scale for different types of impacts and different kinds of decisions is also being planned. Feedback regarding the need for new scale guidelines in EIA, what format they should take, and how they could be implemented in practice can be sent to the author using the form in Appendix D.

Although detailed guidelines are still being developed, the following are two key recommendations for future practice regarding scale issues and EIA. These were strongly supported by the participants of the two workshops on scale issues and EIA that were organised for this research. There should be a mandatory scoping phase to resolve scale issues and this should take place early in the EIA process. Most importantly, in future the choice of scale in EIA should be public and transparent. In other words it should be explained, justified and explicitly stated in the Environmental Impact Statements (EIS).

Another major line of research arising from the project is the need to compare scale issues for Project-EIA with SEA, and how they link in terms of scale. Depending on the importance of scale issues for each type of environmental assessment, the type of guidelines needed might be different in each case. Preliminary results from this research seem to indicate that scale issues are equally important for Project-EIA and SEA, but that SEA would probably require *more guidance*. This is because SEA is a newer field where there is less professional experience and is also due to the type of decisions dealt with in SEA. Moreover, SEA is usually defined prior to individual Project-EIA, and so getting the SEA as accurate as possible can be argued to be correspondingly more important.

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