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Visitation Rate Analysis of Geoheritage Features from Earth Science Education Perspective Using Automated Landform Classification and Crowdsourcing: A Geoeducation Capacity Map of the Auckland Volcanic Field, New Zealand

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Abstract: The increase in geoheritage studies has secured recognition globally regarding the importance of abiotic natural features. Prominent in geoheritage screening practices follows a multicriteria assessment framework; however, the complexity of interest in values often causes decision making to overlook geoeducation, one of the primary facets of geosystem services. Auckland volcanic field in New Zealand stretches through the whole area of metropolitan Auckland, which helps preserve volcanic cones and their cultural heritage around its central business district (CBD). They are important sites for developing tourist activities. Geoeducation is becoming a significant factor for tourists and others visiting geomorphological features, but it cannot be achieved without sound planning. This paper investigates the use of big data (FlickR), Geopreservation Inventory, and Geographic Information System for identifying geoeducation capacity of tourist attractions. Through landform classification using the Topographic Position Index and integrated with geological and the inventory data, the underpromoted important geoeducation sites can be mapped and added to the spatial database Auckland Council uses for urban planning. The use of the Geoeducation Capacity Map can help resolve conflicts between the multiple objectives that a bicultural, metropolitan city council need to tackle in the planning of upgrading open spaces while battling of growing demand for land.

Keywords: geoconservation; geoeducation; landform classification; topographic position index; crowdsourcing; FlickR; GIS; urban planning

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1. Introduction

While the natural environment is disappearing under growing cities and their landscaping activities [1–3], scientists have introduced a new conservation challenge, the protection of geoheritage: the elements of geology and geomorphology providing connection among population and abiotic nature. They not only provide the knowledge about past geological processes but also allow us to make predictions for future events and their effect on human societies. Having to look after geoheritage should be the part of modern society's lifestyle. It formally was a non-existent concept in cultures to quantify the value of geological conservation simply because primordial societies were part of the natural environment, including its abiotic component; hence, human society was interconnected and part of the natural environment [4]. Since the industrial revolution, an accelerated separation of human society from its natural environment polarized our habitats and rapid loss of natural habitats took place [4–8]. This process in recent years reached a level whereby we identify and develop strategies to preserve not only the biological elements, but also the non-living environments. The value of geological features was only characterised (mostly in a semiquantitative manner) when a site was a subject of extraction for raw material.

Geomorphology of various geosites was only valorised when aesthetics functioned to attract tourists on a scale that boosted local and national economic development.

Today, geoscientists are changing the disposition of geology and add an important angle to it that focuses on geoethics [9]. However, due to pressing global issues and crucially, the running of the economy, various levels of authority require measurable and quantifiable evidence of the values of an abiotic nature before expanding activities considered only indirectly as profit-generating activity (e.g., recreational aspects, tourism, or geoeducation) [10] at the expense of industrial–social development (e.g., quarrying, housing development, and landscaping). This conflicting interest within geological and geomorphological elements are placed to generate the expansion of ecosystem services [11] to specifically analyse the full values abiotic nature provided for human society. In this conceptual framework, a new term was designated to express the services abiotic nature provides for humanity: geosystem services [12–14]. Geoheritage is currently considered as a new, educated recreational activity under the scope of conservation science that serves tourist demand to a reasonable level. In effect, justification for geoheritage goes beyond recreation and open space experiments, it is fundamental for geoeducation, resilience, sustainability, geotourism, and community building through local to global geoparks. All these attributes are non-quantitative and are non-scientific disciplines, there is no directly measurable indicator that would safeguard their existence in a rapidly growing urban area. These principles work, however, if there is a visitation flow over a certain threshold value that is measured as instrumental value and applied against opportunity loss and successful conservation is allowed [15,16].

Visitation is highly associated with tourism and considered as a tertiary industry [17–19]. The first question of non-experts will be, therefore, what is the benefit for a city if they hold back lands from generating revenue [20–25]. This is the major shortfall preventing quality implementation, as education, awareness, and resilience are not measurable in profit. Although achieving direct profit in the short-to-medium term is not out of the question through utilization of allocated geosites such as geotourism for instance, the co-development of protecting policies that involves cooperation and involvement of local communities together can generate "revenue" that can be measured indirectly and in long-term create a resilient society against global challenges. The ultimate goal of geoconservation (geoeducation, community building, and resilience) fits perfectly within the concept of a more holistic, transdisciplinary, and global aspect of sustainability. Sustainability was originally developed on the conceptual basis of ecosystem services and humanity; hence, the radical focus on biotic elements of the environment. Geoconservation puts forward geoscience as one of the essential building blocks for the conceptual framework of sustainability [26–29].

Urban areas attract visitors for a myriad of reasons. In the quest of valorising geoheritage worldwide, cities are in an advantageous position. There is less pressure received from economic status toward attracting visitors so more emphasis can be placed on guiding arrivals to locations of high geoeducation interest. The significance is in the combination of experiencing many phenomena with a unifying theme as opposed to an individual item that might not in itself be regarded as sufficient to influence tourists' willingness of visitation [30]. In Hong Kong, the geopark has generated sustainable tourism and revitalized traditional culture [31,32]. Such dynamics encouraged local people to take part in geoconservation activities and naturally formed the main force of geoconservation [32]. Geoparks in the city have the advantage of displaying the multipurpose of a geopark. Geosites are divided into three priority areas of conservation, education, and recreation. While the enjoyment of the visitors is well served, the geological significance of local features is made apparent and the behaviour of the visitors is altered toward protecting rocks and landforms [33]. Geoparks of rural areas face the challenge of promoting geology in a way that increases the willingness to travel to the area. Different activities have been developed such as geo-educational games [34], multimedia presentations [35], or the creation of GEOfood, which delivers quality food and connects the food and raw materials with their place of origin [36].

Tourists possessing environmental knowledge of their destination often make more educated decisions when visiting hazardous areas and naturally grow respect for the local environment and community, and they seek authenticity over marketing [37–39]. The awareness will expand to their home and will feed grassroot initiatives. With time, a larger ratio of society reconnects with the nature, morally causing an overall increase of societal wellbeing. The steps for building a new geopark includes interdisciplinary research and expert collaboration, stakeholder identification and involvement, evaluation of the geoheritage sites, strategy development for sustainable tourism, correlation with local projects, providing training for the locals, and designing educational materials and activities [40–42]

Education, as the main objective, brings an extra dimension to geotourism. Tourism only allows certain geographical locations to be considered; geotourism ultimately should be everywhere including housing or industrial areas [43–51]. Quarrying away geomorphology opens a door for another type of geoheritage. Open-pit and underground mining sites potentially are windows into the geology under the surface and the history of geological processes [52–54]. Strong measures are needed to rescue features revealed during the operation of a quarry that leads to a cooperation between the conservation agency, mining, and quarry or landfill operator [52]. Tourist attractions and geotourism destinations overlap. That overlap accounts for a great percentage of successful implementation. A tourist attraction is largely evaluated on a cost–demand–competitiveness triangle [30,55]. Geotourism destinations primarily focus on conserving their artifacts of present and past geosystems, and on how to form a new habit in tourism; that is, to visit geological features with the drive to understand earth sciences [56,57].

Since the creation of social media, crowdsourcing has been applied to the fields of marketing [58,59], urban planning [60], sustainability [61] tourism [62], public policy and government [63,64], medics [65], bioinformatics [66], higher education [67], disaster risk [68], and product development [69]. A specific type of crowdsourcing uses volunteered geographic information available through photo sharing platforms. FlickR is one of the most popular platforms for such data extraction [70,71]. The data is mostly used for analysing regions of interests [72,73], tourists' spatial behaviour [74], people's activities [75], movement patterns [76,77], or event detection [78].

Landform classification is purely based on geographic information that strengthens the case of the geoconservation inventory. It is important nationally for policy level implementation and internationally for comparison and achieving status at international organizations on geoconservation. A completely automated method for landform classification was developed by Weiss [79] using a topographic position index. Studies proved that the construct advanced adaptation planning by combing precision landform information with relevant geographic or qualitative data in a geographic information system. The method allows for the aggregation of spatial and qualitative data. The classification of landforms aggregated with spatial qualitative, quantitative, or descriptive material of an issue is a powerful tool for planning, such as climate adaption planning [80], prediction of landslides, wetlands distribution [81–83], understanding site-specific management units [84], or simply the study and analysis of landforms [85,86].

The main subject of our research is the geoeducational value of the geoheritage features in the Auckland volcanic field. The volcanic field hosts Auckland, the biggest city in New Zealand. Experts in the area have achieved awareness about the outstanding geoscientific value of both the intact and quarried volcanic cones. The same cones hold high cultural values having been subjects of settlement across New Zealand's human history. The question of this study is to what extent geoheritage sites serve as geoeducational sites, where most of the open space areas coincide with the volcanic edifices of the Auckland volcanic field [87]. This report is important for decision makers because it indicates the migration of geoheritage principles to other burning and more understood issues (e.g., strengthening cultural heritage, sustainable tourism, sustainable development, and community involvement). Auckland (population: 1.5 million), is the economic capital of New

Zealand and faces one of the most severe housing affordability crises in the world leading to rising numbers of homelessness [88,89]. The answer for our research question was attained through four objectives: (1) To identify strengths and gaps in existing legislations relevant to geoconservation, (2) to identify the degree of grass roots initiatives, (3) to define what geological or geomorphological features receive visitation, and (4) to derive geoeducational value of the non-visited geological or geomorphological sites to depict current bases of promotion.

2. Disposition of Formal Decision Instruments

The first objective of this research was to analyse the current policies and other formal decision instruments to understand the directions of conservation strategies. The Auckland volcanic field is a major geological feature of the North Island. Its geological feature as being a monogenetic volcanic field that is still considered to be active has created a general interest in volcanic hazard studies [87,90–94]. In addition, the studies that have highlighted its size, age range, and preservation have potentially made it a globally relevant volcanic field that strongly impacts our understanding of volcanic field evolution. Using the Thomson Reuters's Web of Sciences All Database until 16 September 2021 searching for papers for topics named as "Auckland volcanic field" yielded 184 results, with 95% of them having been published after year 2000. This collection of scientific papers has Hirsh-index of 36 indicating that the global community is also reading these published scientific reports and is likely influenced by their results. Currently, there is no governance authority for the volcanoes due to the varying ownership status over the 53 edifices [95]. The only jurisdiction that cuts across organizational boundaries is the Resource Management Act administered by the Ministry of Environment. The Resource Management Act guides regional and local environmental policies with the ambition to promote sustainable management of natural and physical resources.

New Zealand is generally considered an example of success in its transition into sustainable bicultural economy with an ambition to restore native landcover. Prioritisation of conservation approaches includes the need for the identification of geoheritage along with its relationship to the Māori culture and the indigenous landcover. It is still a challenge for policy makers to put forward a clear set of geoheritage targets with a lack of knowledge on social capacity for responding to and shaping geoconservation dynamics. As long as responsible bodies cannot make informed decisions, the implementation of the elaborated geoconservation inventory will be on hold despite their ambition to follow a holistic conservation plan that includes all aspects of the geo-ecosystem with special relevance to their cultural relations [96–98]. Much of natural resource management is focused on biodiversity species models, and policy recommendations are based on their conservation without accounting for the role of geosystem services.

The Resource Management Act in New Zealand is the main law that sets out principles and priority areas for regional authorities for the development of detailed strategies and plans working toward a common target and a sustainable future. It is clear that New Zealand has an adaptive governance and inclined toward sustainable solutions and that the ambition is to keep the country as close to its natural state as possible for future generations and to keep development disturbance to the minimum [2,99–106]

How Conservation Strategies and Urban Planning Look like Today

The Auckland volcanic field (Figure 1) was one of the first areas providing for early Māori arrivals. The region had a rich, friable, volcanic soil well suited to kumara growing. From about 1300, Māori used the cones as their living environment; there is evidence of systematic gardening and usage of storage pits and canoes around the volcanic field (Muriwai Beach, west Auckland) that are of high cultural value today [107–110]. By about 1700, the population of some thousand made the region the most densely settled area of New Zealand in Māori times; it remains so today [111]. Urban planning became crucial after the industrial revolution when the population boom caused serious public health issues. Areas lacking urban planning outgrew their sewage systems resulting in discharged waste products into water supplies that spread disease like cholera. This was a problem even in ancient Rome, but with the number of large and mega cities expanding dramatically, the importance of urban planning has become a global imperative and has now expanded to include amenity and conservation matters. Any matters of national importance must be researched and communicated to decision makers, and geoeducation is no exemption.

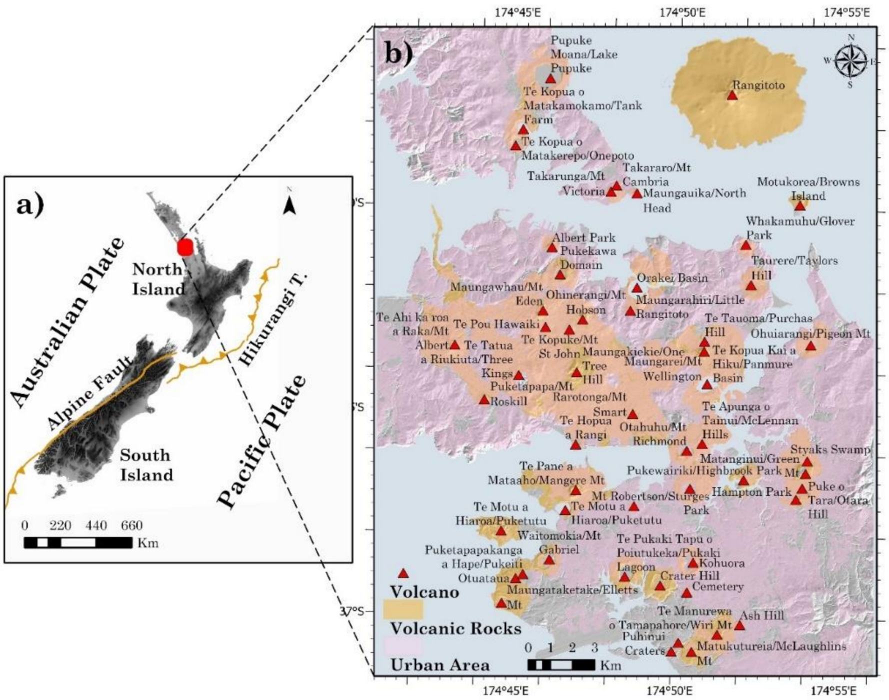

Figure 1. (**a**) New Zealand on a digital terrain model with the location of the study area. Hikurangi Trust is the surface manifestation of the oblique subduction front along the Pacific Plate going under the Australian Plate. (**b**) The map shows the 53 recognised volcanic centres of the Auckland Volcanic Field. The Māori names of the volcanoes shown first followed by their respective English names.

The responsible agencies for the volcanoes vary among council, conservation, education, facility management; Tūpuna Maunga Authority—Tūpuna Taonga o Tāmaki Makaurau, Auckland Council, DOC, and private ownership; however, organisations strictly follow the principles set out by the government.

There is an open opportunity in the legal framework for quality geoconservation implementation. For the law to fall into place, responsible agents must create a strategy with a clear target, objectives, and set of choices. This has been widely researched [112–121] but not yet established for geoheritage. The reason behind, it is the lack of convention on the full range of applicable values. Without evidence on the national importance of a certain geologic exposure or geomorphologic feature, economic opportunities will be missed, causing the disappearance of such features. However, the responsible agents for such tasks are the local and regional councils who require evidence for bottom-up proposals to get policy level support.

Every related strategy includes a call for proposals on making New Zealand and its fastest growing city, Auckland, sustainable and nature friendly [97,99,100,103].

The Auckland Plan is a spatial plan that sets targets that comply with the Resource Management Plan. It summarises the main challenges the region is facing today and organises them into six outcomes. These outcomes are to increase community wellbeing and the liveability of the city. One of these outcomes target environment and cultural heritage. The plan for implementing environment and cultural heritage has no explicit section for geoconservation. However, it opens scopes into which evidence-based proposals can be fit. The supporting strategies and plans are for growing a greener city, for restoring indigenous biodiversity, for reducing waste and recycling more, for restoring and protecting the sacred volcanoes (ancestral mountains) renowned by Tūpuna Maunga Authority, for managing assets of stormwater, water-care and open space, and lastly, for safeguarding Hauraki Gulf.

Destination Auckland 2025 sets directions for Auckland's visitors' economy for a more sustainable future economically, socially, and environmentally. This plan is issued to make sure tourism management aligns with the outcomes detailed in the Auckland Plan. Auckland is the gateway to New Zealand, which meant more than 2.6 million international visitors each year, prior to the pause in international travelling caused by the COVID-19 pandemic. The challenge is to make visitors help protect and improve Auckland's geological heritage, its unique identity, and cultural heritage.

3. The Study Area

AVF is situated on the North Island of New Zealand on a continental crust about 400 km to the west of the Hikurangi Margin subduction zone [122,123]. There are two more intra-plate volcanic fields south of AVF called South Auckland volcanic field (active 1.6–0.5 Ma) [124] and toward the south some slightly older ones such as the Ngatutura and Alexandra Volcanic Fields (active 2.7–1.5 Ma) [125]. Several distinct young Pleistocene to Quaternary volcanic fields are peppered across Northland, interestingly with few very young, potentially Holocene scoria cones. The Auckland volcanic field (AVF) has erupted at intervals of thousands of years over the last 250,000 years. The last eruption, Rangitoto, occurred 600 years B.P. in at least two distinct eruptive episodes about 50 years apart from each other [93], and very likely witnessed by early Polynesian arrivals [126,127]. The AVF is considered to be still active [128]. Magmatic and phreatomagmatic eruptions produced ~53 small volcanic centres [94,129–131]. Scoria cones, lava flows, maars, tuff cones, and tuff rings build up the volcanic landscape stretching over early Miocene shallow marine sediments [128,132].

Spatial-temporal patterns along with the volume of magma suggest that the AVF is at an early stage in its evolution and further eruptions can occur [133]. The young age and ambiguous spatial patterns in distribution make it problematic determining the likelihood and associated risks of future eruptions [134]. Promoting geological sites is of extreme importance because Auckland City with a population of over 1 million people expands out over the entire field. Mitigation of a natural disaster is achieved by effective communication and education from geoscience communities. Residents and visitors need to understand volcanic hazards and the reasons of unpredictability of potential next eruptions. This form of volcanism exposes residents to unpredictable volcanic hazard in cities situated in close proximity [135–137].

The area is on the UNESCO World Heritage tentative list (https://whc.unesco.org/en/tentativelists/, accessed on 20 September 2021). Even so, basaltic scoria cones and maar craters are the most common volcanic features in the world, the Auckland field stands out as a unique volcanic field among them being active under a metropolitan city. To mitigate volcanic hazard and establish resilience in local communities, an extensive amount of research has been carried out within the area that significantly amplified the scientific value of the given volcanic edifices. Furthermore, the subtropical regional climate gave the commonly barren, brown reddish scoria cones a solid green cover with an aesthetic value of international significance.

The Auckland volcanic field has been researched from multiple geoscientific angles [87,91,122,123,132–134,138,139] and its geoeducation potential highlighted in several case studies [95,128,140–145]. The concern over disappearing research and education materials for culturally worshipped geological sites has caused unrest in local communities. Evidence advancing successful implementation by local decision-making bodies is imperative and can be executed using the power of GIS techniques providing clear boundaries of high to low geoeducational areas.

4. Methods and Results

4.1. Formal Decision Instruments and Community Endeavour

Through the first objective of analysing current formal decision instruments, we have concluded that New Zealand has an adaptive governance and is inclined toward sustainable solutions. The ambition is to keep development disturbance to the minimum [2,99–106]. The resource Management Act is the main law that sets out principles and priority areas (Table 1) for regional authorities for the development of detailed strategies and plans.

Table 1. Legal instruments place priority on important matters of culture and nature conservation.

Resource Management Act [146]	**The Act calls upon to recognise and provide for the matters of national importance:** • **The *preservation, protection* of coastal environment, wetlands, lakes, rivers, areas of indigenous flora and fauna, of *outstanding natural features* and landscapes and of historic heritage from inappropriate subdivision, use and development.** • **The relationship pf Māori and their culture and traditions with their ancestral lands, water, sites, wāhi tapu (sacred place) and other taonga (treasure).** • **The maintenance and enhancement of public access to and along the coastal marine area, lakes and rivers.** • **The protection of protected customary rights.**
Reserves Act: Scientific Reserves [147]	**Its purpose is to have effect, in relation to reserves classified as scientific reserves, for the purpose of protecting and preserving in perpetuity for scenic study, research, education and the benefit of the country . . . types of soil, geomorphological phenomena and like matters of special interest.**
Auckland Regional Policy Statement [106]	**Auckland's sense of place is also defined by its volcanic field of which the volcanic cones are the most well-known features. Their identification as Outstanding Natural Features recognises that they are of geological and scientific significance in their own right, as well as having amenity values and being of particular spiritual value to iwi of the region.**
Open Space Provision Policy [105]	**Treasure Auckland's Parks and Open Spaces by protecting and conserving them and improving people's ability to understand and appreciate their value and significance.**
Destination Auckland 2025 [97]	**Because everything is connected, the only way we can ensure the sustainability of any particular subsystem of our region is by adopting a holistic approach. "If planned and managed well", the Executive Director of UN Habitat said recently, "Cities can be the main tool for sustainable development and a solution to many of the challenges our planet is facing today."**

Legally, there is much appreciation for conservation values, and bottom-up approaches are much appreciated, even encouraged. Long-term plans and strategies all firmly target sustainability and the effective collaboration of stakeholders. Strategic priorities include the broadening of measure of value and work with industry partners.

The second objective was the investigation of the degree of community sensitivity to the topic and the magnitude of work invested into the subject. Auckland volcanoes were considered highly among early habitats. The small volume regular landforms provided shelter and fertile land. Scoria cones provided surface easy to landscape for shelter buildings, vegetable gardens, and storage pits. For the modern world, they have provided building material for infrastructure, which have made it a popular part of human livelihood. Human occupation of the area suggests the existence of admiration of the local features. Literature reviews and interviewed experts of the area revealed the existence of an online available, open source Geopreservation Inventory (Figure 2). The inventory not only contains the significant geological and geomorphological features of the Auckland volcanic field but a comprehensive collection of significant outcrops, fossil sites, and landforms of all geological and geomorphological processes selected on the basis of research, education, tourism, recreation, and aesthetic values. The metadata includes the assessment of their importance: (A) of international scientific, aesthetic, or educational value; (B) of national scientific, aesthetic, or educational value; and (C) of regional scientific, aesthetic, or educational value. This classification was later formed as important attribute for the analysis of geoeducational capacity of the Auckland volcanic field.

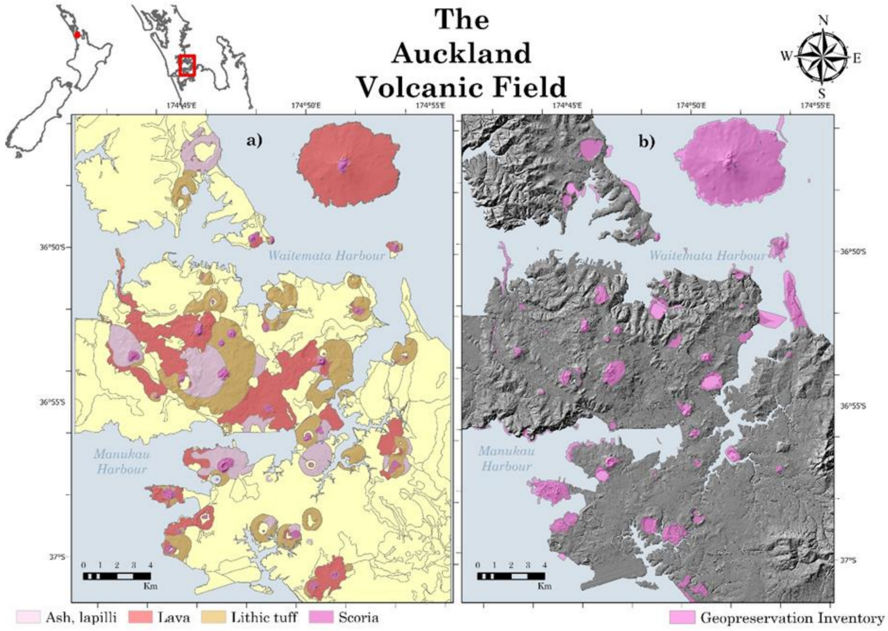

Figure 2. (**a**) Geology of the Auckland volcanic field modified from GNS QMAP Programme Dataset—Geology of the Auckland Urban Area 1:50,000 GIS data [148] "Ash, lapilli": fine to medium grained magmatic explosive products accumulated beyond the scoria cones. "Lava": undifferentiated lava flows, mostly rubbly pāhoehoe, 'a'ā and subordinate pahoehoe surface texture types. "Lithic tuff": accidental lithic clast-rich fine grained pyroclastic rock formed due to explosive phreatomagmatic eruptions. "Scoria": highly vesicular magmatic explosive eruptive products of typical Strombolian style eruptions. (**b**) Geopreservation Inventory (http://www.geomarine.org.nz/NZGI/, accessed on 20 September 2021), which was compiled using the information provided voluntarily by New Zealand's Earth Scientists. The database lists the best representative examples of geologic features, landforms, and fossils discovered and studied over hundreds of years of field work. The map displays the volcanic sites that fall into the study area extracted from the online available, open-source geospatial database of the Geopreservation Inventory.

4.2. The Mapping

The third and fourth objective required data acquisition and analysis. The Auckland volcanic field corresponds to the metropolitan area of Auckland. Volcanic edifices are typically radiotopographic heights that are easily distinguishable from the surrounding topography and are essentially surficial representations of underlying magmatic systems. There are ~53 edifices within the Auckland volcanic field, having erupted during the Quaternary. In addition to the typical cone shaped volcanoes here are also ~33 other monogenetic geoforms, mostly broad tuff rings or shallow maars. From a geoheritage aspect, we would like to know all the individual aspects of each volcano that can help drive further inquiry. The main goals of our project are first to extract the topography of the different edifices, and then to order and visualize them to understand their scientific and educational significance, we used automated landform classification aggregated with geological and Geopreservation Inventory maps. Landform classification is an important factor as it defines the rarity of a given landform and as well providing scale for decision making.

4.2.1. Boundary

To see what features receive visitation, we extracted the boundaries of volcanic edifices. We determine edifice boundaries from topography by terrain attributes. We postulate that highest slope areas correspond most to coastal and volcanic edifices. We first calculated topographic slope of the AVF using 1 m resolution digital elevation model (DEM) derived from LIDAR point-cloud data captured by airborne sensors, available through the LINZ Data Service (https://data.linz.govt.nz/, accessed on 20 September 2021). We generated a filtered map of areas that have slopes higher than a threshold value (Figure 3). Afterwards, we distinguished contours that follow an elliptical shape. Boundaries of the landform were not added into the analytical process because they are necessary for visualisation to understand the advancement of the built-in area (Figure 4) into landforms and promote a sense of urgency for strong measures on geoheritage conservation.

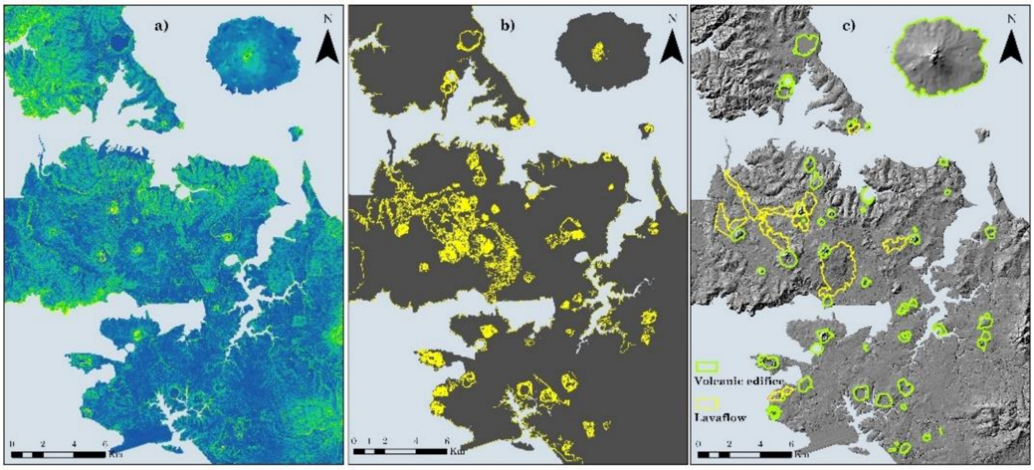

Figure 3. Edifice boundary extraction for the Auckland volcanic field using ArcGIS Pro software package to analyse and process spatial data. (**a**) Topographic slope and (**b**) filtered map of the slope of the volcanic surface higher than a threshold value extracted from the built in ArcGIS Pro statistical analysis tool; (**c**) edifice boundaries.

Analysis on the grass root initiatives resulted in the identification of existing Geopreservation Inventory. The boundary of landforms did not match the boundary of the geoconservation areas in the inventory (Figure 5). A comparison with the land use database revealed that the geopreservation areas are adjusted to the boundaries of open spaces of the city.

The map shows that the boundaries for the items in the Geopreservation Inventory are somewhat adjusted to the boundaries of open spaces. There is no evidence yet that urban planning practices incorporated geoheritage as a factor during multi-criteria decision making. The boundaries of volcanic edifices do not correspond with open space, they show the loss of area. However, due to their environmental principles, urban planning within Auckland have saved many volcanic cones in a not quite intact form, but it is arguable that quarry scars can increase the geoheritage value of a landform by demonstrating more detailed geological processes that contributed to the geomorphology, taking visitors to a journey from the beauty of the surface to the 'centre of the Earth'. Our calculation for edifice boundaries is based on a LiDAR image that scanned the surface in 2013, which already went through landscaping that altered the slope rate.

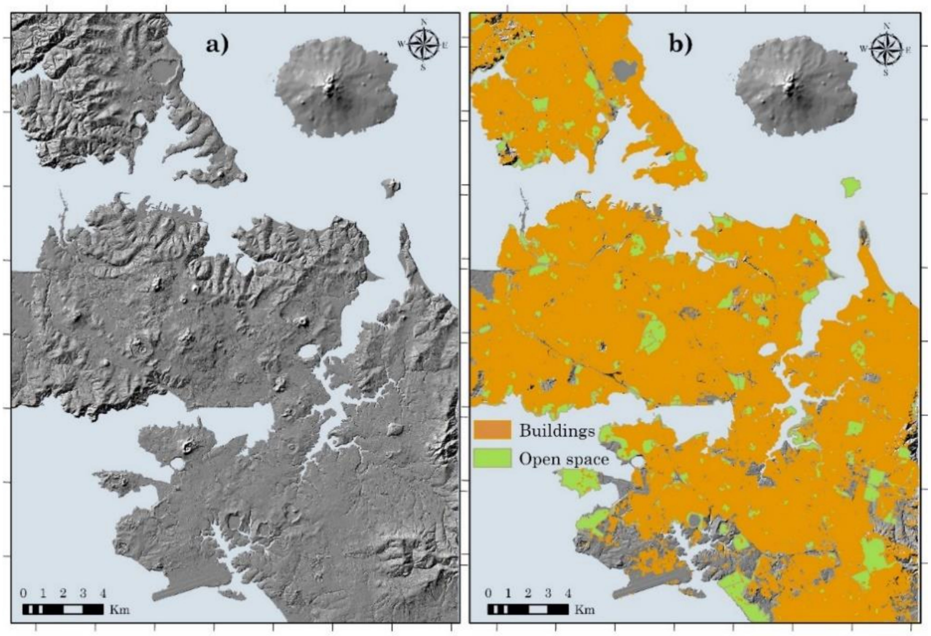

Figure 4. (**a**) Grayscale 3D representation of the Auckland volcanic field's surface with vegetation and objects extracted (1 m DEM built from LiDAR point cloud provided by LINZ Data Service https://data.linz.govt.nz/, accessed on 20 September 2021). (**b**) Open space areas and buildings of Auckland city (data provided by LINZ Data Service https://data.linz.govt.nz/, accessed on 20 September 2021). Open space means any open piece of land that offer important opportunities for sport and recreation and accessibility to the public.

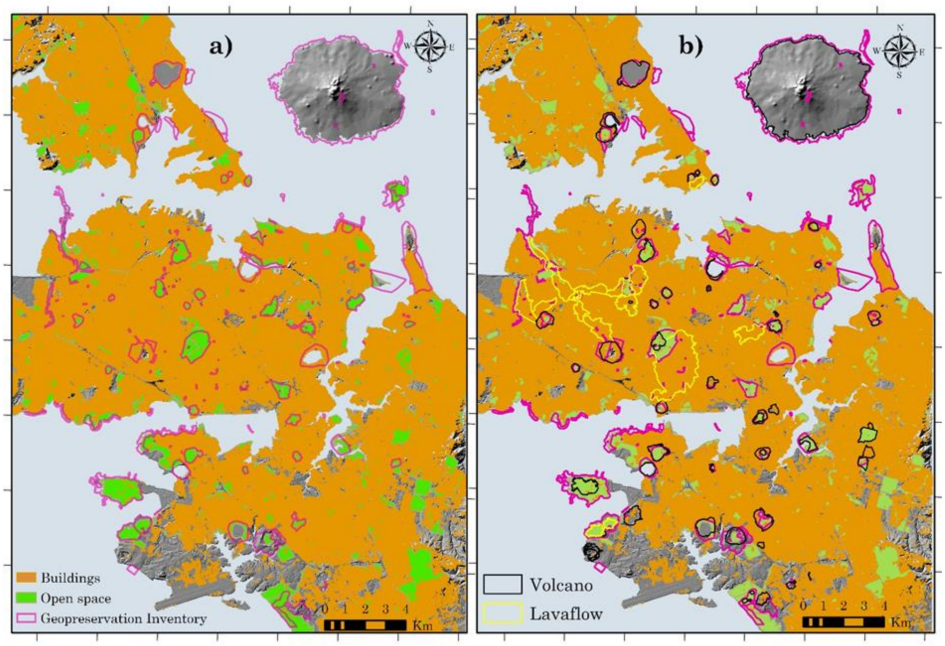

Figure 5. Comparison of boundaries to visualise the impact of urban sprawl on the Auckland volcanic field. (**a**) Building outlines by orange colour represent the urban sprawl. The green polygons are the designated open spaces by the Auckland Council. Pink lines represent the outstanding natural features constituting the Geopreservation Inventory. (**b**) The map depicts the edifices boundaries by yellow and black colour in comparison to open spaces and geopreservation inventory items. The aim of this map is to visualise the loss by the urban sprawl.

4.2.2. Classification

By simply the difference between the cell elevation value and the average elevation of the neighbourhood around that cell, we classify the landscape into slope position and landform category. We used the 1 m resolution DEM to calculate the basic algorithm, called Topographic Position Index (TPI). The algorithm uses the annulus neighbourhood for the average elevation. Positive TPU values represent locations that are higher than the cell average around them (ridges). Negative values represent locations that are lower than their surroundings (valleys). Values near zero are either flat areas or areas of constant slope [79]. We were curious whether within volcanic landforms, quarry scars, craters, outcrops, and tuff rings are categorized into different landform classes.

TPI calculation is inherently scale dependent. Scale can become an apparent issue as craters of monogenetic volcanoes can be too small (few tens to hundreds of metres across), they blur into the topography dominating their environment at a scale of a kilometre. We calculated TPI at scales of 100 m using radii of 5, 10, and 500 m using radii 8, 15 using the formula provided by Weiss [79]:

$$tpi\langle scalefactor\rangle = int((dem - focalmean(dem, annulus,\ irad,\ orad)) + 5 \quad (1)$$

In craters on the AVF, diameters start from about 100 m, with an average of >150 m heigh scoria cones. The average scoria cone diameter starts at 500 m. The landform characteristics were calculated therefore at both scales using focal statistics tool. For best result we combined the small and the large scale.

We standardized the TPI grids to allow craters to be distinguished following the formula provided by Weiss [79]:

$$tpi < sf >_{stdi} = int\left(\left(\frac{tpf\langle sf\rangle - mean}{stdv}\right) * 100\right) + 5 \quad (2)$$

For the breakpoints we chose standard deviation as the basic unit. Next, the standardized TPI values were used to classify the field into slope position classes. For enhancing the classification of volcanic landforms, we used additional topographic metrics, slope and non-standardized TPI at 100 m scale [80], so from the basic landforms, ridges, upper slopes (shoulders), lower slopes (foot slopes), and valley bottoms (toe slopes) we can add craters, tuff rings, and scoria cones (Table 2). A slope threshold of 6° was used to distinguish between flat areas and open lava flows.

The accuracy of distinguishing volcanic landforms can be improved. Future should introduce ruggedness index as a secondary classification factor to move the different landforms to the right classes with higher accuracy. However, for the geoeducational capacity map, we need the summary of the different identified landforms by the TPI algorithm. We used the volcanic landform classes to calculate their extent in order to assign weights to given classes. The extent among the classes showed a large difference that also allowed for the estimated ~10% inaccuracy.

Identifying the main topographic attributes of the elements of a landform, it is possible to automatize the classification of geomorphology (Figure 6) of similar geological features and promote comparability for objective geoheritage evaluation.

Table 2. Landform classes by slope position and volcanism relevant features. The breakpoint among classes shows the slope position based on Weiss (2001) from the negative values of deeply incised streams and valleys to the positive values of upper slopes and ridges and the rolling morphology in between. In our study we adjusted these breakpoints to optimise the classification for monogenetic volcanic landscape.

Slope Position	Volcanic Landform	Class	$TPI100_{stdi}$	$TPI500_{stdi}$	TPI100	Slope
Cliff	Exposure	0				>50°
Deeply incised streams	Deep crater	1	≤−100	≤−100	≤−10	
Deeply incised streams	Quarry	2	≤−100	≤−100	>−10	
Mid-slope drainages	Lava drainages, tuff ring	3	>−100, <100			
Plains	Explosion crater (maar)	4	>−100, <100			<6°
Open slopes	Lava flow	5	>−100, <100	>−100, <100		>6°
Upper slopes, mesas	Tuff ring	6	>−100, <100	≥100	>−1, <1	
Upper slopes, mesas	Shallow or open crater	7	>−100, <100	≥100		
Ridges	Cone, Ridges	8	≥100			

Table 3. The calculated extents and their assigned weights of the geology classes, geopreservation inventory classes, and landform classes.

	Geology					Geopreservation Inventory				Landform Classes								
	Scoria	Ash and Lapilli	Lithic Tuff	Lava	Non Volcanic	Importance 'A'	Importance 'B'	Importance 'C'	Non Volcanic	0	1	2	3	4	5	6	7	8
Extent (km^2)	5.7	23.9	39.8	61.5	283	N/A	N/A	N/A	N/A	2.4	23.6	220	97	39.9	1.7	12.4	11.7	5
Weight	4	3	2	2	1	4	3	2	1	8	4	1	2	3	9	5	6	7

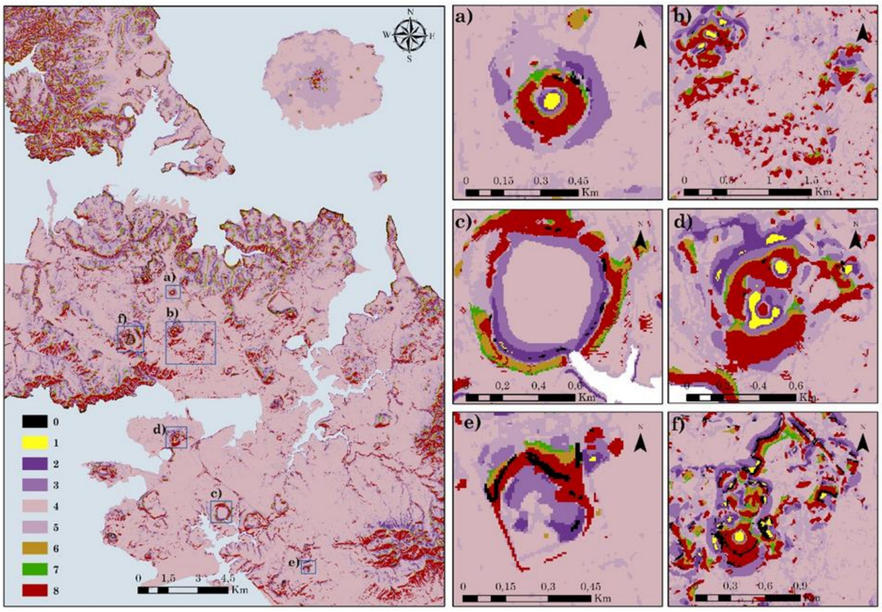

Figure 6. On the left: Landform classification using Topographic Position Index of the Auckland volcanic field using the criteria and colour codes shown in Table 3. The method applied was based on Weiss (2001) and modified threshold values to distinguish slopes characteristic for monogenetic volcanism. (**a**) Mt Saint John scoria cone with steep crater; (**b**) One Tree Hill lava flow; (**c**) Pukaki maar with tuff ring. White area is the estuary; (**d**) Mangere Mt tholoid in main crater and a second steep crater; (**e**) Wiri Mt quarry face; (**f**) Three Kings scoria cone with quarry scars and crater.

To map the visitation rate, we leveraged the vast amount of data generated by the public and available for research purposes on the internet. Crowdsourcing is the practice of obtaining large amount of information of people's habit via the internet. Volunteered geographic information is geospatial content generated by visitors using available mapping platforms on the internet [149]. Flickr is a safe platform for volunteered geographic information. It is based on the data visitors store on the cloud, and their agreement on the use of the metadata for research. Flickr has been used for long time for analysing patterns and interest of visitation. The high level of representativeness of Flickr data is discussed in numerous studies [76,150–153]. There is a low level of inaccuracy involved due to the known errors (atmospheric error, user clock error, orbital error, multi-path error, etc.) of built in geographic position systems; however, the location correctness of geotagged Flickr images is reliable [154]. The technology offers a large amount of cheap and instant data. The data exposes gaps in promotion instruments as well as being useful for monitoring behaviour changes generated by quality implementation.

The most useful social media site is Flickr (compared with Panoramio, Geograph) for the visitation analysis because it is the photograph sharing site with the most photographs uploaded due to its high social networking factor [76,155]. The most popular photo-sharing sites provide an application programming interface (API) to access photo storage database. APIs offer the possibility to download the geographic data within a given bounding box.

Geographic coordinates were integrated into GIS environment to visualize the photo distribution by placing a dot on a map at each image's location. In the case of Auckland, the major tourist attractions are recognizable at first sight. Along with the city centre, the volcanic cones are the most favourable places among photographers based on the number of photos taken in a given location. The data also clearly shows the pathway to the top of the volcanoes. A fishnet tool was used to construct a polygon grid to cover the dot print features. Spatial join analysis was subsequently conducted, which counted the number of events falling within each grid polygon. Last step of geoprocessing was to convert this polygon feature to a raster dataset in order to determine the tourist hotspots. Hotspots are the places that attract most of the 'site-seers", but popularity is not always desirable for local tourism, which raises concerns in addressing place appraisal to understand how locales can achieve more sustainable tourism [156–159].

4.2.3. Analysis

Geoeducational capacity is the depth of information that can be deprived, observed, or attained at a position displaying features of earth system. A flowchart of the methods and materials used for the analysis is shown on Figure 7. For the calculation of the geoeducation capacity map we used the landform classification, geology, and geopreservation maps. Each map was transformed to a low to high value map individually and aggregated to show geoeducation capacity. The items in the Geopreservation Inventory (http://www.geomarine.org.nz/NZGI/, accessed on 20 September 2021) beside a detailed description of their scientific attributes are marked according to their level of importance: 'A' of international scientific, aesthetic, or educational value; 'B' of national scientific, aesthetic, or educational value; and 'C' of regional scientific, aesthetic, or educational value. We simply transformed the importance marks into weight classes: '1' presenting non volcanic features, '2' presenting 'C' importance items, '3' presenting 'B' importance, and '4' presenting 'A' importance. For the geology map and landform classification we calculated the spatial extent of each rock type and landform class and weighted them based on their amplitude (Table 3). Our supposition was that the smaller the spatial extent, the rarer the rock type/landform class, hence it received the highest weight.

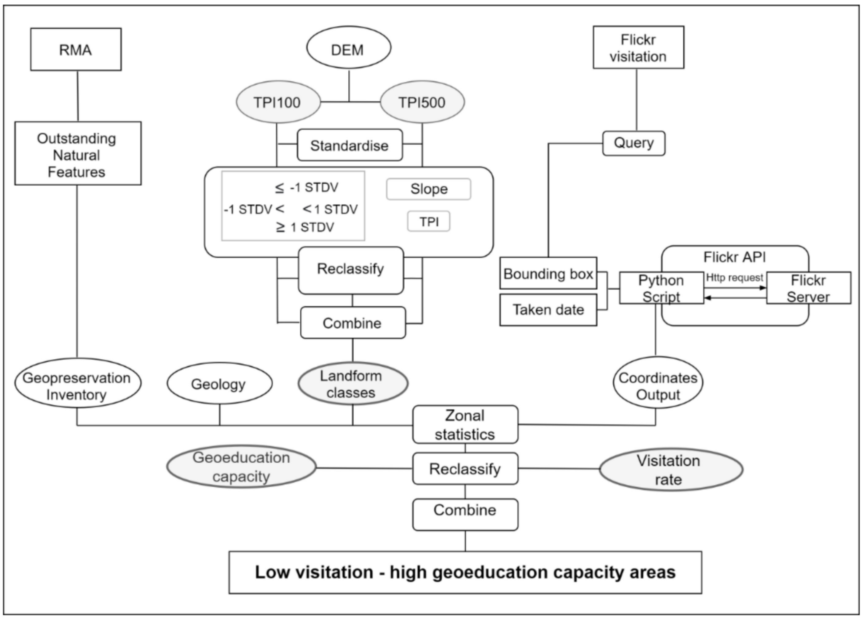

Figure 7. Flowchart of the methods and materials used for the analysis. The four take off points of the study were the basis of all environmental matters: the Resource Management Act (RMA), the collection of significant geological sites in New Zealand (Geopreservation Inventory), Digital Elevation Model of the Auckland volcanic field (DEM), and coordinates of photos taken within the bounding box of Auckland volcanic field extracted from FlickR (Flickr Visitation). The analysis continued in three consecutive stages. First, the landscapes were categorised into 'Landform classes' using Topographic Position Index (TPI) on two different scale range (TPI100 and TPI200). In the second stage, the representative layers of expert's knowledge, Geology map and Geopreservation Inventory, were processed into layers compatible with the acquired layer on Landform classes. We used GIS multicriteria analysis to generate the 'Geoeducation capacity' map from the aforementioned map layers. In the third stage, the photo taken coordinates acquired from FlickR were organised into low to high visitation categories resulting in 'Visitation rate' map. The results of the three stages were combined into the map of underrated geoeducation capacity areas with high scientific value. All of the processes above used the analytical power of ArcGIS.

The following steps were executed using the zonal statistics tool in order to calculate the magnitude of geoeducational value. For each map, we used a 100 m grid cell to count the number units and adding together the weights of the different type of units of geologic, landform, and geopreservation. The classification method for the geoeducation capacity map (Figure 8) used the natural breaks (Jenks) method.

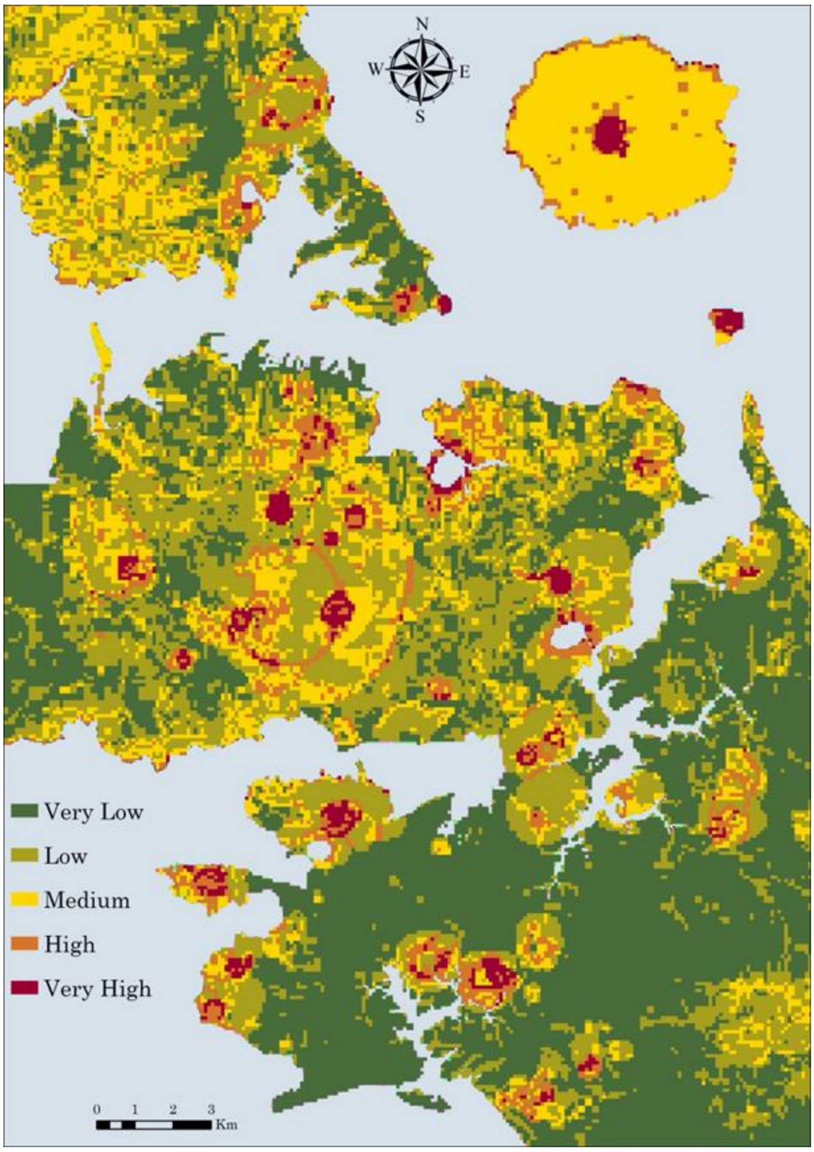

Figure 8. Geoeducation Capacity Map. Values of very low to very high are the result of the GIS multicriteria analysis. We aggregated three different map layers, namely, geology, geopreservation inventory, and landform classes. Standardised weights were assigned to the different classes of each map layers. The weights for geology map and landform map were calculated by the extent of each class. The smaller the extent of a geological class or a landform class, the rarer that class is. The weights for geopreservation inventory were provided ranging from international to regional importance. The aggregation of the map layers was based on variety.

To analyse visitation rate of the highest geoeducational features we took the Flickr coordinates extracted from the cloud. We used FlickR API to return the metadata of photos within a bounding box of specific latitude, longitude, and accuracy. With the spatial joint tool, we affixed the data to form a spatial perspective. By the count of pictures taken within a 100 m grid, we produced a raster of high to low visitation areas. To reduce the effect of the highly skewed distribution of visitation caused by the popularity of the cities' downtown, we ran a log transformation on the joint count data. The high visitation cells on the grid needed to be expanded by 200 m to each direction to reduce the error resulted from the majority of the photos taken at the top of the landforms. The buffer was executed to cover a generalized diameter of a scoria cone (200 m), we hypothesized that a photo taken point was statistically significantly to cover the viewpoint of the landform, but visitation takes place through the entire landform.

For the final map we deducted the high visited high geoeducational values from the geoeducational capacity map to highlight underrated and underpromoted areas (Figure 9).

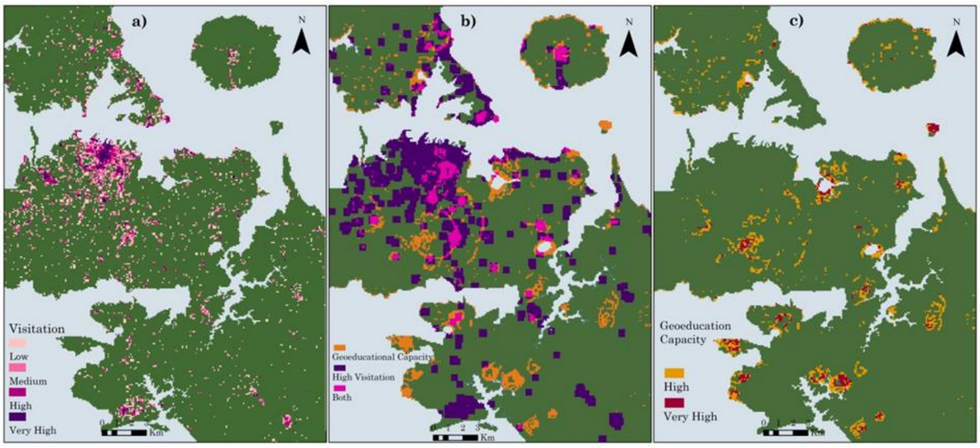

Figure 9. (**a**) FlickR visitation rate (**b**) Flickr visitation compared to high geoeducation capacity cells. On this map, geoeducation capacity transferred to a Boolean system. Yes, colour yellow, when medium, high, or very high capacity is present. No, colour green, when low, very low or not detected is the cell value. This was combined with the visitation that was also simplified into Boolean categories. Visitation cells, colour purple, present medium to very high, and not visited cells; colour green, present low and null cell values. Overlay function produced the areas where Boolean visitation and geoeducation capacity overlaps, colour pink. The purpose of the map is to find areas that need to be prioritised for conservation and promoted as high value geoeducational sites. (**c**) This map has taken away the geoeducation capacity that overlaps with visitation to highlight the low visitation high geoeducation capacity areas.

5. Discussion

5.1. GIS Techniques to Strengthen Geoheritage Case

GIS techniques deliver an ability for users to construct repeatable models. Repeatability of an evaluation method is one of the main criteria to achieve reliability necessary for quality implementation [160]. Spatial techniques also make geologic and geomorphologic features out of sight appear in evaluations providing robust scientific information [161].

Topographic Position Index creates an accurate map for 'rarity' that is a main criterion layer. The technique is developed to classify landforms for further analyses and utilised mainly in ecological decision-making tasks such as biodiversity modelling [162,163], or assessment of soil moisture [82,164,165], or habitat suitability [166,167], to mention a few.

Topographic Position Index technique is used to classify landforms. This means clearly defined boundaries and the opportunity to break down a landform to smaller landform features. This increases the likelihood of implementation by giving opportunities for the identification of sites with the highest potentials. Once the exact locations on the highest information are pinpointed in GIS, the map can be inserted into land use planning. This step is a prerequisite for the promotion of geological heritage in urban settings.

GIS multicriteria analysis is widely used in site selection exercises, for example, wind farm site selection [168,169], agro-industrial complex [170], industrial site selection [171], parking site selection [172], investment site selection [173], landfill site selection [174] or for the detection of land use suitability for example in urban extension [175–177], citrus management [178], agricultural land use [179], land management [180,181], for biomass residues [182], and rainfed farming [183]. GIS multicriteria analysis is very useful technique in hazard mapping such as multi hazard mapping of landslides, floods and earthquakes [184], forest hazards [185], hazards in site selection [186], and forest fire risk [187] also in socio-economic fields to analyse deprivation [188], urban water demands [189], climate change [190], forest landscape restoration preferences [191], or to map zones in groundwater recharge [192], landslide hazard zonation [193,194], protected area zoning [195], or to create multi objective land allocation [196–200]. These applications require precise modelling that underline decision making. Conservation of geological and geomorphological features gain objectivity by using GIS modelling. Multi-criteria analysis is versatile allowing for multiple objectives to be considered and have all the alternatives on record. The main constraint of non-GIS based geoheritage evaluation is the level of subjectivity and the inability to provide multi objective solutions.

5.2. Geoeducational Capacity Map in Urban Planning

Geoheritage lacks clarity in a decision-making environment. This study aims to shed light on the overlaps between values of different conservation branches and lead to the reduction of protection policies and lands. However, providing societal needs is the prime priority and lands taken away need strong evidence from practitioners. Therefore, this study encourages future studies to shift evaluations to geographic information systems for comparability and reproducibility.

Tourism, recreation, and geoconservation have overlapping though contradicting objectives all targeting outstanding geological/geomorphological features. When opportunity is limited, decisions favour objectives that are supported by a firm framework. That is where our study plays a crucial role. In New Zealand, it is of national importance to conserve nature and cultural authenticity. Constant development of geoconservation frameworks that adapt the newest urban planning methods and incorporate the increasing amount of valuable but latent online data is imperative. Urban planning in Auckland is carried out in GIS, therefore our study is quickly and effortlessly implementable into the future planning exercises. Decision makers understand the value of geoheritage, however with a low percentage of geoheritage features already being popular tourist destinations, it would seem practical to exert geoeducation around these features. Our map however shows the areas that receive no visitation and carry very high geoeducational capacity. These areas now on record and cannot be overlooked.

5.3. Geoeducational Capacity Map in Indigenous Knowledge System

Local communities ideally live in harmony with their environment and assign strong meaning to their geology and geomorphology. Significant geological and geomorphological features are the basis of the spiritual well-being of the locals. Humans are bonded with nature in an intertwined system where people are the guardians of the environmental manifestation of the ancestry of all living. Scientific knowledge on the environment developed hand in hand with indigenous knowledge and worldview creating a moral obligation for geoconservation. Communities are attached to geology and geomorphology scientifically and spiritually, which is globally an underrated element of sustainability and quality of life. With the open opportunity in the legal framework for quality geoconservation implementation we can achieve that sustainable development and holistic conservation. Our map provides clarity on the geographical locality and extent of the scientific capacity of these features. The engagement of iwi representatives is the next step that will close the gap between the 'western' and 'indigenous' knowledge. Our map provides a common ground for all the stakeholders and serves as an instrument in this spatial decision-making issue. The maps cannot tell the spiritual value of the natural features for the community. However, maps are crucial for the identification of features that are sacred or otherwise valued by the community and for the analysis of areas under conflict of different objectives. A feature might carries vary high geoeducational value, but if it deemed sacred, the promotional tools become limited and alternative options should be considered. The geoeducational capacity map provides decision makers with alternatives and the most optimal combination of features for conservation under multiple objectives.

5.4. Improving Geoeducational Site Network in Auckland

Geoheritage value presents a range of values including, and mainly recognised, aesthetics, viewpoints, and intactness of geomorphology. In an urban environment, these values are the bases of recreation. Even though this is a great advantage for geoconservation, these values are not the basis for education. From a geoeducation aspect, scientific value weighs the most for making a geological site significant over the other, and these sites often come up short on aesthetic value. Big efforts have been put into geoheritage recognition by experts in the area. The Geopreservation Inventory triggered further community initiatives. The geological sites are used by local tourist agencies (https://www.geotrips.org.nz/map.html, accessed on 20 September 2021) to create geotrails, and guided tours. Their work needs to be promoted and inserted into promotional materials of Auckland. Walking through Auckland as a visitor, however, there is very little promotional material. Some geoheritage features receive high visitation without them understanding their destination and rather using volcanic for the view. The most visited locations, such as Mt Eden, nearly completely lack information on volcanism, and overall, there is only very basic geoeducational indication in situ. The existing motive for visitors to engage in the view from the top of a volcanic cone is an advantage in hand to draw attention to volcanic processes. Strategically placed information panels spark curiosity to discover the story of the volcanic field as a whole and visit outcrops with lower aesthetic value.

The Geoeducation Capacity Map is useful because it gives us a unit of weight, and the implies the next step as an imperative. That is the promotion of geological information, the value of geoeducation for resilience, future research and hazard mitigation, and the advancement of educative boards and instruments generating interest in the non-geologically inclined public. Geoeducational capacity is higher with higher scientific value, whereas geoheritage value is the summarized value of cultural, recreational, and scientific value.

5.5. Big Data Analysis as Decision Making Support Tool

Volunteered geographic information can be used for analysing the patterns of visitors, the path of their movement. Temporal data in the future will help monitoring changes in tourist behaviour and evaluate marketing techniques. It is a very important emerging tool in modern urban planning. To map where tourists go is crucial in deriving pull motives. Pull motives are generated by promotional materials that can be manipulated toward geoeducation. The uncovered patterns of visitation show the strongest pull motives within Auckland. These visitation patterns placed against the geoeducation map show the gap areas needing to be addressed (Figure 10). Additionally, as a side objective, the stress exerted on the hot spot by the mass tourism flow can be evenly spread across Auckland, providing economic opportunities for marginal areas of the city. The ability to estimate visitation rates without survey data accelerates the process of quantifying the tourist value of a certain volcanic site. Raster data shows the exact number of photos within a square of 100 m $\times$ 100 m that is an average size of the Auckland volcanoes. High value raster polygons are the tourist hotspots. The display of the exact locations within the polygons helps the optimum emplacement of promotional and educational materials.

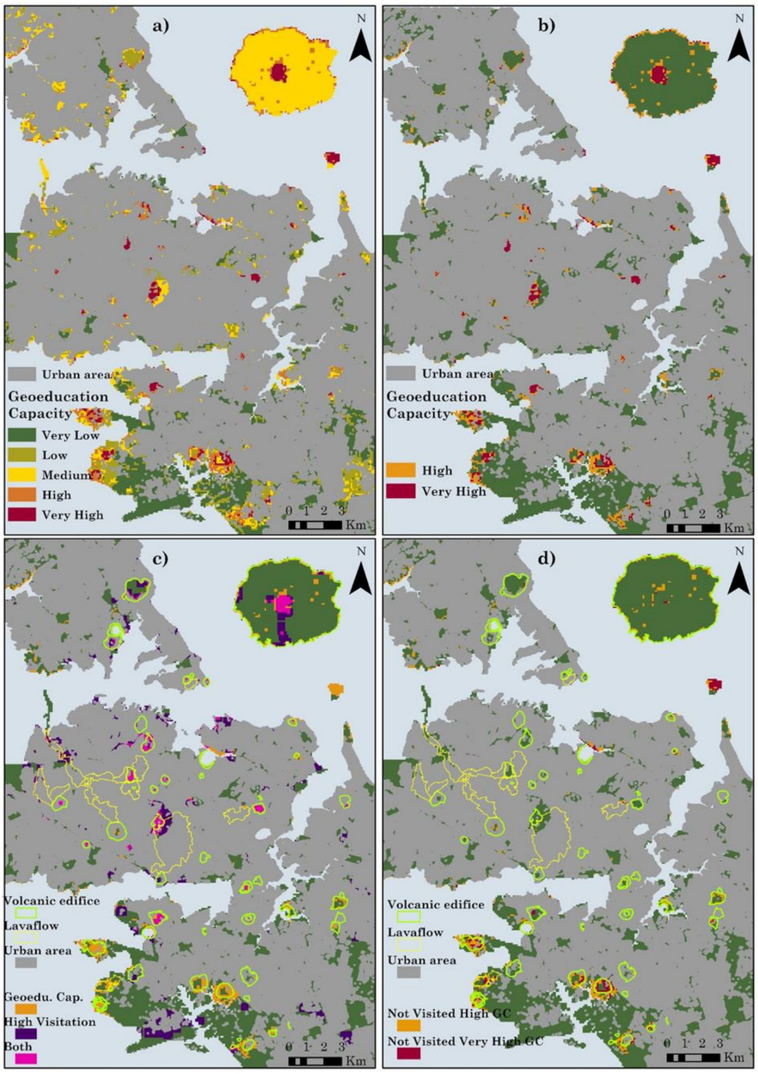

Figure 10. (**a**) Geoeducation Capacity Map with extension of urban area. (**b**) This map shows the locations of High and Very High geoeducation capacity areas that are not covered by buildings of the urban area. (**c**) The buildings of the urban area placed over the geoeducation capacity and visitation depicts the exact area available for the promotion of volcanology. Edifice boundaries are necessary for the better understanding of the threat on geoeducation values. (**d**) The map only shows the high and very high geoeducation capacity areas with the urban area.

6. Conclusions

Legislation in Auckland, New Zealand, allows for an upgrade in geoheritage conservation. Sustainable development and community involvement are very important national matters. These are also among the main supporting arguments for geoheritage conservation. Auckland, as a rapidly developing city, is in search for solutions to ensure the community can keep connection with the nature. Natural features of highest cultural importance are safe under the ownership of local community. However, the area, being geologically active, has natural features of high geoeducational capacity that need to be promoted in order to achieve high resilience within the community.

For the creation of policies that protect and promote high geoeducational capacity features, a robust evaluation instrument was necessary. Achieving a high quality of geoheritage conservation implementation is critical to achieve the desired outcomes set out in the Geopreservation Inventory. The Geopreservation Inventory is the result of a local geoscientist who expressed their concern about the loss of the geoheritage in the urbanisation as early as the 1980s. This extensive work represents the expert's knowledge.

This study inserts this expert knowledge into a suitability map to demonstrate a robust instrument that aids spatial decision making. The suitability map is technically a capacity map. It was important to find evaluation units that can be assigned to the expert knowledge. To attain objective units for our decision-making instrument we used automated landform classification by applying the Topographic Position Index. GIS based multi-criteria analysis aggregated the information into the Geoeducation Capacity Map. Such analysis reveals the feasibility on expanding recent geological conservation strategies toward geoeducation. Modern GIS techniques clearly eliminate the level of subjectivity that often jeopardise geoconservation plans from implementation.

The understanding of visitation patterns facilitates the recognition and promotion of overlooked high geoeducational capacity areas. The comparison of visitation dynamics with the geoscientifically important areas optimizes decision-making and planning processes, and points out gaps and unrecognized opportunities.

A comprehensive network of geoeducational sites within a city that stretches across a geologically active area is an effective field education tool. The general public will achieve a better understanding of the geological hazards and an overview of earth scientific research and its importance. This conceptual direction fits perfectly to a current UNESCO IGCP Project 692, "Geoheritage for Geohazard Resilience" (http://www.geopoderes.com/, accessed on 20 September 2021).

Present day geopreservation locations do not overlap with those areas visited, and have some geological value from a morphological and volcanology perspective. The overlay of Geopreservation Inventory that is marked following boundaries of the urban development and the edifice boundaries shows that there is still extensive geology to protect and promote. Geology is not only important for geoeducation but also for community well-being. High geoeducational capacity areas often do not provide opportunity for high amenity value and need expert enthusiasm and authorities' corporation to be indeed among the high visited areas, and thus create new appeal for visitors to read the geological history of the region through the environment itself.

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References

1. Jiao, L. Urban land density function: A new method to characterize urban expansion. *Landsc. Urban Plan* **2015**, *139*, 26–39. [CrossRef]
2. Auckland Governance Reforms. Spatial Planning Options for the Auckland Council. Cabinet Comittee on Implementation of Auckland Governance Reforms, Ministry for the Environment, New Zealand Government. 2009.

3. Gu, K. Urban morphological regions and urban landscape management: The case of central Auckland, New Zealand. *Urban Des. Int.* **2010**, *15*, 148–164. [CrossRef]
4. UNEP. *Decoupling Natural Resource Use and Environmental Impacts from Economic Growth*; Fischer-Kowalski, M., Swilling, M., von Weizsäcker, E.U., Ren, Y., Moriguchi, Y., Crane, W., Krausmann, F., Eisenmenger, N., Giljum, S., Hennicke, P., et al., Eds.; A Report of the Working Group on Decoupling to the International Resource Panel; United Nations Environment Programme: Nairobi, Kenya, 2011; Volume 2011.
5. Pongsiri, M.J.; Roman, J.; Ezenwa, V.O.; Goldberg, T.L.; Koren, H.S.; Newbold, S.C.; Ostfeld, R.S.; Pattanayak, S.K.; Salkeld, D.J. Biodiversity loss affects global disease ecology. *Bioscience* **2009**, *59*, 945–954. [CrossRef]
6. Brooks, T.M.; Mittermeier, R.A.; Mittermeier, C.G.; Da Fonseca, G.A.; Rylands, A.B.; Konstant, W.R.; Flick, P.; Pilgrim, J.; Oldfield, S.; Magin, G. Habitat loss and extinction in the hotspots of biodiversity. *Conserv. Biol.* **2002**, *16*, 909–923. [CrossRef]
7. Hoekstra, J.M.; Boucher, T.M.; Ricketts, T.H.; Roberts, C. Confronting a biome crisis: Global disparities of habitat loss and protection. *Ecol. Lett.* **2005**, *8*, 23–29. [CrossRef]
8. UNEP-WCMC. Mapping Multilateral Environmental Agreements to the Aichi Biodiversity Targets. 2015. Available online: https://www.unep.org/resources/report/mapping-multilateral-environmental-agreements-aichi-biodiversity-targets (accessed on 20 September 2021).
9. Di Capua, G.; Bobrowsky, P.T.; Kieffer, S.W.; Palinkas, C. Introduction: Geoethics goes beyond the geoscience profession. *Geol. Soc. Lond. Spec. Publ.* **2021**, *508*, 1. [CrossRef]
10. Ruban, D.A.; Tiess, G.; Sallam, E.S.; Ponedelnik, A.A.; Yashalova, N.N. Combined mineral and geoheritage resources related to kaolin, phosphate, and cement production in Egypt: Conceptualization, assessment, and policy implications. *Sustain. Environ. Res.* **2018**, *28*, 454–461. [CrossRef]
11. Gray, M. Valuing Geodiversity in an 'Ecosystem Services' Context. *Scott. Geogr. J.* **2012**, *128*, 177–194. [CrossRef]
12. Fox, N.; Graham, L.J.; Eigenbrod, F.; Bullock, J.M.; Parks, K.E. Incorporating geodiversity in ecosystem service decisions. *Ecosyst. People* **2020**, *16*, 151–159. [CrossRef]
13. van Ree, C.C.D.F.; van Beukering, P.J.H.; Boekestijn, J. Geosystem services: A hidden link in ecosystem management. *Ecosyst. Serv.* **2017**, *26*, 58–69. [CrossRef]
14. Gray, M. Other nature: Geodiversity and geosystem services. *Environ. Conserv.* **2011**, *38*, 271–274. [CrossRef]
15. Németh, K.; Gravis, I.; Németh, B. Dilemma of Geoconservation of Monogenetic Volcanic Sites under Fast Urbanization and Infrastructure Developments with Special Relevance to the Auckland Volcanic Field, New Zealand. *Sustainability* **2021**, *13*, 6549. [CrossRef]
16. Justus, J.; Colyvan, M.; Regan, H.; Maguire, L. Buying into conservation: Intrinsic versus instrumental value. *Trends Ecol. Evol.* **2009**, *24*, 187–191. [CrossRef] [PubMed]
17. Fick, G.R.; Brent Ritchie, J.R. Measuring Service Quality in the Travel and Tourism Industry. *J. Travel Res.* **1991**, *30*, 2–9. [CrossRef]
18. Hassan, S.S. Determinants of market competitiveness in an environmentally sustainable tourism industry. *J. Travel Res.* **2000**, *38*, 239–245. [CrossRef]
19. Leiper, N. Why 'the tourism industry'is misleading as a generic expression: The case for the plural variation,'tourism industries'. *Tour. Manag.* **2008**, *29*, 237–251. [CrossRef]
20. Moreira, J.C.; Vale, T.F.d.; Burns, R.C. Fernando de Noronha Archipelago (Brazil): A Coastal Geopark Proposal to Foster the Local Economy, Tourism and Sustainability. *Water* **2021**, *13*, 1586. [CrossRef]
21. Štrba, Ľ.; Kolačkovská, J.; Kudelas, D.; Kršák, B.; Sidor, C. Geoheritage and Geotourism Contribution to Tourism Development in Protected Areas of Slovakia—Theoretical Considerations. *Sustainability* **2020**, *12*, 2979. [CrossRef]
22. Duarte, A.; Braga, V.; Marques, C.; Sá, A.A. Geotourism and Territorial Development: A Systematic Literature Review and Research Agenda. *Geoheritage* **2020**, *12*, 65. [CrossRef]
23. Beretic, N.; Đukanović, Z.; Cecchini, A. Geotourism as a Development Tool of the Geo-mining Park in Sardinia. *Geoheritage* **2019**, *11*, 1–16. [CrossRef]
24. Lim, K. A Study of Geotourism Growth through Recognition of Geoeducation and Geoconservation for the Geoheritage. *J. Tour. Leis Res.* **2014**, *26*, 43–59.
25. Gordon, J.E.; Barron, H.F. Valuing Geodiversity and Geoconservation: Developing a More Strategic Ecosystem Approach. *Scott. Geogr. J.* **2012**, *128*, 278–297. [CrossRef]
26. Pringle, J.K. Educational egaming: The future for geoscience virtual learners? *Geol. Today* **2014**, *30*, 147–150. [CrossRef]
27. Lukes, L.A.; Jones, J.P.; McConnell, D.A. Self-regulated learning: Overview and potential future directions in geoscience. *J. Geosci. Educ.* **2021**, *69*, 14–26. [CrossRef]
28. Elliott, S.M.; Hanson, H.P. Syndication of the earth system: The future of geoscience? *Environ. Sci. Policy* **2003**, *6*, 457–463. [CrossRef]
29. Manduca, C.; Kastens, K. Geoscience and geoscientists: Uniquely equipped to study Earth. *Spec. Pap. Geol. Soc. Am.* **2012**, *486*, 1–12. [CrossRef]
30. Leiper, N. Tourist attraction systems. *Ann. Tour. Res.* **1990**, *17*, 367–384. [CrossRef]
31. Yeung, S.K. An Evaluation of the Hong Kong Geopark: To What Extent Does It Promote Sustainable Human Development? Master's Thesis, Lund University, Lund, Sweden, June 2013.

32. Wang, L.; Tian, M.; Wang, L. Geodiversity, geoconservation and geotourism in Hong Kong Global Geopark of China. *Proc. Geol. Assoc.* **2015**, *126*, 426–437. [CrossRef]
33. Ng, S.L. Hong Kong Geopark: A paradigm of urban sustainable tourism. *Asian Geogr.* **2014**, *31*, 83–96. [CrossRef]
34. Sütő, L.; Ésik, Z.; Nagy, R.; Homoki, E.; Novák, T.J.; Szepesi, J. Promoting Geoheritage Through a Field Based Geo-education Event, a Case Study of the Hungarian Geotope Day in the Bükk Region Geopark. *Geoconserv. Res.* **2020**, *3*, 81–96.
35. Henriques, M.H.; Tomaz, C.; Sá, A.A. The Arouca Geopark (Portugal) as an educational resource: A case study. *Episodes* **2012**, *35*, 481–488. [CrossRef] [PubMed]
36. Rodrigues, J.; Neto de Carvalho, C.; Ramos, M.; Ramos, R.; Vinagre, A.; Vinagre, H. Geoproducts–Innovative development strategies in UNESCO Geoparks: Concept, implementation methodology, and case studies from Naturtejo Global Geopark, Portugal. *Int. J. Geoherit. Parks* **2021**, *9*, 108–128. [CrossRef]
37. Yeoman, I.; Brass, D.; McMahon-Beattie, U. Current issue in tourism: The authentic tourist. *Tour. Manag.* **2007**, *28*, 1128–1138. [CrossRef]
38. Cohen, E. Authenticity, equity and sustainability in tourism. *J. Sustain. Tour.* **2002**, *10*, 267–276. [CrossRef]
39. Maslow, A.H. *Toward a Psychology of Being*; Simon and Schuster: New York, NY, USA, 2013.
40. Andrasanu, A. Buzau land geopark. Steps in building a new geopark in Romania. In Proceedings of the XIX CBGA Congress, Thessaloniki, Greece, 23–26 September 2010; pp. 503–512.
41. Tomić, N. The potential of Lazar Canyon (Serbia) as a geotourism destination: Inventory and evaluation. *Geogr. Pannonica* **2011**, *15*, 103–112. [CrossRef]
42. Liberatoscioli, E.; Boscaino, G.; Agostini, S.; Garzarella, A.; Patacca Scandone, E. The Majella National Park: An Aspiring UNESCO Geopark. *Geosciences* **2018**, *8*, 256. [CrossRef]
43. AlRayyan, K.; Hamarneh, C.; Sukkar, H.; Ghaith, A.; Abu-Jaber, N. From Abandoned Mines to a Labyrinth of Knowledge: A Conceptual Design for a Geoheritage Park Museum in Jordan. *Geoheritage* **2019**, *11*, 257–270. [CrossRef]
44. Caironi, V.; Zucali, M.; Bollati, I.; Gomba, T.; San Martino, A.; Fumagalli, P. Urban Geology: Itineraries in the city center to discover lithological geodiversity. *Rend. Online Soc. Geol. Ital.* **2019**, *49*, 26–32.
45. Comentale, B. Disused stone quarries in urban landscape, a feature of geoheritage: Case studies from Paris and Nantes. *Physio-Geo* **2019**, *13*, 1–24. [CrossRef]
46. Habibi, T.; Ponedelnik, A.A.; Yashalova, N.N.; Ruban, D.A. Urban geoheritage complexity: Evidence of a unique natural resource from Shiraz city in Iran. *Resour. Policy* **2018**, *59*, 85–94. [CrossRef]
47. Pelfini, M.; Bollati, I.M.; Giudici, M.; Pedrazzini, T.; Sturani, M.; Zucali, M. Urban geoheritage as a resource for Earth Sciences education: Examples from Milan metropolitan area. *Rend. Online Della Soc. Geol. Ital.* **2018**, *45*, 83–88. [CrossRef]
48. Polck, M.A.d.R.; de Medeiros, M.A.M.; de Araújo-Júnior, H.I. Geodiversity in Urban Cultural Spaces of Rio de Janeiro City: Revealing the Geoscientific Knowledge with Emphasis on the Fossil Content. *Geoheritage* **2020**, *12*, 47. [CrossRef]
49. Portal, C.; Kerguillec, R. The Shape of a City: Geomorphological Landscapes, Abiotic Urban Environment, and Geoheritage in the Western World: The Example of Parks and Gardens. *Geoheritage* **2018**, *10*, 67–78. [CrossRef]
50. Wolniewicz, P. Bringing the History of the Earth to the Public by Using Storytelling and Fossils from Decorative Stones of the City of Poznań, Poland. *Geoheritage* **2019**, *11*, 1827–1837. [CrossRef]
51. Capdevila-Werning, R. Preserving Destruction: Philosophical Issues of Urban Geosites. *Open Philos.* **2020**, *3*, 550–565. [CrossRef]
52. Prosser, C.D. Geoconservation, Quarrying and Mining: Opportunities and Challenges Illustrated Through Working in Partnership with the Mineral Extraction Industry in England. *Geoheritage* **2018**, *10*, 259–270. [CrossRef]
53. Gioncada, A.; Pitzalis, E.; Cioni, R.; Fulignati, P.; Lezzerini, M.; Mundula, F.; Funedda, A. the volcanic and mining geoheritage of San Pietro Island (Sulcis, Sardinia, Italy): The potential for geosite valorization. *Geoheritage* **2019**, *11*, 1567–1581. [CrossRef]
54. López-García, J.A.; Oyarzun, R.; Andrés, S.L.; Martínez, J.I.M. Scientific, educational, and environmental considerations regarding mine sites and geoheritage: A perspective from SE Spain. *Geoheritage* **2011**, *3*, 267–275. [CrossRef]
55. Hu, W.; Wall, G. Environmental management, environmental image and the competitive tourist attraction. *J. Sustain. Tour.* **2005**, *13*, 617–635. [CrossRef]
56. Newsome, D.; Dowling, R.; Leung, Y.-F. The nature and management of geotourism: A case study of two established iconic geotourism destinations. *Tour. Manag. Perspect.* **2012**, *2*, 19–27. [CrossRef]
57. Farsani, N.T.; Coelho, C.O.A.; Costa, C.M.M. Analysis of Network Activities in Geoparks as Geotourism Destinations. *Int. J. Tour. Res.* **2014**, *16*, 1–10. [CrossRef]
58. Gatautis, R.; Vitkauskaite, E. Crowdsourcing application in marketing activities. *Procedia-Soc. Behav. Sci.* **2014**, *110*, 1243–1250. [CrossRef]
59. Whitla, P. Crowdsourcing and its application in marketing activities. *Contemp. Manag. Res.* **2009**, *5*. [CrossRef]
60. Brabham, D.C. Crowdsourcing the public participation process for planning projects. *Plan. Theory* **2009**, *8*, 242–262. [CrossRef]
61. Certoma, C.; Corsini, F.; Rizzi, F. Crowdsourcing urban sustainability. Data, people and technologies in participatory governance. *Futures* **2015**, *74*, 93–106. [CrossRef]
62. Sigala, M. Gamification for crowdsourcing marketing practices: Applications and benefits in tourism. *Adv. Crowdsourcing* **2015**, 129–145.
63. Lehdonvirta, V.; Bright, J. Crowdsourcing for public policy and government. *Policy Internet* **2015**, *7*, 263–267. [CrossRef]
64. Prpić, J.; Taeihagh, A.; Melton, J. The fundamentals of policy crowdsourcing. *Policy Internet* **2015**, *7*, 340–361. [CrossRef]

65. Brabham, D.C.; Ribisl, K.M.; Kirchner, T.R.; Bernhardt, J.M. Crowdsourcing applications for public health. *Am. J. Prev. Med.* **2014**, *46*, 179–187. [CrossRef]
66. Good, B.M.; Su, A.I. Crowdsourcing for bioinformatics. *Bioinformatics* **2013**, *29*, 1925–1933. [CrossRef] [PubMed]
67. Solemon, B.; Ariffin, I.; Din, M.M.; Anwar, R.M. A review of the uses of crowdsourcing in higher education. *Int. J. Asian Soc. Sci.* **2013**, *3*, 2066–2073.
68. Besaleva, L.I.; Weaver, A.C. CrowdHelp: A crowdsourcing application for improving disaster management. In Proceedings of the 2013 IEEE Global Humanitarian Technology Conference (GHTC), San Jose, CA, USA, 20–23 October 2013; pp. 185–190.
69. Djelassi, S.; Decoopman, I. Customers' participation in product development through crowdsourcing: Issues and implications. *Ind. Mark. Manag.* **2013**, *42*, 683–692. [CrossRef]
70. Alivand, M.; Hochmair, H.H. Spatiotemporal analysis of photo contribution patterns to Panoramio and Flickr. *Cartogr. Geogr. Inf. Sci.* **2017**, *44*, 170–184. [CrossRef]
71. Zielstra, D.; Hochmair, H.H. Positional accuracy analysis of Flickr and Panoramio images for selected world regions. *J. Spat. Sci.* **2013**, *58*, 251–273. [CrossRef]
72. Shafique, S.; Ali, M.E. Recommending most popular travel path within a region of interest from historical trajectory data. In Proceedings of the 5th ACM SIGSPATIAL International Workshop on Mobile Geographic Information Systems, Burlingame, CA, USA, 31 October 2016; pp. 2–11.
73. Cai, G.; Hio, C.; Bermingham, L.; Lee, K.; Lee, I. Mining frequent trajectory patterns and regions-of-interest from Flickr photos. In Proceedings of the 2014 47th Hawaii International Conference on System Sciences, Waikoloa, HI, USA, 6–9 January 2014; pp. 1454–1463.
74. Höpken, W.; Müller, M.; Fuchs, M.; Lexhagen, M. Flickr data for analysing tourists' spatial behaviour and movement patterns: A comparison of clustering techniques. *J. Hosp. Tour. Technol.* **2020**. Available online: https://www.emerald.com/insight/content/doi/10.1108/JHTT-08-2017-0059/full/html (accessed on 20 September 2021).
75. Kisilevich, S.; Krstajic, M.; Keim, D.; Andrienko, N.; Andrienko, G. Event-based analysis of people's activities and behavior using flickr and panoramio geotagged photo collections. In Proceedings of the 2010 14th International Conference Information Visualisation, London, UK, 26–29 July 2010; pp. 289–296.
76. Kádár, B.; Gede, M. Where Do Tourists Go? Visualizing and Analysing the Spatial Distribution of Geotagged Photography. *Cartogr. Int. J. Geogr. Inf. Geovisualization* **2013**, *48*, 78–88. [CrossRef]
77. Chareyron, G.; Da-Rugna, J.; Branchet, B. Mining tourist routes using flickr traces. In Proceedings of the 2013 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining, Niagara, ON, Canada, 25–28 August 2013; pp. 1488–1489.
78. Chen, L.; Roy, A. Event detection from flickr data through wavelet-based spatial analysis. In Proceedings of the 18th ACM Conference on Information and Knowledge Management, Hong Kong, China, 6–9 November 2009; pp. 523–532.
79. Weiss, A.D. Topographic Position and Landforms Analysis. 2001. Available online: http://www.jennessent.com/downloads/tpi-poster-tnc_18x22.pdf (accessed on 16 August 2021).
80. Theobald, D.M.; Harrison-Atlas, D.; Monahan, W.B.; Albano, C.M. Ecologically-Relevant Maps of Landforms and Physiographic Diversity for Climate Adaptation Planning. *PLoS ONE* **2015**, *10*, e0143619. [CrossRef]
81. Woo, C.-S.; Lee, C.-W.; Jeong, Y. Study on application of topographic position index for prediction of the landslide occurrence. *J. Korean Soc. Environ. Restor. Technol.* **2008**, *11*, 1–9.
82. Riley, J.W.; Calhoun, D.L.; Barichivich, W.J.; Walls, S.C. Identifying small depressional wetlands and using a topographic position index to infer hydroperiod regimes for pond-breeding amphibians. *Wetlands* **2017**, *37*, 325–338. [CrossRef]
83. Ma, J.; Lin, G.; Chen, J.; Yang, L. An improved topographic wetness index considering topographic position. In Proceedings of the 2010 18th International Conference on Geoinformatics, Beijing, China, 18–20 June 2010; pp. 1–4.
84. Mieza, M.S.; Cravero, W.R.; Kovac, F.D.; Bargiano, P.G. Delineation of site-specific management units for operational applications using the topographic position index in La Pampa, Argentina. *Comput. Electron. Agric.* **2016**, *127*, 158–167. [CrossRef]
85. Trentin, R.; de Souza Robaina, L.E. Study of the landforms of the ibicuí river basin with use of topographic position index. *Rev. Bras. De Geomorfol.* **2018**, *19*. [CrossRef]
86. Skentos, A. Topographic Position Index based landform analysis of Messaria (Ikaria Island, Greece). *Acta Geobalcanica* **2018**, *4*, 7–15. [CrossRef]
87. Hopkins, J.L.; Smid, E.R.; Eccles, J.D.; Hayes, J.L.; Hayward, B.W.; McGee, L.E.; van Wijk, K.; Wilson, T.M.; Cronin, S.J.; Leonard, G.S.; et al. Auckland Volcanic Field magmatism, volcanism, and hazard: A review. *New Zealand J. Geol. Geophys.* **2020**, *64*, 1–22. [CrossRef]
88. Demographia. Demographia International Housing Affordability. 2021. Available online: http://www.demographia.com/dhi.pdf (accessed on 1 August 2021).
89. Wetzstein, S. Comparative housing, urban crisis and political economy: An ethnographically based 'long view' from Auckland, Singapore and Berlin. *Hous. Stud.* **2019**, *34*, 272–297. [CrossRef]
90. Hayes, J.L.; Wilson, T.M.; Deligne, N.I.; Lindsay, J.M.; Leonard, G.S.; Tsang, S.W.R.; Fitzgerald, R.H. Developing a suite of multi-hazard volcanic eruption scenarios using an interdisciplinary approach. *J. Volcanol. Geotherm. Res.* **2020**, *392*, 106763. [CrossRef]

91. Deligne, N.I.; Fitzgerald, R.H.; Blake, D.M.; Davies, A.J.; Hayes, J.L.; Stewart, C.; Wilson, G.; Wilson, T.M.; Castelino, R.; Kennedy, B.M.; et al. Investigating the consequences of urban volcanism using a scenario approach I: Development and application of a hypothetical eruption in the Auckland Volcanic Field, New Zealand. *J. Volcanol. Geotherm. Res.* **2017**, *336*, 192–208. [CrossRef]
92. Kereszturi, G.; Bebbington, M.; Nemeth, K. Forecasting transitions in monogenetic eruptions using the geologic record. *Geology* **2017**, *45*, 283–286. [CrossRef]
93. Linnell, T.; Shane, P.; Smith, I.; Augustinus, P.; Cronin, S.; Lindsay, J.; Maas, R. Long-lived shield volcanism within a monogenetic basaltic field: The conundrum of Rangitoto volcano, New Zealand. *GSA Bull.* **2016**, *128*, 1160–1172. [CrossRef]
94. Agustín-Flores, J.; Németh, K.; Cronin, S.J.; Lindsay, J.M.; Kereszturi, G. Shallow-seated explosions in the construction of the Motukorea tuff ring (Auckland, New Zealand): Evidence from lithic and sedimentary characteristics. *J. Volcanol. Geotherm. Res.* **2015**, *304*, 272–286. [CrossRef]
95. Hayward, B.W. *Volcanoes of Auckland: A Field Guide*; Auckland University Press: Auckland, New Zealand, 2019; p. 335.
96. Pressey, R.L.; Weeks, R.; Gurney, G.G. From displacement activities to evidence-informed decisions in conservation. *Biol. Conserv.* **2017**, *212*, 337–348. [CrossRef]
97. Destination AKL 2025. A New Direction for Auckland's Visitor Economy. Auckland Tourism, Events and Economic Development. 2018. Available online: https://www.aucklandnz.com/destinationakl (accessed on 1 May 2021).
98. Németh, B.; Németh, K.; Procter, J.N.; Farrelly, T. Geoheritage Conservation: Systematic Mapping Study for Conceptual Synthesis. *Geoheritage* **2021**, *13*, 45. [CrossRef]
99. Auckland Conservation Management Strategy. In *Auckland Conservation Management Strategy (CMS) 2014–2020*; Auckland City Council: Auckland, New Zealand, 2014; Volume I.
100. New Zealand-Aotearoa Government Tourism Strategy. Enrich New Zealand-Aotearoa through Sustainable Tourism Growth. Department of Conservation, Ministry of Business, Innovation and Employment, New Zealand Government, 2019. Available online: https://www.mbie.govt.nz/dmsdocument/5482-2019-new-zealand-aotearoa-government-tourism-strategy-pdf (accessed on 1 June 2020).
101. *New Zealand Coastal Policy Statement. Replaces New Zealand Coastal Policy Statement 1994*; New Zealand Department of Conservation: Wellington, New Zealand, 2010.
102. New Zealand Geopreservation Inventory. Available online: https://services.main.net.nz/geopreservation/. (accessed on 31 August 2020).
103. The Auckland Plan. The Aucklan Plan 2050. 2018. Available online: https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-plans-strategies/auckland-plan/Pages/default.aspx (accessed on 31 August 2020).
104. Wright, J. The State of New Zealand's Environment: Commentary by the Parliamentary Commissioner for the Environment on Environment Aotearoa 2015, June 2016; Parliamentary Commissioner for the Environment, Te Kaittiaki Taiao a Te Whare Paremata. 2016. Available online: https://www.pce.parliament.nz/publications/the-state-of-new-zealands-environment-commentary-by-the-parliamentary-commissioner-for-the-environment-on-environment-aotearoa-2015 (accessed on 31 August 2020).
105. Auckland Council. Open Space Provision Policy 2016. 2016. Available online: https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-bylaws/our-policies/Documents/open-space-provision-policy.pdf (accessed on 1 May 2021).
106. Auckland Regional Council. Auckland Regional Policy Statement. 1999. Available online: http://www.aucklandcity.govt.nz/council/documents/regionalplans/aucklandcouncilregionalpolicystatement/ACRPS%20Policy.pdf (accessed on 1 May 2021).
107. McCoy, M.D.; Ladefoged, T.N. In Pursuit of Māori Warfare: New archaeological research on conflict in pre-European contact New Zealand. *J. Anthropol. Archaeol.* **2019**, *56*, 101113. [CrossRef]
108. Boswijk, G.; Johns, D. Assessing the potential to calendar date Māori waka (canoes) using dendrochronology. *J. Archaeol. Sci. Rep.* **2018**, *17*, 442–448. [CrossRef]
109. Pool, I. *Te Iwi Maori: Population Past, Present and Projected*; Auckland University Press: Auckland, New Zealand, 2013.
110. Ryks, J.; Pearson, A.L.; Waa, A. Mapping urban Māori: A population-based study of Māori heterogeneity. *N. Z. Geogr.* **2016**, *72*, 28–40. [CrossRef]
111. Stone, R.C.J. *From Tamaki-Makau-Rau to Auckland: A History of Auckland*; Auckland University Press: Auckland, New Zealand, 2001.
112. Németh, K.; Moufti, M.R. Geoheritage Values of a Mature Monogenetic Volcanic Field in Intra-continental Settings: Harrat Khaybar, Kingdom of Saudi Arabia. *Geoheritage* **2017**, *9*, 311–328. [CrossRef]
113. Wimbledon, W. Geosites—A Mechanism for Protection, Integrating National and International Valuation Of Heritage Sites. In Proceedings of the Atti del Convegno nazionale "il Patrimonio geologico: Una risorsa da Proteggere e valorizzare" Periodico della SIGEA, Società Italiana di Geologia Ambientale, Basliicata, Italy, 29–30 April 2010; p. 492.
114. Ruban, D.A. Comment on "Geotourist values of loess geoheritage within the planned Geopark Małopolska Vistula River Gap, Poland" by J. Warowna et al. [Quaternary International, 399, 46–57]. *Quat. Int.* **2016**, *425*, 196–197. [CrossRef]
115. Reynard, E.; Coratza, P.; Hobléa, F. Current Research on Geomorphosites. *Geoheritage* **2016**, *8*, 1–3. [CrossRef]
116. Pelfini, M.; Bollati, I. Landforms and geomorphosites ongoing changes: Concpets and implications for geoheritage promotion. *Quaest. Geograph.* **2014**, *33*, 131. [CrossRef]
117. Višnić, T.; Began, M. Evaluation of geoheritage models—analysis and its application on the loess profiles in Vojvodina region. *Forum Geogr.* **2016**, *XV*, 97–108. [CrossRef]

118. Pralong, J.-P. A method for assessing tourist potential and use of geomorphological sites. *Géomorphosites Définition Évaluation Cartogr.* **2005**, *11*, 189–196. [CrossRef]
119. Pereira, P.; Pereira, D. Methodological Guidelines for Geomorphosite Assessment. 2010. Available online: http://repositorium.sdum.uminho.pt/handle/1822/45573 (accessed on 31 August 2021).
120. Reynard, E.; Fontana, G.; Kozlik, L.; Scapozza, C. A method for Assessing "Scientific" and "Additional Values" of Geomorphosites. *Geograph. Helvetica* **2007**, *62*, 148–158. [CrossRef]
121. Brilha, J. Inventory and Quantitative Assessment of Geosites and Geodiversity Sites: A Review. *Geoheritage* **2016**, *8*, 119–134. [CrossRef]
122. Hopkins, J.L.; Timm, C.; Millet, M.-A.; Poirier, A.; Wilson, C.J.N.; Leonard, G.S. Os isotopic constraints on crustal contamination in Auckland Volcanic Field basalts, New Zealand. *Chem. Geol.* **2016**, *439*, 83–97. [CrossRef]
123. Seebeck, H.; Nicol, A.; Giba, M.; Pettinga, J.; Walsh, J. Geometry of the subducting Pacific plate since 20 Ma, Hikurangi margin, New Zealand. *J. Geol. Soc.* **2014**, *171*, 131–143. [CrossRef]
124. Briggs, R.M.; Okada, T.; Itaya, T.; Shibuya, H.; Smith, I.E.M. K-Ar ages, paleomagnetism, and geochemistry of the South Auckland volcanic field, North Island, New Zealand. *N. Z. J. Geol. Geophys.* **1994**, *37*, 143–153. [CrossRef]
125. Briggs, R.M.; Itaya, T.; Lowe, D.J.; Keane, A.J. Ages of the Pliocene—Pleistocene Alexandra and Ngatutura Volcanics, western North Island, New Zealand, and some geological implications. *N. Z. J. Geol. Geophys.* **1989**, *32*, 417–427. [CrossRef]
126. Newnham, R.; Lowe, D.J.; Gehrels, M.; Augustinus, P. Two-step human–environmental impact history for northern New Zealand linked to late-Holocene climate change. *Holocene* **2018**, *28*, 1093–1106. [CrossRef]
127. Brothers, R.N.; Golson, J. Geological and archaeological interpretation of a section in Rangitoto ash on Motutapu island, Auckland. *N. Z. J. Geol. Geophys.* **1959**, *2*, 569–577. [CrossRef]
128. Hayward, B.W.; Murdoch, G.; Maitland, G. *Volcanoes of Auckland, The Essential Guide*; Auckland University Press: Auckland, New Zealand, 2011.
129. Kereszturi, G.; Németh, K.; Cronin, S.J.; Procter, J.; Agustín-Flores, J. Influences on the variability of eruption sequences and style transitions in the Auckland Volcanic Field, New Zealand. *J. Volcanol. Geotherm. Res.* **2014**, *286*, 101–115. [CrossRef]
130. Agustín-Flores, J.; Nemeth, K.; Cronin, S.; Lindsay, J.; Kereszturi, G.; Brand, B.; Smith, I. Phreatomagmatic eruptions through unconsolidated coastal plain sequences, Maungataketake, Auckland Volcanic Field (New Zealand). *J. Volcanol. Geotherm. Res.* **2014**, *276*. [CrossRef]
131. Németh, K.; Cronin, S.J.; Smith, I.E.M.; Agustin Flores, J. Amplified hazard of small-volume monogenetic eruptions due to environmental controls, Orakei Basin, Auckland Volcanic Field, New Zealand. *Bull. Volcanol.* **2012**, *74*, 2121–2137. [CrossRef]
132. Leonard, G.S.; Calvert, A.T.; Hopkins, J.L.; Wilson, C.J.N.; Smid, E.R.; Lindsay, J.M.; Champion, D.E. High-precision 40Ar/39Ar dating of Quaternary basalts from Auckland Volcanic Field, New Zealand, with implications for eruption rates and paleomagnetic correlations. *J. Volcanol. Geotherm. Res.* **2017**, *343*, 60–74. [CrossRef]
133. Allen, S.R.; Smith, I.E.M. Eruption styles and volcanic hazard in the Auckland volcanic field. *Geosci. Rep. Shizuoka Univ.* **1994**, *20*, 5–14.
134. Cassidy, J.; Locke, C.A. The Auckland volcanic field, New Zealand: Geophysical evidence for structural and spatio-temporal relationships. *J. Volcanol. Geotherm. Res.* **2010**, *195*, 127–137. [CrossRef]
135. Sandri, L.; Jolly, G.; Lindsay, J.; Howe, T.; Marzocchi, W. Combining long- and short-term probabilistic volcanic hazard assessment with cost-benefit analysis to support decision making in a volcanic crisis from the Auckland Volcanic Field, New Zealand. *Bull. Volcanol.* **2012**, *74*, 705–723. [CrossRef]
136. Lindsay, J.; Marzocchi, W.; Jolly, G.; Constantinescu, R.; Selva, J.; Sandri, L. Towards real-time eruption forecasting in the Auckland Volcanic Field: Application of BET_EF during the New Zealand National Disaster Exercise 'Ruaumoko'. *Bull. Volcanol.* **2010**, *72*, 185–204. [CrossRef]
137. Kereszturi, G. *Monogenetic Basaltic Volcanoes: Genetic Classification, Growth, Geomorphology and Degradation*; IntechOpen: London, UK, 2012.
138. Hayward, B. Small satellite explosion craters in the Auckland Volcanic Field. *Geocene* **2015**, *13*, 5–12.
139. Sprung, P.; Schuth, S.; Münker, C.; Hoke, L. Intraplate volcanism in New Zealand: The role of fossil plume material and variable lithospheric properties. *Contrib. Mineral. Petrol.* **2007**, *153*, 669–687. [CrossRef]
140. Gravis, I.; Németh, K.; Procter, J.N. The Role of Cultural and Indigenous Values in Geosite Evaluations on a Quaternary Monogenetic Volcanic Landscape at Ihumātao, Auckland Volcanic Field, New Zealand. *Geoheritage* **2017**, *9*, 373–393. [CrossRef]
141. Gravis, I.; Németh, K.; Twemlow, C.; Németh, B. The Case for Community-Led Geoheritage and Geoconservation Ventures in Māngere, South Auckland, and Central Otago, New Zealand. *Geoheritage* **2020**, *12*, 19. [CrossRef]
142. Nemeth, K.; Casadevall, T.; Moufti, M.R.; Martí, J. Volcanic Geoheritage. 2017. Available online: https://link.springer.com/article/10.1007/s12371-017-0257-9 (accessed on 21 October 2021).
143. Gravis, I.; Németh, K. From Regional Geopark to a UNESCO Global Geopark: Community Initiative with Strong Scientific Support to Evaluate the Geoheritage and Cultural Values at Ihumātao, South Auckland. In Proceedings of the 6th International Maar Conference – Abstracts, Edited by Jiaqi Liu, Rijeka, Croatia, 30 July–3 August 2016; pp. 39–40.
144. Procter, J.; Nemeth, K. Recognising indigenous peoples values and knowledge systems in Geoheritage: Case studies from New Zealand and the South Pacific. In Proceedings of the EGU General Assembly Conference Abstracts, Vienna, Austria, 23–28 April 2017; p. 10979.

145. Hayward, B.W.; Murdoch, G.; Maitland, G. *Human Interaction with Auckland's Volcanoes*; University of Auckland Press: Auckland, New Zealand, 2011.
146. Resource Management Act. Resource Management Act No 69 (as at 29 October 2019), Public Act—New Zealand Legislation. 1991. Available online: https://www.legislation.govt.nz/act/public/1991/0069/latest/DLM230265.html (accessed on 12 October 2020).
147. Reserves Act. Reserves Act 1977 (Reprint as at 7 August 2020 New Zealand Legislation. 1977. Available online: https://www.legislation.govt.nz/act/public/1977/0066/latest/DLM444617.html?search=sw_096be8ed81a057c2_scientific_25_se&p=1&sr=11 (accessed on 1 June 2021).
148. Kermode, L.; Heron, D.W. *Geology of the Auckland Urban Area: Sheet R11: 1:50 000*; GNS Science: Lower Hutt, New Zealand, 1992.
149. Goodchild, M.F. Citizens as sensors: The world of volunteered geography. *GeoJournal* **2007**, *69*, 211–221. [CrossRef]
150. Chen, J.; Shaw, S.-L. Representing the spatial extent of places based on flickr photos with a representativeness-weighted kernel density estimation. In Proceedings of the the Annual International Conference on Geographic Information Science, Montreal, QC, Canada, 27–30 September 2016; pp. 130–144.
151. Sun, A.; Bhowmick, S.S. Quantifying tag representativeness of visual content of social images. In Proceedings of the 18th ACM international conference on Multimedia, Firenze, Italy, 25—29 October 2010; pp. 471–480.
152. Lieskovský, J.; Rusňák, T.; Klimantová, A.; Izsóff, M.; Gašparovičová, P. Appreciation of landscape aesthetic values in Slovakia assessed by social media photographs. *Open Geosci.* **2017**, *9*, 593. [CrossRef]
153. Huiskes, M.J.; Lew, M.S. The mir flickr retrieval evaluation. In Proceedings of the 1st ACM International Conference on Multimedia Information Retrieval, Vancouver, BC, Canada, 30–31 October 2008; pp. 39–43.
154. Senaratne, H.; Bröring, A.; Schreck, T. Using Reverse Viewshed Analysis to Assess the Location Correctness of Visually Generated VGI. *Trans. GIS* **2013**, *17*, 369–386. [CrossRef]
155. Antoniou, V.; Fonte, C.; See, L.; Estima, J.; Jokar Arsanjani, J.; Lupia, F.; Minghini, M.; Foody, G.; Fritz, S. Investigating the Feasibility of Geo-Tagged Photographs as Sources of Land Cover Input Data. *ISPRS Int. J. Geo-Inf.* **2016**, *5*, 64. [CrossRef]
156. Fernández, B.M.C.; González, R.C.L.; Lopez, L. Historic city, tourism performance and development: The balance of social behaviours in the city of Santiago de Compostela (Spain). *Tour. Hosp. Res.* **2016**, *16*, 282–293. [CrossRef]
157. Jacobsen, J.K.S.; Iversen, N.M.; Hem, L.E. Hotspot crowding and over-tourism: Antecedents of destination attractiveness. *Ann. Tour. Res.* **2019**, *76*, 53–66. [CrossRef]
158. Neuts, B.; Nijkamp, P. Tourist crowding perception and acceptability in cities: An Applied Modelling Study on Bruges. *Ann. Tour. Res.* **2012**, *39*, 2133–2153. [CrossRef]
159. Yagi, C.; Pearce, P.L. The Influence of Appearance and the Number of People Viewed on Tourists' Preferences for Seeing Other Tourists. *J. Sustain. Tour.* **2007**, *15*, 28–43. [CrossRef]
160. Malczewski, J. GIS-based multicriteria decision analysis: A survey of the literature. *Int. J. Geogr. Inf. Sci.* **2006**, *20*, 703–726. [CrossRef]
161. Jankowski, P.; Nyerges, T.L.; Smith, A.; Moore, T.; Horvath, E. Spatial group choice: A SDSS tool for collaborative spatial decisionmaking. *Int. J. Geogr. Inf. Sci.* **1997**, *11*, 577–602. [CrossRef]
162. Amatulli, G.; Domisch, S.; Tuanmu, M.-N.; Parmentier, B.; Ranipeta, A.; Malczyk, J.; Jetz, W. A suite of global, cross-scale topographic variables for environmental and biodiversity modeling. *Sci. Data* **2018**, *5*, 1–15. [CrossRef]
163. Wood, S.W.; Murphy, B.P.; Bowman, D.M. Firescape ecology: How topography determines the contrasting distribution of fire and rain forest in the south-west of the Tasmanian Wilderness World Heritage Area. *J. Biogeogr.* **2011**, *38*, 1807–1820. [CrossRef]
164. Parker, A.J. The topographic relative moisture index: An approach to soil-moisture assessment in mountain terrain. *Phys. Geogr.* **1982**, *3*, 160–168. [CrossRef]
165. Dyer, J.M. Assessing topographic patterns in moisture use and stress using a water balance approach. *Landsc. Ecol.* **2009**, *24*, 391–403. [CrossRef]
166. Galparsoro, I.; Borja, Á.; Bald, J.; Liria, P.; Chust, G. Predicting suitable habitat for the European lobster (Homarus gammarus), on the Basque continental shelf (Bay of Biscay), using Ecological-Niche Factor Analysis. *Ecol. Model.* **2009**, *220*, 556–567. [CrossRef]
167. Hook, P.B.; Burke, I.C. Biogeochemistry in a shortgrass landscape: Control by topography, soil texture, and microclimate. *Ecology* **2000**, *81*, 2686–2703. [CrossRef]
168. Van Haaren, R.; Fthenakis, V. GIS-based wind farm site selection using spatial multi-criteria analysis (SMCA): Evaluating the case for New York State. *Renew. Sustain. Energy Rev.* **2011**, *15*, 3332–3340. [CrossRef]
169. Szurek, M.; Blachowski, J.; Nowacka, A. GIS-based method for wind farm location multi-criteria analysis. *Min. Sci.* **2014**, *21*. [CrossRef]
170. Sahnoun, H.; Serbaji, M.M.; Karray, B.; Medhioub, K. GIS and multi-criteria analysis to select potential sites of agro-industrial complex. *Environ. Earth Sci.* **2012**, *66*, 2477–2489. [CrossRef]
171. Eldrandaly, K.; Eldin, N.; Sui, D. A COM-based spatial decision support system for industrial site selection. *J. Geogr. Inf. Decis. Anal.* **2003**, *7*, 72–92.
172. Jelokhani-Niaraki, M.; Malczewski, J. A group multicriteria spatial decision support system for parking site selection problem: A case study. *Land Use Policy* **2015**, *42*, 492–508. [CrossRef]
173. Siejka, M. The role of spatial information systems in decision-making processes regarding investment site selection. *Real Estate Manag. Valuat.* **2017**, *25*, 62–72. [CrossRef]

174. Bahrani, S.; Ebadi, T.; Ehsani, H.; Yousefi, H.; Maknoon, R. Modeling landfill site selection by multi-criteria decision making and fuzzy functions in GIS, case study: Shabestar, Iran. *Environ. Earth Sci.* **2016**, *75*, 337. [CrossRef]
175. Chen, J. GIS-based multi-criteria analysis for land use suitability assessment in City of Regina. *Environ. Syst. Res.* **2014**, *3*, 13. [CrossRef]
176. Mosadeghi, R.; Warnken, J.; Tomlinson, R.; Mirfenderesk, H. Comparison of Fuzzy-AHP and AHP in a spatial multi-criteria decision making model for urban land-use planning. *Comput. Environ. Urban Syst.* **2015**, *49*, 54–65. [CrossRef]
177. Svoray, T.; Bar, P.; Bannet, T. Urban land-use allocation in a Mediterranean ecotone: Habitat Heterogeneity Model incorporated in a GIS using a multi-criteria mechanism. *Landsc. Urban Plan.* **2005**, *72*, 337–351. [CrossRef]
178. Zabihi, H.; Alizadeh, M.; Kibet Langat, P.; Karami, M.; Shahabi, H.; Ahmad, A.; Nor Said, M.; Lee, S. GIS Multi-Criteria Analysis by Ordered Weighted Averaging (OWA): Toward an integrated citrus management strategy. *Sustainability* **2019**, *11*, 1009. [CrossRef]
179. Janssen, R.; Rietveld, P. Multicriteria analysis and geographical information systems: An application to agricultural land use in the Netherlands. In *Geographical Information Systems for Urban and Regional Planning*; Springer: Dordrecht, The Netherlands, 1990; pp. 129–139.
180. Joerin, F.; Musy, A. Land management with GIS and multicriteria analysis. *Int. Trans. Oper. Res.* **2000**, *7*, 67–78. [CrossRef]
181. Nguyen, T.T.; Verdoodt, A.; Van, Y.T.; Delbecque, N.; Tran, T.C.; Van Ranst, E. Design of a GIS and multi-criteria based land evaluation procedure for sustainable land-use planning at the regional level. *Agric. Ecosyst. Environ.* **2015**, *200*, 1–11. [CrossRef]
182. Colantoni, A.; Delfanti, L.; Recanatesi, F.; Tolli, M.; Lord, R. Land use planning for utilizing biomass residues in Tuscia Romana (central Italy): Preliminary results of a multi criteria analysis to create an agro-energy district. *Land Use Policy* **2016**, *50*, 125–133. [CrossRef]
183. Kazemi, H.; Akinci, H. A land use suitability model for rainfed farming by Multi-criteria Decision-making Analysis (MCDA) and Geographic Information System (GIS). *Ecol. Eng.* **2018**, *116*, 1–6. [CrossRef]
184. Skilodimou, H.D.; Bathrellos, G.D.; Chousianitis, K.; Youssef, A.M.; Pradhan, B. Multi-hazard assessment modeling via multi-criteria analysis and GIS: A case study. *Environ. Earth Sci.* **2019**, *78*, 47. [CrossRef]
185. Gigović, L.; Jakovljević, G.; Sekulović, D.; Regodić, M. GIS multi-criteria analysis for identifying and mapping forest fire hazard: Nevesinje, Bosnia and Herzegovina. *Teh. Vjesn.* **2018**, *25*, 891–897.
186. Ahmadisharaf, E.; Tajrishy, M.; Alamdari, N. Integrating flood hazard into site selection of detention basins using spatial multi-criteria decision-making. *J. Environ. Plan. Manag.* **2016**, *59*, 1397–1417. [CrossRef]
187. Huyen, D.; Tuan, V.A. Applying GIS and multi criteria evaluation in forest fire risk zoning in son la province, Vietnam. In Proceedings of the International Conference on Geoinformation Spatial-Infrastructure Development, Hanooi, Vietnam, 12–15 November 2008; pp. 9–11.
188. Bell, N.; Schuurman, N.; Hayes, M.V. Using GIS-based methods of multicriteria analysis to construct socio-economic deprivation indices. *Int. J. Health Geogr.* **2007**, *6*, 17. [CrossRef] [PubMed]
189. Panagopoulos, G.P.; Bathrellos, G.D.; Skilodimou, H.D.; Martsouka, F.A. Mapping urban water demands using multi-criteria analysis and GIS. *Water Resour. Manag.* **2012**, *26*, 1347–1363. [CrossRef]
190. Mokrech, M.; Nicholls, R.J.; Dawson, R.J. Scenarios of future built environment for coastal risk assessment of climate change using a GIS-based multicriteria analysis. *Environ. Plan. B Plan. Des.* **2012**, *39*, 120–136. [CrossRef]
191. Uribe, D.; Geneletti, D.; Del Castillo, R.F.; Orsi, F. Integrating stakeholder preferences and GIS-based multicriteria analysis to identify forest landscape restoration priorities. *Sustainability* **2014**, *6*, 935–951. [CrossRef]
192. Chenini, I.; Mammou, A.B.; El May, M. Groundwater recharge zone mapping using GIS-based multi-criteria analysis: A case study in Central Tunisia (Maknassy Basin). *Water Resour. Manag.* **2010**, *24*, 921–939. [CrossRef]
193. Bera, A.; Mukhopadhyay, B.P.; Das, D. Landslide hazard zonation mapping using multi-criteria analysis with the help of GIS techniques: A case study from Eastern Himalayas, Namchi, South Sikkim. *Nat. Hazards* **2019**, *96*, 935–959. [CrossRef]
194. Rahamana, S.A.; Aruchamy, S.; Jegankumar, R. Geospatial approach on landslide hazard zonation mapping using multicriteria decision analysis: A study on Coonoor and Ooty, part of Kallar watershed, The Nilgiris, Tamil Nadu. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* **2014**, *40*, 1417. [CrossRef]
195. Zhang, Z.; Sherman, R.; Yang, Z.; Wu, R.; Wang, W.; Yin, M.; Yang, G.; Ou, X. Integrating a participatory process with a GIS-based multi-criteria decision analysis for protected area zoning in China. *J. Nat. Conserv.* **2013**, *21*, 225–240. [CrossRef]
196. Hajehforooshnia, S.; Soffianian, A.; Mahiny, A.S.; Fakheran, S. Multi objective land allocation (MOLA) for zoning Ghamishloo Wildlife Sanctuary in Iran. *J. Nat. Conserv.* **2011**, *19*, 254–262. [CrossRef]
197. Ligmann-Zielinska, A.; Church, R.L.; Jankowski, P. Spatial optimization as a generative technique for sustainable multiobjective land-use allocation. *Int. J. Geogr. Inf. Sci.* **2008**, *22*, 601–622. [CrossRef]
198. Gilbert, K.C.; Holmes, D.D.; Rosenthal, R.E. A multiobjective discrete optimization model for land allocation. *Manag. Sci.* **1985**, *31*, 1509–1522. [CrossRef]
199. Matthews, K.B.; Craw, S.; Elder, S.; Sibbald, A.R.; MacKenzie, I. Applying Genetic Algorithms to Multi-Objective Land Use Planning. 2000. Available online: https://www.semanticscholar.org/paper/Applying-Genetic-Algorithms-to-Multi-Objective-Land-Matthews-Craw/8ed77b46a255af01cc2884dd9416a5431b85819a (accessed on 21 October 2021).
200. Zhang, H.; Zeng, Y.; Jin, X.; Shu, B.; Zhou, Y.; Yang, X. Simulating multi-objective land use optimization allocation using Multi-agent system—A case study in Changsha, China. *Ecol. Model.* **2016**, *320*, 334–347. [CrossRef]