Abstract

Football is the most popular sport, globally and in the United Kingdom. However it generates a range of negative environmental impacts, such as climate change, due to an extensive amount of travel involved. The growing contribution of football clubs to the global carbon footprint has been recognised, but never consistently assessed. This study assesses the carbon footprint of the English Premier League (EPL) clubs, using the patterns of their domestic travel in the 2016/2017 season as a proxy for analysis. The study shows that, within the 2016/17 season, the EPL clubs produced circa 1134 tonnes of CO_2-eq. as a result of their travel, where transportation accounts for 61% of the carbon footprint. To reduce this carbon footprint, a careful review of the current corporate travel and procurement practices in the EPL clubs is necessary. This is in order to optimise the travel itineraries, prioritise more climate-benign modes of transport and contract budget accommodation providers with the 'green' credentials.

Keywords: Carbon footprint; Transportation; Sporting events; Football; English Premier League.

1. INTRODUCTION

Global warming is responsible for climate change and, consequently, for the most varied impacts in the world (Pielke *et al*., 2007; Klein, 2011). Mitigating the consequences of climate change to reverse this scenario is one of the most significant challenges in today's society. The major challenge is the intensification of greenhouse gas (GHG) emissions from sources such as tourism (Abegg *et al*., 2007; Nemry & Demirel, 2012) and sporting events (Pereira *et al*., 2017). Its containment is an indispensable task, imposing the need to create and implement mitigation and adaptation measures (Enríquez-de-Salamanca *et al*., 2017). Sporting events play an important role in the modern society (Gibson 1998) as theyhold a significant potential to boost the local economy, enhance subjective well-being of the public, facilitate tourism’s growth and improve regional development (UNEP, 2012). The expansion of major sporting events in recent years (Kirkup & Sutherland 2015) has prompted research on the characteristics of the host destinations (Agha & Taks, 2015). The opportunities and challenges attributed to hosting sporting events in specific destinations have been repeatedly scrutinised as a result (Getz, 1997; Weed & Bull, 2004; Collins *et al*. 2007; 2009; 2012). Due to their size and extensive media coverage, major and mega sporting events have become an object of prime investigation (Müller, 2015), as demonstrated by the related research on the *Fédération Internationale de Football Association*-FIFA World Cups™ (Kim & Petrick, 2005; Preuss, 2007; Du Plessis & Maennig, 2011; Korstanje *et al*., 2014) and the Olympic Games (Solberg & Preuss, 2007; Gratton & Preuss, 2008; Kaplanidou & Karadakis, 2010; Kaplanidou, 2012; Leopkey & Parent, 2012).

Environmental impacts represent an issue of particular concern for the destinations that host large-scale sporting events (Higham, 2005; Taks, 2013; McCool, 2015). Even the location of the infrastructure (airports, stadiums, hotel complexes, etc.) has a major impact

(Triantafyllidis *et al*., 2018). At these destinations, environmental impacts are particularly pronounced in the case of greenhouse gas (GHG) emissions as these are substantial for sports (Manfredi *et al*., 2009). Despite the importance of mitigating the GHG emissions of sporting events, the related research agenda on carbon footprint assessment is under-developed (Schianetz *et al.* 2007). It is, however, paramount to address the critical issues associated with the ways in which sporting events and tourism interact with the environment to ensure the sustainability of sports (Hinch *et al*., 2016). Thus, the agents involved with events have a great responsibility for their development and management, as well as in the evaluation of the local context (Giannoulakis *et al*., 2017). The destinations hosting sport events should encourage event attendees to adopt pro-environmental behaviour which is understood as the behaviour which consciously seeks to minimize the negative impact on the natural and built world (Han *et al*., 2015).

However, the quest of sporting events towards the goal of environmental sustainability is hindered by the marketing decisions of sporting event organisers and by the way the sporting events are managed. For example, the National Collegiate Athletics Association (NCAA) Division I athletic conferences have recently undergone conference realignments. The expanding geographic footprint of these conferences throughout the United States has led to teams having increased travel distances for all sports, especially American football (Farley *et al*., 2017). This is further exemplified by the case of the Super RugbY™ cup, whose managers have recently decided to expand the number of participating countries (Hinch *et al.* 2016). While the socio-economic benefits have risen sharply as a result of this decision, so have the GHG emissions attributed to the increased international travel of the participating sporting teams (Kruger, 2015). Travel is one of the main concerns of the tourism sector, since the main function of transportation in the tourism system is to take tourists from the regions of origin to the regions of destination (Robbins, 2003). In the case of the Super RugbY™ cup, this emphasises the point raised by Thibault (2009), who states that the GHG emissions from sports activities are immense and long-term but, for the most part, they go unnoticed in pursuit of short-term financial gains.

Among the different branches of sports, the problem of GHG emissions is particularly attributed to football (known as soccer in the USA). Football is the most popular sport globally, with an estimated 3.5 billion fan base (Wood, 2017). This popularity determines the disproportionally high, and yet growing, carbon intensity of football (Carbon Trust, 2013). That is, the total amount of GHG emissions caused, directly and indirectly, by a football match /championship. The direct emissions can be attributed to, for example, the emissions resulting from the displacement of fans and teams and/or the energy used in the stadia; the indirect emissions may arise, for instance, from the use of electronic appliances watching football games at home(Carbon Trust, 2013). Despite the increasing importance of the GHG emissions from football, the related research agenda is scarce. Existing studies are few and have predominantly focused on specific football events (see, for instance, Collins *et al.* 2007; Dolles & Soderman, 2010), while the longitudinal investigation of the carbon footprint of entire football tournaments and specific football teams has never been conducted. This calls for a change as effective mitigation of the GHG emissions in sports is only feasible when the magnitude of the carbon footprint attributed to the major actors is known.

This paper contributes to knowledge by assessing the carbon footprint associated with travel patterns of football teams (players and staff), or active football participants, within a major national sports competition. It is seen as a step in developing more complex carbon assessments in football that should be more holistic and inclusive in nature. The study outlines a methodological framework for assessing the carbon footprint of football teams' travel.

2. ENVIRONMENTAL IMPACT ASSESSMENT OF FOOTBALL

Sport tourism is one of the fastest growing forms of tourism internationally (Okayasu *et al.*, 2010; Alexandris & Kaplanidou, 2014). This brings about substantial impacts, positive and negative (Gibson *et al*. 2012). According to Ritchie & Adair (2004), these impacts can be of five types: economic, social, environmental, legal and health-related. As opposed to the case of more generic research on sporting events, the research agenda on their specific impacts is less established (Thibault, 2009). Furthermore, existing studies have focused on the economic dimension of impacts of sporting events, while the social and environmental dimensions have largely been left aside (Kim & Petrick 2005). This is an important drawback (Mallen & Chard 2011) given that a balanced assessment of impacts is necessary to obtain a more holistic view and to develop more effective mitigation measures (Fredline *et al.* 2003).

Recently, there has been an increasing interest in understanding the environmental impacts of sports events, which is reflected in the growing number of studies conducted on this topic (IOC, 2004, 2006; Ecomass Programme, 2005; Wheeler & Nauright, 2006; Mallen *et al.*, 2010). However, the environmental concerns in football are fairly recent (FIFA, 2014; Pereira *et al.*, 2017). This is alarming given that football generates substantial environmental externalities attributed to excessive consumption of energy, significant amounts of water use and high levels of pollution (Collins *et al*., 2007; Carbon Trust, 2013; Miller, 2016). Despite the considerable environmental footprint of football, there is currently no single methodology to accurately assess its magnitude (FIFA, 2013) and the research agenda is restricted to a handful of studies conducted in the context of major and mega football events. These studies are highlighted below.

The first attempt to address the problem of excessive environmental impacts from football was made by FIFA during the 2006 Germany World Cup™. To this end, the Green Goal™ programme was developed to measure the environmental footprint of this event with a view of subsequent reduction (FIFA, 2006). The programme drew upon an earlier initiative of the International Olympic Committee, which had adopted the principles of sustainable development and applied them to the XVII Olympic Winter Games in Lillehammer, Norway, in 1994 (IOC, 2013). The Green Goal™ programme, later renamed as the Football for the Planet™ programme (FIFA, 2014), assessed the environmental implications of the Football World Cup in terms of energy and water use, transportation and waste generation (FIFA, 2006). According to FIFA (2013), this programme represented the first attempt to integrate the environmental management principles into the delivery of a mega football event, thus setting a new direction for international football. Hinch *et al.* (2016) point out that the 2006 FIFA World Cup Germany™ was exemplary in a way that it outlined a pathway towards the reduction of environmental impacts from football.

The principles of environmental management were further adopted by the organisers of the UEFA Euro 2008™ Cup in Austria & Switzerland and the FIFA World Cup 2010 in South Africa™ (UEFA Euro 2008; FIFA, 2010). The carbon footprint assessments conducted for the latter event indicated that the GHG emissions from the 2010 FIFA World Cup in South Africa grew nine-fold compared to the GHG emissions from the 2006 FIFA World Cup in Germany (McCarthy 2009). The largest share was attributed to international (64%) and domestic (18%) travel (Econ Pöyry AB 2009), thus emphasizing the urgency of carbon mitigation in football and outlining the key areas for mitigation intervention, i.e. travel. The Green Goal™ programme raised public awareness of the carbon implications of football mega events and contributed to the development of first measures for their reduction. For instance, for the 2011 FIFA U-20 World Cup in Colombia™, FIFA offset the 9,000 tonnes of GHG emissions generated during the event by planting an additional 35,000 trees in the Colombian Andes (FIFA, 2011). The most recent 2014 FIFA World Cup in Brazil™ produced accurate estimates of its GHG emissions, demonstrating that the main impact (84% or 2.7 million tonnes of CO_2-eq.) came from national and international travel (FIFA, 2013; Miller, 2016). For comparison, this is almost the amount of the carbon footprint generated by the entire nation of Malta in 2014 (Global Carbon Project-GCP, 2015). These FIFA efforts marked a milestone in the development of the environmental sustainability thinking in football as it moved from specific mega events, such as the FIFA Men's and Women's World Cups (OC, 2011), to particular continental and national football tournaments.

Although the environmental concerns highlighted by FIFA have been disseminated to the organisers of all major national football tournaments and their participants (football clubs), the latter have been slow in embracing the principles of environmental management and applying them to their operations (Jenkins, 2012). This is alarming given that national football competitions and specific football clubs are well positioned to not only reduce their environmental impacts, but also to educate their supporters, thus raising public awareness of the environmental footprint of football and highlighting the need for its mitigation. For example, selected German Bundesliga clubs have adopted a number of initiatives to tackle the problem of climate change (Reiche, 2013), ranging from the: promotion of public transportation with combined tickets to stadia and free use of public transport (all clubs, except one); solar energy generation on stadia roofs (five clubs); green electricity procurement (four clubs); adoption of the Environmental Management Systems (EMSs) in the stadia and club offices (10 clubs); and carbon offsetting (three clubs). In a similar way, the Fluminense Football Club in Brazil conducts regular monitoring of the GHG emissions attributed to its operations (Rodrigues Filho, 2016), finding that the largest contribution is made by the club's transportation activities, such as team travel to away games (Fluminense FC, 2014; Saporta *et al.*, 2016). Aside from these examples, an extensive analysis of the literature and corporate materials published online by the football clubs playing in major European and South American leagues has revealed no further evidence of the adoption of environmental sustainability thinking by the organisers of national football tournaments and their participants, i.e. football clubs.

In England, the sustainability implications of football have been acknowledged (Dickson & Arcodia, 2010; House of Lords 2013). Existing research has addressed a number of issues related to the societal (i.e. the health and fitness levels of football players) (Di Salvo *et al.*, 2009; Gregson *et al.*, 2010) and economic (i.e. marketing and revenue generation) (Chadwick & Clowes, 1998; Barros & Leach, 2006) dimensions of sustainability. However, the environmental dimension of English football and, especially, its carbon repercussions have not yet become an established research item (Hickman, 2011), with extant research being limited to a handful of studies that focus on specific, short-term and one-off, events. For example, Collins *et al*. (2007) assessed the environmental consequences of the FA Cup 2003/04 final and the Carbon Trust (2013) unveiled the carbon footprint of watching football during the FA Cup 2010/11. With a notable exception of Newcastle United FC, which is a self-proclaimed 'first carbon positive club in the world' (AOL-UK, 2012), the literature review and the analysis of corporate materials published by the English football clubs online has revealed no further evidence of the application of environmental sustainability thinking in the context of English football.

2.1. The English Premier League (EPL)

The EPL is a major professional football competition in England which was first organised by the Football Association (FA) in 1992 (Premier League, 2016). It consists of twenty clubs playing in an ‘all-play-all’ tournament where each club plays against opponents twice, at home and away, thus totalling 380 matches. The popularity of the EPL is substantial (House of Lords 2013) and it is estimated that circa 800,000 foreign tourists (or 40% of total international tourists in the UK) attended and/or watched its football matches in the 2014/2015 season (EY, 2015; Visit Britain, 2015). The EPL provides 103,354 jobs and generates £6.2 billion in economic outputs, thus contributing with approximately £3.4 billion, or 0.2%, to the national gross domestic product in 2013/14 (EY, 2015).

Besides significant domestic popularity, the international power of the EPL is also substantial. It is the third most important competition (Table 1) in the UEFA's league coefficients (UEFA, 2017). The EPL is also the third largest revenue generator of all sports leagues in the world and the first in football, right behind the two major North American sports leagues, i.e. the National Football League and the Major League Baseball (Harris, 2015). This makes the EPL clubs the richest in the world as, according to Delloite (2016), among the 30 football clubs with the highest global income in 2014/15, 17 were from EPL. Lastly, the EPL is the most-watched sports league in the world as it is broadcast in 175 countries to 645 million homes and holds a potential total TV audience of 4.7 billion people (Ebner, 2013; EY, 2015). The large scale of the EPL suggests that it should be considered a mega-event (Müller 2015).

Insert Table 1

Given the magnitude of the EPL football tournament, it is surprising that its carbon impacts have been neglected in terms of research. As an exception, the Carbon Trust (2013) assessed the GHG emissions from the FA Community Shield match between Manchester United and Wigan to find these to be equal to circa 5,160 tonnes of CO_2, with 5,000 tonnes, or 96.9%, arising from total travel (teams' plus fans' travel). This finding is in line with Collins *et al.* (2007) who identified travel as the largest contributor to the environmental footprint of the FA Cup matches in England. The substantial carbon impacts caused by transportation to/from EPL football games, coupled with a high international profile of the EPL, makes it an interesting research object for carbon footprint analysis.

3. METHOD

3.1. Data Collection and Distance Calculation

The subsequent analysis is based on the EPL participants (clubs) in the 2016/2017 season (Figure 1). First, the information on the participants' host cities, host stadia (and their capacity), and the nearest airport and train stations was compiled (Table 2). The calendar of matches in the 2016/2017 season was then checked (Premier League, 2017). The 18 playing rounds were analysed in order to identify the travel itineraries of clubs.

Insert Figure 1

Insert Table 2

As the literature review showed that travel accounts for the largest share of carbon footprint from sporting events, it was necessary to understand the travel patterns of the EPL teams. To this end, all 20 clubs were contacted within the period of October-November 2016. A self-completion questionnaire was developed and emailed to the clubs to collect the necessary data on the means of transportation and the type of accommodation used in their away games. A number of football clubs refused to participate in the survey due to alleged confidentiality of the data requested. However, the data obtained from the remaining willing clubs allowed generalisations to be made to establish the travel and accommodation patterns across the sample.

Three means of transportation indicated by the clubs were considered in this study: coach, train and airplane. Among these, coach was preferred for short-distance trips due to low cost, flexibility and an opportunity to establish a particular travel itinerary. Train was preferred for medium-haul and long-haul journeys, while airplane was preferred for long-haul trips. To get to an airport and/or a train station, the EPL clubs make use of coach and this additional travel was also considered. Here, the individual trips of club players and staff, by private car or taxi, from their teams to their residences, or in the opposite direction, were excluded due to data availability.

The maximum travel distance identified in this study as suitable for the use of coach was 257.49 km such as, for example, the distance travelled by Bournemouth FC to Swansea. This maximum distance is covered in approximately three hours, depending on traffic conditions, and does not cause discomfort for players. Distances greater than 257.49 km are served by commercial flights. The maximum distance identified for train travel was 344 km, which can be covered in approximately three and a half hours. Travel by train offers less flexibility compared to coach and is therefore less preferred by the EPL teams. Train is however utilised by the EPL clubs based outside London when travelling to and from London. This is because coach trips to London can be unreliable due to the unpredictability of local traffic conditions. The London-based EPL clubs make use of train when attending away games in a direct proximity to London for the same reason. Longer distances are covered by airplane, which is partially due to the issue of comfort and, partially, for the sake of team security. For distance calculations, the following sources were used: RailMiles (2016) for train; Travelmath (2016) for airplane; and AA (2016) for coach trips. The start/finish point for all journeys was assumed to be in the centre of an EPL club's home town. The EPL clubs choose overnight accommodation for the away games if a one-way travel distance exceeds 64.37 km.

The size of a travel delegation considered for the GHG emissions from transportation of the EPL clubs was determined from the information available in the public domain as well as provided by the teams (Table 2). According to the EPL regulations, each team can nominate 11 regular players and 7 reserves for each match (Premier League, 2017). The number of support staff in trips varies from team to team. The size of a support delegation for the Leicester City Football Club (LCFC) was used as a proxy (Table 3). Thus, an average size of a travel party for an EPL team was calculated to consist of 39 members. This is close to an average of 45 members per travel delegation utilised by CO2ZERO (2012) to assess the carbon footprint of football team travelling to partake in the FIFA World Cup 2014^{TM} in Brazil.

Insert Table 3

3.2. The Carbon Footprint Assessment Method

The carbon footprint assessment method developed by the UK's Department of the Environment, Food and Rural Affairs (DEFRA) was used. This is one of the most established tools to assess the carbon footprint from various industrial and transport processes in the UK (DEFRA, 2016) which justifies its choice for this study. DEFRA assesses the magnitude of carbon footprint in kilograms of carbon dioxide equivalents (kg CO_2-eq). This is an official unit of carbon footprint estimates as prescribed by the Intergovernmental Panel on Climate Change (IPCC, 2007). The unique feature of the method by DEFRA is in that it is capable of estimating not only the 'direct', but also some of the 'indirect' carbon impacts, such as those arising from fuel chain (DEFRA, 2015a). The 'indirect' GHG emissions, such as those associated with capital goods and infrastructure, are excluded from the DEFRA's analysis which can be seen as a drawback of this method (DEFRA, 2015b).

The carbon intensity of accommodation for away games was derived from the literature as DEFRA does not provide these data. It was assumed that the EPL clubs stay in upmarket and luxury hotels due to the superior levels of comfort they provide. Thus, the value of 34.32 kg CO_2-eq. per guest night proposed by CarbonNeutral Company (2008 cited Chenoweth 2009), for UK luxury hotels was used.

The training, leisure and catering activities carried out by the EPL clubs at a destination were disregarded. This is because all EPL clubs reported these to be short and insignificant. This is further due to the fact that leisure activities hold a small share, at around 3-5%, in the total carbon footprint of tourism (UNWTO, 2007), while their assessment is problematic due to data availability and systematisation (Becken & Simmons, 2002). The exclusion of the leisure activities is, therefore, deemed feasible and yet it is acknowledged as one of the shortcomings of the analysis. Table 4 presents the carbon intensity coefficients used in this study.

Insert Table 4

The carbon footprint of the trips was calculated by multiplying the distances travelled (by the different means of transportation) by the average number of participants of each football team (39 people), as well as by the coefficients presented in Table 4. Likewise, for the carbon footprint of accommodation, the size of the teams was multiplied by the number of hotel nights in away games, by the value of 34.32 kg CO_2-eq. per guest night, as per above.

4. RESULTS

The analysis shows that air travel (102,605 km) was the most widespread means of transportation by the EPL clubs (Table 5). The largest air distance travelled (475 km) was between the cities of Bournemouth (AFC Bournemouth) and Newcastle upon Tyne (nearest airport to Sunderland AFC). However, the team that used it the most was Swansea City AFC (for 17 away matches). Train represented the least used means of transportation, with the eight clubs based in the north of England and in Wales not using it at all. Coach is the second most popular mode of travel and, yet, it has only been used twice by AFC Bournemouth and Swansea City AFC.

Insert Table 5

The EPL clubs travelled the total distance of 181,791 km in the season 2016/17, having produced 695,452 kg CO_2-eq. (Figure 2), with 589.638 kg CO_2-eq. or about 85% arising from air travel. Air travel is the largest generator of carbon impacts in tourism (Becken, 2001; Peeters *et al.*, 2006; Hanandeh, 2013; Farley *et al*., 2017), which is further confirmed herewith (5.75 kg CO_2-eq per km travelled). Travel by train (21,950 km) produced 41,818 kg CO_2-eq. (or 1.91 kg CO_2-eq per km travelled) while travel by coach (57,236 km) generated 63,996 kg CO_2-eq. (or 1.12 kg CO_2-eq per km travelled) making it more efficient in carbon terms, which is in line with the literature (Zachariadis & Kouvaritakis, 2003; Brand & Boardman 2008; Filimonau *et al*., 2013). Travel by coach is therefore the best option in climate terms. It is comfortable and flexible means of transportation whose major drawback is in its dependence on traffic conditions, especially when driving in major metropolitan areas, such as London, Liverpool and Manchester. For trips to these metropolitan areas, train represents a viable and more carbon-efficient alternative.

Insert Figure 2

The transportation element holds the largest share (about 61.3%) in the GHG emissions attributed to EPL club travel (Figure 2). The contribution of accommodation is lower (about 38.7%) and yet considerable, predominantly due to the stay in upmarket and luxury accommodation facilities that are more carbon intense compared to budget hotels (Filimonau *et al.*, 2011). Table 5 shows that, on average, each club has 16 overnight hotel stays which is equivalent to the carbon footprint of 21,951 kg CO_2-eq. per club. However, for four clubs (Burnley FC, Leicester City FC, Stoke City FC and West Bromwich Albion FC) the carbon footprint from accommodation is larger than the cumulative GHG emissions from transportation. This carbon footprint can be reduced if the EPL clubs make use of budget hotels. This is deemed appropriate given that, according to the data supplied by the clubs, they do not benefit from the use of the luxury hotels' facilities (such as spas) due to a short term of their overnight stay. The variety of facilities and functions available 24 hours a day in luxury hotels are the key contributors to their high energy consumption and associated GHG emissions (Deng, 2003; Khemiri & Hassairi, 2005, Filimonau *et al.*, 2011).

Figure 2 shows that the EPL clubs generate 56,724 kg CO_2-eq. on average, with the Hull City AFC being the most representative team in this regard. The geographical origin of the clubs participating in the EPL affects the magnitude of their carbon footprint, i.e. the teams located remotely and/or farther from the centre of England, such as Sunderland AFC, produce more GHG emissions. The central location of West Bromwich Albion FC (Figure 1) determines its low carbon footprint which is equivalent to the total GHG emissions from train travel made by all EPL teams (Figure 2).

The total carbon footprint attributed to EPL club travel in the season 2016/17 is 1,134,477 kg CO_2-eq or 29,089.15 kg CO_2-eq per member of delegation. This is equivalent to 483,230 litters of petrol consumed or 240 passenger vehicles driven for one year or 4,375,727 km driven by an average passenger vehicle; this is also equivalent to 109 laps made around the Earth by car (EPA, 2016).

5. DISCUSSION

Given the disproportionally high share of air travel in the total carbon footprint of EPL club travel, this transportation mode represents a major mitigation opportunity. Playing games at ‘neutral’ stadia has the potential to reduce the carbon footprint of EPL clubs which is illustrated on the basis of the Southampton FC versus Hull City AFC away game example. Using the method from this study, return travel from Southampton to Hull would involve 80.5 km by coach (90 kg CO_2-eq.), 602 km by airplane (3459.48 kg CO_2-eq.) and one overnight hotel stay (454.35 kg CO_2-eq.). Local travel from the Hull City AFC to its stadium would add 8.64 kg CO_2-eq. to this number, thus totalling 4,012.47kg CO_2-eq. However, if this match was played at the Hawthorns Stadium of the West Bromwich Albion FC, a stadium of equal capacity (Table 2) but located midway for both clubs, the carbon footprint would be reduced by 51.35% to 1,952.38 kg CO_2-eq. There would be no need for air travel and the two clubs would travel by coach, covering a total of 933.42 km and generating 1,043.68 kg CO_2-eq. The remaining carbon footprint would arise from hotel stay which would increase in this specific case given that both clubs would need to stay in West Bromwich overnight. In the case of a ‘neutral’ stadium, the carbon footprint of hotels tends to increase because, in this case, both clubs will play away from home. However, since the reduction in carbon footprint of transportation is considerable, this option can be considered feasible. The concern with the location of stadia is in agreement with Triantafyllidis *et al.* (2018) who show correlation between carbon dioxide emissions and location of football facilities. This reduction is due to the choice of the new means of transportation to reach the stadia as in the example of the EPL clubs above. In the long-term perspective, another mitigation option might rest in the use of aviation biofuels (IATA, 2013). The British Airways (BA) operate the majority of domestic flights in the UK (Morris, 2016) and are a preferred carrier for most EPL clubs. The BA are one of the many airlines trialling aviation biofuels (Stecker *et al.* 2014). Procurement policies of the EPL clubs can be amended in a way that, in the future, air travel services provided by the BA for away games should be operated on biofuel-driven flights.

Same also holds true when devising carbon mitigation strategies for hotel accommodation. The EPL clubs should strive to stay in hotels that have implemented sound GHG emission reduction measures (Chou, 2014; Chan & Ho, 2006). The 'green' procurement strategies adopted and regularly monitored by the EPL clubs can lead to hotel competition in the UK, i.e. where accommodation providers would compete with each other for the right to host football clubs. The EPL clubs would then use the 'green' or climatic credentials of hotels as one of the major selection criteria for contracting. The importance of collaboration between event organisers is relevant in behavioural intentions, that is, in the satisfaction of technical committees, as highlighted by Kaplanidou & Gibson (2010).

The potential for mitigation of the carbon footprint from travel of the EPL clubs should be examined in future research work, especially from the viewpoint of economic viability. It needs to be checked whether the measures proposed increase costs and therefore become unviable from the club's management perspective. Identifying the mitigation costs is still a difficult task, but academic interest to this subject area has been growing (Deegan, 2002; Gray *et al*., 1995). Definition of the mitigation costs is a way to achieve a better environmental quality so that everyone can identify more clearly the policy adopted by their managers (Burnett & Hansen, 2008).

At a time when public and private agencies recognise the importance of sustainable development, the environmental impacts of mega sporting events are commanding increasing attention (Collins *et al.*, 2009). Hence, the findings of this study have important implications for EPL club managers and UK transportation and environmental policy makers. Sports tourism events, such as the national football tournament in England, have large audiences and a high public profile. The sustainability commitments of the EPL clubs should be reinforced and monitored to ensure they stay up-to-date. They should further be broadcast to the public to raise public awareness about the environmental footprint attached to football. A comparative analysis of EPL and other national football competitions is necessary to facilitate the exchange of information and know-how across the countries (Thibault, 2009). This is because the different views of the same problem can stimulate more effective search for viable solutions on a common basis and account for political and cultural differences (Collins *et al.*, 2007).

6. LIMITATIONS AND FUTURE RESEARCH

This research had a number of limitations that should be addressed in the future work:

Football clubs should facilitate research on carbon intensity of football by publicly disclosing information on their travel itineraries and collaborating more closely with academics. Since, for the accomplishment of this work there was a great difficulty to obtain information of the clubs. Since they reported that the information on transportation and lodging were confidential and for the safety of the players. Concerns about this theme should be part of the scope of each football club. Increasingly, there is a great concern about the "sustainability" in institutions.

This study focused on the GHG emissions from EPL club travel, thus excluding the ‘indirect’ carbon footprint attributed to club administrative and support workers, operation of stadia, journalists and, most importantly, the public (namely the club supporters who regularly attend the home and away games of their favourite clubs, and the club amateurs who follow the games on TV and via any other means of technology). Future research should be developed encompassing all components of the national football tournaments, i.e. EPL club travel, their administration and management, travel of supporters and all the ‘indirect’ activities attributed to following the football games online as well as offline. In particular, the carbon footprint of the club supporters should be accounted for if the future assessments of GHG emissions from football are to be made comprehensive. This is because the 2015/16 EPL season had the total audience of 13,851,698 people (ESPN FC, 2016) implying significant impacts attributed to travel to support the EPL games and watch these on TV. Indeed, the football amateurs or the ‘passive public’, according to Gibson (2003), increase the carbon intensity of football substantially. For example, the Carbon Trust (2013) attempted to estimate the GHG emissions arising from watching football games on the different types of media and demonstrated that the carbon figures are high but difficult to assess. This carbon footprint should be a priority topic for future research.

The next step towards more holistic assessments of carbon footprint from football should, thus, involve a better understanding of the travel and football watching habits of football club supporters. This information can be collated by the EPL clubs to aid in developing more effective marketing strategies and using the data collected for the design of carbon mitigation measures.

7. CONCLUSIONS

This study assessed the carbon footprint of travel attributed to the clubs of EPL, one of the most important national football tournaments in the world. It showed that:

1) The choice of travel means by club management greatly affected the GHG emissions from club travel, thus outlining opportunities for mitigation.

2) Aside from reducing the frequency of air travel, the study demonstrated that the choice of stadia and overnight accommodation can affect the carbon footprint of the EPL clubs.

3) This suggests that the ‘green procurement’ strategies need to be adopted by club management when selecting stadia locations and accommodation suppliers.

4) Development of effective carbon mitigation measures is important in the football context, not only because this sport is growing in popularity while producing the disproportionally significant GHG emissions, but also because it has a high public profile. This implies that the sustainability interventions adopted by the EPL clubs will not go unnoticed, thus raising consumer awareness about the carbon intensity of football and, possibly, enhancing more responsible day-to-day consumer behaviour.

5) The leadership of the EPL clubs in environmental sustainability matters could attract sponsors that appreciate and share their corporate sustainability values. Policy-makers can further facilitate these sustainability commitments of the EPL clubs by offering tax incentives and subsidies for the implementation of the ‘green’ solutions at their stadia and during their travel.

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Abstract

Football is the most popular sport, globally and in the United Kingdom. However it generates a range of negative environmental impacts, such as climate change, due to the extensive amount of travel involved. The growing contribution of football clubs to the global carbon footprint has been recognised but never consistently assessed. This study assesses the carbon footprint of the English Premier League (EPL) clubs, using the patterns of their domestic travel in the 2016/2017 season as a proxy for analysis. The study shows that, within the 2016/17 season, the EPL clubs produced circa 1134 tonnes of CO_{2}-eq. as a result of their travel, where transportation accounts for 61% of the carbon footprint. To reduce this carbon footprint, a careful review of the current corporate travel and procurement practices in the EPL clubs is necessary. This is in order to optimise the travel itineraries, prioritise more climate-benign modes of transport and contract budget accommodation providers with the 'green' credentials.

Keywords: Carbon footprint; Transportation; Sporting events; Football; English Premier League.

3. INTRODUCTION

Global warming is responsible for climate change and, consequently, for the most varied impacts in the world (Pielke *et al*., 2007; Klein, 2011). Mitigating the consequences of climate change to reverse this scenario is one of the most significant challenges in today's society. The major challenge is the intensification of greenhouse gas (GHG) emissions from sources such as tourism (Abegg *et al*., 2007; Nemry & Demirel, 2012) and sporting events (Pereira *et al*., 2017). Its containment is an indispensable task, imposing the need to create and implement mitigation and adaptation measures (Enríquez-de-Salamanca *et al*., 2017). In this last paper, the authors review the literature to reveal the relationship between climate change and environmental impacts in order to avoid GHG.

In the specific case of sporting events these play an important role in the modern society (Gibson 1998) and their potential to boost the local economy, enhance subjective well-being of the public, facilitate tourism's growth and improve regional development is well recognised (UNEP, 2012). Kirkup & Sutherland (2015) highlight the expansion of major sporting events in recent years. Characteristics of the host destination are equally important (Agha & Taks, 2015). As a result, the opportunities and challenges attributed to hosting sporting events in specific destinations have been repeatedly scrutinised (Getz, 1997; Weed & Bull, 2004; Collins *et al*. 2007; 2009; 2012). Due to their size and extensive media coverage, major and mega sporting events have become an object of prime investigation (Müller, 2015), as demonstrated by research on the *Fédération Internationale de Football Association*-FIFA World Cups™ (Kim & Petrick, 2005; Preuss, 2007; Du Plessis & Maennig, 2011; Korstanje *et al*., 2014) and the Olympic Games (Solberg & Preuss, 2007; Gratton & Preuss, 2008; Kaplanidou & Karadakis, 2010; Kaplanidou, 2012; Leopkey & Parent, 2012).

Sport tourism is one of the fastest growing forms of tourism internationally industry (Okayasu *et al.*, 2010; Alexandris & Kaplanidou, 2014). According to Gibson *et al*. (2012), the size of sporting events has great influence on the sustainability of tourism, since small-scale events are more successful. The on-going growth of sporting events brings about substantial impacts, positive and negative. According to Ritchie & Adair (2004), these impacts can be of five types: economic, social, environmental, legal and health-related. As opposed to the case of more generic research on sporting events, the research agenda on their specific impacts is less established (Thibault, 2009). Furthermore, existing studies have focused on the economic dimension of impacts of sporting events, while the social and environmental dimensions have largely been left aside (Kim & Petrick 2005). This is an important drawback (Mallen & Chard 2011) given that a balanced assessment of impacts is necessary to obtain a more holistic view and to develop more effective mitigation measures (Fredline *et al.* 2003).

Environmental impacts represent an issue of particular concern for the destinations that host large-scale sporting events (Higham, 2005; Taks, 2013; McCool, 2015). Even the location of the infrastructure (airports, stadiums, hotel complexes, etc.) has a major impact (Triantafyllidis *et al*., 2018). At these destinations, environmental impacts are particularly pronounced in the case of greenhouse gas (GHG) emissions as these are substantial for sports (Manfredi *et al*., 2009). Despite the importance of mitigating the GHG emissions of sporting events, the related research agenda on carbon footprint assessment is under-developed (Schianetz *et al.* 2007). It is, however, paramount to address the critical issues associated with the ways in which sporting events and tourism interact with the environment to ensure the sustainability of sports (Hinch *et al*., 2016). Thus, the agents involved with events have a great responsibility for their development and management processes, as well as in the evaluation of the context in which this evaluation takes place (Giannoulakis *et al*., 2017). The destinations hosting sport events should encourage event attendees to adopt pro-environmental behaviours (Han *et al*., 2015). Behaviour that consciously seeks to minimize the negative impact on the natural and built world.

However, the quest of sporting events towards the goal of environmental sustainability is hindered by the marketing decisions of sporting event organisers and by the way the sporting events are managed. For example, the National Collegiate Athletics Association (NCAA) Division I athletic conferences have recently undergone conference realignments. The expanding geographic footprint of these conferences throughout the United States has led to teams having increased travel distances for all sports, especially American football (Farley *et al*., 2017). This is further exemplified by the case of the Super RugbY™ cup, whose managers have recently decided to expand the number of participating countries (Hinch *et al.* 2016). While the socio-economic benefits have risen sharply as a result of this decision, so have the GHG emissions attributed to the increased international travel of the participating sporting teams (Kruger, 2015). Travel is one of the main concerns of the tourism sector, since the main function of transportation in the tourism system is to take tourists from the regions of origin to the regions of destination (Robbins, 2003). In the case of the Super RugbY™ cup, this emphasises the point raised by Thibault (2009), who states that the GHG emissions from sports activities are immense and long-term but, for the most part, they go unnoticed in pursuit of short-term financial gains.

Among the different branches of sports, the problem of GHG emissions is particularly attributed to football (known as soccer in the USA). Football is the most popular sport globally, with an estimated 3.5 billion base of worldwide supporters (Wood, 2017). This popularity determines the disproportionally high, and yet growing, carbon intensity of football (Carbon

Trust, 2013). That is, the total amount of GHG emissions caused directly and indirectly by a football match /championship. Directly are considered, for example, the emissions resulting from the displacement of fans and teams, the energy used in the stadiums; and, indirectly, can be considered people who are watching football games at home, or even watching by mobile applications, etc (Carbon Trust, 2013). Despite the increasing importance of the GHG emissions from football, the research agenda on carbon mitigation in this branch of sports is scarce. Existing studies are few and have predominantly focused on specific football events (see, for instance, Collins *et al.* 2007; Dolles & Soderman, 2010), while the longitudinal investigation of the carbon footprint of entire football tournaments and specific football teams has never been conducted. This calls for a change as effective mitigation of the GHG emissions in sports is only feasible when the magnitude of the carbon footprint attributed to the major actors is known.

This paper contributes to knowledge by assessing the carbon footprint associated with football teams travel, active participants, within a major national sports competition. It is seen as a step in developing more complex carbon assessments in football that should be more holistic and inclusive in nature. The study outlines a methodological framework for assessing the carbon footprint attributed to football teams travel (players and staff).

4. ENVIRONMENTAL IMPACT ASSESSMENT OF FOOTBALL

Recently, there has been an increasing interest in understanding the environmental impacts of sports events, which is reflected in the growing number of studies conducted on this topic (IOC, 2004, 2006; Ecomass Programme, 2005; Wheeler & Nauright, 2006; Mallen *et al.*, 2010). However, the environmental concerns in football are fairly recent (FIFA, 2014; Pereira *et al.*, 2017). This is alarming given that football generates substantial environmental externalities attributed to excessive consumption of energy, significant amounts of water use and high levels of pollution (Collins *et al*., 2007; Carbon Trust, 2013; Miller, 2016). Despite the considerable environmental footprint of football, there is currently no single methodology to accurately assess its magnitude (FIFA, 2013) and the research agenda is restricted to a handful of studies conducted in the context of major and mega football events. These studies are highlighted below.

The first attempt to address the problem of excessive environmental impacts from football was made by FIFA during the 2006 Germany World Cup™. To this end, the Green Goal™ programme was developed to measure the environmental footprint of this event with a view of subsequent reduction (FIFA, 2006). The programme drew upon an earlier initiative of the International Olympic Committee which had adopted the principles of sustainable development and applied them to the XVII Olympic Winter Games in Lillehammer, Norway, in 1994 (IOC, 2013). The Green Goal™ programme, later renamed as the Football for the Planet™ programme (FIFA, 2014), assessed the environmental implications of the Football World Cup in terms of energy and water use, transportation and waste generation (FIFA, 2006). According to FIFA (2013), this programme represented the first attempt to integrate the environmental management principles into the delivery of a mega football event, thus setting a new direction for international football. Hinch *et al.* (2016) point out that the 2006 FIFA World Cup Germany™ was exemplary in a way that it outlined a pathway towards the reduction of environmental impacts from football.

The principles of environmental management were further adopted by the organisers of the UEFA Euro 2008™ Cup in Austria & Switzerland and the FIFA World Cup 2010 in South Africa™ (UEFA Euro 2008; FIFA, 2010). Carbon footprint assessments conducted for the latter event have shown that the GHG emissions from the 2010 FIFA World Cup in South Africa grew nine-fold compared to the GHG emissions from the 2006 FIFA World Cup in Germany (McCarthy 2009). The largest share was attributed to international (64%) and domestic (18%) travel (Econ Pöyry AB 2009), thus emphasizing the urgency of carbon mitigation in football and outlining the key areas for mitigation intervention, i.e. travel. The Green Goal™ programme raised public awareness of the carbon implications of football mega events and contributed to the development of first measures for their reduction. For instance, for the 2011 FIFA U-20 World Cup in Colombia™, FIFA offset the 9,000 tonnes of GHG emissions generated during the event by planting an additional 35,000 trees in the Colombian Andes (FIFA, 2011). The most recent 2014 FIFA World Cup in Brazil™ generated accurate estimates of its GHG emissions, demonstrating that the main impact (84% or 2.7 million tonnes of CO_2-eq.) arose from national and international travel (FIFA, 2013; Miller, 2016). For comparison, this is almost the amount of the carbon footprint generated by the entire nation of Malta in 2014 (Global Carbon Project-GCP, 2015). These FIFA efforts marked a milestone in the development of the environmental sustainability thinking in football as it expanded and started to advance from specific mega events, such as the FIFA Men's and Women's World Cups (OC, 2011), to particular continental and national football tournaments.

Although the environmental concerns highlighted by FIFA have been disseminated to the organisers of the major national football tournaments and their participants (football clubs), the latter have been slow in embracing the principles of environmental management and applying them to their operations (Jenkins, 2012). This is alarming given that national football competitions and specific football clubs are well positioned to not only reduce their environmental impacts but also to educate their supporters, thus raising public awareness of the environmental footprint of football and highlighting the need for its mitigation. For example, selected German Bundesliga clubs have adopted a number of initiatives to tackle the problem of climate change (Reiche, 2013), ranging from: promotion of public transportation with combined tickets for stadia and free use of public transport (all clubs, except one); solar energy generation on the stadia roofs (five clubs); green electricity procurement (four clubs); adoption of the Environmental Management Systems (EMSs) in the stadia and club offices (10 clubs); and carbon offsetting (three clubs). In a similar way, the Fluminense Football Club in Brazil conducts regular monitoring of the GHG emissions attributed to its operations (Rodrigues Filho, 2016), finding that the largest contribution is made by the club's transportation activities, such as team travel to the away games (Fluminense FC, 2014; Saporta *et al.*, 2016). Aside from these examples, an extensive analysis of the literature and corporate materials published online by the football clubs playing in major European and South American leagues has revealed no further evidence of the adoption of environmental sustainability thinking by the organisers of national football tournaments and their participants, i.e. football clubs.

In England, the sustainability implications of football have been acknowledged (Dickson & Arcodia, 2010; House of Lords 2013). Existing research has addressed a number of issues related to the societal (i.e. the health and fitness levels of football players) (Di Salvo *et al*., 2009; Gregson *et al*., 2010) and economic (i.e. marketing and revenue generation) (Chadwick & Clowes, 1998; Barros & Leach, 2006) dimensions of sustainability. However, the environmental dimension of English football and, especially, its carbon repercussions have not yet become an established research item (Hickman, 2011), with extant research efforts being limited to a handful of studies that focus on specific, short-term and one-off events. For example, Collins *et al*. (2007) assessed the environmental consequences of the FA Cup 2003/04 final and the Carbon Trust (2013) unveiled the carbon footprint of watching football during the FA Cup 2010/11.

With a notable exception of Newcastle United FC, which is a self-proclaimed ‘first carbon positive club in the world’ according to its management (AOL-UK, 2012), the literature review and the analysis of corporate materials published by the English football clubs online has revealed no further evidence of the application of environmental sustainability thinking in the context of English football.

2.1. The English Premier League (EPL)

The EPL is a major professional football competition in England which was first organised by the Football Association (FA) in 1992 (Premier League, 2016). It consists of twenty clubs playing in an ‘all-play-all’ tournament where each club plays against opponents twice, at home and away, thus totalling 380 matches. The popularity of the EPL is substantial (House of Lords 2013) and it is estimated that circa 800,000 foreign tourists (or 40% of total international tourists in the UK) attended and/or watched its football matches in the 2014/2015 season (EY, 2015; Visit Britain, 2015). The EPL provides 103,354 jobs and generates £6.2 billion in economic outputs, thus contributing with approximately £3.4 billion or 0.2% to the national gross domestic product in 2013/14 (EY, 2015).

Besides the significant domestic popularity, the international power of the EPL is also substantial. It is the third most important competition (Table 1) in UEFA's league coefficients (UEFA, 2017). The EPL is also the third largest revenue generator of all sports leagues in the world and the first in football, right behind the two major North American sports leagues, i.e. the National Football League and the Major League Baseball (Harris, 2015). This makes the EPL clubs the richest in the world as, according to Delloite (2016), among the 30 football clubs with the highest global income in 2014/15, 17 were from EPL. Lastly, the EPL is the most-watched sports league in the world as it is broadcast in 175 countries to 645 million homes and holds a potential total TV audience of 4.7 billion people (Ebner, 2013; EY, 2015). The large scale of the EPL suggests that it should be considered a mega-event (Müller 2015).

Insert Table 1

Given the magnitude of the EPL football tournament, it is surprising that its carbon impacts have been neglected in terms of research. As an exception, the Carbon Trust (2013) assessed the GHG emissions from the FA Community Shield match between Manchester United and Wigan to find these to be equal to circa 5,160 tonnes of CO_2, with 5,000 tonnes, or 96.9%, arising from total travel (teams + fans travel). This finding is in line with Collins *et al.* (2007) who identified travel as the largest contributor to the environmental footprint of the FA Cup matches in England. The substantial carbon impacts caused by transportation to/from EPL football games, coupled with the high international profile of the EPL, makes it an interesting research object for carbon footprint analysis.

3. METHOD

3.1. Data Collection and Distance Calculation

The subsequent analysis is based on the EPL participants (clubs) in the 2016/2017 season (Figure 1). First, the information on the participants' host cities, host stadia (and their capacity), and the nearest airport and train stations was compiled (Table 2). The calendar of matches in the 2016/2017 season was then checked (Premier League, 2017). The 18 playing rounds were analysed in order to identify the travel itineraries of clubs.

Insert Figure 1

Insert Table 2

As the literature review showed that travel accounts for the largest share of carbon footprint from sporting events, it was necessary to understand the travel patterns of the EPL teams. To this end, all 20 clubs were contacted within the period of October-November 2016. A self-completion questionnaire was developed and emailed to the clubs to collect the necessary data on the means of transportation and the type of accommodation used in their away games. A number of football clubs refused to participate in the survey due to alleged confidentiality of the data requested. However, the data obtained from the remaining willing clubs allowed generalisations to be made to establish the travel and accommodation patterns across the sample.

Three means of transportation indicated by the clubs were considered in this study: coach, train and airplane. Among these, coach was preferred for short-distance trips due to low cost, flexibility and the opportunity to establish a particular travel itinerary. Train was preferred for medium-haul and long-haul journeys, while airplane was preferred for long-haul trips. To get to an airport and/or a train station, the EPL clubs make use of coach and this additional travel was also considered. Here, the individual trips of club players and staff, by private car or taxi, from their teams to their residences, or in the opposite direction, were excluded due to data availability.

The maximum travel distance identified in this study as suitable for the use of coach was 257.49 km such as, for example, the distance travelled by Bournemouth FC to Swansea. This maximum distance is covered in approximately three hours, depending on traffic conditions, and does not cause discomfort for players. Distances greater than 257.49 km are covered by commercial flights. The maximum distance identified for train travel was 344 km, which can be covered in approximately three and a half hours. Travel by train offers less flexibility compared to coach and is therefore less preferred by the EPL teams. Train is however utilised by the EPL clubs based outside London when travelling to and from London. This is because coach trips to London can be unreliable due to the unpredictability of city's traffic conditions. The London-based EPL clubs make use of train when attending the away games in the direct proximity to London for the same reason. Longer distances are covered by airplane which is partially due to the issue of comfort and, partially, for the sake of team security. For distance calculations, the following sources were used: RailMiles (2016) for train; Travelmath (2016) for airplane; and AA (2016) for coach trips. The start/finish point for all journeys was assumed to be in the centre of an EPL club's home town. The EPL clubs choose overnight accommodation for the away games if a one-way travel distance exceeds 64.37 km.

The size of a travel delegation considered for the GHG emissions from transportation of the EPL clubs was determined from the information available in the public domain as well as provided by the teams (Table 2). According to the EPL regulations, each team can nominate 11 regular players and 7 reserves for each match (Premier League, 2017). The number of support staff in trips varies from team to team. The size of a support delegation for the Leicester City Football Club (LCFC) was used as a proxy (Table 3). Thus, an average size of a travel party for an EPL team was calculated to consist of 39 members. This is close to an average of 45 members per travel delegation utilised by CO2ZERO (2012) to assess the carbon footprint of football team travelling to partake in the FIFA World Cup 2014™ in Brazil.

Insert Table 3

3.2. The Carbon Footprint Assessment Method

The carbon footprint assessment method developed by the UK's Department of the Environment, Food and Rural Affairs (DEFRA) was used. This is one of the most established tools to assess the carbon footprint from various industrial and transport processes in the UK (DEFRA, 2016) which justifies its choice for this study. DEFRA assesses the magnitude of carbon footprint in kilograms of carbon dioxide equivalent (kg CO_2-eq). This is an official unit of carbon footprint estimates as prescribed by the Intergovernmental Panel on Climate Change (IPCC, 2007). The unique feature of the method by DEFRA is in that it is capable of estimating not only the 'direct', but also some of the 'indirect' carbon impacts, such as those arising from the fuel chain (DEFRA, 2015a). The 'indirect' GHG emissions, such as those associated with the capital goods and infrastructure, are excluded from the DEFRA analysis which can be seen as a drawback of this method (DEFRA, 2015b).

The carbon intensity of accommodation for the away games was derived from the literature as DEFRA does not provide these data. It was assumed that the EPL clubs stay in upmarket and luxury hotels due to the superior levels of comfort they provide. Thus, the value of 34.32 kg CO_2-eq. per guest night proposed by CarbonNeutral Company (2008 cited Chenoweth 2009), for UK luxury hotels was used.

The training, leisure and catering activities carried out by the EPL clubs at a destination were disregarded. This is because all EPL clubs reported these to be short and insignificant. This is further due to the fact that leisure activities hold a small share, at around 3-5%, in the total carbon footprint of tourism (UNWTO, 2007), while their assessment is problematic due to data availability and systematisation (Becken & Simmons, 2002). The exclusion of the leisure activities is, therefore, deemed feasible and yet it is acknowledged as one of the shortcomings of the analysis. Table 4 presents the carbon intensity coefficients used in this study.

Insert Table 4

The carbon footprint of the trips was calculated by multiplying the distances travelled (by the different means of transportation) by the average number of participants of each football team (39 people), as well as by the coefficients presented in Table 4. Likewise, for the carbon footprint of accommodation, the size of the teams was multiplied by the number of hotel nights in away games, by the value of 34.32 kg CO_2-eq. per guest night, as per above.

4. RESULTS

The analysis shows that air travel (102,605 km) was the most widespread means of transportation by the EPL clubs (Table 5). The largest air distance travelled (475 km) was between the cities of Bournemouth (AFC Bournemouth) and Newcastle upon Tyne (nearest airport to Sunderland AFC). However, the team that used it the most was Swansea City AFC (for 17 away matches). Train represented the least used means of transportation with the eight clubs, based in the north of England and in Wales, not using it at all. Coach is the second most popular mode of travel and, yet, it has only been used twice by AFC Bournemouth and Swansea City AFC.

Insert Table 5

The EPL clubs travelled the total distance of 181,791 km in the season 2016/17, having produced 695,452 kg CO_2-eq. (Figure 2), with 589.638 kg CO_2-eq. or about 85% arising from air travel. Air travel is the largest generator of carbon impacts in tourism (Becken, 2001; Peeters *et al.*, 2006; Hanandeh, 2013; Farley *et al*., 2017), which is further confirmed herewith (5.75 kg CO_2-eq per km travelled). Travel by train (21,950 km) produced 41,818 kg CO_2-eq. (or 1.91 kg CO_2-eq per km travelled) while travel by coach (57,236 km) generated 63,996 kg CO_2-eq. (or 1.12 kg CO_2-eq per km travelled) making it more efficient in carbon terms, which is in line with the literature (Zachariadis & Kouvaritakis, 2003; Brand & Boardman 2008; Filimonau *et al*., 2013). Travel by coach is therefore the best option in climate terms. It is a comfortable and flexible means of transportation whose major drawback is in its dependence on traffic conditions, especially when driving in major metropolitan areas, such as London, Liverpool and Manchester. For trips to these metropolitan areas, train represents a viable and more carbon-efficient alternative.

Insert Figure 2

The transportation element holds the largest share (about 61.3%) in the GHG emissions attributed to EPL club travel (Figure 2). The contribution of accommodation is lower (about 38.7%) and yet considerable, predominantly due to the stay in upmarket and luxury accommodation facilities that are more carbon intense compared to budget hotels (Filimonau *et al.*, 2011). Table 5 shows that, on average, each club has 16 overnight hotel stays which is equivalent to the carbon footprint of 21,951 kg CO_2-eq. per club. However, for four clubs (Burnley FC, Leicester City FC, Stoke City FC and West Bromwich Albion FC) the carbon footprint from accommodation is larger than the cumulative GHG emissions from transportation. This carbon footprint can be reduced if the EPL clubs make use of budget hotels. This is deemed appropriate given that, according to the data supplied by the clubs, they do not benefit from the use of the luxury hotels' facilities (such as spas) due to a short term of their overnight stay. The variety of facilities and functions available 24 hours a day in luxury hotels are the key contributors to their high energy consumption and associated GHG emissions (Deng, 2003; Khemiri & Hassairi, 2005, Filimonau *et al.*, 2011).

Figure 2 shows that the EPL clubs generate 56,724 kg CO_2-eq. on average, with the Hull City AFC being the most representative team in this regard. The geographical origin of the clubs participating in EPL affects the magnitude of their carbon footprint, i.e. the teams located remotely and/or farther from the centre of England, such as Sunderland AFC, produce more GHG emissions. The central location of West Bromwich Albion FC (Figure 1) determines its low carbon footprint which is equivalent to the total GHG emissions from train travel made by all EPL teams (Figure 2).

The total carbon footprint attributed to EPL club travel in the season 2016/17 is 1,134,477 kg CO_2-eq or 29,089.15 kg CO_2-eq per member of delegation. This is equivalent to 483,230 litters of petrol consumed or 240 passenger vehicles driven for one year or 4,375,727 km driven by an average passenger vehicle; this is also equivalent to 109 laps made around the Earth by car (EPA, 2016).

5. DISCUSSION

Given the disproportionally high share of air travel in the total carbon footprint of EPL club travel, this transportation mode represents a major mitigation opportunity. Playing games at ‘neutral’ stadia has the potential to reduce the carbon footprint of EPL clubs which is illustrated on the basis of the Southampton FC versus Hull City AFC away game example. Using the method from this study, return travel from Southampton to Hull would involve 80.5 km by coach (90 kg CO_2-eq.), 602 km by airplane (3459.48 kg CO_2-eq.) and one overnight hotel stay (454.35 kg CO_2-eq.). Local travel from the Hull City AFC to its stadium would add 8.64 kg CO_2-eq. to this number, thus totalling 4,012.47kg CO_2-eq. However, if this match was played at the Hawthorns Stadium of the West Bromwich Albion FC, a stadium of equal capacity (Table 2) but located midway for both clubs, the carbon footprint would be reduced by 51.35% to 1,952.38 kg CO_2-eq. There would be no need for air travel and the two clubs would travel by coach, covering a total of 933.42 km and generating 1,043.68 kg CO_2-eq. The remaining carbon footprint would arise from hotel stay which would increase in this specific case given that both clubs would need to stay in West Bromwich overnight. In the case of a ‘neutral’ stadium, the carbon footprint of hotel clubs tends to increase because, in this case, both clubs will play away from home. However, since the reduction in carbon footprint of transportation is considerable, this option can be considered feasible. The concern with the location of stadia is in agreement with Triantafyllidis *et al.* (2018) who show correlation between the carbon dioxide emissions and the location of football facilities. This reduction is due to the choice of the new means of transportation to reach the stadia, as in the example of the EPL clubs above.In the long-term perspective, another mitigation option might rest in the use of aviation biofuels (IATA, 2013). The British Airways (BA) operate the majority of domestic flights in the UK (Morris, 2016) and are a preferred carrier for most EPL clubs. The BA are one of the many airlines trialling aviation biofuels (Stecker *et al.* 2014). Procurement policies of the EPL clubs can be amended in a way that, in the future, air travel services provided by the BA for the away games should be operated on biofuel-driven flights.

Same also holds true when devising carbon mitigation strategies for hotel accommodation. The EPL clubs should strive to stay in hotels that have implemented sound GHG emission reduction measures (Chou, 2014; Chan & Ho, 2006). The ‘green’ procurement strategies adopted and regularly monitored by the EPL clubs can lead to hotel competition in the UK, i.e. where accommodation providers would compete with each other for the right to host football clubs. The EPL clubs would then use the ‘green’ or climatic credentials of hotels as one of the major selection criteria for contracting. The importance of collaboration between event organisers is relevant in behavioural intentions, that is, in the satisfaction of technical committees, as highlighted by Kaplanidou & Gibson (2010).

The potential for mitigation of the carbon footprint from travel of the EPL clubs should be examined in future research work, especially from the viewpoint of economic viability. It needs to be checked whether these measures proposed increase costs and therefore become unviable from the club’s management perspective. Identifying mitigation costs is still a difficult task, but it has been growing with the interest of accounting for these values (Deegan, 2002; Gray *et al*., 1995). At a time when public and private agencies recognise the importance of sustainable development, the environmental impacts of mega sporting events are commanding increasing attention (Collins *et al.,* 2009). Hence, the findings of this study have important implications for EPL club managers and UK transportation and environmental policy makers. Sports tourism events, such as the national football tournament in England, have large audiences and a high public profile. The sustainability commitments of the EPL clubs should be reinforced and monitored to ensure they stay up-to-date. They should further be broadcast to the public to raise public awareness about the environmental footprint attached to football. A comparative analysis of the EPL and other national football competitions is necessary to facilitate the exchange of information and know-how across the countries (Thibault, 2009). This is because the different views of the same problem can stimulate more effective search for viable solutions on a common basis and account for political and cultural differences (Collins *et al.*, 2007).

6. LIMITATIONS AND FUTURE RESEARCH

This research had a number of limitations that should be addressed in the future work. First, football clubs should facilitate research on carbon intensity of football by publicly disclosing information on their travel itineraries and collaborating more closely with academics. For example, for the accomplishment of this work, there was a great difficulty to obtain information from the clubs due to perceived commercially sensitivity of the data on travel. Second, this study focused on the GHG emissions from EPL club travel, thus excluding the 'indirect' carbon footprint attributed to club administrative and support workers, operation of stadia, journalists and, most importantly, the public (namely club fans, or supporters, who regularly attend home and away games of their favourite clubs, and club amateurs who follow the games on TV and via any other means of technology). Future research should be developed encompassing all components of the national football tournaments, i.e. EPL club travel, their administration and management, travel of supporters and all the 'indirect' activities attributed to following football games online as well as offline. In particular, the carbon footprint of club supporters should be accounted for if future assessments of GHG emissions from football are to be comprehensive. This is because the 2015/16 EPL season had the total audience of 13,851,698 people (ESPN FC, 2016) implying significant impacts attributed to fan travel to support the EPL games and watch these on TV. Indeed, football amateurs or the ‘passive public’, according to Gibson (2003), increase the carbon intensity of football substantially. For example, the Carbon Trust (2013) attempted to estimate the GHG emissions arising from watching football games on the different types of media and demonstrated that the carbon figures are high but difficult to assess. This carbon footprint should be a priority topic for future research. Lastly, the next step towards more holistic assessments of carbon footprint from football should, thus, involve a better understanding of the travel and football watching habits of football club supporters. This information can be collated by the EPL clubs to aid in developing more effective marketing strategies and using the data collected for the design of carbon mitigation measures.

7. CONCLUSIONS

This study assessed the carbon footprint of travel attributed to the EPL clubs, one of the most important national football tournaments in the world. It showed that:

1) The choice of travel means by club management greatly affected the GHG emissions from club travel, thus outlining opportunities for mitigation.

2) Aside from reducing the frequency of air travel, the study demonstrated that the choice of stadia and overnight accommodation can affect the carbon footprint of the EPL clubs.

3) This suggests that the ‘green procurement’ strategies need to be adopted by club management when selecting stadia locations and accommodation providers.

4) Development of effective carbon mitigation measures is important in the football context, not only because this sport is growing in popularity while producing the disproportionally significant GHG emissions, but also because it has a high public profile. This implies that the sustainability interventions adopted by the EPL clubs will not go unnoticed, thus

raising consumer awareness about the carbon intensity of football and, possibly, enhancing more responsible day-to-day consumer behaviour.

5) The leadership of the EPL clubs in environmental sustainability could attract sponsors that appreciate and share their corporate sustainability values. Policy-makers can further facilitate these sustainability commitments of the EPL clubs by offering tax incentives and subsidies for the implementation of the ‘green’ solutions at their stadia and during their travel.

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Abbreviations

AA - Automobile Association

AFC - Athletic Football Club

BA - British Airways

CO2 - Carbon Dioxide

DEFRA - Department of the Environment, Food and Rural Affairs

EMS - Environmental Management Systems

EPL - English Premier League

FA - Football Association

FC - Football Club

FIFA - Fédération Internationale de Football Association

GHG - Greenhouse Gas

IOC - International Olympic Committee

IPCC - Intergovernmental Panel on Climate Change

kg CO2-eq - Kilograms of Carbon Dioxide Equivalent

LCFC - Leicester City Football Club

NCAA - National Collegiate Athletics Association

UEFA - Union of European Football Associations

UK - United Kingdom

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Table 1: Major European football leagues. Bold letters indicate the highest figures in each category.

UEFA 2016/2017			League Size (Number of Clubs) 2016/2017[b]	Total Attendance 2015/2016[c]	Average Attendance per game 2015/2016[c]	Total Players' Market Value 2016/2017[b]
Leagues[a]		Coefficient (points)*[a]				
1-	La Liga (Spain)	**99.998**	**20**	10,541,027	27,739	£3.08bn
2-	Bundesliga (Germany)	77.498	18	13,252,808	**43,309**	£2.20bn
3-	Premier League (England)	73.391	**20**	**13,851,698**	36,451	**£4.17bn**
4-	Serie A (Italy)	70.998	**20**	8,466,518	22,339	£2.37bn
5-	Ligue 1 (France)	53.999	**20**	7,920,621	20,898	£1.49bn
6-	Premier League (Russia)	50.332	16	2,609,275	11,056	£0.6bn
7-	Liga NOS (Portugal)	49.332	18	3,268,572	10,895	£0.7bn

*The coefficient points are based on the results of each association's clubs' performance for the five previous UEFA Champions League and UEFA Europe League seasons.

Adapted from: [a] UEFA (2017), [b] Transfermarkt (2017), [c] ESPN FC (2016).

Table 2: Participants of the EPL in season 2016/17.

Club	City of Origin	Stadium	Capacity [a]	Nearest Train Station (When used)	Nearest Airport	Registered Players [b]
Arsenal	London	Emirates Stadium	60,432	London Euston/ London St Pancras/ Waterloo Station	London City Airport	39
Bournemouth	Bournemouth	Dean Court	11,464	Bournemouth Station	Bournemouth Airport	31
Burnley	Burnley	Turf Moor	22,546	Burnley Central	Leeds Bradford International Airport	26
Chelsea	London	Stamford Bridge	41,623	London Euston/ London St Pancras/ Waterloo Station	Heathrow Airport	24
Crystal Palace	London	Selhurst Park	26,309	London Euston/ London St Pancras/ Waterloo Station	London City Airport	33
Everton	Liverpool	Goodison Park	40,569	Liverpool Lime Street	John Lennon Airport	29
Hull City	Hull	KCOM Stadium	25,404	Hull Paragon Interchange	Humberside Airport	31
Leicester City	Leicester	King Power	32,500	Leicester Station	East Midlands Airport	28
Liverpool	Liverpool	Anfield Stadium	54,167	Liverpool Lime Street	John Lennon Airport	29
Manchester City	Manchester	City of Manchester	55,097	Manchester Piccadilly	Manchester Airport	28
Manchester United	Manchester	Old Trafford	76,100	Manchester Piccadilly	Manchester Airport	26
Middlesbrough	Middlesbrough	Riverside Stadium	35,100	Middlesbrough Station	Durham Tees Valley International Airport	26
Southampton	Southampton	St Mary's Stadium	32,689	Southampton Station	Southampton Airport	32
Stoke City	Stoke-on-Trent	Bet365 Stadium	28,383	Stoke-on-Trent Station	Manchester Airport	27
Sunderland	Sunderland	Stadium of Light	49,000	Sunderland Station	Newcastle International Airport	36
Swansea City	Swansea	Liberty Stadium	20,972	Swansea Station	Cardiff Airport	26
Tottenham Hotspur	London	White Hart Lane	36,274	London Euston/ London St Pancras/ Waterloo Station	London City Airport	31
Watford	Watford	Vicarage Road	21,977	Watford Junction	London Luton Airport	33
West Bromwich Albion	West Bromwich	The Hawthorns	26,500	The Hawthorns Station	Birmingham Airport	25
West Ham United	London	Olympic Stadium	57,000	London Euston/ London St Pancras/ Waterloo Station	London City Airport	33

[a] Belfast Telegraph (2016). Premier League club guide 2016/17. Football Stats, July, 22. Available at: <http://www.belfasttelegraph.co.uk/sport/football/premier-league/premier-league-club-guide-201617-34903616.html>. Retrieved October 14, 2016.

[b] Premier League (2016). Premier League 2016/17. Available at: <https://www.premierleague.com/players>. Retrieved October 11, 2016.

Table 3: LCFC staff composition for the 2016/17 season.

Staff Sector	**Detailed description of employees**	**Number**
Coaching Staff	Manager; Goalkeeper Coach; General Assistants	6
Medical Staff	Doctor and Physiotherapists	4
Sport Science Staff	Nutritionists and Physical Trainers	6
Performance Analysis and Recruitment	Tactical Analyst; Heads of Sports Science and Performance Analysis and others	5
	TOTAL:	**21**

Source: Based on the LCFC (2017) information.

Table 4: The carbon intensity factors for transportation (kg CO_2-eq.).

Mode of transportation	Unit of measurement	Direct and fuel chain related 'indirect' GHG emissions
Train[a]	Passenger	0.04885[b]
Coach[c]	Km	0.02867[d]
Air Travel[e*]	Km	0.14735

[a] The factor has been derived by DEFRA from the Office of the Rail Regulator's National rail trends for 2014-15 (DEFRA, 2016).

[b] 'National passenger rail' category.

[c] DEFRA (2016) indicates that the average occupancy is 17.56%, however it acknowledges that this occupancy can be significantly higher in reality; hence, the occupancy value of 75% and the maximum load factor of 49 were utilized instead as suggested by Filimonau *et al.* (2014).

[d] Value updated by DEFRA (2016).

[e] Assuming domestic occupancy of UK flights is equal to 72% with the maximum load factor of 190.

[*] Estimates of the GHG emissions from air travel do not include the radiative forcing (RF) effect (see, for example, Berners-Lee *et al*., 2011 for more details).

Table 5: Number of games, hotel stays and the distance traveled by each EPL club using the different means of transportation. Bold letters indicate the highest figure in each category.

Football Club	Airplane		Coach		Train		Total	Away Hotel (days)
	Games	Km travelled	Games	km travelled	Games	km travelled	km travelled	
Arsenal	10	5,720	5	1,429	4	1,294	8,443	14
Bournemouth	11	6,875	2	1,838	**6**	2,124	10,837	18
Burnley	3	1,934	10	3,223	**6**	**4,075**	9,233	17
Chelsea	10	5,443	5	1,609	4	1,294	8,346	14
Crystal Palace	10	5,720	5	1,696	4	1,294	8,709	14
Everton	10	5,263	9	3,095	-	-	8,357	16
Hull City	9	4,609	10	**4,832**	-	-	9,441	**19**
Leicester City	4	1,796	10	4,054	5	1,577	7,427	**19**
Liverpool	10	5,263	9	3,100	-	-	8,363	16
Manchester City	9	4,574	10	3,062	-	-	7,636	15
Manchester United	9	4,574	10	3,096	-	-	7,669	15
Middlesbrough	10	6,917	9	4,241	-	-	11,158	18
Southampton	10	6,164	3	1,972	**6**	1,564	9,700	18
Stoke City	5	2,256	8	2,702	**6**	2,746	7,704	18
Sunderland	14	**9,785**	5	3,544	-	-	**13,329**	18
Swansea City	**17**	8,488	2	4,217	-	-	12,704	**19**
Tottenham	10	5,720	5	1,655	4	1,294	8,668	14
Watford	9	4,377	6	2,328	4	1,511	8,217	14
West Bromwich	3	1,410	**11**	4,023	5	1,883	7,316	18
West Ham United	10	5,720	5	1,521	4	1,294	8,534	14
Total:	**183**	**102,605**	**139**	**57,236**	**58**	**21,950**	**181,791**	**328**
Total (%):	**48.17**	**56.44**	**36.57**	**31.49**	**15.26**	**12.07**	**100%**	**-**
Average:	**9,35**	**5,130**	**7.17**	**2,862**	**2.47**	**1,098**	**9,090**	**16**

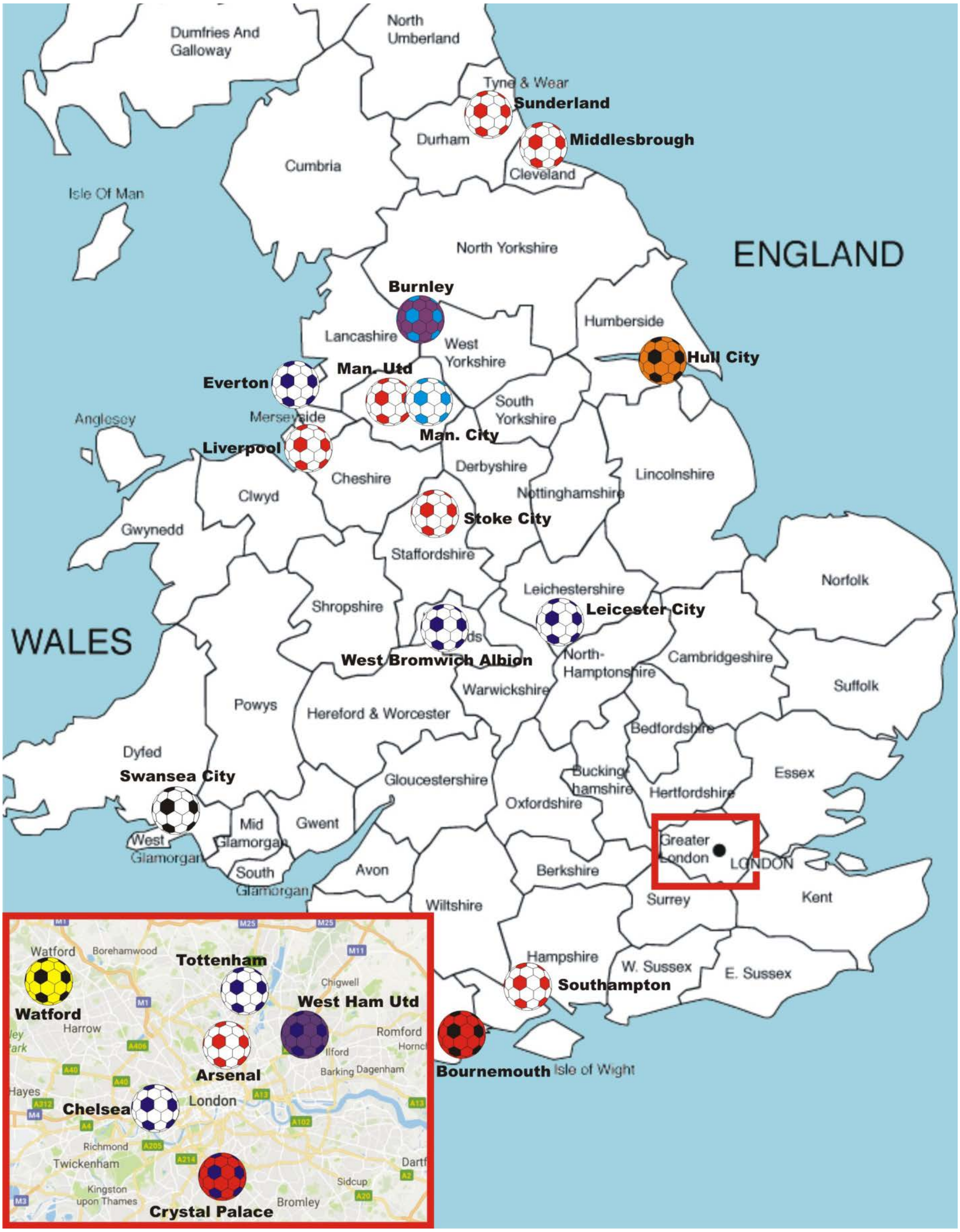

Figure 1: UK Map with locations of EPL clubs - Season 2016/17.

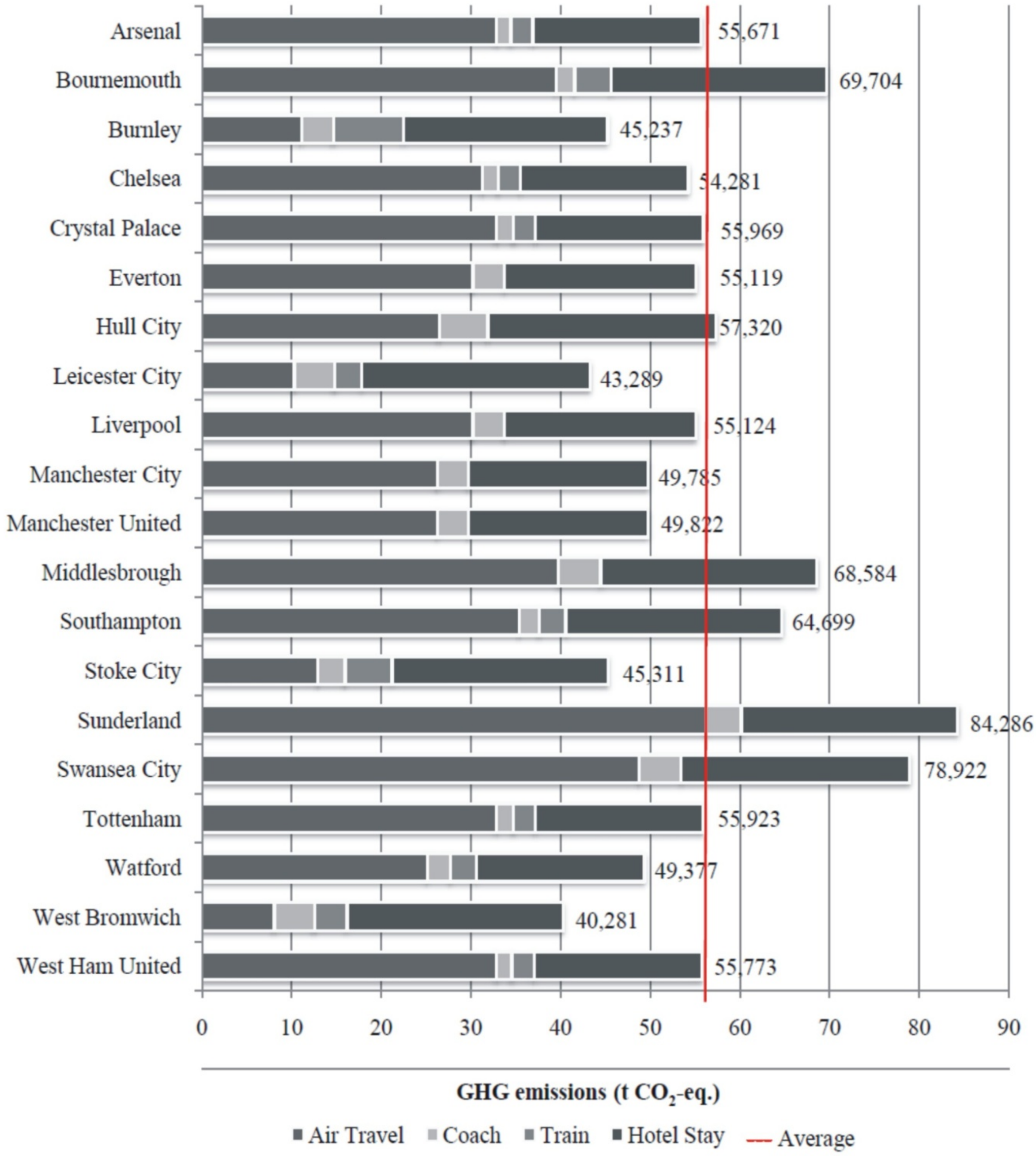

Figure 2: The carbon footprint (t CO_2-eq.) from EPL clubs.