Environmental Impact Assessment Review 73 (2018) 104–113

Contents lists available at ScienceDirect

Environmental Impact Assessment Review

journal homepage: www.elsevier.com/locate/eiar

Methodology for environmental assessment in Antarctic buildings

Dielly Christine Guedes Montarroyos[a,*], Cristina Engel de Alvarez[b], Luís Bragança[a]

[a] Department of Civil Engineering, University of Minho Portugal, Campus de Azurém, 4800-058 Guimarães, Portugal
[b] Laboratório de Planejamento e Projetos, UFES, Brasil, Av. Fernando Ferrari, 514, Room 7, Vitória - Espírito Santo 29075-910, Brazil

1. Introduction

Antarctica, known as the most remote, coldest, windiest, driest, highest, most desert and least inhabited land, presents some of the worst conditions of habitability on the planet, and stands out for its environmental vulnerability and scientific importance (Alvarez, 2014).

It is known that the Antarctic continent is the site of scientific research, whose results have global implications (Dodds et al., 2017). Researches in the areas of the marine environment, environmental and climate changes and forecasts, and soil investigations that may lead to significant pharmacological discoveries (Dodds et al., 2017) are examples of the above mentioned. It is worth remembering that the inhospitable conditions, environmental fragility, and isolation will further encourage the research in the area of construction. These studies generally rely on the continued human presence on the site and require that the environment remains without interference that could endanger the fragile Antarctic ecosystem (Alvarez, 2014). Thus, it is extremely important to achieve a balance between the interests that attract humans to Antarctica and the impacts that may be caused by the human presence there (Bargagli, 2005).

Currently, there are few areas on the planet that have not yet been altered by humans - called inviolate areas - which, in addition to being rare, are valuable to the scientific world (Hughes et al., 2011).

Therefore, in accordance with the scientific importance and the desire to preserve the continent, 29 countries signed the Protocol on Environmental Protection to the Antarctic Treaty. This document is used as a reference and leads the participant countries to conduct Environmental Impact Assessments (EIA) for all Antarctic activities and to prioritize environmental discussions, treating, among other aspects, the prohibition of mineral resource activities, and declaring the Antarctica as a scientific territory with strict environmental protection legislation (Secretariat of the Antarctic Treaty. SAT, 2016a, 2016b).

Besides the Protocol, the Antarctic Treaty Consultative Meeting's (ATCM) have also established guidelines and resolutions to effectively assess the environmental impacts. In these documents, in particular on the Resolution 1 named “Guidelines for Environmental Impact Assessment in Antarctica”, the ATCM suggested a method to analyze impacts by identifying environmental aspects: nature, extent, intensity, duration, significance and effect of the impact (Secretariat of the Antarctic Treaty. SAT, 2016a, 2016b). Noting that most of the environmental assessments conducted in accordance with the Protocol, annexes or resolutions, assess only the mandatory issues or the main impact factors and sources.

Considering that Antarctica is an area of environmental protection, all impacts at any level on the environment must be foreseen, and those documents should present strategies to avoid them. Despite being legally protected by the Protocol, among other legislations, the growing number of buildings and individuals interested in the continent (i.e. tourists and researchers) increases the threats to the ecological integrity and vulnerability of protected areas (Shaw et al., 2014). The content of the Environment Protocol mentions a guarantee of the implementation of constructions with adequate solutions to minimize environmental impacts. As yet, there are no effective guidelines for the development of sustainable projects for new scientific stations, containing generic recommendations, and little or no input in the design process (Montarroyos et al., 2015). Thus, each nation has been free to set its own assessment criteria and priorities.

Antarctica is an inhabited area of interest and environmental protection, there are no regulatory instruments directed for sustainable practices in the construction guidelines for the planning and execution in low environmental impact. The combination of strict environmental protection and high scientific value of the Antarctic territory imply more effectiveness in the project planning and execution of constructions. In many countries, the assessment tools are considered active instruments for the production of sustainable buildings. The tools can measure levels of sustainability promoting improvements in the building performance and in the user's life quality, and reducing costs and environmental impacts (Ali and Al Nsairat, 2009). Given the specific conditions of each region in which a building is located, most tools have been structured for specific locations and cannot be reproduced in other settings (Alyami and Rezgui, 2012). The tools comprise numerous indicators that are adapted to the characteristics of the assessed location, and their combination with their corresponding weights is one of the adopted strategies for conducting site-specific assessments.

Recognizing that the use of assessment tools by a number of countries has contributed to more sustainable buildings (Kibert, 2012), and that there are no specific assessment tools for the Antarctic context, indicators for the assessment of environmental issues can assist in the

* Corresponding author at: Av. Fernando Ferrari, 514, Room 7, Goiabeiras, Vitória – Espírito Santo 29075-910, Brazil.
E-mail addresses: dielly.christine@faesa.br (D.C.G. Montarroyos), cristina.engel@ufes.br (C.E. de Alvarez), braganca@civil.uminho.pt (L. Bragança).

https://doi.org/10.1016/j.eiar.2018.08.003
Received 20 April 2018; Received in revised form 10 August 2018; Accepted 10 August 2018
Available online 22 August 2018
0195-9255/

planning and construction of buildings aimed at eliminating or mitigating the negative effects of human occupation on the continent.

In Antarctica, the factors that interfere with the design process of infrastructures include: area covered by ice; water in a solid state; extremely low temperatures; low precipitation rate; low level of absolute humidity; long periods of absence of sunlight; strong winds; energy originating from fossil fuels; flora and fauna sensitive to human interventions; high radiation rate; absence of local materials, trained workers and equipment; geographic distance from other continents; reliance on logistics systems; environmental susceptibility to waste disposal; climatic variations; absence of monetary system; and sensitivity to emissions of harmful substances (Montarroyos et al., 2015).

In accordance with the atypical characteristics of the place, these factors can contribute to set relevant sustainability indicators and their weights for developing projects. Knowing that this site requires the application of concepts that differ from those traditionally adopted in urban areas underlines the need for a more effective implementation.

Note that the sustainability indicators appropriate to highly populated urban centers do not apply to areas of environmental interest. Certain aspects of great importance to the “Land of Superlatives” may be negligible in urban areas; the reverse situation may also occur.

The development of assessment tools specifically focused on the Antarctic context may allow the improvement of existing buildings, stimulate the precautionary principle in natural resource management, as well as induce preventive measures related to the production and destination of waste, the protection of soil, water, atmosphere and species affected by human occupation.

Moreover, the proposal of an assessment methodology, considering specific indicators and weights for Antarctica, can contribute to abide by the current international protocols. Furthermore, these indicators serve as an instrument for the development of design guidelines for the construction of environmentally-responsible buildings. Hence, the presented research aims at proposing an environmental assessment methodology for planning and project phases of Antarctic scientific stations.

2. Methodology

According to Andrade and Bragança (2016), for the development or adaptation of a sustainability assessment method of the built environment, the process starts from the recognition of the specific characteristics of the place or region, and such information is generally used in all stages, from the selection of the indicators until the definition of the weights of each one.

It is worth mentioning that the assessment tools are composed of categories, criteria, and indicators that seek to align with the issues inherent to the global concept of sustainability, respecting the local characteristics (Mateus and Bragança, 2011). However, there is no consensus in the meaning of the nomenclatures used in the several assessment methods and tools (Wallhagen et al., 2013). So, for the present work, the meanings are adopted according to the ones presented in Table 1.

To achieve the aimed results, authors organized this study according to the following steps: 1) Establishment of environmental indicators for construction of new scientific stations; 2) Verification of the relevance of each indicator; 3) Weighting from the Environment Protocol viewpoint; and 4) Definition of weights.

Table 1
Nomenclature and definitions.

Nomenclature	Definition	Example
Category	Set or combination of indicators	Water
Criteria	Performance required for the achievement of a goal	Water use in building systems
Indicator	Variables that condense the relevant information for evaluations. It allows quantifying and evaluating compliance with the associated criteria.	Use of water-saving equipment and/or use of rainwater storage systems

2.1. Step 1 – Defining environmental indicators

The initial research had as objective the bibliographical review for the contextualization of the Antarctic environment. The review includes the Protocol, resolutions, EIAs, ATCM documents, article, thesis and dissertations, from 1991 until 2018, related to Antarctica environment, sustainable buildings and environmental impacts of the construction activities in Antarctica. The review contributed to the definition of adjusted indicators to the continent for the construction of scientific stations, through the survey of environmental restrictions, in addition to the limiting factors and potential of Antarctica and, afterwards, the insertion of data in the analytical structure Pressure-State-Response (PSR). The PSR structure is characterized by a dynamic analysis in which the cause, the effect, and the possible mitigating or compensatory measures can be identified for a given situation. It can be adapted and, given the flexibility that it presents, this analytical structure has undergone changes, such as the Driving force-State-Response (DSR) and the Driving force-Pressure-State-Impact-Response (DPSIR), to be used for many other purposes (Organization for Economic Cooperation and Development. OECD, 2003).

Therefore, for the use of the PSR in this research, it was necessary to make an adjustment on the incompatibility of the structure with the specificities inherent in Antarctica. The adequacy of the analytical structure was accomplished through the adaptation of the Pressure and of the State usual conditions, as they do not represent the reality of a preservation area, in which its fragility does not allow environmental pressures or changes in the environment state throughout the construction activities, use and disassemble of buildings. Thus, the analytical framework was adapted and the analysis elements considered were State-Pressure-Response or SPR.

The SPR analytical framework represents a cycle that describes the pressures caused by the construction activities and possible solutions. The process of analysis of the response elements of the analytical framework also contributes to enriching the data, as it enables new solutions and techniques to be proposed; thus, this framework exhibits potential temporary adequacy.

The State generates one or more responses that could also function as an indicator for the design guidelines for Antarctic buildings, as exemplified in Table 2. The answers generated the indicators named as List 1.

In parallel to List 1 of SPR indicators, a review of selected sustainability indicators from the Sustainable Building Tool (SBTool) was carried out. SBTool was chosen as the main source of indicators because it is worldwide recognized as the first assessment method and global tool specially developed to be adapted in other regions (Andrade and Bragança, 2016).

SBTool covers a wide range of issues and more than 100 criteria. The system allows third parties to modify as desired and change weighting parameters according to specific context factors. For that matter, the basis of the SBTool weighting system presents pre-set values related to extend, duration and intensity of the potential effect. An authorized user can change those values up or down to 10% to adapt the tool for local context (Larsson and Bragança, 2012).

In this methodology, SBTool was used to provide Antarctica-specific indicators. Considering the broadness of the SBTool framework for the identification of the indicators compatible to the Antarctic context, the selection of indicators was made taking into account the prerequisites of adaptability and vulnerability as follows:

1) Adaptability, ability of an indicator to change according to Antarctica's reality; and 2) Sensitivity to changes, given the importance of building adaptability over the years in environmentally vulnerable