

## Article

# Scientific Utility of Selected Latin American Global Geoparks: A Literature-Based Case Study

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**Abstract:** Global geoparks, i.e., the members of the UNESCO Global Geopark (UGGp) network, possess highly valuable geoheritage resources, which can be used for the purposes of not only education and tourism, but also science. Five examples from four Latin American countries (Chile, Ecuador, Mexico, and Peru) were employed to realize the importance of these global geoparks as facilitators of international research. Journal articles devoted to these geoparks were selected with the major bibliographical databases, and the information from them was analyzed quantitatively. Particularly, the numbers of articles published before and after the UGGp membership, paying significant and marginal attention to geoparks, and published by international teams were calculated; the general themes of the articles were outlined. It was established that the total number of publications grew after the UGGp membership of these geoparks, but not steadily. The established dynamics of publishing are unstable and differ between the geoparks. Geoparks of Mexico (Mixteca Alta) and Peru (Colca y Volcanes de Andagua) are notable examples because they started to facilitate international research before the UGGp membership. Many articles consider geoparks only marginally (nonetheless, there are also articles paying significant attention to geoparks, especially in the cases of two Mexican geoparks). The author teams are often not restricted to Latin America. The research themes are rather diverse (geoheritage, geology, ecology, innovations, society, technology), although the majority of the publications are geoheritage-focused. Of special interest is the Colca y Volcanes de Andagua global geopark, which has been considered in the innovation-focused article. Generally, our results indicate a moderate importance of the considered global geoparks to international research activity and the incomplete exploitation of their scientific potential. Two Mexican geoparks (Comarca Minera and Mixteca Alta) seem to be the most successful in the facilitation of international research. Indeed, the scientific utility of global geoparks should be strengthened.

**Keywords:** geotourism; innovation; natural resources; research activity; scientific potential



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## 1. Introduction

The importance of geological resources to the contemporary society is undisputable, and their diversity and multiple exploitation opportunities are determinants of socio-economical development. It has been realized that not only such economic resources as iron ore, oil, lithium brine, building stones, and groundwater are valuable geological resources [1–3], but also that geological heritage (geoheritage) is an important object of economic geology [4,5]. Geoheritage can be defined provisionally as the entity of unique geological (also geomorphological) features, manifestations of which are suitable for geoscience, geoeducation, and geotourism [6–10]. Research in geoheritage and its various applications is an important, mainstream direction in contemporary geological science [11–18]. One major aspect of this direction is related to geopark studies [19–22].

Geoparks are special establishments that serve the efficient conservation and rational exploitation of geoheritage resources (first of all, geosites with outstanding heritage importance) and, thus, contribute to sustainable development [23–28]. About two hundred geoparks from dozens of countries have joined the UNESCO Global Geopark (UGGp) network as of the beginning of 2024 [29]. Although geoparks are closely related to geotourism [30,31], their highly valuable geoheritage resources can also be exploited for the purposes of science advancement [32–34] and innovation development [35–39]. As some of them have already functioned for several years, it is reasonable to check their contribution to international research. This is also reasonable taking into account that the UGGp network is neither ideal, nor well-balanced [40,41].

Latin America hosts many geoheritage objects [42–49], and more than ten global geoparks (i.e., the members of UGGp) have been launched in Brazil, Chile, Ecuador, Mexico, Nicaragua, Peru, and Uruguay [29]. The contribution of Latin American countries, institutions, and researcher teams to the international geopark movement has become remarkable [19,50,51]. Global geoparks from this region support the growth of geotourism and sustainability [52,53]. Hypothetically, they can facilitate research activity, but this proposition is yet to be addressed systematically. If it is valid, it would be reasonable to transfer Latin American experience to other regions, particularly Africa, where global geoparks are available and the advancement of geological science is on the agenda [54,55].

The objective of the present study is an analysis of the importance of global geoparks as objects of international research. Several Latin American geoparks are employed as examples. The focus on this region is explained by its significance in the international geopark movement, the presence of extensive research communities there, and the intention to make the analyzed sample of data more or less homogenous. Although the bibliographical survey is the core of this study, the latter is analytical and provides novel insights into the urgent problem outlined above. This paper presents the analysis of published scientific articles about several geoparks selected by several criteria to realize the intensity of the research related to each geopark. The expected outcome is the presence (or absence) of an elevated publication rate after the receipt of UGGp membership. The relatively small size of the analyzed sample is unavoidable, but the homogeneity of this sample permits some generalizations—at least, for the considered entity of the global geoparks. In this regard, the present paper is a case study. It should be stressed that the authors are not connected to the development or management of the considered geoparks, and their common research deals with other parts of the world; in this regard, this paper presents a kind of view from the outside, i.e., the scientific utility of these geoparks is viewed as something that can be performed by many specialists who are not from Latin America.

## 2. Materials and Methods

From the Latin American global geoparks that have already joined the UGGp network, it is necessary to select only those, which can permit us to analyze their scientific utility in the proper temporal perspective. To make such a selection, several propositions should be followed. First, the receipt of the status of a global geopark seems to be the most important time marker in the history of each geopark, and, thus, the year of the UGGp membership should be considered. Second, the creation and development of global geoparks are not quick, and the related procedures can last for many years; therefore, each geopark can stimulate research activity before, the same year as, and after receiving the UGGp membership. Third, it is unreasonable to consider “too old” geoparks because the international research interest in geoparks only reached a considerable level in the 2010s [19]. Fourth, to judge the scientific utility of global geoparks, it is necessary to have the possibility of examining the related research several years before their UGGp membership and several years after this. In regard to these propositions, it is logical to conclude that the only global geoparks that joined UGGp in 2014–2020 are suitable for the present analysis. The available information [29] permits us to specify five global geoparks of this time span (Table 1), located in four countries of Latin America (Figure 1). Their content differs, essentially; although, they

have something in common. These geoparks represent volcanic and magmatic phenomena that are characteristic to the geological environments of Central America and the western margin of South America. Importantly, these geoparks joined UGGp in 2017 and 2019 (Table 1), i.e., almost at the same time (these years were characterized by the comparable and already elevated interest of researchers in geoparks), and, thus, the analyzed sample is homogenous chronologically. Indeed, the considered entity of geoparks is relatively small, which makes generalizations of the outcomes of the analysis rather tentative. Nonetheless, it appears better to deal with a small, but homogenous sample than with a larger, but heterogeneous and inconsistent sample.

**Table 1.** Outline of the global geoparks considered in the present study (based on [29]).

| Country | Geopark                     | Year of UGGp Membership | Area, km <sup>2</sup> | Main Geological Phenomena   |
|---------|-----------------------------|-------------------------|-----------------------|---|
| Chile   | Kütralkura                  | 2019                    | 8053                  | Volcanism   |
| Ecuador | Imbabura                    | 2019                    | 4794                  | Volcanism, hydrothermal systems   |
| Mexico  | Comarca Minera              | 2017                    | 1848                  | Landforms, magmatism, ore deposits, history of mining                           |
|         | Mixteca Alta                | 2017                    | 415                   | Erosional landforms, sedimentary, magmatic, and metamorphic features, tectonics |
| Peru    | Colca y Volcanes de Andagua | 2019                    | 6011                  | Volcanism, erosional landforms, geoarchaeology                                  |



**Figure 1.** Geographical location of the considered geoparks. Base image was generated with Google Earth Pro engine.

If a given geopark becomes the object of international research, the outcomes of the latter are normally published in international (not necessary English-language) journal(s) indexed by major bibliographical databases. Therefore, the examination of the publishing activity permits judgments of the scientific importance of global geoparks. The validity of bibliographical surveys in the studies of geoheritage, geotourism, and geoparks has already been proven [13,19,20,56]. For the purposes of the present study, the on-line bibliographical database “Scopus” was used to collect journal articles that mention the selected geoparks in titles, abstracts, and/or key words. This database boasts a significant

coverage of international journals [57,58], including those published in Latin America and in Spanish. This basic search permitted us to identify only sources whose authors appreciate the importance of geoparks enough to consider them in the noted elements of their articles. However, there can be other articles, in which geoparks are mentioned in the full text. To find them, a supplementary search was carried out with the bibliographical databases of the major publishers (“Elsevier” (Amsterdam, the Netherlands), “Springer” (Berlin, Germany), “MDPI” (Basel, Switzerland)), the journals of which frequently publish papers on geology and geoparks. The search engines of these databases permitted us to find many other articles where geoparks were mentioned in full texts.

The noted procedures permitted us to collect enough bibliographical information about the five considered geoparks. Three additional remarks are necessary: first, only journal articles were considered because they are the principal and best-covered scientific publications; second, the only notions of geoparks (not the related localities) in the literature were taken into account; third, the search procedures were applied in mid-February of 2024, and, thus, the articles available in the bibliographical databases to this time were considered. Indeed, some articles (especially those published in local journals either in English or Spanish) could be missed, but, this is unavoidable. On the other hand, this study focuses on the international research importance of geoparks, for the purposes of which focusing on international journals is enough. All sources used for the purposes of the present analysis, including the works published in English and Spanish, are cited in this paper, and this bibliographical information is summarized below for better visibility. One can note that the considered articles were published in such geoheritage-focused journals as “Geoheritage” and “International Journal of Geoheritage and Parks”, as well as in international, but regionally published journals such as “Investigaciones Geograficas” and “Revista Mexicana de Biodiversidad”.

The collected bibliographical information can be used for some analytical procedures for each considered global geopark. First of all, the dynamics of scientific publishing can be established. For this purpose, three parameters were measured and plotted, namely the total number of journal articles concerning a given geopark (these articles were found with the basic and supplementary searches—see above), the number of articles found only by basic search, and the number of articles with significant attention paid to a given geopark. As for the latter, it should be explained that some articles present the outcomes of research related strongly to particular geoparks; other articles consider geoparks only very marginally, but they cannot be ignored because even passing mention of geoparks in the scientific literature stresses their importance to research. Nonetheless, the above-mentioned calculation of the number of articles that pays significant attention to geoparks permitted us to avoid the possible influence of the “noise” from the literature with only marginal attention. The established dynamics help to understand whether the UGGp membership was associated with the growth of research, and, if yes, when this happened and to what degree. It is also important to calculate the number of articles that were published before, the same year as, and after the UGGp membership. It should be added that the articles published in 2024 and those available “in press” were considered only for general reference because the bibliographical record of 2024 is incomplete (the analysis was carried out in February 2024). Therefore, the relatively low or zero numbers calculated for 2024 should not be understood as a sign of any parameter’s decrease. Nonetheless, to consider these “too young” articles was reasonable to make the bibliographical summary for each geopark truly comprehensive.

The collected bibliographical information permitted two other procedures, which are related to the scope of the present study. The authors’ affiliations made it possible to understand whether the authors represent the countries hosting the considered geoparks, other Latin American countries, or countries from other parts of the world. This is important to realize the internationalization of the geopark-focused research collaboration. The content of the selected articles indicates the principal themes of this research, which can

deal with geoheritage, geology, or other aspects of the considered geoparks. The results of all the above-mentioned procedures are quantitative and allow for further interpretations.

The present study intended to be literature-based only. This was necessary to provide the foundation for further in-depth and qualitative (also interview-based) deciphering of the multiple processes and factors that are related directly or indirectly to the scientific utility of global geoparks. The comprehensive understanding of the dynamics of geopark-related research requires step-by-step analyses, which are unrealistic to include in a single project. Nonetheless, this study permitted us to identify a notable problem on the international research agenda, as well as to offer some tentative, qualitative inferences.

### 3. Results

The *Küttralkura* global geopark is located in Chile (Figure 1), and it joined UGGp in 2019 [29]. Its large area represents volcanic phenomena (Table 1). The established number of articles that deal with this geopark is limited. The first of them appeared in 2019; the total number peaked in 2020 and then remained low (Figure 2). The majority of articles consider this geopark only marginally (Table 2). Notably, specialists from other parts of the world participated in ~90% of the articles (Table 2). Thematically, the latter are moderately diverse, and the majority of the articles deal with geoheritage-related topics (Table 2).

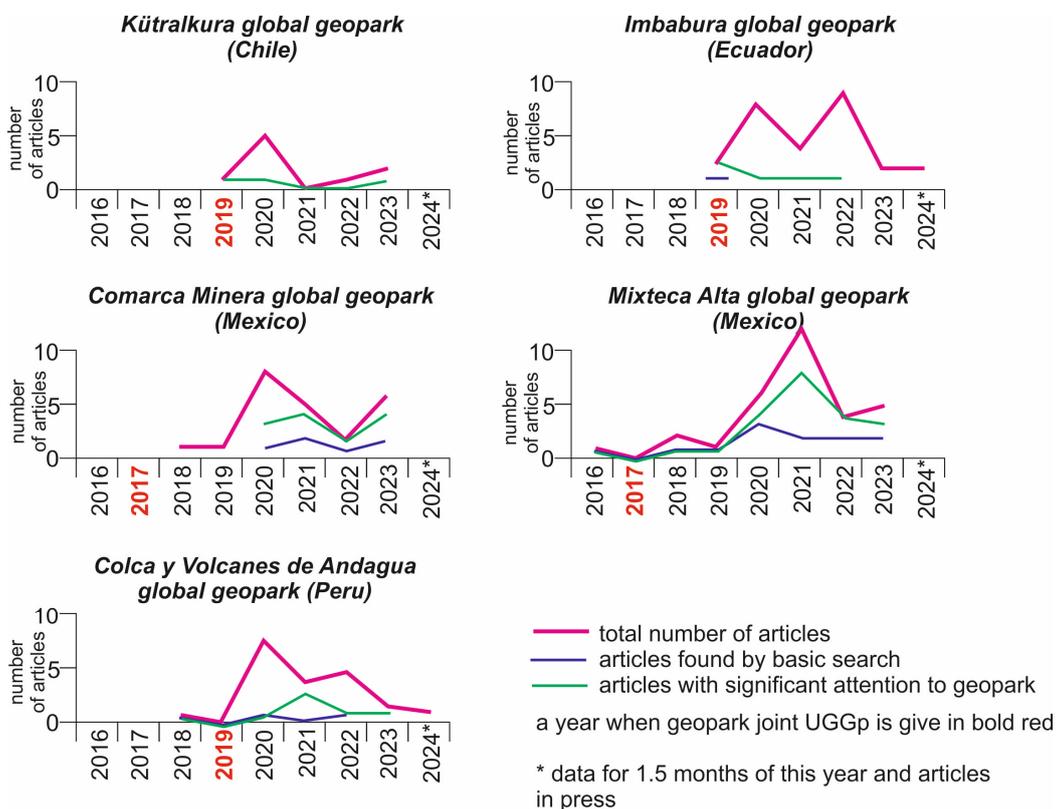


Figure 2. Dynamics of the scientific publishing related to the considered global geoparks.

The *Imbabura* global geopark is situated in Ecuador (Figure 1), and it joined UGGp in 2019 [29]. Volcanic and hydrothermal phenomena are represented there (Table 1). This geopark boasts a significant number of articles, which were published in 2019 and later (Figure 2). Their number did not remain stable and peaked twice. However, >80% of them consider this geopark marginally, and the basic search permitted us to find a single article (Figure 2, Table 2). The majority of the collected articles were (co)authored by non-Ecuadorian specialists, chiefly from other parts of the world (Table 2). The thematic diversity of these articles is low, and 96% of them deal with geoheritage-related topics (Table 2).

**Table 2.** Summary of the international research focused on the considered geoparks (see text for more explanations).

| Geopark                           | Articles in Journals<br>(State for Mid-February, 2024) |  | Attention to Geopark * |          | Year of Articles * |      |      | International<br>Research,<br>X/Y *** | Themes ****   |
|-----------------------------------|--|--|------------------------|----------|--------------------|------|------|---------------------------------------|---|
|                                   | Basic<br>Search  | Supplementary<br>Search                      | Significant            | Marginal | B **               | S ** | A ** |                                       |   |
| Kütralkura                        | -  | [22,42,59–65]                                | 3                      | 6        | 0                  | 1    | 8    | 8/8                                   | Geoheritage (7),<br>geology (1),<br>society (1)                     |
| Imbabura                          | [66]   | [22,49,52,60–62,64,67–85]                    | 5                      | 22       | 0                  | 2    | 25   | 23/22                                 | Geoheritage<br>(26),<br>geology (1)                                 |
| Comarca<br>Minera                 | [86–91]  | [50,52,59,61,63,69,85,<br>92–101]            | 13                     | 10       | 0                  | 0    | 23   | 14/14                                 | Geoheritage<br>(17), ecology<br>(2), society (2),<br>technology (2) |
| Mixteca Alta                      | [102–112]  | [50,52,61,63,70,90,94,<br>95,98,101,113–122] | 22                     | 9        | 1                  | 0    | 30   | 15/15                                 | Geoheritage<br>(16), geology<br>(1), ecology (4),<br>society (10)   |
| Colca y<br>Volcanes de<br>Andagua | [123–125]  | [22,52,59–<br>61,63,81,126–136]              | 7                      | 14       | 1                  | 0    | 20   | 20/20                                 | Geoheritage (16),<br>geology (4),<br>innovations (1)                |

Notes: \* number of the related sources is indicated; \*\* B—before the year in which a geopark joined UGGp, S—same year as when a geopark joined UGGp, A—after a geopark joined UGGp; \*\*\* X—number of articles with authors from countries other than that hosting a geopark, Y—number of articles with authors from regions other than that hosting a geopark; \*\*\*\* number of the related articles is indicated in parentheses after each theme (the theme “Geoheritage” includes articles about geoconservation, geoheritage, geoparks, geosites, and geotourism; the theme “Geology” includes articles about pure and applied geology and geomorphology).

Two Mexican global geoparks are considered (Figure 1). The first of them is the *Comarca Minera*, which joined UGGp in 2017 [29] and represents a rather broad spectrum of phenomena (Table 1). This geopark became an important object of international research, although with certain delay after its UGGp membership. The total number of articles rose in 2020 and remained considerable, although not stable. Importantly, more than half of them paid significant attention to this geopark (Table 2), and the portion of these articles became larger with time (Figure 2). The other peculiarity is that 39% of the collected articles were written by only Mexican specialists (Table 2). Finally, one should note the significant thematic diversity of the articles, although 74% of them deal with geoheritage-related topics (Table 2).

The other Mexican geopark is *Mixteca Alta*, which also joined UGGp in 2017 [29]. Apparently, its content is the most diverse among the considered global geoparks, and a broad spectrum of rocks are represented there (Table 1). This geopark has been investigated actively, with the first article appearing before it joined UGGp. Initially, the total number of articles was low, but it peaked at the beginning of the 2020s (Figure 2). The articles with significant attention to this geopark prevail (>70%), and this geopark is distinguished by the relatively high number of articles found by the basic search (Table 2). These peculiarities remained during the entire time interval (Figure 2). About a half of the collected articles were written by only Mexican specialists (Table 2). Thematically, these articles are diverse, and the relative number of geoheritage-focused and other articles are comparable; moreover, this geopark was studied actively in a sociological aspect (Table 2). Notably, this geopark is the smallest of those considered (Table 1).

The *Colca y Volcanes de Andagua* (Colca and Volcanoes of Andagua in English) global geopark is located in Peru (Figure 1), and it joined UGGp in 2019 [29]. It represents phenomena, which are moderate in number, but essentially different (Table 1). The established number of articles is not low, and the first of them was published before the UGGp membership (Figure 2). The total number of articles peaked in 2020 and then

gradually declined. In total, 33% of the articles paid significant attention to this geopark (Table 2), and their percentage became bigger after the noted peak (Figure 2). The majority of them were (co)authored by specialists from other parts of the world (Table 2). These articles demonstrate a moderate thematic diversity, with 76% of the articles dealing with geoheritage-related topics (Table 2). Interestingly, this geopark is distinguished by the relatively large number (19%) of articles focused on geological aspects.

#### 4. Discussion

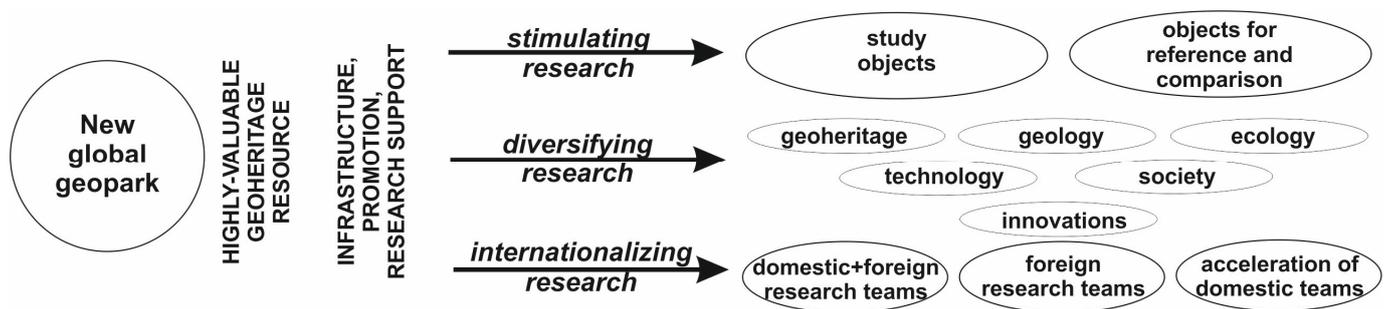
The analysis proves the importance of the considered global geoparks of Latin America as objects of international research, although the real importance seems to be lower than that potential. On the one hand, the UGGp membership led to the publication of articles paying both significant and marginal attention to geoparks, and specialists from other countries and parts of the world were involved into the related research. Moreover, some themes of this research were linked directly to innovations and sustainable development (not only environmental). On the other hand, the number of articles (including those paying significant attention to geoparks) did not grow steadily, but only peaked (sometimes, with certain delay relative to the UGGp membership); many articles considered geoparks only marginally (but significant attention was paid in many articles to two Mexican geoparks), and the majority of them dealt with only geoheritage. One should note that the development of geoparks required to achieve the UGGp status did not result in a higher publishing rate; the number of articles that appeared before or the same year as the UGGp membership is small. Two notable examples are the works by Palacio-Prieto et al. [120] and Gałaś et al. [124] that preceded the the UGGp membership of the Mixteca Alta and Colca y Volcanes de Andagua global geoparks, respectively. Moreover, although the activity of international research teams should be appreciated, the significant prevalence of publications from such teams over those from only national teams, established in some cases, may be a sign of a barrier in the globalization of national science, which needs self-development in addition to international collaboration.

In regard to the above-mentioned outcomes of the present case study, it appears that the analyzed Latin American experience implies only partial exploitation of the potential of global geoparks as triggers of international research. Two Mexican geoparks seem to be the most successful in their facilitation of international research activity, although this occurred with delays after the UGGp membership in contrast to the geoparks of Chile, Ecuador, and Peru (Figure 2, Table 2). Probably, the most serious problem registered by the present analysis is that the considered global geoparks became objects of chiefly geoheritage-related research (Table 2), although their resources offer exciting opportunities for geological, biological, socio-economical, pure touristic, and other investigations. Good examples are the Comarca Minera and Mixteca Alta geoparks (Table 2), and one should also note the exciting example of the Colca y Volcanes de Andagua global geopark employed for the purpose of innovative research [136].

The hypothetical explanations of the registered patterns can be linked to two aspects of the supposed global geopark functioning. First, particular research teams may be linked to the global geopark development (before, the same year as, or just after the UGGp membership), but the number of such teams is limited in each case. The dominance of publications from the limited number of teams is registered for the considered geoparks (Table 2). Second (and potentially more important), the international scientific community can be very conservative and even passive in the exploration of new research opportunities. For instance, the collected evidence implies that the Latin American global geoparks were promoted actively and effectively in the international literature, but often attracted only marginal attention (Figure 2, Table 2). It is possible that many specialists in the world still misunderstand the scientific potential of geoparks (at least, those of Latin America), as well as ignore (or do not appreciate) the already visible power and maturity of geoheritage studies [16]. Additional studies are necessary to understand whether the above-mentioned or any other explanations matter, but it is evident that the established partial exploitation

of the scientific potential of global geoparks could be caused by the processes (also, barriers and biased vision) of international science.

The results of the present analysis permit us to conceptualize the scientific utility of global geoparks (Figure 3). However, the same results imply that the elements of this utility can be unbalanced. For instance, some geoparks are used for general reference and comparison more actively than as objects of new research (Figure 2), and the diversity of the research themes is not as important due to the prevalence of a single theme (Table 2). Geoparks are created, particularly, for the appropriate use of their geoheritage resources, innovative solutions, and sustainable development [23,31,36,137,138]. If so, all aspects of their potential are important, not only the touristic and educational ones. Additionally, it is necessary to stress that global geoparks bear world-class natural features, which can be first-order attractions to tourists (not only geotourists). If so, they have significant importance for pure touristic studies.



**Figure 3.** A conceptual view of the scientific utility of global geoparks in the light of the outcomes of the present study.

It appears that the scientific importance of geoparks can be related to their governance, which itself is a challenging issue [139]. Administrations of global geoparks, as well as national and international authorities and the local, regional, and national governmental divisions involved into their governance, should put effort into reducing the unbalances and problems established in the present study (see above). This can be done via better the promotion of geoparks’ geoheritage resources among scientists (including young generations), funding geopark-based (but not necessarily geoheritage-related) research projects, and broader cooperation with scientists (not only experts in geoheritage) in their development. It appears to be very urgent to “cultivate” the proper culture of geopark-based research. When specialists (for instance, mineralogists and palaeontologists) work in museums, the latter are appreciated and properly reflected in the subsequent publications. The same should become a norm in geopark-based research. Moreover, the considered global geoparks of Latin America differ by their importance to international research. If so, it is very reasonable to address the most successful examples and to transfer the related knowledge and experience to the other, existing and newly created, geoparks.

Indeed, the selected and other global geoparks can employ different “formulae” of management. For instance, some of them are deeply related to particular universities and research groups, and others are not. Although this may partly influence their scientific utility, it is expected that the UGGp membership means the existence of outstanding geological features of international importance in their areas. In an ideal case, a global geopark can attract many researchers, irrespective of the preferred management “formula”. If this geopark is university-related, the research teams from this university receive an excellent tool for intensifying their investigations. If this geopark is university-unrelated, it can be very attractive to many research teams from the outside because they can enjoy the favorable conditions, in which they do not need to “compete” with any local, well-established teams. Apparently, the perception of the research utility (and the related attractiveness) of global geoparks by the international research community can matter more than the peculiarities of their management.

## 5. Conclusions

The present case study of the international scientific utility of five global geoparks from Latin America permits us to draw the following three conclusions:

(1) All considered geoparks facilitated research activity, although their full scientific potential was not exploited (at least, as can be deduced on the basis of the publications dealing with these geoparks);

(2) The dynamics of scientific publishing about the considered geoparks were unstable, many journal articles considered geoparks only marginally, and geoheritage-related topics prevailed over geological and other topics (fortunately, a portion of the collected literature is linked to innovations and sustainable development);

(3) Special efforts and measures are necessary to strengthen the scientific performance of global geoparks, which can play a big role in research similar to that of museums.

The high importance of the geoheritage resources of global geoparks is undisputable (alternatively, it would be unreasonable to create these geoparks). The present analysis stresses that the related potential of geoparks is yet to be exploited adequately. Indeed, this analysis is only preliminary and based on a case study in a single region, and, thus, it cannot escape certain limitations. For instance, the considered geoparks are still too young to allow for analyzing the long-term dynamics of scientific publishing, which would require a decade or more of observations. However, this limitation is unavoidable when taking into account the relative novelty of the very idea of global geoparks and the only recent intensification of the related research. The other limitation of this case study is the relatively small size of the sample. Indeed, the generalizations and the interpretations made above are meaningful only to the analyzed entity of geoparks. Nonetheless, one should note that these geoparks represent different countries of Latin America, and they joined UGGp when the international geoheritage studies matured.

This study permits us to draw attention to some interesting (both theoretically and practically) patterns, which should be investigated in the course of the future research. Particularly, comparing the Latin American experience with that of other regions seems to be promising. The situation in Africa, Asia, and North America may differ. The other contexts of geopark-related research in these regions should be considered (for instance, other trends of geoheritage research, other interests and sizes of national research communities, other traditions of scientific collaboration). The examination of the opinions of researchers and geopark managers can also be informative, and has to be carried out in the future. As explained above, the understanding of the scientific utility of global geoparks is a highly complex task, and the solution requires a sequence of studies with attention paid to the different patterns. Particularly, the tentative inferences presented above indicate that the opinions of researchers not involved in geopark-related studies and not linked to geopark management would be very important to analyze because the scientific utility of global geoparks seems to be strongly dependent on their perception by the world's research community. In other words, the wide scientific marketing of UGGp needs attention.

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