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Assessing the Ecological Impact of Ultramarathon Events in Protected Natural Sites: 'Le Grand Raid Réunion'

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Abstract: Outdoor sport events evidently have an impact on the environment. If they are taking place in naturally protected areas this impact is even greater. By taking 'Le Grand Raid Réunion', an international ultramarathon annually organized in the heart of an UNESCO World Natural Heritage site, as a case study, this paper concentrates on assessing the ecological impact of an outdoor sports event in a protected natural site. On the basis of datasets taken from official logistics lists and from a survey conducted among all event participants the analysis embraces ecological and carbon event footprinting. Measuring those two indicators allows identifying the specific event-related ecological impacts, including diverse variables caused by the athletes, the spectators, and the related organizational requirements. The results of the study thereby have the ability to strongly influence the future event policy and to function as a model for the assessment of the ecological impact of other outdoor sports events.

Keywords: ecological impact; event management; footprint; UNESCO world heritage; nature sports; outdoor sports

1. Introduction

Almost 5000 athletes running three days long through a naturally protected area: environmentalists might argue that this is unportable. It happens though each year anew in the frame of the ultramarathon race 'Grand Raid', the most popular sporting event of the French overseas department of Reunion Island. The 'Grand Raid' is also called 'Diagonale des Fous' (madmen's diagonal) and was inaugurated as early as in 1989, at a time when nature conservation ideas already existed [1] (pp. 18–32): Greenpeace, for instance, was already founded 18 years earlier, and UNESCO assigned its first list of world heritage sites at the end of the 1970s [2,3]. Those first initiatives did, however, not lead to strict consequences in the event management as is increasingly the case nowadays. In the 21st century, the interest in the wider consequences of sporting events has generally increased. In 2010, for instance, the United Nations Environment Programme explicitly discussed the impact of large sporting events [4]. The International Olympic Committee (IOC) has early recognized the signs of the time and regularly since 1995 has organized the biennial 'World Conference on Sport and the Environment' [5]. No possible host city for the Olympic Games like for other mega sporting events, too, can nowadays apply without an elaborated concept of sustainable event organization.

What is true for large international sporting events is not yet the case for smaller contests which are less in the focus of media attention and pressure but also have fewer financial capacities to adapt to ecological regulations. Ecological consequences of event organization and certain aims to reduce them—partly enforced by regional authorities—remain and contribute to a positive image of the event. Thus, the organizers of 'Le Grand Raid' include regulations to punish polluting participants

and explicitly point at their sporting event as ecologically 'clean' [6]. Their environmental policy has, however, not been analysed yet. Whereas it might seem that the importance of studying comparably smaller events (with a globally seen lower ecological impact) is lower than those which attract an audience of several million people, one must not forget that events like the 'Grand Raid' are generally followed by the same ecological impacts as big events and might even result in higher per person impacts. Moreover, parallel to the main race, the 'Diagonale des Fous' is run which features a 163 km length and an elevation gain of 9920 m. In 2013, two smaller mountain races took place which partly used the same terrain and thereby further increased the impact: 'Le Trail de Bourbon' with 93 km and an elevation gain of 5200 m and 'La Mascareignes' with 67 km and an elevation gain of 4000 m. As the participants in the three sub-races of the 'Grand Raid'—the name 'Grand Raid' includes from here on, if not expressed differently, all three presented mountain races—run through a National Park which has had UNESCO World Heritage status since 2010. The sensitivity and thus the threat to nature is comparatively even greater than for other events. Athletes, spectators, and the related organizational requirements—rubbish, air pollution, energy and water consumption, etc.—do not remain without ecological consequences in this vulnerable region.

Therefore, this study concentrates on analysing the ecological impact of the 21st edition of 'Le Grand Raid' that took place on 17–20 October 2013. It evaluates the current organization of the event from an ecological perspective, provides insights into the quality of the current environmental policies of an outdoor sports event by measuring the ecological and the carbon footprint of the event and points at possible areas for improvement in the future. By taking 'Le Grand Raid Réunion' as a case study furthermore the particular impact of event organizations in protected natural sites is demonstrated.

As a consequence of the contemporary popularity of sustainable event concepts, scholars—mainly from the fields of ecology, geography, management, and sport science—increasingly deal with the subject of environmentally-friendly event organization. Several studies have already been conducted on the organization of major sporting events like the Olympic Games or the Football World Cup: many concentrate on economic issues [7,8]; some also include ecological impacts [9–11] and historical elements [12]. Coming back to the regional focus of this study, scholars have already researched the 'Grand Raid Réunion'—from a historical, sociological, training, or physiological point of view [13–21]—but until now none of them explicitly focused on measuring the impact of the event and thereby evaluating the quality of the current environmental policy. To date also only few studies on the regional environmental policy of Reunion Island or other Indian Ocean Regions exist, and they consequently neglect sporting events [22,23]. It is moreover striking that the majority of studies on Reunion Island, its environment, and its sporting culture are only available in French language—the book entitled "The Uplands of Reunion Island: Where Tradition Meets the Future", edited by Jean-Michel Jauze [18], represents an exception—even though the results of those works might also be of interest in non-French-speaking countries. It can only be assumed that the geographic distance and the French (and Creole) language skills needed to conduct a study on-site have hindered non-French scholars in selecting regional case studies. Thus, this project aims to assess and present the ecological impact of 'Le Grand Raid Réunion' to an international readership, thereby pioneering an analysis of the region as a suitable research objective in event-related ecological studies.

2. Materials and Methods

2.1. Study Area: Reunion Island

Reunion Island, French overseas department, and southernmost part of Europe, is located in the Indian Ocean, around 700 km to the east of Madagascar, and embraces around 2507 km^2. The island is home to many endemic plants and thus especially vulnerable and worthy of protection. The study area covers large parts of this island as the event which is in the focus of this research crosses the island from south to north. The heart of the island is a National Park nominated by UNESCO as World Natural Heritage site in 2010 and concerns more than 40 % of the area [24] (cp. Figure 1).

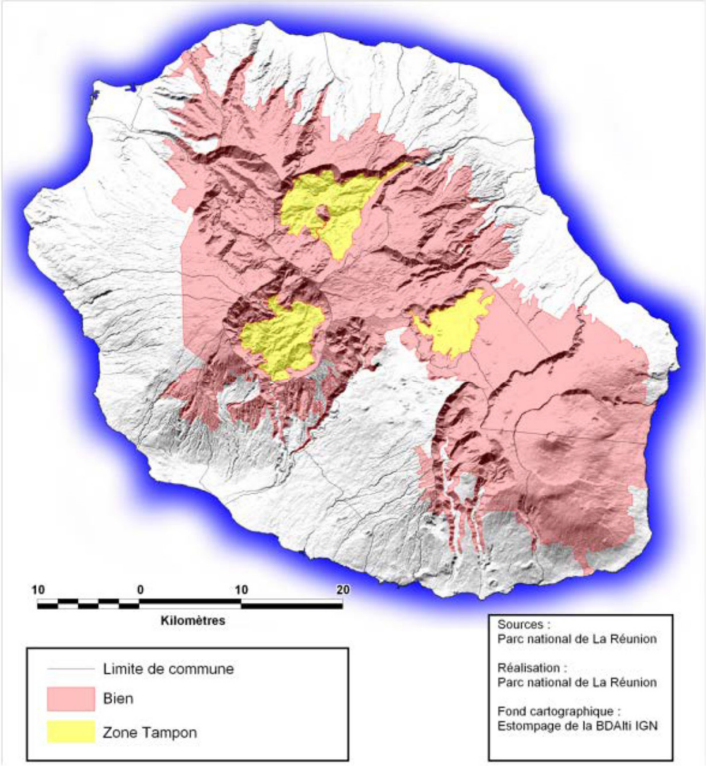

Figure 1. Map of the property of Reunion Island inscribed as UNESCO World Heritage in 2010. Source: [25].

2.2. Using Footprinting to Measure Ecological Impact.

Everyday life but also events leave a footprint behind them. Thus, human behaviour is resulting in a specific ecological footprint which correlates with the specific biocapacity of the region or country. The non-profit organization Global Footprint Network explains that the footprint varies "with consumption and production efficiency" and the biocapacity "with ecosystem management, agricultural practices (such as fertilizer use and irrigation), ecosystem degradation, and weather, and population size" [26].

How can effectiveness with respect to an ecologically sustainable event organization be measured? There is not one clear proven way. Among the concepts to evaluate the event impact the ecological footprint has, however, emerged to one of the most successful indicators [27–29]. It is internationally used by a variety of institutions for the evaluation of ecological impacts of human activities [28,30] and has already demonstrated to be a "valuable tool from which to assess the environmental impacts of major sporting events" [9]. The method "calculates the area, which nature would require for renewing the resources and absorbing the wastes which human beings have consumed [...]" (all translations are mine); [31] and can also be used as "an awareness-raising tool" [9].

Ecological footprinting was originally introduced by Mathis Wackernagel and William Rees in 1996 as "the land and water area that is required to support indefinitely the material standard of living of a given human population, using prevailing technology" [32]. Over the years, the definition has not significantly changed but includes the term 'consumption' which stronger emphasis the human impact. Best Foot Forward (Anthesis Group), for instance, defines an event-related ecological footprint as a method that enables to prove the dependence of the event on resources by measuring "the bioproductive area (land and sea) required to sustainably maintain current consumption" [33]. The ecological footprint is measured in global hectares with one global hectare being "equivalent to one hectare of biologically productive space with world average productivity" [34]. Globally, there is an 'ecological overshoot', meaning that today the equivalent of 1.5 planets is needed to provide the

used resources and to absorb the produced waste. In other words: For the regeneration of what is used in a year the Earth today requires one year and six months [35].

According to the World Wide Fund for Nature (WWF) the available global ecological biocapacity is currently 1.8 gha per person or 2.0 billion gha in total which contrasts with humanity's estimated ecological footprint of 2.7 gha per person or 18.2 billion gha (all based on calculations in 2008) [36]. The per-person demand and the biocapacity for the world between 1961 and 2010 demonstrate that the global ecological overshoot is continuously increasing since the late 1960s. In the coming years and decades, this negative trend is supposed to continue. When resources are quicker turned into waste than waste can be turned back into resources finally the resources on which human life and biodiversity depend are depleted. This makes footprint calculations an essential part of demonstrating human impact and working out aspects of possible improvement.

Besides the ecological footprint, the carbon footprint, the CO_2-emissions resulting from the event, can also be measured. The carbon footprint is widely used in literature and for instance defined as "the total set of greenhouse gas (GHG) emissions caused directly or indirectly by an individual, organization, event or product" [37,38]. So why is it helpful to calculate two different footprints?

Both the ecological and the carbon footprint deal with resource usage. The ecological footprint concentrates on resources which are consumed and compares them with the land and water area needed to replace them [39]. The carbon footprint in contrast centres on the greenhouse gases emitted into the atmosphere and does not refer to the biocapacity. It is primarily used to increase awareness of climate change and measured in units of carbon or carbon dioxide equivalents [40,41]. With their specific foci, both footprints complement one another and help to "illustrate the impact of human activity on the environment" [42]. They help to understand the ecological impact of events in general and in relation to specific event factors.

2.3. Assessing the Ecological Impact of Outdoor Events

For the retrospective measurement of footprints related to companies, products, and services already standards and guidelines exist but "there is currently no universally agreed approach to measure the footprint of an event" [42]. When searching a tool to calculate the 'ecological footprint' diverse sustainability consultants offer their products. For my purposes, an ex-post event analysis in the Indian Ocean Region, the Footprint Reporter™ of the Anthesis Group (event version) seemed best adequate. It is though partly UK-based but allowed a transfer to other regions and has, for instance, also been involved in the assessment of large sporting events like the Olympic Games in London in 2012 or the bid of Chicago for the 2016 Olympic Games. Both the ecological and the carbon footprint could be measured while including diverse emission sources and up-to-date factors. It thereby offered a suitable accounting and reporting tool.

The analysis focused on emissions sources which were expected to have a high ecological burden on the event: travel, accommodation, freight transport, energy consumption, accommodation, merchandising, and catering. The footprint calculation embraced the impact of different groups of people involved in the race: the runners, the organizers, the volunteers and the spectators. Concerning the carbon footprint, different emissions-generating activities were investigated depending on the specific organizational, and operational boundaries. For the use in the Calculator of the Footprint Reporter™, ecological impacts were generally 'aggregated into commonly used components' [43]. Within those common accounting categories, single items were again grouped by type (represented by icons) which made an assignment easier. Not all of the numerous criteria which were offered could be used; a choice had to be made. The boundaries were selected so as to include only those elements over which reliable data existed. Datasets taken from official logistics lists, from a survey conducted among all participants and from interviews were formatted to allow for integration into the Footprint Reporter™ tool. There, to each item a specific carbon dioxide or global hectare value was allocated to allow measuring the footprints.

As the Footprint Reporter™ is a web-based application, all data could be recorded, saved and viewed online (after login). The calculations are generally based on conversion factors which are used to convert physical quantities into footprint values [42] and are frequently updated, for instance when the Department for Environment, Food and Rural Affairs (DEFRA) publishes new transport und utility factors [44]. The UK DEFRA factors are particular to the European context, but can also be transferred to other geographical regions. The results of all presented categories could finally be viewed as 'EF (gha)', the ecological footprint in global hectares, or in 'CO_2' (tonnes), the carbon footprint, either for the total event or for single of the categories or items.

2.4. Sources of Data

The calculation of the carbon and ecological footprint required a rich set of high quality consumption data, possibly with information on the accommodation of the mentioned parties during the race, assets, travel kilometres, consumables, food and drink, freight transport, and utilities. At the same time, it proved the complexity of events and of their resulting impacts on nature. As these data were not automatically widely documented in the case of the 'Grand Raid'—like it is nowadays the case for big (sporting) events—and moreover partly incomplete, several requests and expert interviews with the responsible authorities were necessary. Additionally, empirical data had to be collected through an online survey diffused among the participants of the three races.

Among the interviewees were the president of the Association Grand Raid, Robert Chicaud, and the responsible for the logistics, Jean-Marie Payet. Their answers not only provided data for the calculations of the ecological and carbon footprint but also gave useful background information. The online survey was conducted with the help of the software SoSci Survey which was specifically developed for scientific studies. The advantages and disadvantages of online surveys will not be widely discussed here [45–47], but with regard to the limited time for the creation and evaluation of the questionnaire, the choice of an online survey had many advantages, like, for instance, the possibility to directly upload the results including the labels into the statistic programme SPSS without the need of encoding each variable individually afterwards. SoSci Survey allowed the creation of a particular layout, partly requiring some basic knowledge in programming, the conduction of a pre-test to eliminate basic faults as well as features like response time measuring and multi-language surveys (in this case French and English). The survey embraced 17 questions on 13 pages (including the introductory page) resulting in 307 variables. For the evaluation of the data the software IBM SPSS Statistics 22, one of the leading tools for statistical analyses, was used. The unit of observation to which the survey was addressed to were all runners who took part in one of the three mountain races in 2013 (N=4718). 1212 (26 %) finally participated in the survey and 972 (21 %) have completed the data records until the last page (no duplicate records could be found).

3. Results

Event Footprinting: Factor Analyses

The total carbon dioxide emissions of the event encompass 14,433,233 tonnes, the total ecological footprint 4,981,782 global hectares. For both the carbon and the ecological footprint, 'audience travel' had the greatest impact (64/54.3 %) of all categories (cp. Figures 2 and 3). This was followed by the category 'accommodation' which likewise concerned spectators and additionally runners and thereafter by 'staff & performer travel'. The impact of the sections 'assets', 'consumables', and 'food and drink' respectively remained under 1 %; 'freight transport' and 'utilities' were respectively accounted with 0%, as they made less than 0.1 % of the total footprint.

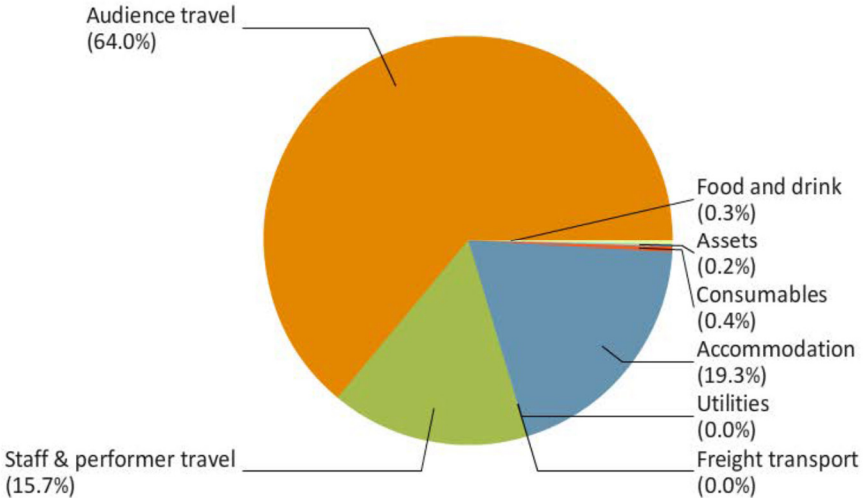

Figure 2. Carbon footprint (in CO2 tonnes) of the total event.

Figure 2. Carbon footprint (in CO_2 tonnes) of the total event. Source: own calculation with the help of the Footprint Reporter™/Anthesis Group).

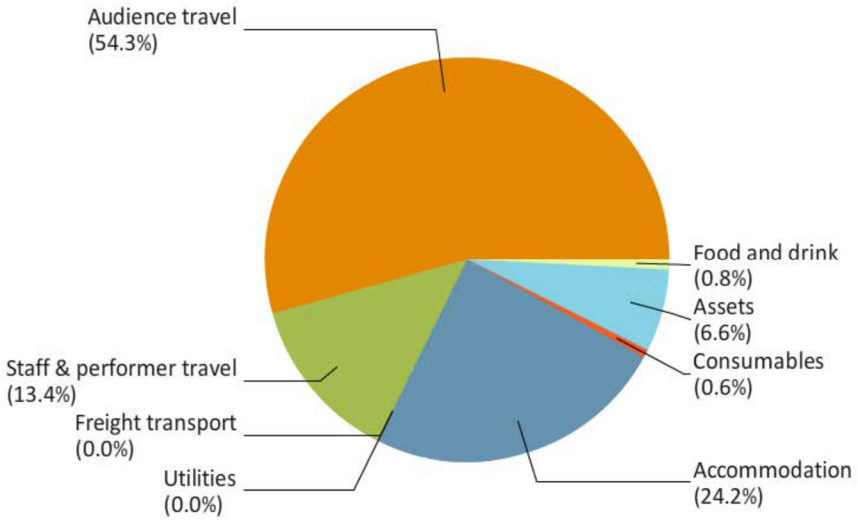

Figure 3. Ecological footprint (in global hectares) of the total event. Source: own calculation with the help of the Footprint Reporter™/Anthesis Group.

4. Discussion.

4.1. International Comparisons to the Carbon Footprint Results

The 14,433,233 tonnes of carbon dioxide which have been directly and indirectly caused by the organization of the 'Grand Raid 2013' are impressive but only constitute a negligibly small part of the average yearly world CO_2-production which was 31,387 Mt (million tonnes) in 2010 [48] or of the emissions of whole France which were 361,273,000 tCO_2 in the same year [49]. With regard to Reunion Island, the event produced around 0.331 % of the yearly carbon dioxide emissions (4 367 000 tCO_2 in 2010). At a first glance this seems not much, also not in comparison to big international sporting events like the Olympic Games in London 2012 with an estimated actual footprint of 3.3 $MtCO_2e$ (million tonnes of carbon dioxide equivalents) [50].

When comparing the carbon footprint of the 'Grand Raid' to other events, it though has to be taken into consideration that the footprint measurements around big sporting events like the Olympic

Games allow pre-event-reductions due to early recommendations and are generally much wider and detailed in their frame, conducted by big research teams and embracing several years already before the start of the event. For instance, the footprint of the 2012 London Olympic Games additionally included impacts of the sale of official merchandise and food franchises and many emissions which the organizers were not directly responsible for [42]. Furthermore, for the 'Grand Raid' no construction of venues and other buildings had to be conducted which positively influenced its CO_2 balance in comparison to the London Olympics where the Olympic Park and Village made with 65% (1219 $ktCO_2$ (kilotons CO_2)) the largest emission sources for which the organizers were directly responsible. The two sporting events have in common a high impact of spectators' air travel to watch the event [39]. Another example is the 2014 Soccer World Championships in Brazil which are comparatively expected to generate over 2.7 $MtCO_2e$ including, similarly to the Olympic Games, the whole time of preparation and the staging of both the FIFA Confederations Cup and the World Cup [51]. Four years earlier, the estimated carbon impact of the 2010 FIFA World Cup in South Africa was already estimated to have the largest emissions of any international sporting event in history with a carbon footprint of 2,753,250 tCO_2e [52,53]. In this case the high result was explained by the long-haul location which is likewise the case for the 'Grand Raid' (even though the number of spectators was much lower).

As every event is different and every footprint calculation has other boundaries, comparisons remain difficult and therefore rare, if not conducted by the same team using exactly the same frame. This is likewise true for the results of the ecological footprint where the CO_2 emissions are generally incorporated but expressed in global hectares.

4.2. International Comparisons to the Ecological Footprint Results

The 4,981,782 global hectares calculated for the 2013 edition of the 'Grand Raid' are only an abstract figure at a first glance. Compared, for instance, to the results of the ecological footprint of the 2004 'UK's Football Association (FA) Cup Final' which resulted in a total footprint of 3083 gha [9,54] or to the UK Stages of the 2007 'Tour de France' with a footprint of 57,990 gha [55,56] the results can be slightly easier categorized. However, also here a comparison is complicated and often misleading because both the 'FA Cup Final' and the 'Tour de France' study are concentrating on visitors' footprint only and moreover on the impact per visitor and day. To be able to compare the results at least the consumption categories of those two studies need to be equalled with those of the 'Grand Raid' analysis, as, for instance, in the 'FA Cup Final' research accommodation was not considered but venue construction was. As the 'Tour de France' study, moreover, was conducted six years earlier, results might differ due to the different years; it can, however, be expected that the struggle towards a continuous improvement in sustainable event organization and thereby in green marketing has in the meantime continued for both and even increased with the popularity of greening the events.

In both the 'Tour de France' and the 'Grand Raid' studies, travel by air (international) had a huge impact [55]. Whereas the total visitor travel generated an estimated ecological footprint of 43,719 gha for the Grand Depart of the 'Tour de France' (6–8 July 2007), for the 'Grand Raid' (17–20 October 2013) only 2706 gha were calculated (cp. Table 1). These figures are, however, again relative and have to be interpreted carefully, as they are based on different spectator numbers: Transport for London estimated 2.85 million spectators for those first three days of the 'Tour de France', whereas my calculations assumed that around 15,200 spectators followed the races during the four days. Comparing the ecological footprint per person, with 0.0153 gha for the 'Tour de France' and 0.178 gha for the 'Grand Raid', it is obvious that despite the larger total impact of the 'Tour de France', the 'Grand Raid' had a significantly higher impact per person. Calculated as impact per person and day this leads to 0.005 gha for the 'Tour de France' against 0.045 gha for the 'Grand Raid'.

Table 1. Carbon and ecological footprint by category. Source: own calculation with the help of the Footprint Reporter™/Anthesis Group.

Category	CO_2 (tonnes)	EF (gha)
Audience travel	9230.877	2705.667
Staff & performer travel	2266.110	666.043
Freight transport	3.899	1.123
Utilities	3.811	1.040
Accommodation	2789.295	1206.664
Consumables	63.662	31.857
Assets	27.343	328.246
Food and drink	48.235	41.142
Total	14433.233	4981.782

4.3. Global Ecological Biocapacity and Ecological Event Footprint per Year

All events generally create a higher impact on the environment than everyday life. Unfortunately, no data on the ecological footprint of persons living on Reunion Island exists which could be perfectly compared to the time of the event or even subtracted to find out the additional impact of the event. Nevertheless, some comparisons to global figures contribute highlighting the influence quantity of the event. Calculating the per-person-impact of each of the estimated 21,340 persons who have been accounted in this study—runners, paid staff, volunteers and spectators— results in an ecological footprint of 0.362 gha/per person for the four event days and 0.905 gha/per person and day.

If the consumption was likewise high during the whole year, this would result in an ecological footprint of 33.023 gha/per person per year. Confronting this result with the global ecological biocapacity which is currently around 1.8 gha/per person and year [36], proves that a comparatively local and small sporting event as the 'Grand Raid' already consumes 18 times more global bioproductive area than is available to sustainably maintain current consumption. This shows that the level of consumption caused by the event was inequitable in 2013 and thereby contributed to the global overshoot which signifies that nature's capital is being spent faster than regenerated.

4.4. Limitations

The Footprint Reporter™ requires (like every method to calculate footprints) a large and reliable dataset. Obviously, this is a general difficulty which concerns also other studies and necessarily increases the number of assumptions [57]. It is impossible to gather information about all offered items of the event-related consumption. Some items are event-specific or region-specific, and in comparatively small events like the 'Grand Raid' one cannot rely on complete data sets. Moreover, organizers or related institutions are not always motivated to support scientific approaches and thereby to let somebody look behind the scenes. In this study also the language barrier between French and English sometimes resulted in difficulties to find the exact corresponding item. It is in any case a diligent routine piece of work to find out the required total weight of those items about which only the quantities are available and to calculate the resulting weight by using scales or online figures single by single. Depending on the size of the research team, it can be recommended to rather focus on certain aspects of the organization and make sure that for this category all required data are available in a high quality. If in contrast all concerned parties, staff, spectators, performers, volunteers, are included in the analyses, defining boundaries is a challenge.

Coming back to the calculation tool, the Footprint Reporter™ contained, despite its general suitability for international use, single UK-based items which created some transfer problems. The factors for domestic flights, for instance, are based on assumed distances referring to a UK convention. Related to the Indian Ocean region where this study took place another problem occurred as average footprints of residents were not available like it is, for instance, the case in large parts of the United Kingdom. Therefore, the calculated footprint does not take account of any 'displacement effects' [9] generated by the event and reflected, for instance, in a reduced residents' consumption in usual restaurants during the time of the event. Also, no data was available on the average daily

ecological footprint of Reunionese people or of tourists on the island in general which could have been subtracted to have the additional impact. Even if it can be assumed that those aspects diminished the total impact, the presented footprint results are generally still an underestimate. Items on which not data was available—for instance, the merchandising products or further event-related publications or printouts—could not be included in the calculations.

As the study of the ecological impact of sporting events is a relatively new field, internationally agreed standards for the measurement of the carbon and ecological footprint are lacking. This makes comparisons to related events which could be so enlightening still difficult. Therefore, if the required financial and institutional means are offered, studies which embrace several event years should be favoured, as this gives a historical reference and the opportunity for valuable comparisons. If future research can, besides ecological issues, also deal with social and economic measurements, a complete analysis of the event's sustainability is possible.

The findings moreover had practical applications as they point out the ecologically crucial points in the event planning and thereby provide the organizers with the means to prioritize their future decisions with regard to their specific ecological impact. It though has to be considered that changes in the organization of an event have always multiple and not only ecological effects. Throwing an isolated view on ecology only numerous improvements are possible but with regard to a sustainable development of the event, the social and the economic dimension of the 'Grand Raid' cannot be neglected either. Considering that still 46% of the annual visitors on Reunion Island stay at their family or friends [58], the regional tourism deeply benefits from the regular stimulation caused by the sporting event. This is true for every event somehow but in the Indian Ocean Region tourism marks an essential pillar for the increase of employment and social development.

It is true that the island knows also other ecological problems which persist during the whole year, related for instance to the heavy traffic [59]; the 'Grand Raid', however, is a single annual happening which results in a high number of people frequenting natural protected areas in a shorter time and leaving their specific footprints behind them. Efforts to minimize the ecological impact of the event could already be identified in 2013. This included the choice of reusable goblets for each runner, the installation of some ecological toilets, the assignment of an eco-friendly enterprise for the installation of the firework (using biodegradable products) and the allocation of dishes out of cardboard (not plastic) at the catering stations. Nevertheless, the remaining ecological impact of the event cannot be denied. It would be interesting to measure again and compare whether further changes in the event organization have led to different results in the carbon and/or ecological footprint of the event.

5. Conclusions

One can hardly disagree that the over 20,000 persons which were involved as athletes, staff, volunteers, and spectators in the 'Grand Raid Réunion 2013' resulted in a remarkable ecological impact. With more than 14,000 tonnes CO_2 and almost 5,000 global hectares the 'Grand Raid 2013' left an impressive footprint behind its organization. The results demonstrate that the mountain ultramarathon 'Grand Raid' is not automatically a green event because it takes place in nature. The already existing environmental campaigns should thus be extended to sensitize the runners and the event spectators for their personal ecological impact. As the 'Grand Raid Réunion' is an internationally well-known event and picks up the people in a true-to life situation, great chances for increasing public awareness exist. However, changing attitudes is a long process as "most people don't react well to being lectured and hectored. Sports has a vital role to play in delivering a softer, more powerful message [60]". This again underlines the importance of studies which focus on sport events and their specific social power.

The benefits of an ecological event organization for legacy are difficult to quantify, but due to the increasing public awareness the importance to show efforts towards a 'green' event organization will probably continue to rise in the following years. This is expected to come along with further analyses on the ecological impact of international sporting events. It is hoped that the presented study

contributes to this field of research, encourages scientists to choose other than mega-events only for footprint calculations and thereby serves for further fruitful comparisons in the future.

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