

Assessing the Environmental Consequences of Major Sporting Events: The 2003/04 FA Cup Final

Andrea Collins, Andrew Flynn, Max Munday and Annette Roberts

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Summary. Policy-makers are increasingly interested in the wider ramifications of sporting events, including the environmental impacts of event visitation. This paper demonstrates how two separate though related methodologies were used to inform conclusions on the economic and environmental impacts related to event visitation. The approaches used to assess the case event were environmental input–output tables and ecological footprint analysis. Combining these tools provided valuable insights into a series of economic and environmental impacts, together with an appreciation of the global significance of average visitor consumption patterns associated with a high profile event, the 2004 Football Association (FA) Cup Final. The paper demonstrates how these tools can be used to provide valuable intelligence for policy-makers.

1. Introduction

Policy-makers are increasingly concerned with the environmental as well as the economic impacts of major sports events in the regions. In general, there are growing regional needs for higher levels of environmental accountability in line with locally and nationally set sustainable development objectives. This paper demonstrates how two separate though related methodologies were used to provide conclusions on the economic and environmental impacts related to event visitation. The approaches used to assess the case event were environmental input–output tables and ecological footprint analysis. The paper demonstrates the value of these two techniques and

how they provide different perspectives on the environmental effects of the case event. The paper is set in the context of a shortage of tools with which to assess the environmental effects of events and, in particular, tools linking event-related consumption to environmental effects. In consequence, the paper addresses the challenge of linking conventional expenditure aggregates in tourism economic analysis to environmental consequences, then allowing the investigation of inherent trade-offs between the two. It is argued that this type of appraisal should become more of a standard in the evaluation of the impacts of tourism and event-related expenditures.

Andrea Collins is in the ESRC Centre for Business Relationships Accountability Sustainability and Society (BRASS), Cardiff University, 55 Park Place, Cardiff, CF20 3AT, UK. Fax: 02920 876061. E-mail: CollinsA@cf.ac.uk. Andrew Flynn is in the Department of City and Regional Planning, Glamorgan Building, King Edward VII Avenue, Cardiff, CF10 3WA, UK, and the ESRC Centre for Business Relationships Accountability Sustainability and Society (BRASS), Cardiff University, 55 Park Place, Cardiff, CF20 3AT, UK. Fax: 02920 876061. E-mail: FlynnAC@cf.ac.uk. Max Munday and Annette Roberts are in the Welsh Economy Research Unit, Cardiff Business School, Colum Drive, Cardiff, CF1 3EU, UK, and the ESRC Centre for Business Relationships Accountability Sustainability and Society (BRASS), Cardiff University, 55 Park Place, Cardiff, CF20 3AT, UK. Fax: 02920 874119. E-mail: mundaymc@cf.ac.uk and robertsa1@cf.ac.uk. The authors wish to acknowledge the assistance of the Stockholm Environment Institute at York University, particularly Dr John Barrett, and Dr Thomas Wiedmann, who provided the detailed spreadsheets for national ecological footprint and material flows for the UK, which provided a basis for some of the ecological footprint estimates in this paper.

The case material considered in this paper is the 2003/04 Football Association (FA) Cup Final. The FA Cup is one of the most prestigious competitions for football clubs in the UK and the final is arguably one of the greatest single matches in world club football. The match generates spectators and media interest world-wide. Cardiff (the capital city of Wales) has hosted the FA Cup Final event (and other major football matches including the Worthington Cup Final) at the Millennium Stadium since 2001 while Wembley Stadium in London is being rebuilt. In an economic impact review of Cardiff's first year as a host to the Cup Final and other major matches, it was estimated that £16.3 million of net additional expenditure was generated (a £11.7 million increase in the local economy's GDP) (Andrews, 2002). The Cup Final in 2001 had an audience of 600 million viewers in 70 countries world-wide and raised the international profile of Wales and Cardiff. Sport and event-related visitation has become an important part of Cardiff's development strategy as an 'events city' (Jones, 2001). The 2003/04 FA Cup Final was held in Cardiff's Millennium Stadium on 22 May 2004. The two football clubs to reach the Cup Final were Manchester United Football Club and Millwall Football Club, and an estimated 73 000 visitors travelled to Cardiff for the event. Based on information provided by the Football Association, it is estimated that some 70 per cent of ticket holders were supporters of Manchester United FC and 30 per cent were supporters of Millwall FC. The hosting of the FA Cup Final was perceived by tourism, event managers and local institutions as bringing significant economic benefits to the city, some of which have been assessed (see Andrews, 2002). However, there has also been recognition of broader impacts in terms of other visitor displacement and a series of more 'hidden' environmental and social costs that are becoming more difficult to ignore in the context of local duties towards sustainable development. Then there was a challenge to provide more detailed information on visitors' consumption patterns at such a major sporting event that would enable its ecological

impacts to be considered alongside economic effects.

This paper is structured as follows. The next section provides a review of studies that have examined the effects of sporting and cultural events and summarises the main themes and results from these studies, particularly in terms of analytical focus. Following this, we then provide some local background to the case. The third section explains the methodological framework adopted for the FA Cup Final case study and highlights the nature of local input–output tables with environmental extensions and the ecological footprint analysis. This section aims to show the value in combining perspectives gained from these two techniques into a policy-relevant analysis. The fourth section summarises the main findings, with the final section providing a discussion on the merits of the approaches adopted and the value or otherwise of such major events to the local economy.

2. Assessing Sports Events: Economic, Social and Environmental Perspectives

2.1 Economic Assessments of Sporting Events

The immediate economic effects of sports events are usually considered within a framework of the overall additionality of the activity, with allowances made for any leakages from the reference economy, and then with some estimates of any displacement effects. Methods for assessing the economic effects of events range from a simple tally of event-based gross spending, but with more complex analyses using economic models of reference economies to gauge net expenditure effects and any multiplier impacts caused by spending on local factor inputs. For example, UK Sport has sponsored a large number of studies (see UK Sport, 2004) examining the additional spending attributable to UK-hosted events including the World Badminton Championship (Glasgow, 1997), European Show Jumping Championships (Hickstead, 1999) and World Indoor Athletic Championships (Birmingham, 2003). These studies also examined the wider public profile of events and the value of

associated media coverage. In 14 out of 16 UK-hosted events reviewed in UK Sport (2004), the additional spending generated in the reference location was less than £4 million. The report authors highlight that what is 'major' in terms of sporting profile might not necessarily be 'major' in terms of local economic impact (for other recent UK studies, see for example, Gratton *et al.*, 2005; McQuaid and Greig, 2002; Jones, 2001).

Economics-based impact studies of major sporting and other events have been subject to a number of criticisms. First, impact assessments are often undertaken or sponsored *ex ante* by groups with a stakeholding in the process and therefore with some danger of economic effects being overstated to gain additional public support, or to reinforce regeneration coalitions (see for example, Cochrane *et al.*, 1996). Jones demonstrates that 'host' objectives can often drive the objectives of the assessment

Studies that assess the impact of hallmark and mega-events often focus on the economic impact on the host economy, as such events are often rationalised as an economic initiative on the part of the host governing authority (Jones, 2001, p. 241).

Secondly, there has been criticism that studies focus on the short-run as opposed to the longer-term effects of events. This is a particular problem with 'mega' sporting events such as the Olympic Games where inadequate attention has been given to longer-run economic consequences on host locations and on long-term infrastructure use *ex post* (see for example most recently, Preuss, 2004; and for an evaluation of the Athens games, PwC, 2004).

Thirdly, some studies fail to encompass fully the indirect and induced economic effects of events, with a tally of receipts or event-related visitor consumption not providing an assessment, for example, of the degree to which spending is on goods imported into the reference economy. Moreover, studies may ignore a series of broader fiscal effects with a proportion of visitor spending resulting in tax revenues to central authorities as opposed to host areas. Fourthly, the analyses

include residential and organisational spending that would have occurred whether the event had taken place or not. Finally, there has been a failure to account for the extent to which 'event'-based activity 'crowds out' other business activity, and also a failure to assess the opportunity costs associated with public expenditures to promote events or develop new infrastructure.

2.2 Sporting Events: Other Impacts

More generally, there is a developing literature around the impacts of sports events which asks whether a focus on events as mere economic drivers serves to relegate a series of equally important welfare issues. Ruiz (2004) shows that mega-events have the potential to assist community development, strengthen future tourism prospects, create productivity spillovers for local firms and increase labour participation (see also Jones, 2001). Cochrane *et al.* (1996) demonstrate how even the process of bidding for major events (Manchester's Olympic bids) can be a means of mobilising people and capital around new growth coalitions. They show how the bid process played a role in changing the *modus operandi* of local economic development in the case area, resulting in institutional and political restructuring.

However, against any potential benefits of hosting sports events are likely to be a series of 'costs' that are rarely considered in *ex ante* or *ex post* economic assessments. These might include the effects of overcrowding and noise pollution, increased crime rates and 'hidden' costs associated with policing and security, 'removal of undesirables', sanitisation and property cost inflation around venues. In this respect, Jones, considering the effects of the 1999 Rugby World Cup in Cardiff, states that

A more inclusive approach to impact modelling would identify many more negative impacts than is the case with a straightforward expenditure impact methodological approach (Jones, 2001, p. 242).

Whilst studies have succeeded in investigating selected social and welfare effects

connected to sporting events, fewer studies have investigated their local and global environmental impacts. Studies have identified the environmental impacts of sport events (see for example, Cashman and Hughes, 1999; Holden, 2000). This paper, however, moves beyond an identification of environmental impacts and takes steps towards estimating them. Specifically, this paper also links local and global environmental impacts to event-related consumption. Such an assessment is becoming increasingly relevant in the context of contemporary duties towards sustainable development at international, national and local levels (see below and DETR, 1999). Indeed, a series of environmental factors have featured in recent submissions to host the 2012 Olympic Games, not least in terms of eco-friendly transport modes, use of brown-field sites and waste reduction.

2.3 Assessing Sports Events in Wales

In Wales, sporting and event impact studies have tended to focus on the additional spending levered by events with, in some cases, due consideration of net activity additions and local multiplier effects within an input-output framework of analysis (see WERU and Cardiff Research Centre, 2002; Andrews, 2002; Jones and Munday, 2004). There has been rather less attention given to the environmental effects of events.

Some consideration of environmental impacts is increasingly relevant. The Assembly Government has a unique duty to promote sustainable development in all of its actions (NAW, 2001). The Assembly Government has adopted a broad definition of sustainable development—i.e. the stated objective is developing the needs of present generations without compromising the ability of future generations to meet their own needs. Elements of this legal duty involve the setting of targets for sustainable development and the development of indicators to assist in the evaluation of activities and policy. There are six broad objectives of sustainable development as set out in the Assembly's first *Scheme for Sustainable Development* (NAW, 2000, 2001)

- The environment should be cherished and protected so that it remains healthy and biologically diverse, and can continue to support us all.
- A self-sustaining economy should be developed which respects the environmental and social context of Wales and responds to sustainable development opportunities.
- Action should be taken to make our communities strong and viable, and people healthier.
- People should be enabled to play a part in taking decisions that affect them.
- The needs of all parts of Wales should be recognised.
- Wales should contribute to sustainable development at a global as well as a local level.

As part of its interpretation of its sustainable development duty, the Assembly has sought to promote sustainability in its funding activities. Within Wales, Cardiff County Council in particular has a reputation for being innovative and is taking steps to mainstream sustainability into its operations. The Council is beginning to recognise the need to pay greater attention to the environmental impacts that may arise from major events in the city.

For Wales, a series of major sporting events have been promoted as an important economic driver helping the development of the regional tourism product. Whilst such events have been subject to *ex ante* and *ex post* analysis of economic effects, rather less has been done to consider the wider social and environmental consequences. We argue that a more inclusive framework of sports event impact analysis is needed, particularly in the context of the Assembly Government duty for sustainable development. In what follows, we suggest some impact assessment tools that can be used to provide an evaluation of selected environmental effects linked to visitor expenditures. We accept that the methods adopted in this paper only provide a partial appreciation of expected environmental effects. However, the addition of these environmental perspectives allows for a more balanced and inclusive discussion of event effects.

3. Ecological Footprints and Environmental Input–Output Tables: Discussion of Methods

The purpose of this section is to review the two methods that have been used to analyse the environmental impacts of the FA Cup Final.

3.1 Environmental Input–Output (ENVIO) Analysis

Input–output analysis has a long pedigree as a method for examining the economic consequences of tourism activity and sports events. Studies tend to use national input–output tables, or scaled-down variants or simply use ‘tourism multipliers’ from prior analyses, to assess the indirect and induced effects connected to identified additional tourism spending or to related tourism and sports infrastructure developments (see Fletcher, 1989; Mondello and Rische, 2004; McQuaid and Greig, 2002).

The general limitations attached to the use of input–output analysis to model the effects of changes in final demand are well known, particularly the assumption of fixed technical coefficients and a passive supply side (Miller and Blair, 1985). Jones (2001), in a review of the use of the approach to assess sports events, shows the need for analysts and policy-makers to be aware of such assumptions, particularly where a major event may exceed the productive capacity of the reference region.

General input–output based analysis in Wales has a long history. The latest iteration of Welsh input–output tables relates to the year 2000. These were produced with support from the Welsh Development Agency and have been used widely in the region by public institutions in the absence of officially constructed tables (see Bryan *et al.*, 2004). The construction of the tables includes a regional survey component and most recently has included the addition of information to enable a better assessment of the tourism economy. The general Welsh input–output framework and tourism extensions have already been used to explore the economic impacts of sports events. Jones and Munday (2004), for example, show the

indirect and induced effects associated with events such as the 1999 Rugby World Cup. Research has also investigated the regional effects of the Network Q (now Wales) Rally GB (WERU and Cardiff Research Centre, 2002). However, the general input–output approach adopted in these studies focuses on the additional incomes, output and employment connected with additions to tourism and other event-related spending (although each of the above studies in Wales has described a wider set of social effects).

In this paper, we use the Welsh input–output table framework but within the system we examine selected environmental effects linked to the case event through a specially developed environmental module. This method is not new, with Leontief (1970) examining the connections between economic activity and the environment (for further details, also see Miller and Blair, 1985, pp. 236–263). However, in this paper there is an attempt to apply this method at the local (Cardiff) level and to the study of a major event. Environmental input–output (ENVIO) approaches in the UK have been largely limited to academic applications; however, ECOTEC (2001) highlight the developing scope for a policy-relevant economic–environmental accounting and modelling framework. A fully integrated ENVIO model would capture all interactions between the economy and the environment, and could be represented by the partitioned matrix

$$\begin{matrix} A_1 & A_4 \\ A_2 & A_3 \end{matrix}$$

A_1 a matrix of coefficients representing economy–economy interactions

A_2 a matrix of coefficients representing economy–environment transactions (showing the output of environmental good per unit of economic good)

A_3 a matrix of coefficients representing environment–environment interactions

A_4 a matrix of coefficients representing environment–economy transactions (showing the output of economic good per unit of environmental good).

Few practical studies incorporating all elements of the above model have been undertaken in the UK or elsewhere. Research has tended to revolve around the addition of the A_2 matrix to a pre-existing A_1 matrix. It is this approach that has been followed in Wales. Research by AEA Technology for the Environment Agency and its partners has provided Welsh data covering air emissions (by category), electricity consumption and production, energy production, waste arisings and water consumption. Here, for illustrative purposes, we use the data derived from this source for greenhouse gas emissions in Wales (see REWARD, 2003; and Table A1 in the Appendix). The regionally derived information on emissions can then be used in conjunction with the input–output framework to generate the direct and indirect volume of the given pollutant generated by changes in final demands. The framework then allows one industry's production to be linked with another industry's pollution creation. In this paper, we therefore link additional tourism spending from the FA Cup Final (see Table 3) to economic effects and then environmental externalities from local (Cardiff) industries.

The case sports event was held in Cardiff such that the use of the Welsh input–output framework to model the effects of the 2003/04 FA Cup would have been inappropriate with the Cardiff economy being different from the Welsh economy. For this reason, it was necessary to develop a Cardiff input–output table. This was derived by a mechanical reduction of the Welsh transactions table for 2000 using the normal RAS procedure (see Miller and Blair, 1985). The Welsh input–output table describes the production structure of 74 defined industries (see Bryan *et al.*, 2004). The need to derive sectors similar to those used in the REWARD study, and limits on the industry data available at the local level, meant that the number of industries was reduced to 12 in the constructed Cardiff table (see the Appendix). Then, regional pollution coefficients are applied to a sub-regional input–output table. This is far from ideal and assumes that local industries

pollute in the same way as industries in the region. This could mean, for example, that if Cardiff industries use older technologies than industries in the region as a whole, then environmental externalities could be overestimated under this assumption.

This type of analysis at the sub-regional level focuses on pollutants directly and indirectly produced in the sub-region. The magnitude of total effects is then tightly related to the import propensities of the selected industries such that significant pollution may be indirectly generated elsewhere in the region and abroad. Moreover, the approach does not permit a comprehensive analysis of the environmental effects of transport. For example, it only includes spending on park and ride, taxis and fuel spending in Cardiff. However, the Cardiff input–output framework can be nested within the Welsh framework such that regional-level spending and resulting externalities could also be investigated through the method.

For policy-makers, such an environmental extension to the basic input–output tables provide an important means of investigating selected environmental trade-offs of event visitation. For the case area, the outputs of policy simulations using ENVIO could potentially be used as 'inputs' to predict possible wider outcomes on other sustainable indicators or tools, and to give practical support to planning and *ex ante* evaluation processes—for example, demonstrating how additions to tourism demands may directly and indirectly create externalities. There are caveats with this type of approach. The focus is on the estimation of the effect of the economy on some aspects of the environment. The potential feedback effects from the environment to the economy, or the interactions between environmental variables are not easily permitted by such analysis.

3.2 Ecological Footprint Analysis

Ecological footprint analysis was initially pioneered in the early 1990s (see Wackernagel and Rees, 1995). Following its early conceptual development, the ecological footprint has

gained interest amongst academics and practitioners internationally (see for example, James and Desai, 2003; WSP Environmental and Natural Strategies, 2003; NRG4SD, 2004; Aall and Norland, 2005). The starting-point for the ecological footprint concept is that there is a limited amount of bioproductive land on the planet to provide for all human resource demands. Sustainable development requires that we live within the carrying capacity of the earth, allowing our economies to develop whilst still ensuring that human needs are met.

The ecological footprint is an aggregated indicator of global ecological impact, similar to the way in which GDP is used to represent dimensions of the financial economy. The footprint is measured using a standardised area unit equivalent to a world average productive hectare or 'global hectare' (gha) and is usually expressed in global hectares per person (gha/capita). The ecological footprint is derived for a defined population usually for one year by estimating the area of bioproductive land and sea required to support their resource consumption using prevailing technology—for example, the demands of that population in terms of their food, travel and energy use. This demand on nature can be compared with the available Earth's biocapacity, which translates into an average of 1.8 gha/capita in 2001 (WWF, 2004). However, humanity is currently using 2.2 gha/capita which indicates a situation of 'overshoot' where nature's capital is being spent faster than it is being regenerated (WWF, 2004). Overshoot may permanently reduce the Earth's ecological capacity and this is a key concern for sustainability.

Although the ecological footprint is being widely used and applied in the UK and elsewhere, the concept has faced a number of criticisms. Amongst the main points, critics have argued that the footprint does not accurately reflect the impacts of human consumption (see van den Bergh and Verbruggen, 1999; Ferng, 2002); it does not allocate responsibilities of impact correctly (see McGregor *et al.*, 2004); and does not provide decision-makers with a useful tool for policy-making as there

is limited understanding of how different consumer activities relate to impact (see van den Bergh and Verbruggen, 1999; Moffatt, 2000; Ferng, 2002). A more recent critique of the ecological footprint concept can be found in McDonald and Patterson (2004, pp. 52–54). Whilst the method has been criticised, the ecological footprint does offer a number of advantages to those wanting to understand the impact of major events and also for those that plan and organise such events.

As the ecological footprint relates to the consumption activities of a defined population, it has potentially many applications. For example, the footprint has had a number of applications in the UK including to products, organisations, services, different levels of government, proposed major developments and tourism (see Barrett and Scott, 2003; Barrett *et al.*, 2005; Collins and Flynn, 2005; Collins *et al.*, 2005). Here, we apply the concept to additional visitor consumption that occurs during the FA Cup Final. This approach is useful for a number of reasons. First, the footprint method provides valuable insights into natural resource use and an estimate of the land area required to support that level of consumption. As the ecological footprint aggregates the impacts of different consumption activities into a single measure, it also offers policy-makers the potential to identify clearly and compare the environmental impact of different visitor activities such as transport, waste and energy use. Secondly, the footprint provides the potential for policy-makers to prioritise their actions in a more informed and integrated manner. Thirdly, the footprint is a good awareness-raising tool because it personalises sustainability by assessing the impact of consumption from a consumer perspective (i.e. it takes into account the impact of residents within a defined boundary rather than the industries in a particular locality). The footprint can therefore be a useful tool with which to communicate with people and for them to appreciate the link between their local (consumption) activities and global environmental impacts.

Traditionally, national ecological footprints (the "National Footprint Accounts") have

been calculated based on a country's domestic production, imports and exports of primary and secondary products together with an estimate of the embodied energy of secondary products (Monfreda *et al.*, 2004). However, this method does not assign accurately the resource flows to final consumption categories as it omits all mutual interrelationships between product sectors and excludes the environmental effects of tertiary products, such as services. Recent methodological developments allow intermediate resource flows to be assigned to final consumption, thereby adding significant strength to the ecological footprint calculation (see Barrett *et al.*, 2005; Wiedmann *et al.*, 2006). The footprinting method then (following Barrett *et al.*, 2005) takes the existing National Footprint Account provided by the Global Footprint Network (GFN, 2004) as a starting-point. The total footprint of the UK is then disaggregated by economic sector and reallocated to final demand by using input–output analysis based on economic supply and use tables. The breakdown of final demand categories includes detailed household consumption activities according to the international 'Classification of Individual Consumption According to Purpose' (COICOP) classification system and a detailed breakdown of capital investment. With this method, it is possible to calculate footprints for sub-national areas (see Barrett *et al.*, 2005; Collins *et al.*, 2005) or socioeconomic groups, whilst ensuring full comparability of results with the National Footprint Account data. The method can be applied to every country for which a National Footprint Account exists and where appropriate economic and environmental accounts are available. A detailed description of this method is published in Wiedmann *et al.* (2006) and addresses issues including the accounting of capital investment, the embedded impacts throughout all consumption categories as well as limitations and assumptions inherent to the method.

The methodological approach to footprinting that we have described above is also designed to capture the resource use and environmental impacts that residents generate via their direct consumption and has a number

of distinct advantages for policy-makers. First, as the method uses standardised, official and annual statistics, this increases its robustness and reliability as an indicator and aids comparability across studies. Secondly, by using localised and detailed household expenditure data, footprints can be generated at regional and local levels. The method has been successfully used to calculate the footprint of the UK, Wales and Cardiff (see Barrett *et al.*, 2005; Collins *et al.*, 2005). Finally, by allocating the footprint to final demand categories, the method highlights consumer responsibilities, which in turn are valuable in developing policy scenarios.

An ecological footprint study of Wales has calculated that the overall footprint in 2001 was 15.2 million global hectares (gha) (see Barrett *et al.*, 2005). On a per capita basis, the ecological footprint of an average resident in Wales is 5.25 gha/capita (see Table 1). This shows that the level of consumption by residents in Wales is currently inequitable as they are using resources almost three times the average 'earthshare' of 1.8 gha/capita.

In Table 1 we highlight the ecological footprint results for UK, Wales and Cardiff in 2001 and the relative size of the different components in the footprint. The results for Wales show that food and drink is the single largest component and accounts for almost 25 per cent of the total footprint figure and together with three other components—travel, energy and consumables—contributes 69 per cent of the total footprint. That four factors can so dominate the Wales footprint is indicative of how contemporary patterns of consumption have major implications for resource use.

Domestic energy consumption is the second-largest component with a footprint of 0.92 gha/capita. This is followed by travel and consumables with a footprint of 0.78gha/capita and 0.64gha/capita respectively. Of the 'other' consumption categories, gross fixed capital formation (capital investment) has the largest ecological footprint, with an impact of 0.74 gha/capita. Gross fixed capital formation relates principally to investment in tangible fixed assets such as plant and machinery, transport equipment,

Table 1. Comparison of the ecological footprints of the UK, Wales and Cardiff for 2001 (gha/capita)

	Cardiff	Wales	UK
<i>Household consumption</i>			
Food and Drink ^a	1.33	1.29	1.34
Energy	0.99	0.92	0.90
Travel ^b	0.99	0.78	0.72
Housing	0.16	0.17	0.18
Consumables	0.64	0.64	0.75
Services	0.26	0.24	0.32
Holidays abroad	0.10	0.10	0.12
<i>Non-household consumption</i>			
Capital investment ^c	0.74	0.74	0.74
Government ^d	0.41	0.41	0.41
Other ^e	−0.03	−0.03	−0.12
Credits for recycling	−0.030	−0.027	−0.108
Total	5.59	5.25	5.35
Waste (satellite account)	0.81	0.71	0.71

^aIncludes catering services.

^bIncludes transport services and air travel.

^cCapital investment or gross fixed capital formation (GFCF): relates principally to investment in tangible fixed assets such as plant and machinery, transport equipment, dwellings and other buildings and structures. However, it also includes investment in intangible fixed assets, improvements to land and also the costs associated with the transfer of assets. The investment relates to assets which are used repeatedly in the production process for more than one year and thus covers such purchases as software, mineral exploration and purchases of dairy cattle. The footprint calculations assume shared responsibility—i.e. equal values for the UK and Wales.

^dIncludes central and local government. The footprint calculations assume shared responsibility—i.e. equal values for the UK and Wales.

^eIncludes non-profit institutions serving households, valuables, changes in inventories and overseas tourists in the UK. Overseas tourists result in an overall negative footprint in the Cardiff, Wales and UK results as this figure is included in the footprint for visitors' country of origin.

dwellings and other buildings and structures. The footprint figure for capital investment is the same for Cardiff, Wales and the UK, as it is assumed within the ecological footprint model that residents have equal responsibility for such shared investments.

The ecological footprint for waste is not included in the 'standardised' footprint calculations but instead is treated as a satellite account. The reason for this is that the impacts of household consumption can only be counted once, either as 'inputs', when products are bought or consumed, or as 'outputs', when these products are discarded. As the footprint methodology used here considers the environmental impacts of consumables, double counting would occur if the impact of waste from these consumables was included in the final result.

The footprint figure for waste only provides a partial picture of the impact of waste as it refers only to household waste and excludes other waste such as construction, demolition and commercial waste. Wales' waste has a footprint result of 0.71 gha/capita (see Barrett *et al.*, 2005). 'Credits for recycling' produce a negative footprint of −0.027 gha/capita as recycled materials re-enter the economy (see Table 1).

The ecological footprint of tourists also takes the form of a satellite account. The footprint of tourists can be calculated using two different methods: top-down and bottom-up. The 'top-down' approach calculates the footprint using modelled expenditure data, and the 'bottom-up' approach uses locally specific data. Similarly, the ecological footprint of an event such as the FA Cup Final

will also take the form of a satellite account and include the environmental impact of visitor resource consumption. Whilst the top-down approach can be useful in providing an indication of visitor impact, the consumption patterns of visitors at an event such as the FA Cup Final will be event-specific. For the purposes of calculating the ecological footprint of the FA Cup Final, it was therefore necessary to use the bottom-up approach to ensure that data used in calculations accurately reflected the consumption patterns of visitors attending the event.

Estimating visitor consumption. For the case event, the geographical boundary of the study was the host city of Cardiff. The study population was all event visitors and included both ticket and non-ticket holders. The period for which the visitors' footprint would be calculated was one day (i.e. the day of the event). Clearly, some visitors may have stayed in overnight accommodation in Cardiff. However, information provided by Cardiff County Council suggested that the majority of visitors travelled to Cardiff on match day. Primary data relating to visitors' consumption were collected for the following areas as they were considered to have the most significant impacts

- travel to the event;
- food and drink;
- infrastructure of the event venue;
- waste.

Next, we briefly outline how visitors' consumption was calculated for each of the areas listed. Table 2 provides a summary of the data sources that were used for each of the areas.

The transport component of the footprint included return journeys made by all visitors to Cardiff. Distances travelled by visitors were estimated using return journeys made by all visitors from their home location to the event venue. Although Manchester United FC has a geographically extensive fan base, for reasons of data availability only UK travel was accounted for within this study. Within the calculations, it was assumed that the average distance travelled by visitors

supporting Manchester United FC and Millwall FC was equivalent to Manchester and Millwall respectively. As most journeys made within the UK were by rail and road (i.e. car, limousine, coach, mini-bus, park and ride), domestic air travel was not included in the calculations. The total number of visitor journeys made by each transport mode was calculated using the number of vehicles using designated coach and car parking facilities (i.e. car, limousine, coach, mini-bus) and vehicle occupancy levels, and passenger figures for rail and park and ride.

The amount of food and drink consumed by visitors attending the event was calculated using business sales data on items sold and an estimation of the proportion of customers on match day that were event visitors. Sales data were obtained through a survey of food and drink businesses, licensed mobile food operators and caterers operating at the event venue. This survey also informed parts of the ENVIO analysis. Food and drink items sold were then converted into total amounts using the Ministry of Agriculture Food and Fisheries (MAFF) food portion sizes (MAFF, 1993). Where food items contained more than one ingredient, food packaging labels were used to provide an estimate of the key ingredients. For example, an average chicken and salad sandwich that weighed 170 grams, had an average composition of 30 per cent meat, 45 per cent bread and 25 per cent salad.

The amount and composition of materials used to construct the event venue (including fixtures and fittings) were used to calculate the footprint of the stadium infrastructure together with an estimation of the expected lifespan of the venue and number of users during that period. Data on material quantities and composition were provided by the stadium owners, construction companies and sub-contractors. As far as possible, all materials used to construct the stadium were identified and then assigned an ecological value.

The total amount of waste generated by visitors attending the event was calculated using estimates of the quantity and composition of waste generated from the event and whether it was recycled or sent for landfill.

Table 2. Estimating visitor consumption for the FA Cup Final

Visitor resource consumption	Data source	Estimated using
Travel	Cardiff County Council Supporters Survey (1 per cent sample)	Return distances travelled by visitors from home location to event venue. It was assumed that the home location of visitors was the home area of each football club—(i.e. Millwall and Manchester) Included UK and local travel only (excluding domestic air travel) Passenger numbers based on average occupancy levels per mode of transport
Food and drink	Stadium owners Survey of food and drink businesses (24.9 per cent sample) and licensed mobile food operators (100 per cent sample)	Quantity and type of food and drink items sold to visitors on match day (included event venue, food and drink businesses and licensed mobile food operators in Cardiff city centre and Bay area) Composition of food items based on food labels and UK government guidance on food portion sizes (MAFF, 1993)
Infrastructure event venue	Stadium owners Sub-contractors for fittings and services	Quantity and composition of materials used to build stadium and supply all fittings and services (lifts, seating, toilets, etc.) Transport of materials from manufacturer to venue Number of visitors expected at stadium based on number attending events during first five years (1999–2004)
Waste	Waste contractors for event venue Cardiff County Council Survey of food and drink businesses (24.9 per cent sample) and licensed mobile food operators (100 per cent sample)	Quantity and composition of waste generated on match day that was land filled and recycled Included waste collected from: event venue, food and drink businesses, licensed mobile operators, litterbins and street sweepings, designated coach and car parks

This included waste that was collected from the event venue, food and drink businesses, licensed mobile food operators, coach and car parks, and street sweepings and litter bins from streets adjacent to the event venue.

3.3 Approaches in Tandem

Before proceeding, it is useful to compare the ENVIO and the ecological footprint tools that are being used here to provide a dual insight for local policy-makers. The ecological footprint method

—identifies resource use as a result of visitation to the event;

—examines waste generated as a result of visitation;

—provides a measure of the total impact of resource use and also impact on a component basis (i.e. travel, food and drink, waste and capital investment);

—presents key results in terms of the area of land (i.e. global hectares) required to produce resources consumed by visitors at the event.

The Environmental input–output framework reveals

—the indirect and induced effects of additional consumption of event-related visitation;

- identifies environmental externalities by type directly associated with event-related spending in the case area;
- identifies externalities created indirectly as a result of local event-related spending;
- presents findings in monetary terms and in terms of physical units of various pollutants produced.

The ENVIO framework provides an account of impacts from a very local perspective (i.e. focusing on emissions created in Cardiff as a result of spending). However, the ecological footprint as a measurement provides a global picture of environmental impact and can demonstrate the environmental sustainability or otherwise of visitors' consumption patterns when attending sports events of this type.

Understanding consumption and its environmental impact can potentially assist decision-makers and those managing events to plan and organise them in such a way as to limit their impact. Furthermore, the monetary input–output approach underpinning both methodologies means that changes in event-related expenditure patterns could be explored. This could assist in exploring the impact of different policy scenarios and developing future sustainable consumption policies (for example, trade-offs between the

footprint reduction and local economic effects such as requiring visitors to travel to events by public transport rather than car). We return to these issues in the conclusions.

4. Findings

This section summarises the impacts of 2003/04 FA Cup Final using the two approaches. The section also highlights some of the problems in coming to the results set. Further details of data sources that informed elements of the input–output, and ecological footprint analysis are found in Tables 2 and 3.

4.1 *Estimates of Effects Using the Input–Output Framework*

Table 3 provides the spending inputs that were placed in the developed Cardiff input–output framework. It was estimated that in 2004 that there was some £2.9 million of spending by visitors at the FA Cup Final. This is a gross figure and therefore includes imports into Cardiff and any taxes paid. For example, in the case of food and drink, merchandising and general shopping, much of the expenditure by visitors related to imported goods such that local effects need to be understood more

Table 3. 2003/04 FA Cup Final: estimated visitor spending

Item	Amount (£000s)	Notes
Food and drink	1668.8	Derived from Supporter Survey as part of footprint study. Survey revealed that most of food and drink was brought into the local economy such that elements retained were largely value added in retail, wholesale and hotel and restaurant sectors
Local transport	33.4	Largely 'park and ride' and small number of taxi fares
Merchandise	606.4	Proportion goes to Football Association, very little retained in local economy
Non-food shopping	262.8	Goods purchased largely made outside local economy; local element largely retail margins
Leisure	22.3	Largely visiting cinemas and local tourist attractions (i.e. museum and castle)
Accommodation	300.0	Estimated using available bed-spaces in Cardiff and expected number bed-nights around the event
Total	2893.7	Representing an estimated £39.63 per match attendee

in terms of margins accruing to retail, wholesale, and payments to hotels and restaurants.

When account is taken of the import and tax component of gross spending, then the amount of spending that is on locally produced goods and services fell to a little over £1.5 million. However, the £1.5 million of spending on locally produced goods and services supports further output and incomes in the supply chains of the local industries (Table 4). Once allowance is made for a series of indirect and induced income effects, then the initial increase in expenditure supports a further £0.7 million of output in the Cardiff economy. Much of this indirect effect is in local manufacturing, wholesale and retail, other business services and recreation and other services. The total output supported by the spending injection is therefore around £2.2 million. In other words, each £1 of direct spending by visitors supports an estimated additional £0.46 of output in the Cardiff economy.

As revealed in the review, this result is grounded in the narrow assumptions of the linear input–output framework. It is also expected to be an overestimate of effect. For example, this takes no account of displacement. On Saturday match days in Cardiff, there is an expectation that some retail visitors will either defer shopping to another day, or simply visit other regional centres. In the case of Cardiff, there is a strong expectation that temporary and permanent visitor displacement will be

more acute on football days than on rugby international days, largely because of the greater levels of anti-social behaviour connected with the former. Any estimate of displacement effects is difficult. However, a comprehensive survey by Cardiff Research Centre in 2001 (see Andrews, 2002) suggested that large prestige football matches on a Saturday in Cardiff could permanently displace as much as £0.65 million in retail sales alone.

Furthermore, the visitor-based approach fails to take into account other costs for organisations such as Cardiff County Council in hosting this event. Analysis of council costs associated with football matches held at the Cardiff Millennium Stadium in 2001 suggested that direct costs linked to holding the FA Cup Final that year were in excess of £0.25 million. This was largely related to traffic management, signage and lost opportunities associated with venues close to the stadium (which were given over to event hospitality), and lost advertising space adjacent to the stadium (see Andrews, 2002). Of course, some additional revenues could also accrue to the area. This could include television-related incomes, but with the expectation that much of this money goes to the competing clubs. Each of these issues is also pertinent to the footprint analysis (see section 4.2).

When these factors are taken into account, then the narrowly defined economic effects linked to the event are fairly small. Clearly, these effects would be larger if one placed the spending within the wider regional (Wales) input–output framework. Furthermore, set against these more measurable effects are the less quantifiable effects linked to the promotion of the location around many countries, with, for example, the media value of events to host locations examined in UK Sport (2004).

We turn now to consider selected environmental effects. For illustrative purposes, here the additional visitor spending is connected to direct and indirect greenhouse gas emissions in terms of tonnes of carbon equivalent. The Appendix (Table A1) shows Cardiff industry gross outputs and associated estimated greenhouse gas emissions. Table 5 uses this information and the Cardiff input–output

Table 4. Economic effects of 2003/04 FA Cup Final visitor spending

Spending on Cardiff-produced goods and services (£000s)	1523.2
Indirect output supported in Cardiff economy (£000s)	703.9
<i>Of which, percentage in</i>	
Manufacturing	14.8
Energy and water	4.5
Wholesale and retail	15.5
Hotels and restaurants	4.6
Transport	8.4
Other business services	31.2
Recreation and other services/sectors	20.0
Estimated total output linked to event (£000s)	2227.1

Table 5. Estimated emissions connected with visitation to the 2003/04 FA Cup Final

Direct greenhouse gases (tonnes carbon equivalent)	123.48
Indirect and domestic-sector greenhouse gases (tonnes carbon equivalent)	436.57
Total greenhouse gases (tonnes carbon equivalent)	560.05
<i>Of which, percentage in</i>	
Energy and water	21.0
Hotels and restaurants	11.7
Transport	12.0
Domestic sector	33.3
Other	22.3

framework to estimate the indirect greenhouse gas emissions connected with the event visitor spending. It was shown earlier that an estimated £1.5 million of visitor spending was on Cardiff-produced goods and services. This is directly associated with an estimated 123 tonnes of carbon emissions. The indirect output supported in the local supply chain creates a further 250 tonnes of carbon emissions, whilst additional household consumption

supported in the supply chain creates a further 187 tonnes of emissions. This gives a total of 560 tonnes of carbon emissions once the direct, indirect and induced income effects are included. The large multiplier effect here between direct and total emissions related to the event visitation is because, whilst sectors such as retail, wholesale, hotels and catering produce little in the way of direct emissions per £1 million of output, they do purchase from industries that produce higher levels of emissions per £1 million of output, including transport and energy.

4.2 Estimates of Global Environmental Impacts Using Ecological Footprint Analysis

The ecological footprint results for the FA Cup Final can be expressed as ‘total’ global hectares and as global hectare (gha) per capita. Table 6 provides a summary of the ecological footprint results for the 2003/04 FA Cup Final. Based on those consumption categories included in this study, the total footprint of the event was 3051 global hectares

Table 6. Summary of ecological footprint of 2003/04 FA Cup Final

Category	Visitor total ecological footprint (gha/day)	Visitor additional ecological footprint (gha/day)	Visitor ecological footprint at home location per day ^a (gha/day)
Transport ^b	1670 (0.0228 gha/visitor)	1550 (0.0212 gha/visitor)	120 (0.0016 gha/visitor)
Food and drink	1381 (0.0189 gha/visitor)	1113 (0.0152 gha/visitor)	268 (0.0037 gha/visitor)
Stadium infrastructure (capital investment) ^c	0.10 (0.000001 gha/visitor)		
Total	3051 (0.0417 gha/visitor)	2663 (0.0364 gha/visitor)	388 (0.0053 gha/visitor)
Waste (satellite account) ^d	146 (0.002 gha/visitor)		

^aBased on levels of consumption for average UK resident per day.
^bAll transport calculations have excluded air travel to enable comparisons to made.
^cThe ecological footprint of infrastructure for the average UK resident is not directly comparable as it includes the impact of housing and other general infrastructure including offices, schools, etc.
^dThe ecological footprint for event waste is not directly comparable with that of an average UK resident as it will include other household waste such as furniture and garden waste.

(gha). On a per visitor basis, the ecological footprint of an average visitor was 0.0417 gha/visitor (see Table 6). The additional footprint generated by visitors attending the event was 2633 global hectares, or 0.0364 gha/visitor. This additional impact is calculated by estimating visitor resource consumption at their home location (per day) and subtracting this from their total consumption at the event for each of the footprint component areas. For this case event, the additional impact was calculated for the transport and food and drink components only. The reason for this was that comparable data were not available for capital investments (i.e. stadium infrastructure) and waste in visitors' home location. However, a key question here is how significant is the impact of consumption at this event? If we compare the footprint of an average visitor at the event with that at their home location for the same duration (i.e. one day), the total impact at the event is seven times greater. Not surprisingly, by attending the FA Cup Final, visitors are consuming in a different way from their normal practices. Next, we provide a deeper analysis of the factors that contribute to the footprint results.

Visitor travel. The most significant impact generated by the event was visitor travel patterns. Visitor travel to the event created an ecological footprint of 1670 global hectares, 55 per cent of the total footprint of the FA Cup Final. The footprint figure for visitors' travel is 14 times greater than the footprint for an average UK resident for the same period of time. The car was the most popular mode of travel and accounted for 47 per cent of total distances travelled by all visitors (43 000 000 pkm). As shown in Table 7, car travel had the most significant impact and was responsible for more than two-thirds (68 per cent) of the total transport footprint for the event. Although rail travel accounted for 34 per cent of the total distances travelled by all visitors, it was responsible for only 20 per cent of the total travel footprint figure as it has a much lower footprint modal impact, compared with the car. Travel by all other modes of transport (coach, minibuss and

Table 7. Distances travelled by visitors and their corresponding ecological footprint

Transport mode	Distance travelled by average visitor (pkm)	Ecological footprint (gha/capita)
Car	20 199 991	1 139
Surface rail	14 527 114	325
Coach	7 473 245	164
Private hire bus	955 754	41
Local bus	1 052	0.05
Total	43 157 157	1 670

park and ride) accounted for 12 per cent of the total transport footprint.

Food and drink consumption. Visitor consumption of food and drink was the second-largest component and created a footprint of 1381 global hectares (see Table 8). This footprint figure for visitors was four times greater than the footprint for visitors at their home location over the same time-period. The reason why this footprint figure is so large relates to the scale, type and pattern of visitor food and drink consumption. The individual food and drink items that were consumed in large amounts—namely, alcoholic drinks and meat and meat products are highly processed foods and this requires substantial amounts of energy. A further reason

Table 8. Visitors' food and drink consumption and corresponding ecological footprint

Food type	Total amount consumed (kg)	Ecological footprint (gha)
Drinks (alcoholic and non-alcoholic)	275 005	556
Meat and meat products	14 109	652
Bread/cakes	12 533	34
Fruit and vegetables	9 701	19
Diary products	7 242	114
Confectionery	722	6
Total	319 313	1 381

why the footprint figure is so high is that the majority of food and drink items were purchased from 'eating out' establishments such as restaurants and fast-food outlets. This food will be intensively produced and prepared, and can involve relatively large amounts of energy use and result in a high footprint figure.

Infrastructure (Event venue). Visitors used a range of fixed assets (i.e. capital investment) whilst attending the event—for example, shops, car parks, roads and the event venue. Although the impact of these assets is included in the footprint results for Cardiff, Wales and the UK (see Table 1), it is important that visitor use of these assets is accounted for within the event satellite account. For reasons relating to difficulties in assessing visitor use of such assets, their total impact could not be accounted for. However, this study did include in its analysis the impact of the event venue as it was considered to be the main fixed asset that the majority of visitors would use during the event.

Although on an event basis the total impact of the event venue was small, it was included in the footprint calculation for two main reasons. First, its inclusion would enable comparisons to be made with other areas of visitor consumption such as visitor travel. Secondly, although the total footprint of the stadium infrastructure will remain the same irrespective of the number of events held during its expected lifespan, the footprint model will show that, on a per event basis, the impact of that infrastructure will be lower if the venue can host a larger number of events. Based on the estimated 100-year lifespan of the stadium combined with an estimated 100 million visitors during that period, on an event basis the venue attracts a very low footprint score of 0.104 global hectares per event.

Waste. As previously discussed in section 3.2, the ecological footprint for waste is not included in the total ecological footprint of the event but instead is treated as a satellite account in order to avoid double counting. The FA Cup Final generated a total of 59 tonnes of waste (Table 9) and the majority

Table 9. Composition and total amount of waste produced by visitors

Waste composition	Total waste (kg)	Ecological footprint all visitors (gha)
Glass	39.0	7.8
Food	10.8	117.0
Paper and card	5.9	15.9
Plastic	2.7	3.3
Metals	0.4	1.1
Miscellaneous	0.1	0.5
Total	58.9	145.6

of this was sent for landfill. This resulted in a total waste footprint of 146 global hectares or 0.02 gha/visitor. Food waste and food and drink packaging accounted for 80 per cent and 11 per cent of this footprint figure respectively.

In summary, the ecological footprint results show how, within a short space of time, a large ecological impact can be produced by visitors at major events such as the FA Cup Final. The number of visitors, how they travel to an event, the types of food and drink they consume and the wastes that they produce have resulted in large global ecological impacts. Moreover, those areas of consumption where visitors to events are likely to have the greatest effect, such as transport or food and drink, are also those that impact the most on the Cardiff resident's footprint (see Table 1).

5. Discussion and Conclusions

The paper has demonstrated the value of two very different models with which to assess the environmental consequences of a major sports event. We argue that this type of appraisal should become more commonplace in the investigation of the effects of major events. Decision-makers in the devolved administrations and in the English regions are now charged with a series of environmental responsibilities. A critical issue is whether they have the measurement and analytical tools to meet these responsibilities effectively,

such that they can examine trade-offs between commonly reported economic aggregates and environmental impacts. This paper demonstrates how two different models can work alongside one another to provide a relatively sophisticated and rigorous examination of the economic and environmental effects of a major event. The economic benefits of hosting this major event are small, but its global environmental impacts are significant and should not be ignored in future event and tourism planning. Whilst the methods used here can only cover a selection of effects (impacts) connected to the event visitation, they do permit the analysis of policy-relevant perspectives.

In 2003, it was estimated that tourism spending in Cardiff amounted to over £420 million (derived from data supplied by Cardiff County Council). The more the city acts as a draw for visitors, the greater the ecological impact that will occur. Then the policy implications of the results in the paper are not so much in terms of whether such events should be attracted or not, but understanding the wider environmental implications of visitation and minimising undesirable effects (or wider global impacts).

The ecological footprint provides an understanding of the global environmental impacts that a major sporting event such as the FA Cup Final can create. Our analysis of the FA Cup Final using the ecological footprint has shown that it is a sophisticated tool able to identify key environmental pressure-points. It also has the potential to illustrate ways in which those pressures might be reduced through the development of scenarios—for example, substituting car travel with coach travel, which has a lower modal impact, or increasing recycling of food and drink packaging. Inevitably, the approach is not without difficulties. For example, the method did not account for all visitor consumption at the event, such as visitor use of water services or hospital services. Moreover, the footprint as used in this case does not take account of any displacements effects generated by the event—for example, reduced consumption by Cardiff residents who did not eat out in the

city that day. Added to this is a problem of data availability for all areas of consumption.

However, the footprint methodology developed relates to the consumption activities of a defined population and, therefore, has many potential applications. It could also be applied to a range of events such as those attended only by local residents or where the boundaries of an event extend beyond the geographical boundary of a city. For example, the footprint could be applied to a regional event such as the Wales Rally GB, or one that takes place in an entire country such as the Tour de France. The footprint could also be applied to events such as the Olympics that are held over a longer time-period. In the case event presented here, only the impact of UK travel was included; this could be extended to included visitor travel from abroad.

The footprint results clearly demonstrate that the 2003/04 FA Cup Final did have a significant global ecological impact. Those activities that had the most significant impacts were visitors' travel, their food and drink consumption and the waste they produced. The actual infrastructure of the event venue has a relatively small footprint because of the durability of materials used in its construction and the number of visitors that will use the venue over its estimated lifespan.

The environmental input–output approach is well known and has had a wide application, although it has not often been used to assess the environmental impacts of a discrete event. The approach connects event-related spending to environmental externalities in a relatively transparent fashion. The approach can be developed to deal with different types of externalities (for example, waste and different types of emission). Key limits are the normal assumptions of the input–output approach (see Miller and Blair, 1985). Other limitations are the very local perspective provided by the approach in this case, although as highlighted in the paper the Cardiff input–output framework can be nested within the regional framework to broaden the impact analysis spatially. Clearly, an important

analytical issue is to tie pollution being created in the wider UK or internationally to event-related demands (see for a study of this general issue in Scotland, Ferguson *et al.*, 2003). In order to examine these extraregional consequences of the event-related spending, one would need an interregional input–output framework. However, the absence in the UK of detailed interregional trading data and limited information on pollution coefficients across all regions precludes such a wider analysis at the present time. This constitutes one rationale for combining the perspectives from the environmental input–output with those from the ecological footprint analysis. Practically, another issue is that few regions, let alone unitary authority areas, have officially sanctioned input–output frameworks.

The results using the input–output framework show limited local effects because much of the event spending was on goods and services imported into the local economy. Whilst the 2003/04 FA Cup Final was estimated to be connected directly and indirectly to £2.2 million of output, the effects of permanent displacement could reduce this. The ENVIO framework reveals that directly and indirectly the event is connected to around 560 tonnes of emissions. This framework shows how the visitor spending can be tied to production externalities in a transparent manner.

Both methodologies can be used to consider different visitor scenarios and this would assist event organisers and decision-makers to manage the impacts of events in a very specific way. This would also enable organisers and promoters to demonstrate whether they are organising and promoting sustainable events. This is expected to become a more important facet of successful area marketing in the future. The overall results indicate that there is a need to review the way in which events in Cardiff and elsewhere are currently being managed and consider how visitors' impacts can be reduced when attending similar events in the future.

More generally the analysis in the paper permits some consideration of the trade-offs

between policy objectives. Recent strategic economic development documents from the Assembly Government have highlighted a series of conventional economic targets. Set against these are a series of sustainable development indicators. There has already been criticism that not enough has been done in the region to show how the achievement of economic targets in terms, for example, of improving levels of gross value added per capita links to the achievement, or non-achievement, of sustainable development targets (Munday and Roberts, 2006). The tools reviewed in this paper, in part, reveal how such trade-offs can be understood and assessed.

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Appendix

Table A1. Summary emissions and Cardiff industry gross outputs

	Estimated greenhouse gases Cardiff (t/C equivalent)	Cardiff Gross Output (£ million)	Estimated greenhouse gases Cardiff per £000/output (t/C equivalent)
Agriculture, etc.	72 357.8	23.4	3.097
Food and drink	25 786.6	244.4	0.105
Other manufacturing	1 495 121.1	1 350.1	1.107
Energy	3 371 587.5	985.0	3.423
Construction	28 229.6	552.0	0.051
Wholesale and retail	82 762.1	835.8	0.099
Hotels and restaurants	15 182.2	271.9	0.056
Transport	315 276.8	436.9	0.722
Post and telecoms	17 105.4	299.1	0.057
Other business services	178 727.7	3 275.2	0.055
Non-market services	134 848.3	2 075.2	0.065
Recreation and other services	91 208.5	663.1	0.138
Domestic sector	1 222 345.0	3 935.7	0.311
Total	7 050 538.6		

Source: Derived from Bryan *et al.* (2004) and REWARD (2003).

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