

An Environmental Atlas as a Tool for Improving Local Environmental Education and Awareness in Arequipa

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Abstract. The success of any environmental management requires the active participation of the community that should be involved in the awareness and solution of environmental problems, which can only be achieved through environmental education. This research takes as a case study the city of Arequipa, Peru to, firstly, understand the gap between the environmental education provided nationwide by the Ministry of Education and the lack of awareness of local problems by university students. Secondly, to analyze the methodological framework for the development of the Environmental Atlas of Arequipa, as an educational tool to fill-up that gap. Finally, a strategy for the use of the atlas a massive urban-environmental education tool in Arequipa will be proposed.

Keywords: environmental education, local environmental awareness, Environmental Atlas, Arequipa

1 Introduction

Environmental management recognizes the importance of citizen participation as a fundamental component in the success of the objectives of sustainable development, the solution of environmental problems, as well as for the increase of resilience in communities [1]. One of the most effective ways to develop participation is through environmental education, which allows knowledge of situations and problems as well as support for decision making. Therefore, a good environmental management requires access to systematized, accessible and understandable information, which in

developing countries is typically currently dispersed, scarce, inaccessible and too technical. In turn, it is necessary to rethink environmental education by combining typical concepts of global interest with understanding local (provincial, metropolitan, district-level) problems that are aimed at changing attitudes and modifying collective behaviors [2], which, by means of massive communication tools [3]

In Peru, significant advances have been achieved through the development of a National Plan of Environmental Education (PLANEA), which discusses concepts such as climate change, health, risk management and environmental efficiency in the schools nationwide which has produced a general interest and even activism in these topics by the youth. However, the level of knowledge of local environmental problems by the community is much lower, given the lack of information available or simply the absence of it. In particular, many young university students, while having empathy for environmental issues, they are unaware of the environmental problems of their locality. This is due, in part, to the fact that school texts used for learning are mostly developed in the capital and do not address situations at the regional, provincial or metropolitan level, and also because there is no systematized and organized information that can easily be consulted by the community.

This situation has important effects on the increase of the environmental deterioration of the cities, partly due to a lack of knowledge of the population. Therefore, this article addresses the following questions:

- What are the characteristics of school texts on Science, Technology and Environment that are used in Arequipa in relation to the local environmental education?
- What is the degree of awareness of university students regarding attitudes, behaviors and spatial knowledge of the environmental problems in Arequipa?
- What characteristics and methodology should have a document such as the Environmental Atlas of Arequipa in order to contribute to local environmental education in schools?
- What strategies should be followed to ensure that this document is known by the community and particularly by students in schools and universities?

2 An Overview of National and Local Environmental Education

Environmental education is key to achieve a sustainable development. In 2015 the UN defined 17 global objectives as part of the new sustainable development agenda, which seeks to eradicate poverty, protect the planet and ensure the prosperity of all its inhabitants in a period of 15 years [4]. Although the Sustainable Development Goals (SDGs) are interrelated, “Sustainable Cities” seeks “to make cities and human settlements inclusive, safe, resilient and sustainable” [5].

A collaboration between the Peruvian Ministry of Education and the Ministry of Environment, has promoted the development of the National Plan Environmental on Education (PLANEA) [6], which has been developed through a participatory process and was validated in various workshops and working meetings with a broad participation of stakeholders of public entities (ministries, regional and local governments, etc.), private institutions (companies, universities, NGOs, etc. .) and

civil society organizations (rural and indigenous communities, environmental volunteer networks, etc.).

PLANEA proposes four key themes: a) **Climate change education**, aimed at increasing awareness and adaptive capacity against climate change, b) **Health education**, which allows to achieve healthy lifestyles in the educational community, c) **Eco-efficiency education**, to develop skills in research, entrepreneurship participation and applicability of progressively controlling the environmental impacts and d) **Risk management education**, to strengthen the culture of prevention and adaptation.

Among the most effective ways to improve education in local environmental management at various levels are the environmental atlases, which are specialized compendiums of the characteristics of a given place.

One of the first experiences of creating an environmental Atlas was in Porto Alegre, Rio Grande do Sul, Brazil [7], a city where several environmental management and popular participation policies had already been developed. Published in the year 2000, the Atlas managed to systematize the city's environmental information, becoming an important tool for city planning, and at the same time an effective means of disseminating this information among citizens, particularly teachers and schools. Also, the environmental Atlas became a tool to promote citizen participation [8]. After 20 years of its publication, the Environmental Atlas of Porto Alegre has been digitized and it is available for consultation on the web, although it does not have the characteristics of a digital geographic platform, it is only an online book [9]. Over 20 years, the atlas has contributed to the construction of an environmental identity in schools, building concepts of value of its immediate surroundings, improving the knowledge of the problems of the city and contributing to the conception of solutions by its citizens [10].

Given this successful experience, the Education Program for Urban Management in Peru (PEGUP) [11], in agreement with the IHS and ITC institutes from the Netherlands, developed Environmental Atlases in Arequipa, Lima, and Trujillo, having as a counterpart to the municipalities of these cities. A draft for the atlas draft was developed in Arequipa, but for political reasons it was never published by the municipality. However, it served as a model for the environmental atlases of Lima (on a provincial scale) [12] and Trujillo (on a provincial and metropolitan scale) [13], which were published and have been used as a reference in various planning and research projects of these cities. In the case of the environmental atlas of Lima, citizenship education and awareness was encouraged, for which it was distributed freely to the main national universities, to several public schools and to the district municipalities [14]. This atlas was a high quality technical tool, but unfortunately its dissemination was not continued again for political reasons.

3 Materials and Methods

Different methods have been used to address each of the research questions.

3.1 Characteristics of school texts

In this case, the revision of Science and Technology school textbooks was carried out, verifying their content on environmental subjects and their scope at national, regional or local level. Personal interviews with students regarding the importance of these books in their awareness of environmental issues were also carried out.

3.2 Knowledge of Young University Students Regarding Environmental Problems in Arequipa

a) Evaluation of attitudes and behaviors on environmental issues

An electronic data collection sheet was developed using a Google form (<https://forms.gle/vK7KGiy92ryjk6ob9>). The instrument evaluated sociodemographic variables such as age, academic training, evaluation of attitudes and behaviors on environmental issues by the population surveyed.

For the evaluation of attitudes, questions such as: "I am concerned about the amount of waste produced in Peru.", "More land should be reserved for wild habitats" or "I think I can contribute to the solution of environmental problems" were included. For the evaluation of behaviors, questions such as "I strive to reduce the amount of products I consume," "I avoid buying products that have a negative impact on the environment," or "I recycle paper, glass and / or metal waste products at home or at school " were included. Subsequently, a sum of every graded question was made according to attitudes and behaviors. The survey was distributed through the use of social networks, to exceed the desired number of respondents. Likewise, the evaluation of the results was carried out using the Excel software and SPSS Statistics.

The Likert scale was used to calculate the results, which were then converted into percentages and analyzed under the following ranges; the group A percentages greater than 60, which indicates a highly developed environmental culture. Group B included percentages between 50 and 60, indicating a moderately developed environmental culture and group C included percentages lower than 50 indicating very little awareness in environmental issues.

b) Evaluation of the spatial situation of the environmental problems of Arequipa

A graphic survey was carried out with 4 maps requesting the identification and graphing of points or areas of a) risk of disasters b) environmental problems in the Chili River c) urban heat islands d) loss of green areas. Subsequently, the maps were digitized into ArcGIS, converted to raster format and then, through map algebra, managed to identify which were the areas that most students perceived as problematic and then contrasted with reality.

3.3 Methodological framework of Environmental Atlas of Arequipa

Geographic Information Systems were used as a powerful analysis and modeling tool [16] that promotes research and better understanding of various environmental problems [17]. The different themes were compiled in a geodatabase, which was

standardized and georeferenced in the WGS84 Projected Coordinate System and the 18S zone. According to the degree of information production, there have been 2 levels of maps:

1. Cartographic representation: obtained from primary sources, whether national, international or self-produced.

a) Vector maps: Made up of a georeferenced vector graphic component (points, lines or areas) and a database [18].

b) Satellite photographs: were obtained from various international sources such as USGS / NASA's Global Explorer, and used as background for contextual reference.

c) Creation of orthomosaics: Historical aerial photographs have been orthoreferenced and reprojected because they have a photographic distortion as they approach the edge of the image, due to the angle generated by the surface photographed with the aircraft [19].

2. Scientific analysis based on GIS: In these cases where, new information was produced through a GIS operation.

a) Statistical analysis: made of the combination of vector maps or raster image analysis.

b) Point density maps: characterize the pattern of a point distribution and its agglomeration variations with respect to the study area [20], simplifying a large amount of information and show the trends of a given point map, based on its concentration or dispersion.

c) NDVI multispectral analysis: For the analysis of Landsat 8 satellite images, the ENVI program has been used, which allows the study of the different bands that make up a multispectral image. A map algebra correction, a radiometric correction and an atmospheric correction were made by the FLAASH method. Finally, spectral indexes were used to generate the NDVI image.

d) MODIS multitemporal vegetation change analysis. Images from the same month of two different years are used, using the MOD13Q1 product of the MODIS satellite. Map algebra was used to subtract the most recent image from the oldest and later reclassified to determine the gains and losses of the vegetation cover.

e) Temperature maps based on satellite image and drone survey: allows to verify the surface temperature and urban heat islands. The TIR (Thermal Infrared) image of Landsat 8 was selected, the respective projection, the radiometric and atmospheric corrections and finally the conversion of Kelvin degrees to Celsius were made in order to show the location of heat islands on a macro scale. For a micro analysis a Flir Duo camera mounted on a drone has been used, determining the air temperature, humidity, atmospheric conditions and emissivity.

4 Results

4.1 Characteristics of school texts

For the purposes of the study, books of the Science, Technology and Environment course from Bruño Publishing and Santillana Publishing were reviewed. The texts

addressed environmental issues in a graphic and didactic way but very generally. They are aimed at creating environmental awareness in the student but not raise a critical and proactive attitude towards problems. In conversation with some students, they refer to the development of some recycling activities within the course, but not an understanding of the real problems of the locality. The reviewed material addressed environmental subjects only at an international and national level.

4.2 Perception surveys

a) Evaluation of attitudes and behaviors on environmental issues

Data were collected from 282 people, which were processed and systematized according to their professional background [21] [22] [23]. They were distributed as follows; 45.65% corresponds to university and college students, and 54.3478% corresponds to graduates and professionals.

Table 1. Data analysis.

Educational level	Component	Average	Standard deviation
University/college students	Attitudes	48.8 %	6.893
	Behaviors	58.9 %	15.832
Graduates/professionals	Attitudes	47.6 %	6.474
	Behaviors	62.5 %	15.339

Universities and college students are placed in category C regarding their attitudes and B as for their behaviors, with a medium to low environmental awareness. (Fig. 1).

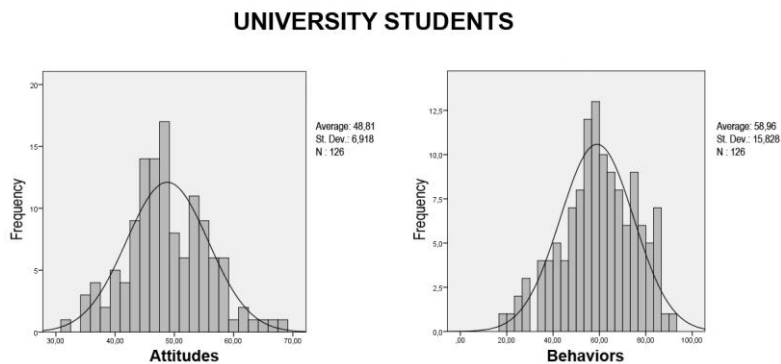


Fig. 1. Attitudes and behaviors in university and college students

Also, most professionals belong in category A regarding behavior, which means that in their actions demonstrate positive behaviors with the environment, but they have less positive attitudes, as they fall into category B. (Fig. 2).

PROFESSIONALS

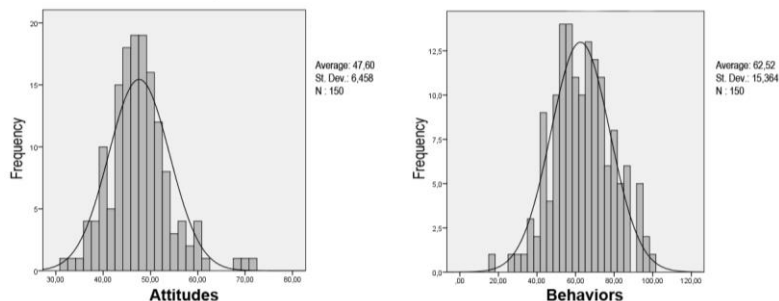


Fig. 2. Attitudes and behaviors in graduates and professionals

The results indicate that among the interviewees there is an interest and empathy for environmental issues. However, there is lack of knowledge about the environmental problems that afflict the city. Bad practices are also evidenced in terms of environmental awareness. By having small improvement in these behaviors, by large numbers of people, can have a great positive impact in the society.

b) Evaluation of the spatial situation of the environmental problems of Arequipa

Although there is a recognition of the areas with more conspicuous environmental problems in Arequipa, in general there is a distortion of the spatial perception of students with respect to reality. The question regarding environmental risks had the closest answers to the real situation. However, the issues of the loss of green areas and pollution had very different responses to the real situation. This shows that spatial intelligence has not been developed to associate the existence of environmental problems and their location and magnitude.

4.3 The development of the Environmental Atlas of Arequipa

In order to ease the deficiencies of environmental education evidenced in the surveys, an environmental atlas has been developed consisting of 325 figures and maps. A printed version was chosen rather than a digital one, given that in Arequipa reading e-books on tablets or computers is not very widespread among school students and the general public, due to technological and economic restrictions, while a book allows be easily shared between users who do not have a computer available or who are not familiar with certain technologies at the time of reading. While the development of an interactive digital atlas is the next natural step, the most important thing is the construction of a consistent and systematized geodatabase content.

The atlas is based on the systemic approach, which is the study of the ecosystems that make up our habitat as well as the relationships and flows of matter and energy that co-exist in them. An ecosystem is composed of two elements: the **Biotope**: which is the "Territory or living space whose environmental conditions are adequate for a specific community of living beings to develop in it" [24] and the **Biocoenosis**: which

“is the whole of organisms of all species that coexist in a defined space called a biotope, which offers the necessary environmental conditions for their survival”[25]. However, the systemic approach also focuses on the ecosystems interrelations [26].

For didactic purposes, emphasis has been given to certain topics, grouped into three main areas: a) **The natural environment**: which contains the study of ecosystems and its two major components: biotopes (the territory, soils, hydrology, climate, and temperature) and biocoenosis (flora and fauna); b) **The built environment**: it focuses on the city's built habitat, its urban evolution, heritage, land uses, its road and utilities infrastructure and its agricultural and recreational green areas and c) **The social environment**: it focuses on the relationship between society and the environment: the demographic composition of the community, its behavior towards risks and its environmental culture.

Despite this classification, several topics also address their interrelation, using the multi-thematic analysis capabilities offered by GIS.

5 Strategies for disseminating the atlas among school students

The Environmental Atlas of Arequipa has been published in November 2019 and it will be introduced to schools after March 2020, therefore it is not possible at this stage to measure the impact that it will have among the community. However similar surveys will be conducted in 2022 to understand if it improved environmental education and awareness among young university students.

However, some strategies may allow greater acquisition of the atlas content.

a) Massive atlas dissemination

The Universidad Católica de Santa María, which has carried out the publication of the atlas, could play an important role in incorporating the content of the atlas into the environmental education of Arequipa students, through two concrete measures:

1) The donation of a percentage of books to public libraries and schools, organizing, along with other universities, several dissemination workshops.

2) The inclusion of the atlas content in the university entrance exam. This will force pre-university students to read and discuss local environmental problems.

b) Development of an interactive digital version

After the printed publication, the production of a digital atlas is planned. The advantages of the digital format include easily updated data, the interactivity between layers, the verification in situ, the possibility of enlarging the maps to a larger scale and the exchange of various types of information.

A web-based version will be a platform that will allow interaction with the user combining and comparing different levels of information. A mobile application version will display concrete layers, such of land use, risk areas, water courses, natural areas, etc. in order to promote in-situ learning activities.

The expected results after the publication of the Environmental Atlas of Arequipa in its physical and virtual stages include a) the strengthening in the knowledge awareness and of local environmental issues, to enrich the local environmental culture of citizens, starting with the young population and b) its use as an instrument for decision making as well as a model for capacity building focused around an

environmental culture. Additionally, it can encourage for the creation of new Environmental Atlases focused on districts, provinces, regional or countries, based on the Environmental Atlas of Arequipa or other cities in Peru.

6 Conclusions

- In the light of the results, it is determined that environmental education is currently one of the pillars for the sustainable development of cities, this being a transversal axis and closely linked to environmental culture [27]. In order to transform the environmental culture of young people, it is important to combine general knowledge with local environmental awareness.
- Based on this study, there is no evidence that school texts have contributed to local environmental education as they have a very general approach and contents.
- This is related to the fact that many young university students have moderate to low environmental behaviors and attitudes. However, a small percentage of graduated professionals show developed environmental behaviors as they afford higher results when compared to the group of students; therefore it can be inferred that university education contributes in a positive but not significant way to the improvement of environmental culture.
- The flaws in the spatial knowledge of local environmental problems are evident. The diffusion of the environmental characteristics and problems of a city has become an important means for environmental management among decision makers and a powerful instrument of environmental education at different levels.
- The development of environmental atlases has proven to be an effective tool to promote both environmental management and education, being a resource for the acquisition of new knowledge, providing a framework for citizen participation.
- The university can play a role in disseminating the contents of the atlas, encouraging the discussion of local problems and envisioning well-documented possible solutions.

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