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Environmental Consequences of Antarctic Tourism from a Global Perspective

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Abstract

Antarctica tourism evidently harms its ecosystem in direct and indirect ways. Ecosystems are dynamic and complex systems, which simultaneously depend on various humanity and natural factors. The nature of tourist activities continuously changes, which in turn needs improved policies and protection standards. If the varied tourism activities and the diverse consequent impacts are not adequately addressed, they would not be thoroughly considered by international treaties. This could pose unacceptable environmental risks supposedly legally safeguarded by these treaties. Hence, this study elaborated Antarctic tourism impacts in five major groups from a global perspective. The results are useful for future legislations and implementations.

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1. Introduction

The services provided by ecosystems play a vital role for humanity. Ecosystems support the life, supply materials and energy and absorb waste disposals (Daily, 2000). Thus, maintaining the ecosystems' integrity through appropriate protective means is important. However, ecosystems are complex and these dynamic systems are affected by various temporal and spatial factors (Kariminia, Ahmad, & Hashim,

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2012). This makes it difficult to distinguish the levels of stress these systems can endure and the limits of the replacing functions (Gössling, 2002). Meanwhile, the contribution of human activities in the environmental degradation is known. It is believed that these activities reduced the ecosystems' capacity and influenced their services, which in turn, resulted in worrying phenomena such as global warming. Recreation activities, namely tourism undoubtedly contributed to the human-environmental impacts. International treaties e.g. the UN Framework Convention on Climate Change have asked for anticipation, prevention or minimisation of the causes of global climate change and mitigation of its adverse effects (FCCC, 1992). This is more critical on remote destinations such as Antarctica that has fragile and pristine nature. The ways in which these activities impact the environment are the most important step of the related assessment and management processes. The individual influences of tourism activates on local ecosystems have caught research interest, however; due to the interaction relations, environmental degradation aspects should be studied integrally and from a global perspective. Moreover, the role of tourism on environmental stress is not limited to the physical aspect only, but extends to the intangibles such as the tourists' perceptions of the environment (Dyer, Gursoy, Sharma, & Carter, 2007; Nicoletta & Servidio, 2012).

Antarctica is almost thoroughly covered by ice, and the ice sheets supply a large part of earth's fresh water and its thermal mass contributes to the global climate (Kriwoken & Rootes, 2000). Since 1989, almost all sites, including 20 research stations have been visited in the Antarctic Peninsula region (IAATO, 2013). The Antarctic Treaty System consists of international instruments such as 1959 Antarctic Treaty; 1964 Agreed Measures for the Conservation of Antarctic Fauna and Flora; 1972 Convention on the Conservation of Antarctic Seals, 1980 Convention for the conservation of Antarctic Marine Living Resources; 1991 Protocol on Environmental Protection to the Antarctic Treaty (Madrid Protocol 1991) and other special meetings that made decisions and formed measures and instruments. As the most significant instrument, Madrid Protocol 1991 contained a number of environmental protection instruments. The five annexes, namely Environmental Impact Assessment, Antarctic Fauna and Flora, Waste Disposal Management, Marine Pollution and Area Protection provided a comprehensive measure on the Antarctic region protection (Kriwoken & Rootes, 2000). Nevertheless, an increasing number of academics and parties have raised concern on the Antarctic environment degradations (Bastmeijer & Roura, 2004; Kriwoken & Rootes, 2000).

Historically, the modern era of Antarctic tourism started in the late 1950s. Between 1958 and 1987, the average number of Antarctic tourists did not exceed 1000. However, in a period between 1993 and 1994, this population unprecedentedly exceeded the number of scientists who travelled to this area (Bastmeijer & Roura, 2004). Despite the limited growth or even gentle decline of visitor pollution in some parts of Antarctic tourism industry, there were close to 35000 visitors in 2012-2013 season; an increase from almost 26000 in 2011-2012 (IAATO, 2013). The increase of passengers on small- and medium-sized vessels and travellers who preferred to experience cruise-only adventure is believed to be the reasons of this jump.

This paper aspires to comprehensively address the environmental impacts of Antarctic tourism on ecosystems from both local and global, and physical and psychological perspectives. In addition, it aims to estimate the scale of these impacts and theoretically assess the role of each for the environmental sustainability. Hence, the Antarctic environmental changes, in both local and global, are firstly reviewed. In the next step, the study concentrated on impacts to which tourism contributes. Both laboratory and field studies were reviewed in these stages. Some parts of the data were presented by previous studies and some parts were reported for other environmental situations or non-systematically explained. The further review, comparison and evaluation shed light on the most critical aspects of the impacts which should be noted in forming the new international treaties.

2. Environmental consequences of Antarctic tourism

The tourism environmental impacts have occurred locally but added up to a global dimension. From a wide view, these impacts can be categorized into direct and indirect (Gössling, 2002), polluted and non-polluted (Kariminia et al., 2012) and physical and non-physical groups (Nicoletta & Servidio, 2012). Due to the pristine and vulnerable ecosystems in Antarctica, the environmental changes presented by tourism are linked to many factors, namely land use, energy consumption, waste generation, biotic diseases and psychological aspects.

3. Discussion

3.1. Changes in land cover and land use

Up to half of the Earth’s ice-free surface has been changed by human through land use and land cover alterations (Vitousek, Mooney, Lubchenco, & Melillo, 1997). Land cover change is the physical and biotical alteration at the site while land use change addresses the alterations in the way which humans use the land. Many researchers have reported land alteration as the most important environmental change (Vitousek, 1994; Vitousek et al., 1997) which decisively contributed to increasing the greenhouse gases (GHGs), i.e., CO₂ and CH₄ (Gössling, 2002). In the tourism industry, infrastructure development is an important part of land alteration. Tourist facilities and infrastructures contributed to a big proportion of impervious surfaces, which in turn, caused more runoff (nutrients, suspended particles, oil and gas) to water bodies (Davies & Cahill, 2000). In the Antarctic continent, the ice-free surface consists only 2% of the total surface (Fig. 1). Furthermore, expeditions were mostly ship-based, and the land adventures generally included short-term ashore visits. In fact, tourism-related constructions in Antarctica are mostly provided for the air base stations and supports. Thus, infrastructure development still remained in a low amount (Lu et al., 2011). Direct local land alterations can be categorized into accommodation establishments (which is limited), land needed for traffic infrastructures and tourist activities and a wider area indirectly affected by the conversions.

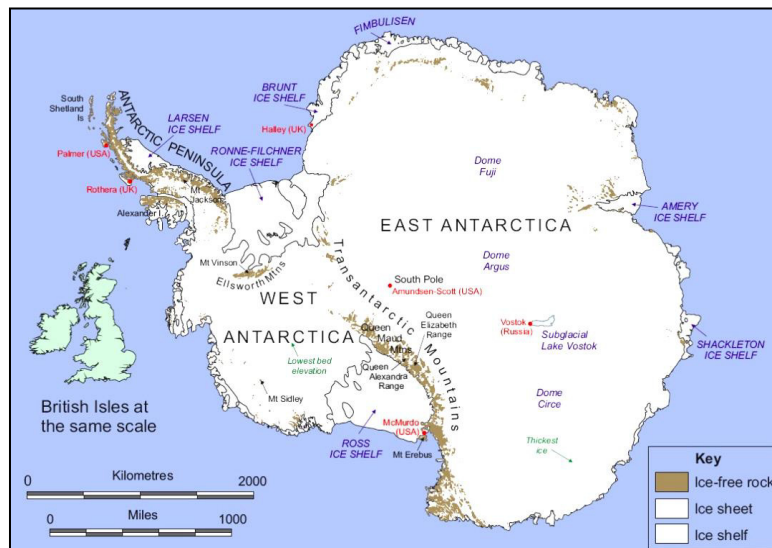


Fig. 1. Map of Antarctica (Scentofpine.org)

The accommodation facilities are allocated to the tour operators and the scientific programmes. In terms of traffic infrastructures, airports, marinas, roads and parking contributed to the land conversions. As the only non-governmental permanent tourism air-based facility, the E-base was founded by an NGO in King George Island (Kariminia et al., 2012). It aimed to enhance the public awareness on protecting the Antarctic ecosystem. Furthermore, a Canadian company established a semi-permanent camp at Patriot Hills in 1987, which provided logistic support and organised flights for airborne tourism operations and private expeditions. Although the proportion of covered surface by infrastructures in Antarctica was not considerable, policymakers are concerned with the involved construction and demolition (Liggett, McIntosh, Thompson, Gilbert, & Storey, 2011). In addition, land alterations have indirect impacts such as loss of lands, coastal erosion (Wong, 1998) and sedimentations.

3.2. Energy and material use

A large part of energy use worldwide is generated by fossil fuel consumptions. According to IPCC (2007), the transportation sector significantly relied on fossil resources, particularly petroleum (supplies 95% of the world total energy use by transport). This report argued that in 2004, transportation was responsible for 23% of energy usage-related GHG emissions worldwide. As the most important part of the leisure-related energy use and GHG emissions, transport was responsible for 94% of the total contribution of tourism to global warming (Gössling, 2002).

The Antarctic tourism industry utilised energy for two purposes; transport and destination related. The greater proportion was in transportation as cruise-based travel is the most common expedition. Seven different types of ships are used to ferry tourists: dive boats, expedition ships, icebreakers, motor yachts, Russian ships, sailing vessels and small ships (IAATO, 2013). The fuel consumptions from these vessels result in emissions of GHGs such as carbon dioxide (CO₂), nitrogen oxides (NO₂), sulfur dioxide (SO₂), which in turn contributed to harm biogeochemical cycles (Biesiot & Noorman, 1999) and impact the composition of the atmosphere and biosphere. The most important degradation outcome of these emissions is global warming. In addition to this climate change, the GHG emissions contributed a chain reaction; for instance, rising CO₂ concentrations changed plant physiology (Gössling, 2002). The warmer climate aggregately affected the ecosystems (Sala et al., 2000). Elevated CO₂ and warmer temperatures negatively affected the climate through expansion of higher ecosystems' productivity into the regions (Sturm et al., 2001; Tape, Sturm, & Racine, 2006). In fact, terrestrial ecosystems were feedbacks of changing climate as a function of surface energy balance and patterns of sources as well as sinks of atmospheric CO₂. Furthermore, energy use also contributed to changes in other areas of the global environment; for instance, it increased the possibilities for the exchange and dispersion of diseases (Gössling, 2002).

As the most vital resources to humanity, water crisis is expected to exacerbate in the future with regards to climate change and growing human population (Vitousek et al., 1997). As individuals generally used more water while travelling rather than at home (CEED, 1994; Gössling, 2001), tourism development would result in the increase in overall water use in Antarctica.

3.3. Waste production and environmental pollution and disturbance

In general, the role of tourism in environmental pollution and disturbance included travel and destination related aspects. The destination related degradations are categorized into accommodation and activities and involve a wide range of activities, namely construction and maintenance of facilities. The construction and maintenance of facilities generated waste material and energy, which affected the

surrounding ecosystem. Although construction in Antarctica is limited, due to the pristine environment, the effect was considerably higher compared to urban areas. The environment pollution could be immediate, such as engine fallout; sewage disposal or gradual such as eutrophication and depleting dissolved oxygen supplies through leaching of nutrients from septic systems into the water body.

3.4. Travel

Travel agencies are defined as all the facilities and individuals involved in providing services for tourists. In terms of facilities, large vessels are the highest potential risk as they might have a crash or accident, ground on uncharted rocks, break the ice lands or pollute the water. Operators preferred to use large vessels as small vessel were not economical enough. Liggett et al. (2011) reported twenty-nine accidents and incidents such as damage, aircraft crash; ship grounding and oil spill recorded in Antarctic area between 1967 and 2003. Surprisingly, almost half of all accidents are accrued during the last 12 years. Although IAATO has provided a swift accessible precautions and assistance, the sinking of MS Explorer in 2007 demonstrated that potential risk of vessels crash still remained (Fig. 2).



Fig. 2. Explorer in trouble near South Shetland Islands in 2007 (IAATO, 2011)

In addition, the cruise vessels generally have high potential to pollute the air through engine emissions. It is due to used residual fuels, which have higher contaminants. The annual sulfur emissions by ships can be even higher than that from land (Capaldo, Corbett, Kasibhatla, Fischbeck, & Pandis, 1999). Waste oil is normally generated through leaks from engines, generators and hydraulic systems, and from the fuel filters while conducting maintenance work. Furthermore, toxic chemicals, dry-cleaning wastes, used batteries and paint waste from brush cleaning are possible to occur (Davies & Cahill, 2000). Animals could be exposed to contaminants and discharged wastes. Although the International Convention has prohibited the use and carriage of heavy and intermediate fuel oils for the ships in the Antarctic treaty area for the Prevention of Pollution from Ship since 2009, the concern on the environmental contamination still remains.

The amount of garbage (dry garbage, food waste and disposes) produced by a cruise ship carrying 2700 passengers can exceed a tonne per day (Davies & Cahill, 2000). Illegal dumping of solid waste has been witnessed. For instance, in 1999, Royal Caribbean, the world's second largest cruise line, pled guilty to twenty-one felony counts for dumping oil and chemicals from its cruise ships. Thus, the possibility of both shipboard waste and land generated waste once onshore should be taken into consideration.

Furthermore, airborne travelling could lead to the possibility of air crash, air pollution and wildlife disturbance. After a growth between 1950s and 1970s, the number of tourists frequenting this area via

flight seemed to have steadily declined during past few years. However, the potential of crash and degradation related to air based supports exists.

3.4.1. Destination

Tourists inherently tend to visit the most picturesque and wildlife-rich areas with vulnerable ecosystems. According to IAATO (2011), Antarctic tourism currently comprised of eight activities: ship borne expeditions, small boat landing, kayaking, extended walk, station visit, scuba diving, science support and camping (Fig. 3). Site degradation, waste generation and littering, discharging sewage wildlife disturbance and damage to the ice layers could occur with these activities. In addition to the aesthetic issue, littering alters the nutrient compositions and lead to the wildlife disturbance. Sewage contains pathogens, which can contaminate water and affect its quality. The effluent accelerates the growth of algae, which cover the filter-feeding corals and results in hampering their ability to get food. The marine debris, on the other hand, could harm the ecosystems. It aesthetically impacts the coastal areas and ecologically damages the water through gas exchanges between different water surfaces. Moreover, opportunistic organisms could choose debris as its habitat, which could cause changes to the compositions of the ecosystem.

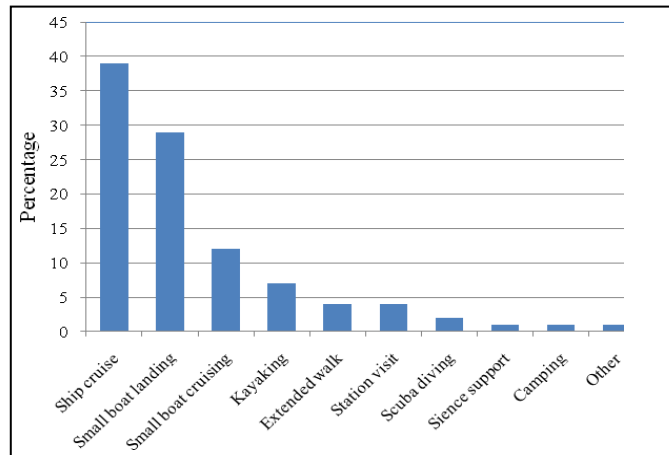


Fig. 3. Distribution of Antarctic tourism activities (IAATO, 2011)

Meanwhile, the new generation of Antarctic tourists who travel individually or in small parties also have a high potential of environmental risk (Fig. 4). The environmental degradation caused by this group would be substantial as they might not have adequate information on the environment they encounter.

3.5. Fauna and flora exchanges and disease

Enormous exchange of species is a result of human mobility, which leads to homogenization of biota and disruption of natural systems. International commerce, trade in live organisms and transport by tourists are ways to transport species between different environments (Gössling, 2002). The number of new disease-causing organisms discovered in the past three decades has reached thirty (Rodriguez-Garcia, 2001). The exchange and dispersion of diseases through transporting infectious organisms was also a decisive aspect of travel. A growing proportion of travels was nature adventure-based which increased exposure to a greater variety of species and pathogens (Ahlm, Lundberg, Fessé, & Wiström, 1994). Indeed, tourism contributed to the extinction of species both directly and indirectly. The direct ways

included voluntary acts such as physical and noise disturbance, littering, and collection of natural objects. However, they can also indirectly disturb the species; for instance, when transporting exotic species, viruses, bacteria, insects or other small organisms. Tourists can transport non-human microbes through their bodies, clothes, animals, goods, food, seeds, etc., which could increase the risk of flora and fauna diseases (Fig. 5).



Fig. 4. Individual travellers to Antarctica (IAATO, 2011)



Fig. 5 Tourists transport non-native species to the Antarctic environment (IAATO, 2013)

In addition, the facilities related to the tourists' travel and accommodation could lead to the exchange of biota. The accommodation-related facilities, for instance, import plant species alien to the environment. Vessels such as cruise ships are known to transport organism over the long distance of travel to Antarctica. Due to the isolation from other landmasses, Antarctic terrestrial ecosystems currently contain few non-native species. Nevertheless, its indigenous biota is vulnerable to human mediated introductions on non-native species. Hughes, Convey, Maslen, and Smith (2010) reported an incident of the transportation of contaminated soil containing non-native angiosperms, bryophytes, micro-invertebrates, nematodes, fungi, bacteria and seeds through four construction vehicles imported in 2005 by contractors working for the Rothera Research Station (Antarctic peninsula).

There were also rising concerns on the chance of genetic exchange of microbes and evolution of viruses in new environments which in turn would increase the diseases (Goldsmith, 1998). Tourism is believed to contribute to climate change which involve old, new and re-emerging infectious diseases (Kumate, 1997). Climate change was partly caused by the El Niño–Southern Oscillation (ENSO) phenomena which led to the reduction in the thickness of the ice layers (IPCC, 2007).

In isolated areas such as Antarctica, tourists exert considerable pressure on animals while closely interacting with them. This reduces the breeding success or threaten them with human pathogens. Antarctic expeditions are usually offered in the austral summer (November to March) as the critical time for the wildlife to breed. For instance, this period is the courting season for penguins, seals being visible on fast ice to establish their breeding territory and penguin chicks start to fledge (IAATO, 2013). The animals would scrounge for the food given by tourists. It could make them accustomed to human food, which would affect their behaviours. Changes in the seal and krill population were one of the results of the marine environment degradation in Antarctic (Wiedenmann, 2010). Penguins show both behavioural and physiological response to visitors which could change their breeding and survival pattern (Bertellotti, D'Amico, & Cejuela, 2013). In addition, the increasing number of tourism communities contributes to changes in the wildlife habitats.

3.6. Psychological aspects

The environmental effects of Antarctic tourism are not only limited to the physical aspects. Travelling to a pristine area also altered the visitors' perception and understanding of the environment as a complex system of relations between individual, society and nature (Steiner, 1993). This understanding is concerned with environmental knowledge, attitudes and behaviour which can either facilitate or complicate the sustainable processes of the societies (Gössling, 2002). Indeed, there are two paradoxical situations; in one hand, Antarctic tourism promotes the visitors' environmental consciousness on its ecosystem while in the other hand, the proximity to the biota and consumption of the natural resources characterises the personal behaviours of the tourists. Thus, from a psychological perspective, travel to Antarctica alters the travellers' perception of its environment in two ways:

- Environment proximity: Visiting isolated environments diminish the visitors' image of the environment vulnerability. It disrupts their feeling of being responsible to the nature and shrinks it in their eyes. Compared to those who have not this experience, these visitors lack the attachment to nature. The lower responsibility to nature probably increases the consumptions of resources.
- Environmental awareness: Exposure to the new representations of the pristine nature fosters the visitors' environmental awareness (in addition to the role of education, media or comparison between different environments). For example, visitors perceived wild animals as a representative or symbols of naturalness (O'Rourke, 2000). This alteration in the relations between human and nature increases environmental consciousness, which in turn promotes tendency to travel more.

Fig. 6 depicts the Antarctic ecological tourism impacts in the addressed major categories as well as the defined sub-categories. The severity of the impacts relatively increases from the first to last impact group. Meanwhile, the third group of degradations demonstrates the highest level of direct pollution.

4. Conclusion

This study shed light on the Antarctic tourism related environmental degradations. It aims to elaborate the tourism impacts not only in a local scale, but also from a global perspective. The psychological dimensions are also taken into consideration. The five major fields of these impacts are land alteration, energy and material use, pollution, biotic exchange and change of perception towards the environment.

Land alteration is more allocated to traffic infrastructures, while the accommodation related changes are still limited. The fuel consumption in the transportation results in the GHG emission and contributes to negative impacts on biogeochemical cycles and changes the composition of atmosphere and biosphere. Tourism also increases the usage of fresh water. Environmental pollution is categorized into travel and destination related dimensions. In addition to the wildlife disturbance by through noise pollution, large cruise vessels have run the risk of accident that would pollute the environment. Shipboard and land generated waste contribute to environmental pollution.

Besides the direct disturbances, visitors unintentionally disturb the ecosystem. They transport non-native species through their bodies, clothes and belongings. The cruise shops also carry exotic organisms. The Antarctic expeditions' season in summer is a critical time for the wildlife and visitors activities may affect the animals' mating season. Sustainable tourism aims to promote environment-responsible behaviours. Although travelling fosters the knowledge on the environment, it does not necessarily make positive changes in environmental behaviours.

The study demonstrates in detail the substantial environmental consequences of tourism in Antarctica. As future study, it is essential to deepen the debate on Antarctic ecosystem protection and address the protection scenarios in the context of global warming.

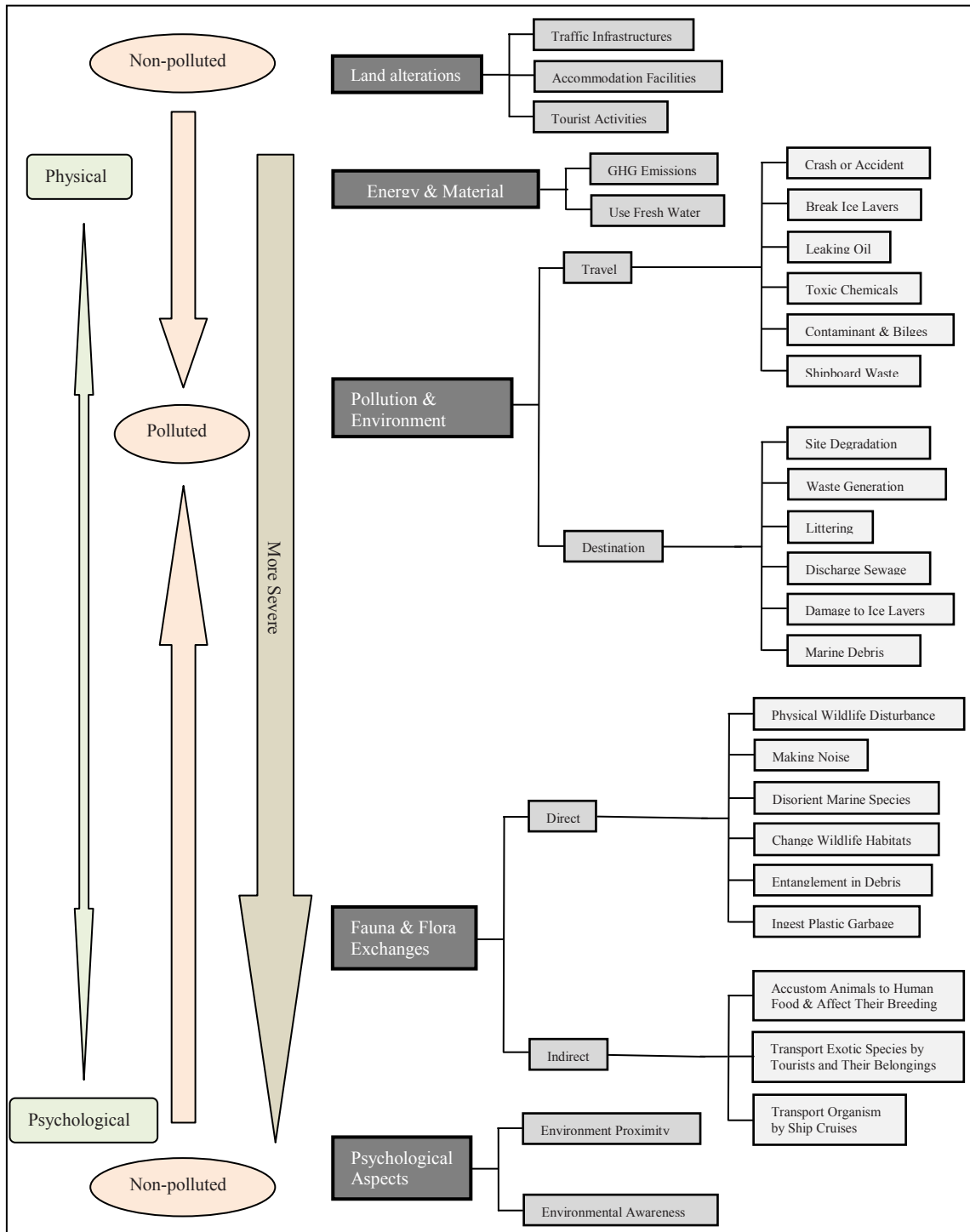


Fig. 6. Local and global environmental impacts of Antarctic tourism

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