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Pacific Geotourism: Funafuti Geopark Desktop Study, Funafuti Atoll, Tuvalu

(Photo Source: WANTSEE, 2019)

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Executive Summary

The prospect of developing a UNESCO Global Geopark in Funafuti is a strategic opportunity which warrants further consideration. The opportunity provides a holistic framework for developing the sustainable tourism in Tuvalu and marketing the nation on the global stage. A Geopark has the potential to integrate and strengthen existing tourism activities, and Tuvalu is strategically positioned to leverage the success of neighbouring PICT's tourism sectors, particularly Fiji which had 968,926 visitor arrivals in 2019, compared to Tuvalu's 3,611 visitors the same year.

UNESCO Global Geoparks are single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education, and sustainable development. They focus on ten key areas: natural resources, geological hazards, climate change, education, science, culture, women, sustainable development, local and indigenous knowledge, and geoconservation. Due to the holistic nature of UNESCO Global Geoparks, the potential benefits are abundant, including employment creation, increased tourism revenues and broader economic growth, education, environmental protection, conservation and elevation of traditional knowledge, research, and innovation, raising awareness of climate change and natural hazards, increasing resilience, and broader sustainable development.

There are currently 169 UNESCO Global Geoparks in 44 countries around the world, but none in the Pacific region. Geoparks have proven very popular in Asia and Europe, highlighting the potential for Geoparks to act as a strategic drawcard to attract a new demographic of tourists to the Pacific from outside the traditional source markets of Australia, New Zealand, and USA.

Funafuti has significant geological and cultural heritage forming the basis to develop a unique and fascinating Geopark. Atolls are distinctive geological features consisting of a coral reef structure developed on top of a submerged volcano, yet no atolls currently have UNESCO Global Geopark status globally. Funafuti has particularly significant scientific history of international importance in terms of investigations conducted in the late 1800's to test Charles Darwin's theory of atoll formation.

Climate change and coastal hazards are crucial areas of concern in Tuvalu. A Geopark in Funafuti could serve as an effective communication tool for raising the awareness of Tuvalu's context on the international stage, with potential to act as a catalyst for increased advocacy, support, and action.

Tuvalu has rich cultural heritage and history for integration with a Geopark. The Geopark concept provides a platform to conserve, showcase and celebrate Tuvalu's unique culture and traditional knowledge. Tuvalu's WWII history also strengthens the potential historical theme of the Geopark.

Importantly, a Geopark in Funafuti could form the basis of an 'outdoor classroom' or 'natural museum' for students, members of the public, and tourists to engage in a variety of learning experiences.

This desktop study has been prepared to introduce the concept of a Geopark in Funafuti. It is intended to stimulate further imagination, thought, consideration, and inform the scope of future work. The report identifies initial ideas for a Geopark in Funafuti and makes recommendations for further work to be led in Tuvalu. For a Geopark to be successfully developed and managed in Funafuti it would require local leadership in Tuvalu, with strong community involvement. SPC, SPTO and UNESCO are available to provide technical support and assistance, however local leadership is critical should Tuvalu wish to pursue a Geopark.

Table of Contents

Acknowledgements

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1 Introduction

1.1 Scope of Work

'Pacific Geotourism' is a $NZ60k project financed by the Ministry of Foreign Affairs New Zealand (MFAT) as part the internal Pacific Community (SPC) 'Funding with Intent' initiative. The project aims to evaluate the potential of developing UNESCO Global Geoparks in Fiji, Samoa, Tuvalu, and Vanuatu. The project has two primary purposes:

1. Support recovery following the destructive economic and social impacts of the COVID-19 pandemic.
2. Enable long-term sustainable and resilient development of the Pacific tourism sector.

The project is led by SPC and implemented in partnership with the Pacific Tourism Organisation (SPTO) and the national governments of Fiji, Samoa, Tuvalu, and Vanuatu. UNESCO is also supporting the project team with valuable technical advice and guidance.

The project follows a staged approach in each country consisting of the following principal components:

- Desktop study: preparation of a report compiling a baseline of relevant information, to stimulate further consideration and support the design of fieldwork programs.
- Fieldwork: data collection informed by the desktop study findings to address information gaps and engage with a broad range of relevant stakeholders. This will be conducted by relevant national governments, with remote support provided by SPC and SPTO (due to COVID-19 travel restrictions).
- Feasibility study: analysis of information collected during the desktop study and fieldwork phases. Preparation of a report highlighting the potential benefits and risks of Geopark development. The report will aim to identify the scope and extent of further work required to develop a Geopark and will make recommendations on future actions.

The project is essentially incubation funding to conduct preliminary feasibility work only. Therefore, if the findings of the project are positive, the intention is to develop a larger project proposal(s) aimed at fully funding the development of Geoparks in interested member countries.

This Desktop Study Report has been prepared by SPC to introduce the concept of a Geopark in Funafuti. The intentions of the report are twofold:

1. Stimulate further imagination, thought, and consideration regarding a potential Geopark in Funafuti.
2. Inform the scope of future work.

1.2 Background & Strategic Overview

Tourism is a major sector in the Pacific region accounting for the largest contribution to Gross Domestic Product (GDP) in several Pacific Island Countries and Territories (PICTs). In 2019 the sector contributed USD$ 4 billion in visitor spending to regional economies and provided employment opportunities for hundreds-of-thousands of Pacific people (including informal and spill-over). Due to the COVID-19 pandemic and associated travel restrictions total visitor arrivals to the region plummeted from 3,013,736 in 2019 to 590,658 in 2020 (SPTO, 2020), a trend which has continued into 2021. This dramatic reduction in visitor arrivals has resulted in significant adverse consequences for the tourism sector and subsequently the livelihoods of numerous Pacific people.

Diversification is a key economic strategy to support recovery in the Pacific, which in the context of the tourism sector encompasses two principal categories. Firstly, 'external' diversification to more resilient economic activity (external to the tourism sector), with the aim of reducing reliance on tourism. Secondly, 'internal' diversification within the tourism sector to increase the competitiveness of Pacific destinations in the global tourism market, with the aim of attracting tourists to the Pacific (when travel restrictions are eased) and increasing the long-term resilience of the sector. SPC has identified the prospect of developing a network of UNESCO Global Geoparks across the Pacific region as an innovative opportunity aligned with the 'internal' diversification strategy outlined above.

Although the COVID-19 pandemic was the triggering event that instigated the conception of this strategic opportunity, the potential merits of developing a Pacific network of UNESCO Global Geoparks are significant and warrant investigation regardless of COVID-19 recovery. In fact, preliminary investigations of prospective geoparks were conducted at the national level in Samoa and Vanuatu in 2016 and 2017 respectively, yielding promising findings (Fepuleai, 2016; Leodoro, 2017). Research by the Pacific Asia Travel Association (PATA) identified that traveller patterns and preferences are changing, with visitors desiring more environmentally responsible experiences, off the beaten track destinations, opportunities to be immersed in culture and give back to communities. These evolving traveller dynamics coupled with the current reality that many tourists perceive the Pacific as a largely homogenous destination comprising "sun, sand and sea" emphasises the need to diversify the Pacific tourism sector by developing and marketing new attractions which celebrate the unique, diverse, and rich cultural and natural heritage of the Pacific (SPTO, 2020).

UNESCO Global Geoparks are single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education, and sustainable development (UNESCO, 2021). UNESCO Global Geoparks focus on ten key areas: natural resources, geological hazards, climate change, education, science, culture, women, sustainable development, local and indigenous knowledge, and geoconservation. Due to the holistic nature of UNESCO Global Geoparks the potential benefits are abundant, including employment creation, increased tourism revenues and broader economic growth, education, environmental protection, conservation and elevation of traditional knowledge, research and innovation, raising awareness of climate change and natural hazards, increasing resilience, and broader sustainable development.

There are currently 169 UNESCO Global Geoparks in 44 countries globally, however none in the Pacific region. Yet considering the Pacific's fascinating geology, substantial cultural heritage, and abundant tourism sector there is immense potential for the development of Geoparks in the region. UNESCO Global Geoparks have proven very popular in Asia and Europe with countries in these regions having the following numbers of Geoparks; China 41, Japan 9, Indonesia 6, South Korea 4, Spain 15, Italy 11, United Kingdom 8, France 7, and Germany 6 (UNESCO, 2021). The popularity of Geoparks in Asia and Europe highlights the potential for Geoparks to act as a strategic drawcard to attract a new demographic of tourists from outside the traditional source markets of Australia, New Zealand, and United States of America (USA), which accounted for 28.2%, 21.5% and 11.3% of tourist arrivals respectively in 2019. Whereas in 2019 the top Asian source markets of China, Japan and South Korea accounted for just 5%, 3% and 1% of tourist arrivals to the region, with the UK accounting for only 1% and the European Union countries collectively accounting for 10.9% (SPTO, 2019).

In Tuvalu the tourism sector is relatively underdeveloped compared to other countries in the Pacific region. Over the 6-year period between 2014 and 2019 Tuvalu had average annual visitor arrivals of 2,593. The highest visitor arrivals over this period were recorded in 2019, 3,611, which in absolute terms was still the lowest arrivals for any country in the Pacific that year (SPTO, 2020). The 2019 arrivals figure equate to an arrivals per capita ratio of approximately 0.3:1 for Tuvalu, compared to other countries in the region (with more developed tourism sectors) such as Cook Islands 10:1, Niue 6:1, Fiji 1:1, Samoa 0.9:1, French Polynesia 0.8:1, New Caledonia 0.5:1 and Vanuatu 0.4:1. In 2019 the tourism sector is estimated to have contributed USD$ 2.4M to Tuvalu's GDP (5.6% of total national GDP) and employed 87 people (SPTO, 2019).

Considering the relatively underdeveloped nature of Tuvalu's tourism sector, the prospect of developing a UNESCO Global Geopark in Funafuti provides a holistic framework for developing sustainable tourism and marketing Tuvalu on the global stage. A geopark has the potential to integrate and strengthen existing tourism activities and provide a clear marketing brand. The development of a Geopark involves a staged approach consisting of collaboration between a broad range of stakeholders, therefore the potential benefits and risks of developing a Geopark in Funafuti will evolve over time as more information becomes available. However, at this preliminary stage several potential benefits and risk of developing a geopark on Funafuti are apparent.

Potential benefits of a Geopark in Funafuti are social, environmental, and economic. According to the 2017 Population and Housing Census, Tuvalu has a national labour force participation rate of 49.3% and an unemployment rate of 28.5%, highlighting the need to create new employment opportunities (Government of Tuvalu , 2017). A Geopark in Funafuti has the potential to create a range of new employment opportunities including construction work during development of geopark infrastructure, direct operational jobs such as geopark management, maintenance and tour-guide roles, indirect jobs in support sectors such as accommodation, food and beverage, transport, retail, recreational activities, and culture, which could benefit from increased tourist arrival numbers, and broader job creation associated with economic multiplier effects.

Tuvalu is strategically positioned to leverage the success of neighbouring PICT's tourism sectors, particularly Fiji which had 968,926 visitor arrivals in 2019 (SPTO, 2020). There is potential for tourists planning trips to neighbouring PICTs to incorporate a visit to Tuvalu in a multi-destination trip. This factor is particularly relevant if a network of UNESCO Global Geoparks were developed in multiple Pacific countries, which would open pathways for the network to be marketed collectively, such as package deals for tours of multiple Pacific Geoparks. Increased tourist arrival numbers would create increased demand for flights to and from Tuvalu, and thus impact the economics of air travel in Tuvalu. Subsequently if a Geopark was successful at attracting sufficient increased tourists it could theoretically have the potential to result in more regular flights, thus improving the connectivity of Tuvalu.

Education is a key focus area of UNESCO Global Geoparks. A Geopark in Funafuti could form the basis of an ‘outdoor classroom’ or ‘natural museum’ for students, members of the public, and tourists to engage in a variety of learning experiences. This could include learning experiences in a range of areas such as geology, climate change, coastal hazards, culture, indigenous knowledge, history, and marine biology. University students and researchers are a potential target market for Geopark visitors. This highlights the possibility for the stimulation of increased research, which could lead to new knowledge and innovations.

Climate change and coastal hazards are crucial areas of concern in Tuvalu. A Geopark in Funafuti could incorporate climate change and coastal hazards as focus themes. Consequently, a Geopark could serve as an effective communication tool for raising the awareness of Tuvalu’s context on the international stage, with potential to act as a catalyst for increased advocacy, support, and climate action. There is also scope for the Geopark to protect and conserve key areas which serve natural resilience functions. Additionally, the potential education and research benefits of a Geopark could lead to increased knowledge, capacity, and resilience.

A Geopark has potential to form an important platform for conserving of Tuvalu culture and traditional knowledge. The local education dimension of a Geopark could facilitate intergenerational knowledge transfer to Tuvaluan youth. The tourism dimension of a Geopark could raise the awareness of Tuvaluan culture, history, and traditional knowledge on the international stage. The research dimension of a Geopark could elevate the importance and wisdom of traditional knowledge, and support integration with relevant scientific disciplines.

Potential risks of developing a Geopark in Funafuti are also social, environmental, and economic. Increased tourist numbers could compound existing population density issues and add stress to existing resources, infrastructure, and the environment. As with any tourist activity there is potential for conflict between visitors and local populations due to cultural differences, and within local populations due to different perceptions and interests. Regarding these risks, it should be noted that environmental sustainability and local community development are at the heart of the Geopark concept, therefore Geoparks fundamentally seek to mitigate these risks by providing a sustainable pathway for environmental protection and local community development. Geoparks also seek to attract environmentally and socially conscious tourists which are low-impact-high-value in character.

The conservation element of the prospective UNESCO Global Geopark may raise concerns regarding land-use restrictions hindering other development aspirations, such as infrastructure projects. Preliminary consultations with UNESCO have indicated that although Geoparks boundaries cover large areas, only specific ‘Geosites’ within the broader Geopark boundary require protection under the national legal and policy framework, therefore normal economic activity is free to take place within the broader Geopark boundary. It would be recommended that future planned infrastructure projects are considered when designing the Geopark and selecting ‘Geosites’ to prevent potential land-use conflicts. In fact, there is scope for the Geopark to compliment planned infrastructure projects such as the Tuvalu Coastal Adaptation Project (TCAP) reclamation in Funafuti, for example a visitor centre could be constructed on the reclaimed land and signage erected explaining the climate change adaptation.

The relatively underdeveloped nature of Tuvalu's tourism sector has resulted in the country experiencing relatively low negative impacts associated with COVID-19 compared to other Pacific countries more dependent on tourism. For example, in the Cook Islands, the tourism sector contributed 87% to GDP and employed 34.4% of the national workforce prior to COVID-19, resulting in severe economic impacts and widespread unemployment (MFAT, 2020). This is a clearly a factor that decision makers in Tuvalu should consider when evaluating the potential of expanding the tourism sector, which would evidently increase dependence on tourism and exposure to market shocks such as COVID-19. However, when considering this risk in the context of a prospective Geopark in Funafuti it is important to consider the plethora of other potential benefits which aren't reliant on international tourism, thus relatively resilient to market shocks such as COVID-19.

Qualification for UNESCO status requires development and successful operation of a Geopark at the national level prior to submission of an application which is subject to a thorough evaluation process. Funafuti is naturally constrained in terms of size and potential geopark attractions due to the fact it is an atoll, therefore the prospective site is relatively small compared to geoparks globally. However, as highlighted within the body of this report, Funafuti has sufficient geological heritage of international significance (see Appendix 2) to be pragmatically optimistic regarding the prospects of qualifying for UNESCO status, such as the borehole drilled to test Charles Darwin's theory of atoll evolution in the late 1800's (David T. E., 1904; Creak, 1904; Darwin, 1842), climate change being a focus area (Tuvalu Meteorological Service; Australian Bureau of Meteorology; CSIRO, 2011), and the fact that atolls are unique geological features consisting of a coral reef structure developed on-top of a submerged volcano (Finlayson, Konter, Konrad, Koppers, & Jackson, 2014; Konrad, et al., 2018; Gaskell & Swallow, 1953; Ohde, et al., 2002), yet no atolls are currently Geoparks.

Considering the details outline in the discussion above, SPC identified the prospect of developing a National Geopark in Funafuti (with the intention to apply for UNESCO Global Geopark status) as a promising strategic opportunity which warrants further investigation. Subsequently a presentation of the Geopark opportunity was given to Tuvalu Cabinet in March 2021, resulting in Cabinet endorsement for preliminary feasibility work to be conducted in Funafuti.

1.3 UNESCO Global Geoparks

UNESCO has three different prestigious site designations, namely, UNESCO World Heritage Sites, UNESCO Biosphere Reserves, and UNESCO Global Geoparks. UNESCO Global Geoparks are the most recent site designation, ratified by member countries in 2015. Of the three designations the UNESCO Global Geopark designation has been identified as the most commensurate with Funafuti's context due to numerous factors discussed in this report, including alignment with multiple sustainable development priorities and the potential to provide broadscale support to the local community.

UNESCO Global Geoparks are sites and landscapes of international geological significance. They are single, unified geographical areas, meaning the boundary of a geopark covers a broad area. Within the broader Geopark boundary are numerous specific sites of interest (Geosites) which are managed collectively with a holistic concept of protection, education, and sustainable development. Geoparks link numerous aspects of a regions natural, cultural, and intangible heritage.

UNESCO Global Geoparks focus on ten key areas: natural resources, geological hazards, climate change, education, science, culture, women, sustainable development, local and indigenous knowledge, and geoconservation. Due to the holistic nature of UNESCO Global Geoparks the potential benefits are abundant, including employment creation, increased tourism revenues and broader economic growth, education, environmental protection, conservation and elevation of indigenous knowledge, research, and innovation, raising awareness of climate change and natural hazards, increasing resilience, and broader sustainable development.

As of 2021 there are 169 UNESCO Global Geoparks in 44 countries, with the Pacific being the only major region of the world without a Geopark besides Antarctica. The locations of the 169 current UNESCO Geoparks are shown in Figure 1, notably Geoparks are particularly popular in Asia and Europe.

UNESCO has recently published two useful designed to introduce the concept of a UNESCO Global Geopark. These videos are useful resources for introducing the concept to stakeholders in Tuvalu:

"What is a UNESCO Global Geopark?":

https://www.youtube.com/watch?v=xlWoMlaTjQo&t=2s

"What do you need to become a UNESCO Global Geopark?":

https://www.youtube.com/watch?v=ImIE4KSFnrw

The process to develop a UNESCO Global Geopark requires a staged approach:

1. Firstly, is the <u>Planning Phase</u> consisting of mapping of geological heritage, stakeholder engagement, feasibility assessments and geopark design.
2. Secondly, is the <u>National Geopark Establishment Phase</u> consisting of the construction of relevant infrastructure (such as signs and paths), development of relevant policy to protect specific sites and designate the Geopark in the national legal framework, creation of the Geopark management body, formation of the operational team, and marketing of the National Geopark (including website development). It is a requirement that a Geopark operates at the National level prior to applying for UNESCO status.
3. Thirdly, is <u>the UNESCO Application Phase</u> consisting of the preparation of an application dossier and submission to UNESCO for the evaluation process.
4. Finally, should the National Geopark be successful in acquiring UNESCO status is the <u>UNESCO Global Geopark Operational Phase,</u> initially commencing with the upgrading signage and marketing material to incorporate the UNESCO status.

The overall timeframe to develop a UNESCO Global Geopark varies with site specifics such as existing parks or protected areas, infrastructure requirements, engagement with relevant stakeholders and communities, and establishment of a management body. Typically, the overall process takes a minimum of 5 years, with the UGGP application process itself taking 18 months as outlined below:

- Aspiring UNESCO Global Geopark sends a letter of intent, ideally by 1 July
- Submission of applications between 1 October and 30 November
- Verification check on completeness of documents after 1 December
- Desktop evaluations until 30 April
- Field evaluation missions starting 1 May
- Recommendations on applications by the UNESCO Global Geoparks Council in September
- Decision by the Executive Board of UNESCO during its spring session

Figure 1.0: Map of UNESCO Global Geoparks 2021. Note the popularity in Asia and Europe, and no Geoparks currently present in the Pacific region (Source: UNESCO, 2021)

1.4 Prospective Geopark Site Location

Tuvalu is an archipelago of nine islands located in the western South Pacific Ocean (Siaosi, et al., 2012). It is the fourth smallest nation in the world in terms of land area and consists of five true atolls; namely Funafuti, Nanumea, Nui, Nukufetau and Nukulaelae, and four reef platform islands; Nanumaga, Niutao, Vaitupu and Niulakita (Siaosi, et al., 2012), see Figure 1.1. These nine islands are spread out in a 680km long linear cluster between 5°-10° S latitude and 176°-180° E longitude, with an approximate total land area of 26 sq. km (Rodgers & Cantrell, 1988; Krüger, 2008). In comparison to its relatively small land area, Tuvalu's exclusive economic zone (EEZ) covers a vast ocean-space of approximately 900,000 sq. km (Krüger, 2008; Government of Tuvalu; UNDP , 2011). Subsequently, Tuvalu has a ratio of ocean to land area greater than any other nation (Sauni, 2002), thus is the world's foremost example of a Small Island-Large Ocean state.

Funafuti, which is the focus site of this desktop study, is Tuvalu's largest atoll island and Capital, however it is the fourth smallest in terms of land area. Funafuti is comprised of 33 reef islets with a total land area of 2.8 sq. km (Lane, 1993; Thaman, et al., 2016). The central lagoon is characterised by an 18km wide basin surrounded with an annular reef rim and numerous natural reef channels (Krüger, 2008; Ohde, 2011). The atoll accommodates for more than half (60.2%) of Tuvalu's population and is where most of the country's economic activity is concentrated (Government of Tuvalu , 2017). Fongafale is a key islet on Funafuti atoll as it accommodates essential infrastructure such as the Funafuti International Airport (Macdonald, 2021), Princess Margaret Hospital (DAISI, 2021), and government offices (Fisk, 2007), see Figure 1.2 and 1.3.

In terms of the specific location of the prospective Geopark, it is too early to define a specific boundary. The Geopark boundary would be defined following a comprehensive design process subject to identification on specific 'Geosites' (specific attractions within the Geopark), consultations, and approvals from relevant landowners, communities, and authorities. However, there are three fundamental principles of Geopark boundary delineation:

1. A Geopark is a single unified geographical area comprising multiple 'Geosites', meaning the Geopark boundary is a large area with several specific attractions within it.
2. The Geopark boundary must consider pre-existing boundaries such as protected areas and administrative limits.
3. A Geopark boundary is not restricted to land and must include marine areas where relevant.

Therefore, in Funafuti, a potential Geopark boundary could comprise a relatively large area of Funafuti atoll, including both land and marine areas, and incorporating existing protected areas such as the Funafuti Conservation Area. Economic activity would remain unrestricted within the broader geopark boundary, except for specific 'Geosites' which would require protection.

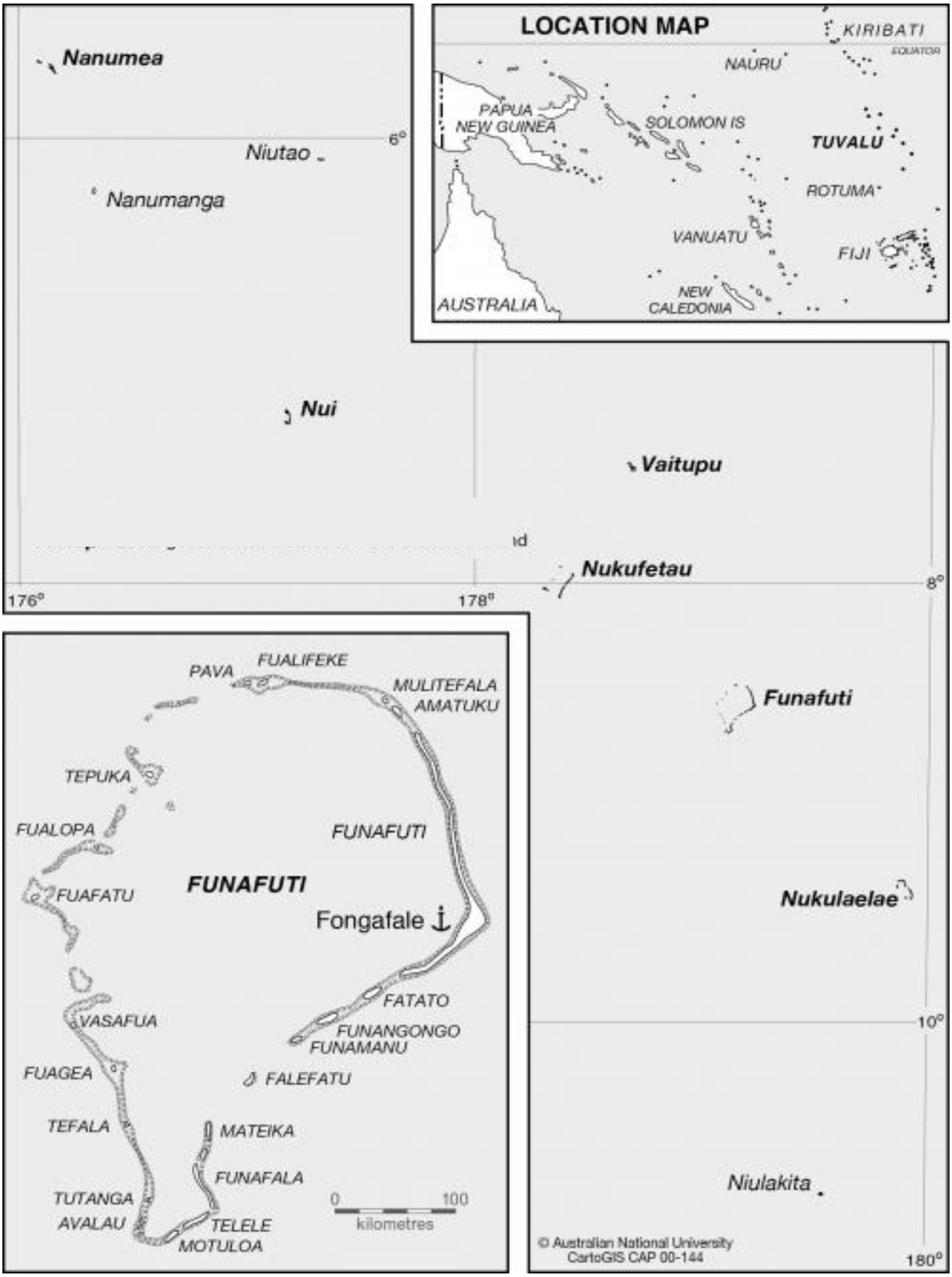

Figure 1.1: Map of Tuvalu showing location in the Pacific region and inset of Funafuti Atoll. This map is for illustrative purposes only, we note that an official UN map is required for a UGGP application. (Source: The Australian National University, College of Asia and the Pacific, & CartoGIS Services, 2020)

Figure 1.2: Fongafale Islet, looking SW (Source: The Guardian, 2019)

Figure 1.3: Fongafale Islet, looking NE (Source: The Guardian, 2019)

2 Geology

An overview of relevant geological aspects is discussed in this section, and a bibliography of 'international geological significance' is provided in Appendix 2.

2.1 Tectonic Setting

Tuvalu's seamount chain is situated on the mid-west of the Pacific Plate in a northwest-southeast orientation, isolated from the active boundaries of the Pacific Ring of Fire (Konrad, et al., 2018). The 'Pacific Ring of Fire' is a seismically active belt characterized by a high frequency of earthquakes and active volcanoes encircling the Pacific basin (The Editors of Encyclopaedia Britannica, 2020). About 90% of Earth's earthquakes and 75% of Earth's volcanic activity occur along this region due to the amount of movement at tectonic plate boundaries (National Geographic Society, 2019). Tuvalu's distance away from the Pacific Ring of Fire, ensures that the island has a relatively low risk of experiencing violent volcanic eruptions, dramatic seismic events (Rong, Mahdyiar, Shen-Tu, Shabestari, & Guin, 2010), and tsunamis (Thomas & Burbidge, 2009). If a network of Pacific Geoparks is developed, the 'Pacific Ring of Fire' could be a crosscutting theme across all Pacific Geoparks, highlighting the regional tectonic setting and the specific characteristics are each respective Geopark.

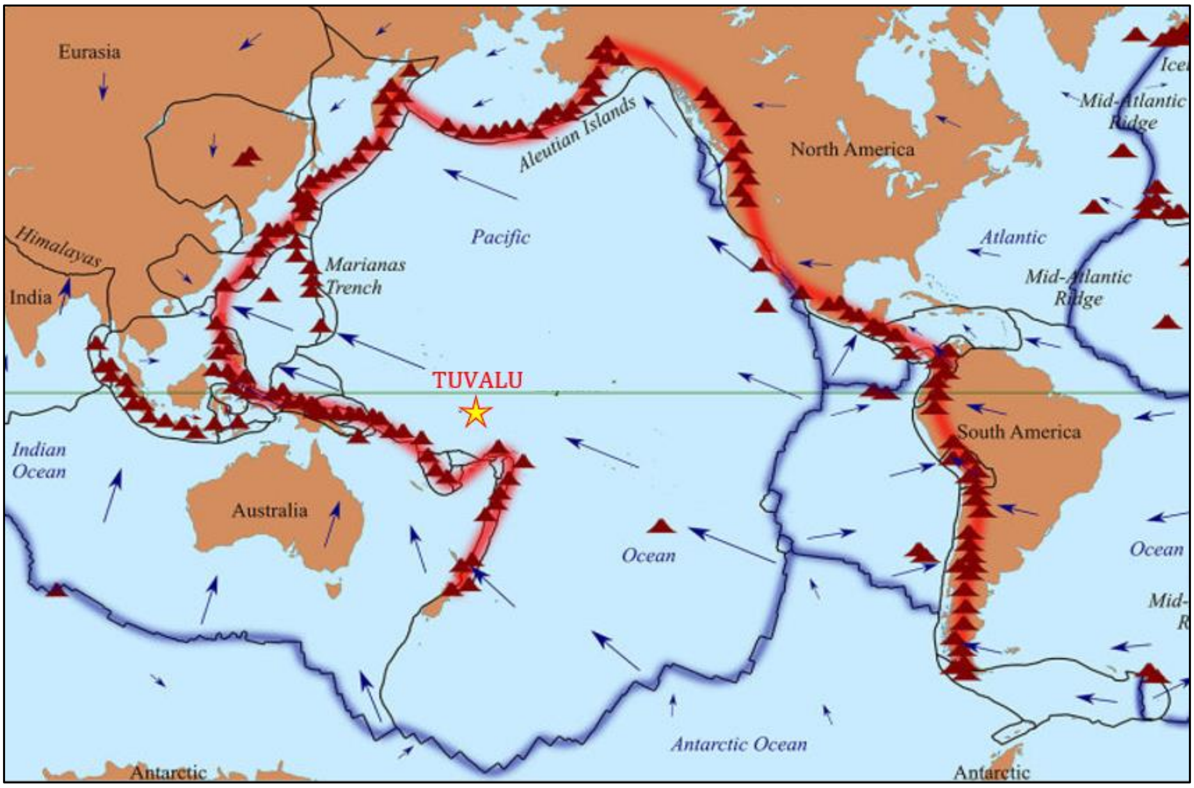

Figure 2.0: The approximate location of Tuvalu in relation to the Pacific Ring of Fire and tectonic plate boundaries with their associated movements (Source: Mancini, 2020)

Funafuti, which is part of Tuvalu's seamount chain, is classified as a reef island (Nunn, Kumar, Eliot, & McLean, 2016) due to its low elevation, small landmass, and high composition of unconsolidated material (Hosking, 1991). The lithosphere on which the atolls of Tuvalu sit was generated from the Cretaceous paleomagnetic super normal (around 110 to 85 million years ago) and is of oceanic nature (Konrad, et al., 2018). The estimated age of the chain of seamounts, however, is relatively younger and spans to the Palaeocene and Eocene epochs, approximately 47 to 64 million years old.

2.2 Island Formation

To understand the formation of Tuvalu's chain of atoll islands, it is best explained in three stages; firstly, the development of the northwest-southeast volcanic seamount chain which forms the foundation of Tuvalu's islands, secondly the subsequent processes which formed the overlying carbonate atoll structures, and thirdly the recent Holocene processes forming the present-day island morphology. The first two stages are discussed below, and the third stage is discussed in the following section '2.3 Geomorphology'.

The development of Tuvalu's seamount chain is associated with movement of the Pacific plate in a northwest direction at a speed of 7cm to 11cm per year (Pacific Northwest Seismic Network , 2021), in concurrence with the Rurutu hotspot (Finlayson, Konter, Konrad, Koppers, & Jackson, 2014; Konrad, et al., 2018). At the hotspot, magma from the Earth's mantle rises upward, melting the overlying oceanic lithosphere, and pushes through weak areas in the crust to form a volcano (National Geographic Society, 2014). The volcano eventually loses its source of heat as it moves with the tectonic plate away from the fixed location of the hotspot. It then cools down and becomes extinct forming an oceanic island or seamount, as another active volcano is developed over the hotspot (National Geographic Society, 2014). This volcanism cycle continues and creates a chain of seamounts in the process, as illustrated below in Figure 2.1.

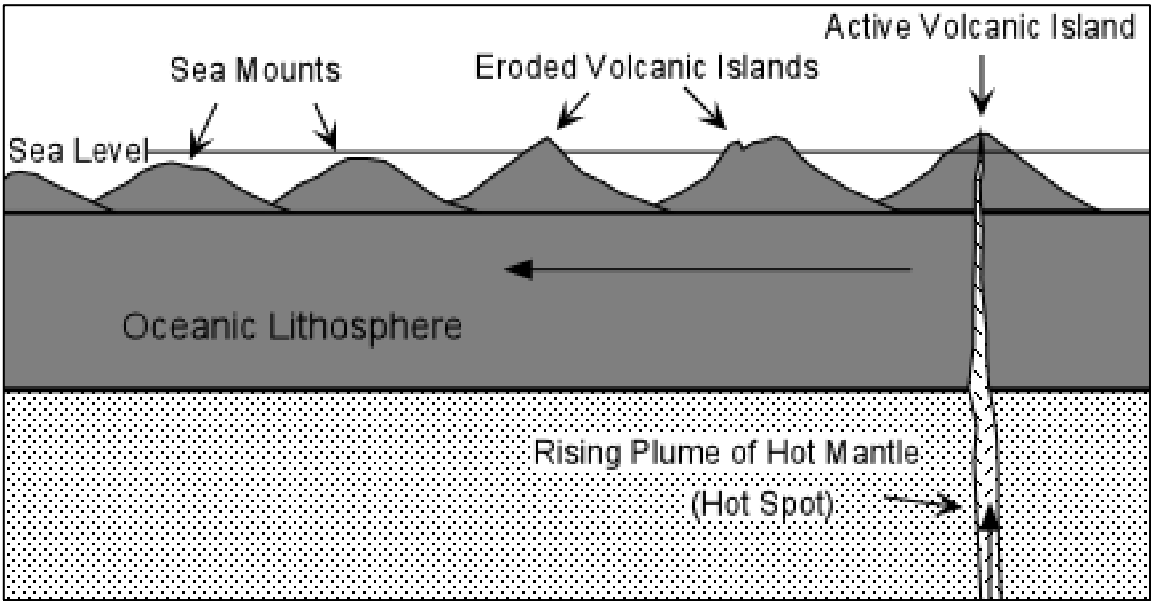

Figure 2.1: Movement of oceanic lithosphere over a hotspot and its associated landforms (Source: Nelson, 2015)

Secondly, the formation of Tuvalu's atolls can be explained through Charles Darwin's subsistence theory of atoll evolution (Darwin, 1842; Lane, 1993). This theory suggested that reef and atoll islands were created as the result of oceanic islands or seamounts undergoing gradual subsidence partnered with the vertical build-up of coral reefs around the island (refer to Figure 2.2) (Lane, 1993). This process discusses the evolution of coral reefs over time; beginning with the formation of a fringing reef attached to the border of a volcanic island, then as the volcanic island continues to subside (due to isostatic processes) a lagoon is created between the land and the reef, which is now known as a barrier reef. Eventually the volcanic island sinks completely beneath the surface of the ocean leaving behind a ring of corals for atoll islands to form on (Cannon, et al., 2018).

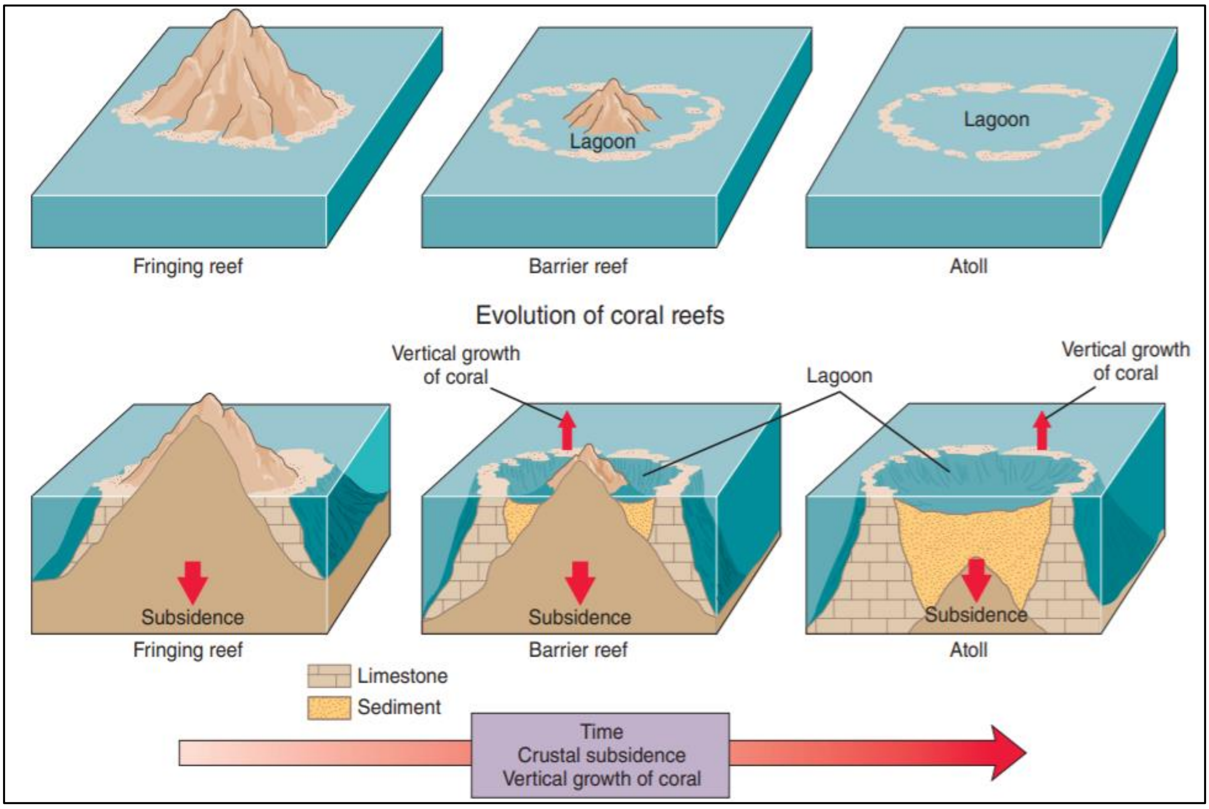

Figure 2.2: Evolution of coral reefs; from a fringing reef, to a barrier reef, and finally to an atoll (Source: Morrissey, Sumich, & Pinkard-Meier, 2018)

To test this concept, the Royal Society set out on a Coral Reef Expedition between 1896-1898 to carry out an experiment outlined by Charles Darwin that would assess the origin and history of atoll formation (Ohde, et al., 2002). This experiment involved the drilling of several cores on Funafuti Atoll, the deepest core reaching a depth of 340m, which was then studied and interpreted as a modern reef deposit overlying Pleistocene limestone (Ohde, et al., 2002). Therefore, the drilling expedition did not reach sufficient depths to encounter volcanic rock, meaning the results were insufficient to conclusively prove or disprove Darwin's theory (David T. E., 1904; Ohde, et al., 2002). The drilling site is now known as both 'Darwin's Drill' (after Charles Darwin who proposed the theory of atoll formation) and 'David's Drill' (after the geologist Sir T. W. Edgeworth David who led the expedition). The cores have since then been preserved in the Natural History Museum in London, United Kingdom (Ohde, et al., 2002). Additional studies on the sub-surface geology of Funafuti Atoll included a magnetic survey (Creak, 1904) and seismic tests inside the central lagoon (Gaskell & Swallow, 1953). These data sets proposed that there was at least 500m of limestone beneath the lagoon floor, with a presumed basement of volcanic origin (Locke, 1991; Krüger, 2008).

Darwin's theory was eventually proven correct in the early 1950s during the U.S. Navy's Mid-Pacific Expedition to Marshall Islands (Emery, J. I. Tracey, & Ladd, 1954). The results gathered from seismic refraction experiments and the successful drilling of two boreholes on Eniwetok Atoll at extensive depths of 1,283m and 1,405m respectively, confirmed that there were in fact volcanic (basalt) rocks located below approximately 900m of Eocene limestone (Emery, J. I. Tracey, & Ladd, 1954; Schlanger, 1963; Smith, 2021).

While this theory of atoll development is widely recognized, it was hypothesized before discussions on glaciation and its associated sea level fluctuations were advanced (Woodroffe, 2008; Dickinson, 2009). Incorporating sea level oscillations to Darwin's theory provides a clearer understanding of how atolls form their irregular morphology or annular shape (MacNeil, 1954; Terry & Goff, 2012). Glacial eustasy driven by factors described by the Milankovitch theory caused sea levels to fall and rise throughout the Quaternary period (MacNeil, 1954; Berger, 1988). MacNeil (1954) inferred that when Pleistocene sea levels dropped (during glacial periods), platform reefs emerged above the surface of the ocean and underwent subaerial erosion, creating saucer-shaped surfaces. As sea-level increased at the end of the last glaciation by approximately 120m, the weathered saucer shaped surfaces became re-submerged, providing ideal substrates for coral growth to occur in an annular shape. Coral growth on the annular structure kept pace with the rising sea level and thus developed modern atoll islands (Dickinson, 1999), as shown in Figure 2.3.

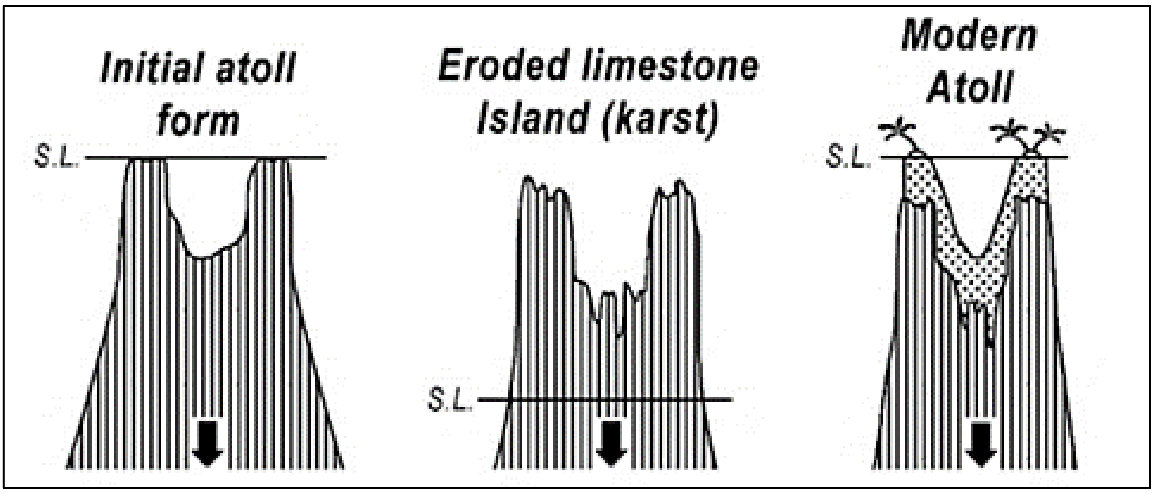

Figure 2.3: Sideview diagram of the development of an atoll with respect to changes in sea level, subduction and subaerial erosion (Source: Woodroffe, 2008)

Figure 2.4 shows another important proccess influencing the shape of atoll islands. Irregular morphologies or *arucate bight-like structures* (ABLS) are the morphological expression of submarine failures that are frequent on the slopes of volcanic edifices (Terry & Goff, 2012). Such failures stem from structural weaknesses and unstable submarine deposits which promote slope instability and generate landslides and slumping (Terry & Goff, 2012). This can occur at any time during the process of atoll formation and heavily influences the modern shape of many atoll islands. Terry and Goff's (2012) extension to Darwin's theory does not only contribute to the shape of atolls, but also confirms the instability of volcanic foundations. Additionally, Kruger (2008) explains other factors that can trigger submarine slope instability as well as how such events can shape atolls and, in the case of Funafuti, clearly exert control on the position and size of modern channels and islets (details discussed in section '2.3 Geomorphology'). By identifying submarine landslides and understanding why they occur we can gain insights into the processes that construct an atoll's modern morphology.

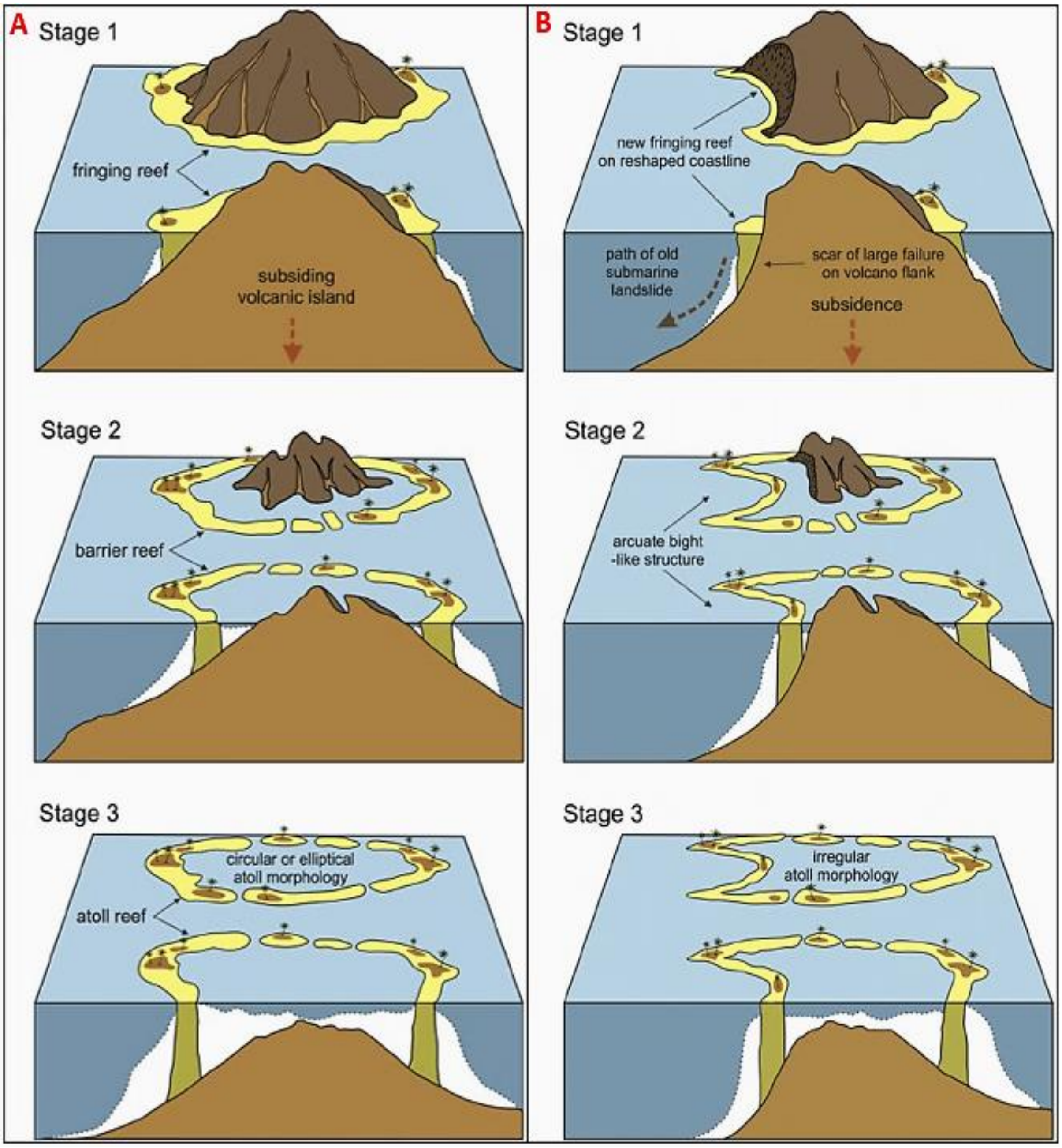

Figure 2.4: (A) Darwin's subsistence theory of atoll formation, showing the classic interpretation of the development of an elliptical atoll morphology. (B) Modified version of Darwin's model to incorporate the formation of ABLS. (Source: Terry & Goff, 2012)

2.3 Geomorphology

The geomorphology on Funafuti reflects formative processes that have been operating since before the mid-Holocene sea level highstand (Woodroffe & Biribo, 2011). As sea levels began to rise during the late Pleistocene and early Holocene, wave erosion became significantly enhanced and influenced the shoreline morphology on many islets (Dickinson, 1999). There are also other notable features that formed as a result of tropical cyclones and anthropogenic activities (Hosking, 1991; McLean & Hosking, 1992). The geomorphology of Funafuti has previously been mapped and described in detail by McLean and Hosking (1992), Dickinson (1999), and Kruger (2008). Therefore, this subsection will only look at the general topograhy and bathymetry features of Funafuti.

As mentioned under section ‘1.3 Site Location’, Funafuti is the largest atoll in Tuvalu with its long-axis stretching for about 25km in length and 18km in width across the centre at its widest points (McLean & Hosking, 1992). The 33 islets sitting atop the atoll rim can be generally categorised into two different types; (i) cays composed of unconsolidated coral rubble and calcareous sand, and (ii) larger islands, also known as *motu*, where similar unconsolidated deposits are underlain by cemented coral-rubble extending upward into the modern supratidal zone (Dickinson, 1999). The islets and reef flats on the eastern half of the atoll provide a barrier to the prevailing easterly trade winds and wave energy entering the lagoon, while those on the western and northern parts are exposed and widely spaced out at average distances of 3km (McLean & Hosking, 1992).

Topographic features commonly found on the atoll of Funafuti include; ocean ridges, lagoon ridges, central depression, interior flats and ridges, and borrow pits (Hosking, 1991; McLean & Hosking, 1992; Woodroffe, 2008). On the windward side of the atoll, ocean ridges are often made up of gravel, whereas leeward and lagoonward ridges are mostly sand (Woodroffe, 2008). A central depression usually occurs between oceanward and lagoonward ridges (Woodroffe, 2008). Ocean ridges also reach higher elevations than lagoon shores, but the highest point on many of these islets are found on spoil from the excavation of pulaka pits (Woodroffe, 2008). Pulaka pits are located mainly within village areas and were dug for taro to be planted near the water table of the freshwater lens. Similarly, in 1942, pits were also excavated by the American Construction Battalion as part of the Pacific War effort, and excess material was used to fill in mangrove swamps and construct the main airstrip on Fongafale (McLean & Hosking, 1992). This anthropogenic feature was restricted to Tengako and Fongafale, and had increased land area by approximately 8.5% changing the overall structure and function of the islets (Hosking, 1991; Webb, 2006). In 2015, the borrow pits from WWII were infilled and reclaimed using dredged sediments from Funafuti’s lagoon as well as rock imported from Fiji to expand habitable space and enhance coastal protection (Thaman, et al., 2016; Onaka, et al., 2017).

There are also fossil beaches present along Funafuti’s coast indicating the continuous movement of the shoreline over hundreds of years (Webb, 2006). Other evidence of changes in the shoreline’s position have been observed on both inhabited and uninhabited islets suggesting the dynamic nature of the coastal area, especially on Fongafale’s lagoon-side coast (Webb, 2006).

In 1972, Hurricane Bebe contributed considerably to the constructive and destructive forces of island building, especially on the reef flats and islets along Funafuti’s southern coast (Hosking, 1991). Hurricane banks and ridges were created on the islets of Funamanu, Tengako, and Motuloa (McLean & Hosking, 1992), adding 10% to the total land area of the atoll (Woodroffe, 2008). Rubble was eventually redistributed by wave conditions and the ridge migrated landwards across the reef flat, resulting in further buildup of the island shoreline in some places (Woodroffe, 2008).

Moreover, a comprehensive study on the bathymetric features of Funafuti was conducted by Kruger (2008). The following description of the seabed geomorphology was made:

> *“Depths vary from 1m in the lagoon, to 2224m on the deeper margins of the atoll edifice flank. The nearshore bathymetry of Funafuti is more complex than other atolls in Tuvalu. A near continuous shoreline parallel terrace and break in slope in water depth of 100-150m is observed approximately 100-450m seaward of the modern reef (termed as ‘reef front slope’ in Figure 2.5). A 2km wide submarine terrance is evident at the southern apex of the atoll flank. The landward upslope margin is at 250m, while the seaward break in slope occurs in water*

depths of 700m. The northwest, southeast, and southeast flanks exhibit numerous stacked high gradient slopes, interpreted as mass movement features (termed 'landslide scars' in Figure 2.5). The dominant seabed feature is an oval-shaped submarine landslide on the northwest flank in water depths of about 150m. The 10km long shoreline-parallel scarp is flanked by a series of stacked cross-slope sidewall failures that mave maximum slope angles approaching 80°. The landward break in slppe of the scarp occurs in water depth of 350m, with a scarp height of 650m, creating a near vertical drop off that terminates in 1000m water depth.This submarine landslide complex has significantly altered the shape of the atoll, deeply incising the annular reef rim. Similar alterations are assumed to have occurred in the southwest and southeast of the atoll rim. This can produce seaward convex notches on the annular ring reef, and thereby control the subaerial shape and position of modern atoll islets and channel positions." (Krüger, 2008)

The seabed features explained in this paragrah are illustrated below in Figure 2.5.

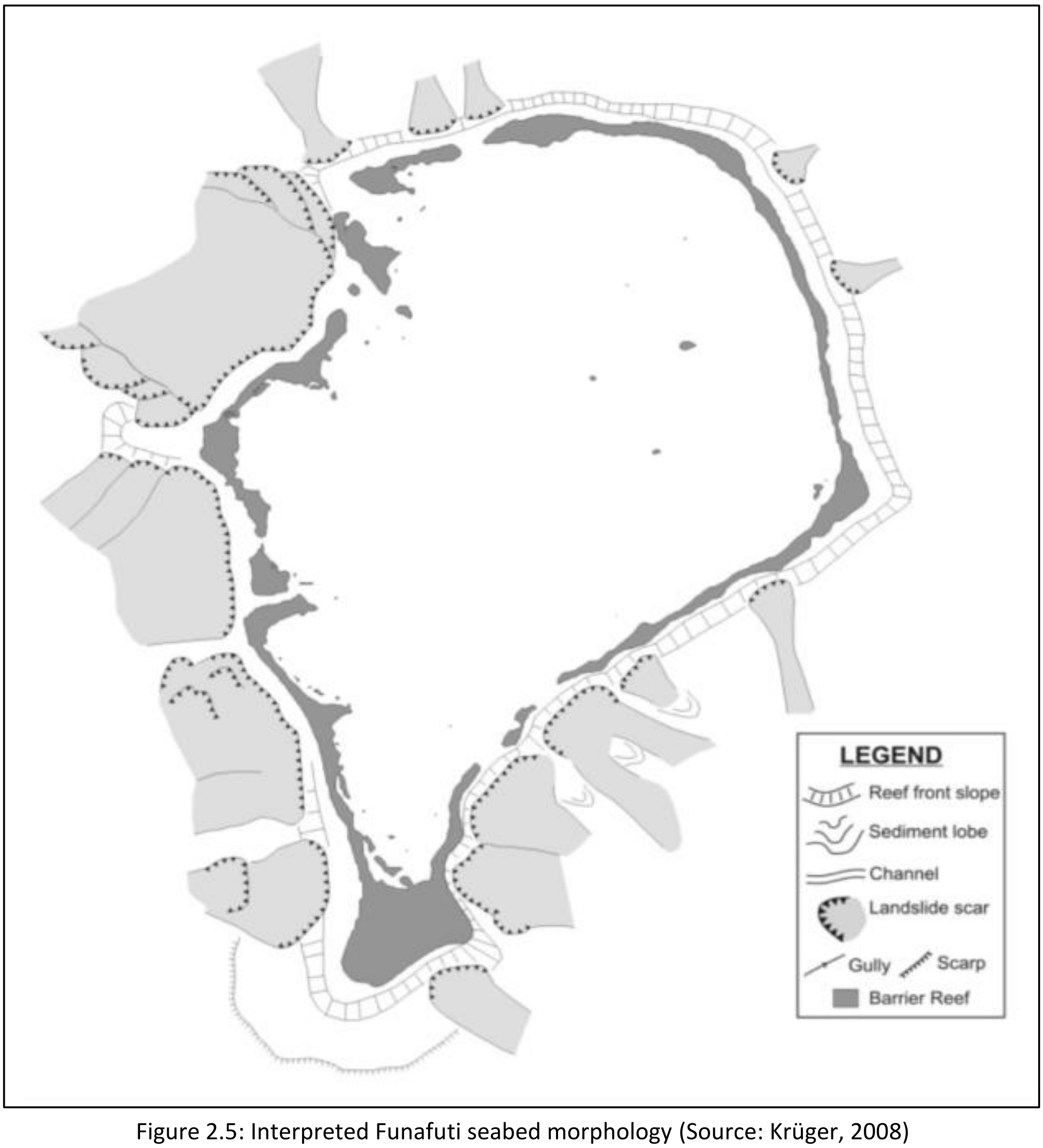

Figure 2.5: Interpreted Funafuti seabed morphology (Source: Krüger, 2008)

2.4 Soils & Rock

According to FAO-UNESCO (1974, 1978), the soils of Tuvalu are defined as Calcaric Regosols which are very weakly developed soils on a highly calcareous parent material (McLean & Hosking, 1992). The different types of soils and substrates distributed on Funafuti Atoll have already been mapped and described by McLean and Hosking (1992) and Thaman (2016). These included exposed limestone rock, beach or reef rock, unaltered sand and gravel, light soils, dark sands, phosphatic soils, saline soils, and soils created in pulaka pits (McLean & Hosking, 1992). They are normally characterised as being shallow, porous, alkaline, coarse-textured, nutrient deficient, with a carbonate mineralogy and high pH readings (8.2 to 8.9) (Thaman, et al., 2016). For instance, the light soils are typically found along the fringe of the atoll (McLean & Hosking, 1992) and can be described as foraminifera rich sand with occasional coral fragments (Lee, Roqica, Sovea, & Momoivalu, 2020). These soils are distinguishable from beach deposits by the presence of organic matter (leaves, branches, roots) that stain the calcareous sand during decomposition processes (McLean & Hosking, 1992; Lee, Roqica, Sovea, & Momoivalu, 2020). Dark soils are essentially deeper coloured soils with a greater composition of decomposed organic matter which gives it a silty and loamy texture (McLean & Hosking, 1992). There is often a gradual transition from light to dark soils as the degree of staining increases moving away from the shore.

Moreover, the interaction of organic matter, guano, and water above the calcareous parent material, produces multicoloured phosphatic soils that occur within the village area on Fongafale. Whereas saline soils reflect a soil phase and comprises of coarse sand and silt, with a discontinuous crust of partly cemented sediment and blue-green algae matting (McLean & Hosking, 1992). The soil found in or around pulaka pits contain a mixture of organic material and sand as the pits were excavated near the level of the water table (McLean & Hosking, 1992).

2.5 Hydrogeology

Tuvalu relies on groundwater lenses in highly permeable aquifers, underlain and surrounded by seawater, as their main source of freshwater (White & Falkland, 2010; Thaman, et al., 2016). The quantity and quality of groundwater depends on replenishment from rainfall, and losses due to evapotranspiration by phreatophytes, submarine discharge to the sea, tidal mixing with underlying seawater, and consumptive use by communities (White & Falkland, 2010, 2012). It is also affected by climatic variability, changes in sea-level, storm surges, and pollution (White & Falkland, 2012).

The groundwater lens can be described as a thin lenticular shaped body, that is separated from the underlying seawater by a transition zone of mixed freshwater and seawater (Underwood, Peterson, & Voss, 1992). In the transition zone, groundwater salinity increases with depth from freshwater to seawater due to mechanical mixing and dispersion (White & Falkland, 2010). The freshwater zone is contained in the relatively low permeability coral sediments, as mixing of freshwater and seawater is rapid in the high permeability karst limestone (White & Falkland, 2012). The size, shape, and relative salinity level of the groundwater lens is determined by two major factors: (i) the geologic framework and (ii) hydrodynamics of a two-fluid miscible groundwater system, including replenishment to the system (Underwood, Peterson, & Voss, 1992). The geologic framework of atoll aquifers is unique as it comprises of two significant layers, i.e., an upper layer consisting of recent Holocene sediments (mainly coral sands and fragments of corals) lying unconformably over an older Pleistocene karst limestone deposit (Bailey, Jenson, & Olsen, 2009; White & Falkland, 2012). This unconformity, usually occurring at depths of 10-15 m below mean sea level, is one of the controlling factors to the thickness of freshwater lens (White & Falkland, 2012). Likewise, islands on the leeward side of an atoll tend to have a thicker lens due to being larger in size and possessing finer substrate deposits compared to those exposed to the prevailing winds on the windward side (Bailey, Jenson, & Olsen, 2009).

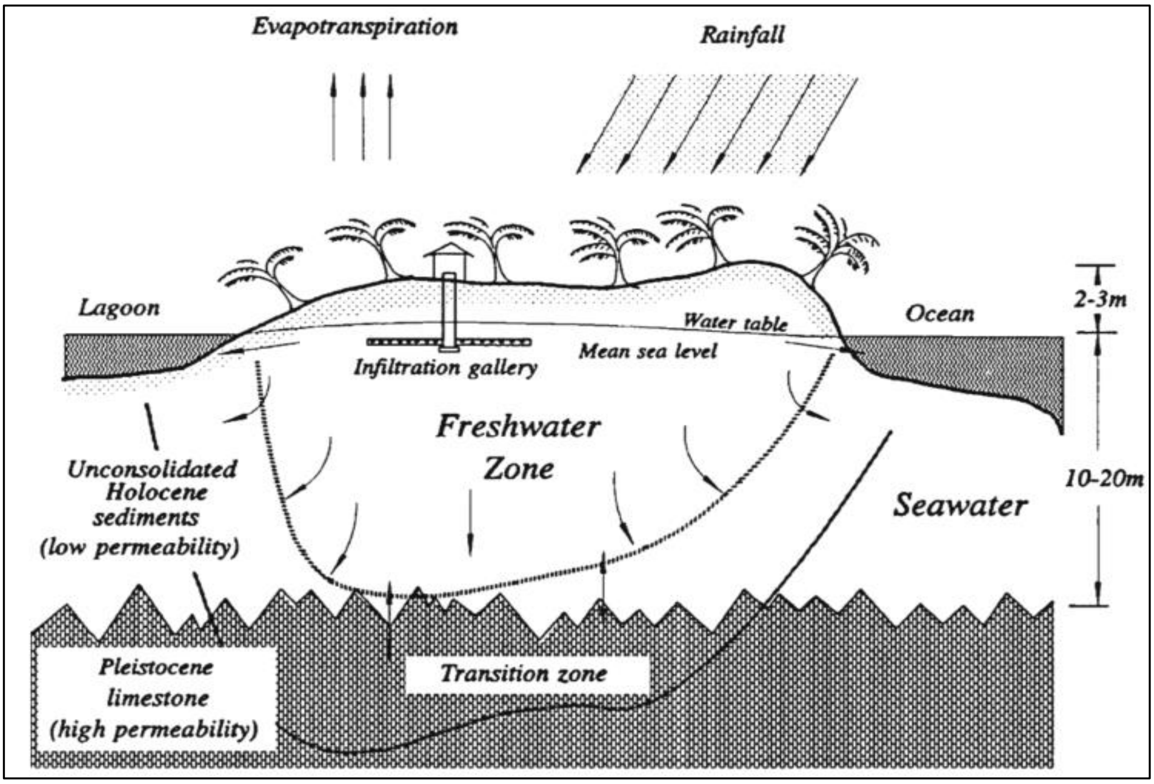

Figure 2.6: Vertical cross section through an atoll showing the main features of a freshwater lens (Source: White & Falkland, 2010)

Freshwater lenses are extremely vulnerable to threats from both natural events and human activities (White & Falkland, 2010). The main natural threats are extended droughts, sea level rise (SLR), and storm surges associated with tropical cyclones (Spennemann, 2006; White & Falkland, 2010). SLR and storm surges can result in saltwater intrusion into the freshwater lenses, which risk contamination of the groundwater, making it unusable by surrounding communities (White & Falkland, 2010). With climate change, these events are most likely to become more frequent and severe, which could have great impacts on the island and its people (White & Falkland, 2010). Furthermore, relative anthropogenic threats include unsustainable extraction, pollution from land use and waste disposal, mining of sediment and gravel from groundwater source areas, and shoreline development that stimulates erosion (White & Falkland, 2010, 2012). Rapid population growth in urban areas will also put additional stress on groundwater supply due to increased demands for freshwater resources, such as in the case on Fongafale (White & Falkland, 2010; Thaman, et al., 2016). Here, the freshwater lens is most extensive and highly developed, but the resource is extremely limited because of population demands (Thaman, et al., 2016). Therefore, much of Fongafale is reliant on rainwater catchment systems and desalination as alternative sources of freshwater (Thaman, et al., 2016).

3 Climate Conditions, Climate Change, & Natural Hazards

Climate change and coastal hazards are crucial areas of concern in Tuvalu. A Geopark in Funafuti could incorporate climate change and coastal hazards as focus themes. Consequently, a Geopark could serve as an effective communication tool for raising the awareness of Tuvalu's context on the international stage, with potential to act as a catalyst for increased advocacy, support, and climate action. There is also scope for the Geopark to protect and conserve key areas which serve natural resilience functions. Additionally, the potential education and research benefits of a Geopark could lead to increased knowledge, capacity, and resilience.

Therefore, it is proposed that climate change be a core theme of the Funafuti Geopark, emphasising links to the geology, biology, culture, and the future of Tuvalu. This section discusses Tuvalu's past, present, and projected future climates. Associated coastal hazards and adaptation measures practiced by Tuvaluans are discussed, as well as other natural hazards including earthquakes, landslides, and tsunami.

3.1 Paleoclimate

Paleoclimatology is the study of Earth's climate history, prior to the availability of modern weather instruments by using different types of environmental evidence (known as proxies) to interpret past environmental and atmospheric conditions (Schmittner, 2018; NOAA, 2021). The various types of proxies include ice cores, tree rings, corals, and ocean and lake sediment cores, all of which hold temperature and precipitation records that cover different time periods at a range of temporal resolutions (Schmittner, 2018; National Geographic Society, 2019). These proxies can also be dated to construct a chronology of paleoclimate conditions for up to many thousands of years ago which allows us to better comprehend how the Earth's climate system has shifted over time and what factors have had a major influence on this (Schmittner, 2018; NOAA, 2021). For example, foraminifera shells are a type of proxy that can be found buried in layers of marine sediments that have built up over time, containing chemical signatures which indicate climate conditions when the shell was originally formed (National Geographic Society, 2019). These properties include oxygen isotopes ($^{18}O/^{16}O$) which reflect water temperatures during their formation period and can be analysed to determine past ocean temperature records (Ingram & Sloan, 1992; National Geographic Society, 2019).

The study of paleoclimate has supported research on how plate tectonics, solar energy, atmospheric chemistry, and variation in Earth's orbit (Milankovitch Theory) have impacted the earth's climate over time (National Geographic Society, 2019). In Tuvalu, the Funafuti cores that were drilled by Royal Society were examined by Ohde, et al. (2002) for carbonate mineralogy and isotopic measurements when evaluating atoll formation. The core was dated, and this chronology provided an account for the Pleistocene sea-level history as well as the following conclusions:

> *"(i) Holocene reef growth recorded in the core indicated that 26.4 m of upward reef growth occurred in the last 8 ka because space was generated through erosional processes during the last glacial period, in accord with the model of atoll carbonate accretion of Gray et al. (1992).*
>
> *(ii) Records of the Quaternary sea-level history is preserved in the drill core at Funafuti in the tropical Pacific. During the Pleistocene, more than 150 m of carbonate was deposited through interaction between eustatic sea-level change and plate subsidence.*

> *(iii) Heavily dolomitized sections in the lower core reflect discrete diagenetic events, which in turn reflect the interaction between atoll carbonate sedimentation, tectonic subsidence, and eustatic sea-level change."* (Ohde, et al., 2002)

Another survey using proxy samples from Tuvalu includes the coral cores taken from Funafuti's lagoon in 2009 by Nakamura, et al. (2020). The aim of this study was to investigate the coral core's annual black bands to understand the relationship between anthropogenic activity and productivity of coral reef ecosystems (Nakamura, et al., 2020). Massive corals provide excellent paleoclimate and paleoenvironmental records in their aragonite ($CaCO_3$) skeletons and are known to form annual black bands when environment conditions are anoxic due to elevated presence of heavy metals (especially iron) (Nakamura, et al., 2020). In this case, the supply of iron to Funafuti atoll (particularly Fongafale) originated from WWII when tanks and equipment for the construction of the airstrip were delivered (Nakamura, et al., 2020). The relationship that was observed in this study was that the increase of human activity and domestic waste promoted eutrophication and ecosystem transition from healthy coral reefs to turf algae proliferation in the lagoon (Nakamura, et al., 2020).

By looking at paleoclimate and studying the above-mentioned environmental proxies, we gain insights into the historical environmental and climatic events that occurred in and around Tuvalu and how it has affected the general geology and marine biology of Funafuti Atoll.

3.2 Current Climate Conditions & Seasonal Cycles

According to the Köppen Climate Classification, Tuvalu's climate is characterised as tropical with two distinct seasons – a wet season from November to April and a dry season from May to October (Lane, 1993; Australian Bureau of Meteorology; CSIRO, 2014). The two seasons are affected by the movement and strength of the South Pacific Convergence Zone (SPCZ) as shown in Figure 3.0 (Tuvalu Meteorological Service; Australian Bureau of Meteorology; CSIRO, 2011). This band of heavy rainfall is caused by air rising over warm water where winds converge, resulting in low pressure systems and thunderstorm activity that is most intense from November to April. However, average monthly rainfall in Funafuti is more than 200mm due to its location near the West Pacific Warm Pool, where convective rainfall occurs year-round (Australian Bureau of Meteorology; CSIRO, 2014).

Additionally, Tuvalu's rainfall varies considerably from year to year due to the El Nino-Southern Oscillation (ENSO), which is a natural climate pattern that occurs across the tropical Pacific Ocean and affects weather around the world (Tuvalu Meteorological Service; Australian Bureau of Meteorology; CSIRO, 2011). There are two extreme phases of ENSO, i.e., El Nino and La Nina. In Funafuti, El Nino events occur when the SPCZ moves north-east over the atoll causing extreme wet and warm conditions (Australian Bureau of Meteorology; CSIRO, 2014). During La Nina events when the SPCZ changes direction to south-west, the impacts are more evident as extreme dry and cool seasons create favourable conditions for severe droughts to occur (Australian Bureau of Meteorology; CSIRO, 2014).

In contrast to rainfall in Funafuti, there is little variation in temperature throughout the year with maxima averaging between 31-32°C and minima between 25-26°C (Tuvalu Meteorological Service; Australian Bureau of Meteorology; CSIRO, 2011). Air temperatures are closely related to the sea-surface temperatures surrounding the atoll (Australian Bureau of Meteorology; CSIRO, 2014). Likewise, the warmer ocean temperatures around Tuvalu influences maximum temperatures to be greater (>36°C) during El Nino years, and minimum temperatures to be lower (<21°C) in La Nina years (McLean & Hosking, 1992; Australian Bureau of Meteorology; CSIRO, 2014).

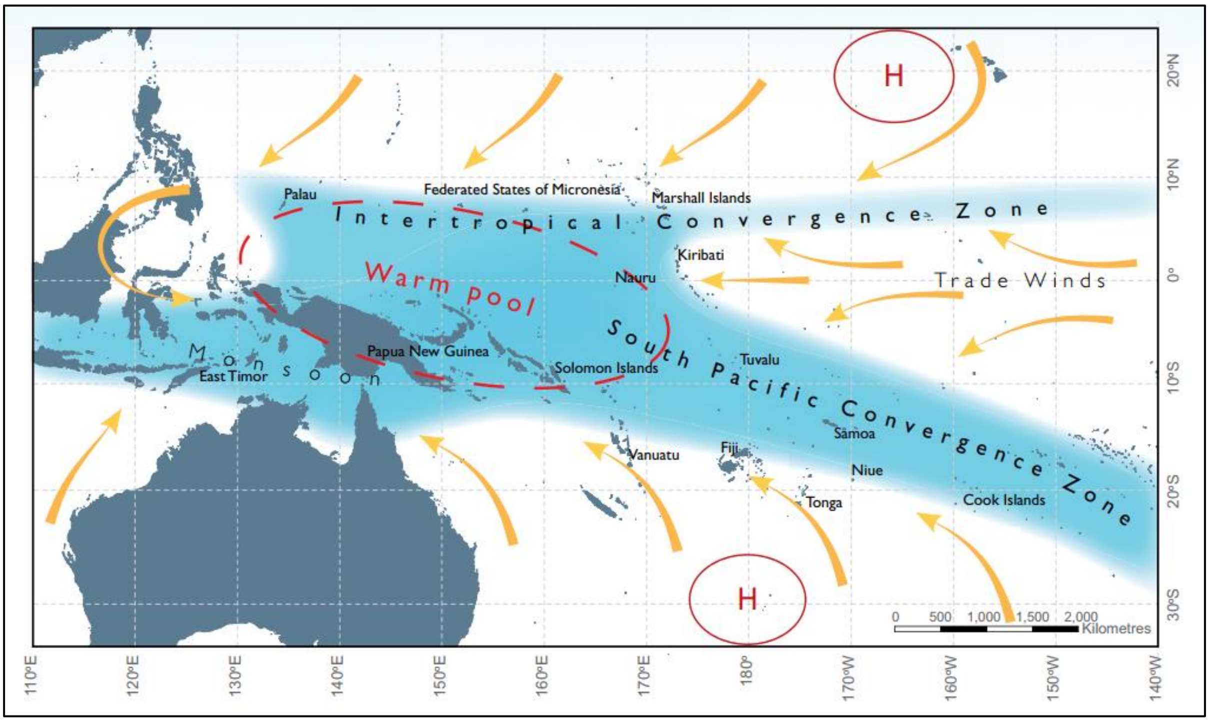

Figure 3.0: Average positions of major climate features during Tuvalu's wet season. The arrows show near surface winds, the blue shaded area represents bands of rainfall convergence zones, and the dashed oval indicates the position of West Pacific Warm Pool. (Source: Tuvalu Meteorological Service, Australian Bureau of Meteorology, & CSIRO, 2011)

3.3 Observed Trends

The observation of climatic trends in Funafuti are possible through data collected from scientific instruments such as the Funafuti Meteorological Station and recently constructed (in 2017) state-of-the-art Tide Gauge Facility which includes a global positioning system to provide information on land motions (McLean & Hosking, 1992; Australian Bureau of Meteorology; CSIRO, 2014). Such data includes rainfall records since 1927, air temperature data from 1933, as well as monthly-averaged sea level data from 1977 (Australian Bureau of Meteorology; CSIRO, 2014). There is potential for the respective scientific instrumentation to be incorporated into the Geopark, such as installing informative signage near the instrumentation.

According to Volume 2 of *Climate Change in the Pacific: Scientific Assessment and New Research* by the Australian Bureau of Meteorology and CSIRO (2014), the following trends in Funafuti were observed:

- Maximum air temperatures have increased at a rate of approximately 0.24°C per decade since monitoring began in 1950.
- Water temperatures have been gradually increasing around Tuvalu since the 1950s, however from the 1970s the warming rate has been approximately 0.13°C per decade.
- SLR near Tuvalu measured by satellite altimeters since 1993 is about 5mm per year (this is greater than the global average of 3.2mm per year).

- The season for tropical cyclones in Tuvalu is from November to April, with an average of eight cyclones taking place per decade.
- The productivity of coral reef ecosystems in Tuvalu has dropped from optimal in the late 18th century to adequate by the year 2000 due to increase in ocean acidification rates.

3.4 Climate Projections & Associated Hazards

Global climate models are the best tools for understanding future climate change (Tuvalu Meteorological Service; Australian Bureau of Meteorology; CSIRO, 2011). Scientists from the Pacific Climate Change Science Program (PCCSP) evaluated several global models and discovered 18 of which best represents the climate of the western tropical Pacific region (Tuvalu Meteorological Service; Australian Bureau of Meteorology; CSIRO, 2011). The 18 global climate models were used to develop climate projections for Tuvalu in Volume 2 of *Climate Change in the Pacific: Scientific Assessment and New Research* (Australian Bureau of Meteorology; CSIRO, 2014). These models provided plausible representations of future climates in Tuvalu over the course of the 21st century, which have been summarised below:

- Surface air temperature and sea surface temperature (SST) are projected to continue to increase as warming is significantly consistent with rising greenhouse gas concentrations.
- Seasonal and annual average rainfall are projected to increase in the equatorial Pacific under a warmer climate.
- Warmer temperatures are projected to result in an increase in the number of hot days and warm nights, and a decline in cooler weather.
- The intensity and frequency of extreme rainfall events are projected to rise.
- The incidence of drought is projected to decrease due to projections of increased rainfall.
- Tropical cyclones are projected to occur less frequently but more intensively towards the end of the century.
- Ocean acidification is projected to continue increasing as its rate is driven primarily by the increasing oceanic uptake of CO_2, in response to rising atmospheric CO_2 concentrations.
- Mean sea level is projected to continue to rise in response to increasing ocean and atmospheric temperatures, due to thermal expansion of water and melting of glaciers and ice caps.

The associated hazards of these climate projections pose significant challenges in Tuvalu.

Climate change is expected to compound existing threats to coral reef and mangrove forest ecosystems, resulting in declines in their overall size and quality (Siaosi, et al., 2012). Fisheries for demersal fish, and intertidal and subtidal invertebrates are projected to show progressive declines in productivity due to both the direct (e.g., increased SST) and indirect (e.g., changes to fish habitats) impacts of climate change (Siaosi, et al., 2012). In contrast, fisheries for nearshore pelagic fish are projected to increase in productivity due to the redistribution of tuna populations to the east (Siaosi, et al., 2012). As ocean acidification is expected to increase it is suggested that coral reefs in Tuvalu will be more vulnerable to dissolution as the increased acidity will inhibit corals ability to produce calcium carbonate required for skeletal development (Siaosi, et al., 2012). This may have a negative impact on the net growth rates of coral reefs to exceed natural bioerosion rates, it will also affect other ocean life such as calcifying invertebrates, non-calcifying invertebrates and fish (Siaosi, et al., 2012).

Additionaly, the impact of acidification change on the health of reef ecosystems is likely to be intensified by other factors including coral bleaching, storm damage and fishing pressure (Australian Bureau of Meteorology; CSIRO, 2014).

The most recent tropical cyclone to affect Tuvalu was Tropical Cyclone Pam in March 2015 (Government of Tuvalu, 2015; Thaman, et al., 2016). The strong winds and storm surges from this category 5 cyclone caused coastal erosion, loss of coastal vegetation, saltwater intrusion, increased salt spray (Thaman, et al., 2016), as well as substantial damages to many houses and essential infrastructure (Government of Tuvalu, 2015). These impacts are expected to intensify through this century with potential for significant impacts.

While drought events have been projected to decline in the future, it is still a recurrent climate feature of Tuvalu, with significant meteorological and socioeconomic effects (McGree, Schreider, & Kuleshov, 2016). A drought that began in March 2009 on Funafuti atoll became the worst (in both duration and magnitude) in almost a century (Kuleshov, et al., 2014). By mid-2011, Tuvalu experienced a major water availability crisis, and a state of emergency was declared in September of that year resulting in households on Funafuti being rationed to about 40 litres of fresh water a day (McGree, Schreider, & Kuleshov, 2016). As local agricultural crops failed, Tuvaluans had to pay higher costs for imported food to resolve the situation (Manhire, 2011). The scarcity of rainfall also caused contamination of the remaining groundwater supplies with the Red Cross declaring the water unsafe for human consumption (Benns, 2011). This incident was associated with the 2010-2012 La Nina event which was one of the strongest on records (Kuleshov, et al., 2014) compared to the strength of La Nina events in 1917, 1955, and 1975 (McGree, Schreider, & Kuleshov, 2016). Subsequent installation of rainwater capture, storage, and desalination infrastructure has helped to increase the resilience of water supply in Tuvalu.

Most of Funafuti's population lives on land less than two meters above sea level, meaning the population is particularly vulnerable to coastal hazards such as sea level rise and coastal inundation. Projected sea level rise poses significant challenges in Funafuti, namely through increasing rates of flooding, coastal erosion, and saltwater intrusion (Nurse, et al., 2014; Webb, 2016). This may bring about problems with local food security leading to increased fishing pressure on coastal habitats if traditional garden crops fail (Siaosi, et al., 2012). Likewise, wave over-wash can be expected to occur more frequently with SLR, posing a significant threat to fresh groundwater resources (Nurse, et al., 2014).

Kench, Thompson, Ford, Ogawa, and McLean (2015) analysed shoreline positions of Funafuti Atoll over the past 118 years to determine their physical response to SLR. It was found that despite the increasing rates of SLR many islets had increased net land area by 7.3% over the past century. Reef islands in Funafuti proved to be robust and dynamic landforms that continually adjust their size, shape, and orientation to a range of drivers such as storms, sediment supply, anthropogenic modifications, and sea level change (Kench, Thompson, Ford, Ogawa, & McLean, 2015). These results demonstrate that island building processes can persist in the context of SLR, however the rate of sea level rise is projected to increase in the 21st century and it is unclear how reef islands will respond. Webb (2016) also discussed that while reef edges have responded positvely to SLR in the past, the ability of coral reefs to continue to do so under accelerating rates of SLR combined with additional stress from increased SST and acidificaion seems highly unlikely. If the vertical growth of coral reefs will not be able to keep up with SLR then it may become permanently submerged. Likewise, if the production of debris such as sand, gravel and cooble is reduced through climate stress, the capacity of island beaches to continue to build and protect the island will progressively decline, leading to shoreline instability and coastal erosion (Webb, 2016). It was also stated by Dickinson (2009) that SLR will adveresly impact the habitation of atolls once high-tide levels exceed mid-Holocene low-tide levels. This crossover will submerge the resistant paleoreef flats that underpin stable atoll islets and subject their unconsolidated sediment cover to constant wave attack before sea level actually dominates the islets (Dickinson, 2009). In regards to this research it is important to stress the distinction between 1) an islands ability to respond to the impacts of climate change and sea level rise, and 2) an islands ability to support human habitation. These are two separate issues, meaning an island may respond and persist, but in terms of human occupation it may become unhabitatble due to issues such as regular inundation and saltwater intrusion.

In the context of the geopark, it is important to note that climate change can directly impact environmental resources that may be major tourism attractions on Funafuti. For instance, challenges such as beach erosion and coral bleaching have been found to negatively impact the perception of destination attractiveness in several locations (Nurse, et al., 2014). Tuvalu's tourism industry should also consider other climate risks of tourism operations including those associated with the availability of freshwater. As discussed earlier, freshwater is a limited resource on atoll islands (especially Funafuti), and changes in its availability or quality during drought events have adverse impacts on tourism operations (Nurse, et al., 2014). Tourism is a seasonally significant water user in many island destinations, and in times of drought concerns over limited supply for residents and other economic activities become heightened (Nurse, et al., 2014). The use of desalination plants is one adaptation to reduce the risk of water scarcity in tourism operations (Nurse, et al., 2014).

A Geopark has excellent potential to build upon and strengthen existing awareness campaigns regarding the impacts of climate change in Tuvalu, such as the signage adjacent to Funafuti International Airport shown in Figure 3.1. We recommend fieldwork to identify sites which showcase the impacts of climate change in Tuvalu, such as the 'narrowest part of Funafuti' which particularly showcases vulnerability to sea level rise and coastal hazards. This is a sensitive area requiring respect and care conducted at the local level, therefore we do not recommend any specific areas in this report other than the 'narrowest part of Funafuti'.

Figure 3.1: Existing awareness signage highlighting the impacts of climate change in Tuvalu

3.5 Energy, Greenhouse Gas Emissions, & Mitigation Measures

The severity of climate projections discussed above in section '3.4 Climate Projections & Associated Hazards' is greatly dependent on ongoing and future global community efforts to mitigate greenhouse gas (GHG) emissions (Webb, 2016). Tuvalu recognises this and has committed to reducing GHGs regardless of their emissions being negligible in a global context (PCREEE, 2019). The main GHGs locally emitted in Tuvalu are CO_2, methane (CH_4), and nitrous oxide (N_2O) where electricity generation has shown to be the main contributor to GHG emissions (Government of Tuvalu, 2015). Hence, the goals and objectives of Tuvalu's energy sector have shifted significantly over the past decade from diesel-based generated electricity to renewable energy (Government of Tuvalu, 2015).

Tuvalu's energy sector is managed by the Ministry of Works and Energy while the Tuvalu Electricity Corporation (TEC) is a government-owned commercial utility responsible for providing cost-effective and reliable electricity supply to all of the islands of Tuvalu (Government of Tuvalu, 2015). Traditionally these entities have been reliant on imported fuels as a source of energy for transport, electricity generation and household use, especially on Funafuti where urbanisation rates are highest (Government of Tuvalu, 2015). Their high reliance on imported fuels has restricted development and exposed the nation to fluctuations in the international fossil fuel markets (Government of Tuvalu, 2015). Investment in renewable energy is critical for Tuvalu to reduce reliance on fossil fuels and to achieve sustainable development (Government of Tuvalu, 2015).

In 2012, Tuvalu adopted its Renewable Energy and Energy Efficiency Master Plan and there has been substantial investment in solar energy across the country (Government of Tuvalu, 2015; PCREEE, 2019). By 2015, solar PVs had been installed in several locations on Funafuti and their first Nationally Determined Contribution was also submitted with the substantial commitment of 100% reductions in

GHG emissions from the electricity generation sector by 2025, reduction in total GHG emissions from the entire energy sector to 60% below 2010 levels by 2025, and reductions from other key sectors such as agriculture and waste upon necessary technology and finance (PCREEE, 2019).

Besides solar power, Tuvalu is ready to also embrace other technologies, for example harnessing ocean energy, once these become available and affordable (Government of Tuvalu, 2015). For those living on the islets of Funafuti solar home system is the most viable form of renewable energy. The potential for ocean energy on Funafuti is yet to be determined but it poses an alternative form of renewable energy that can be harnessed in the future and one of the channels between islets can be identified as a potential site for tidal energy to showcase sustainable use of ocean resources. Other plans for mitigation actions include revising policies in energy, climate change and electricity sector in line with sustainable development strategies as contained in their National Strategic Development Plan, conservation, education, energy efficiency, and gaining international support (Government of Tuvalu, 2015). By mitigating GHG emissions, Tuvalu will be able to acquire the benefits of reduced oil imports, improved energy security, improved local air quality, increased employment, and investments, and being a green tourism destination.

The Geopark has potential to showcase and raise awareness of Tuvalu's world leading renewable energy commitments, with potential to act as a catalyst for increased advocacy and action on the global stage.

3.6 Adaptation Measures

Tuvalu has proved to be a resilient nation by adopting a variety of measures to adapt to the impacts of climate change. Whether it be through traditional ecological knowledge (TEK) or modern scientific research, Tuvalu has shown great ambition in implementing measures to preserve its environment and ecological services. Tuvalu has invested in a variety of resource restoration initiatives including artificial beach nourishment, coral and mangrove restoration, and the establishment of marine parks and protected areas (Lane, 1993). These adaptation measures could be showcased as part of the proposed Geopark, a few of these measures are discussed below.

As discussed in other areas of this report, marine biology plays a critical role in the generation of sediment in Funafuti, and the island is almost entirely composed of the skeletal remains of marine organisms. One of the most significant organisms in terms of sediment generation is foraminifera. In a world first research initiative the Government of Tuvalu collaborated with researchers from Japan to assess the feasibility of mass culturing sand (Hosono, Lopati, Makolo, & Kayanne, 2014). This research investigated the potential of growing foraminifera sand (species Baculogypsina sphaerulata) in tanks fitted with artificial grass to replicate the natural habitat, as shown in Figure 3.2. The results of this research yielded promising findings and recommended further research.

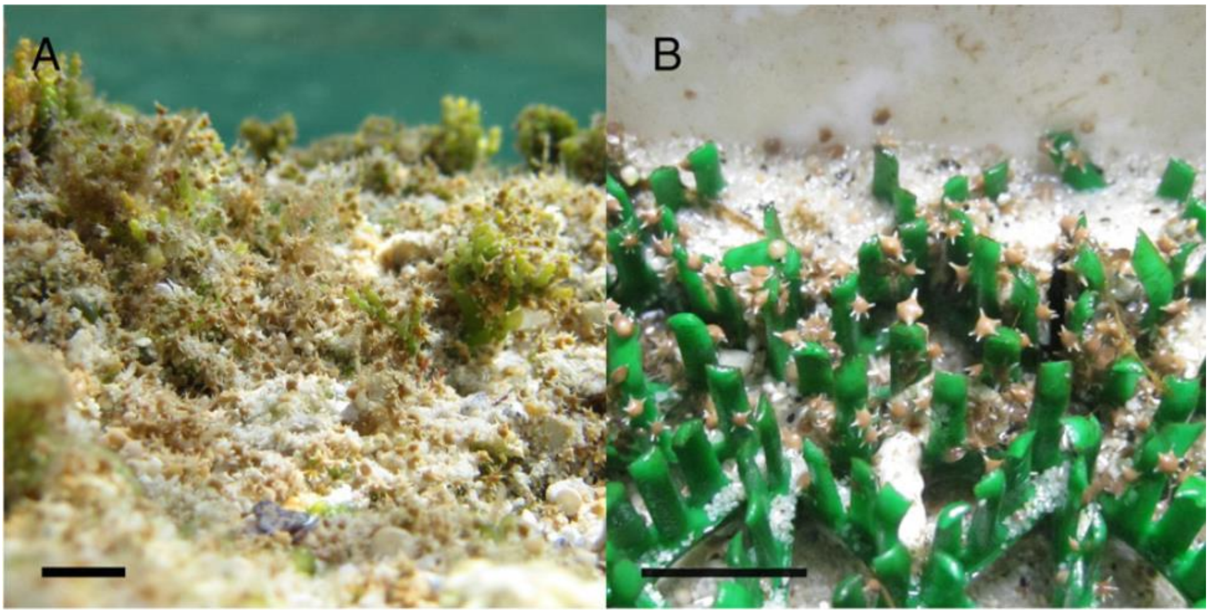

Figure 3.2: Photos of foraminifera in (A) natural habitat and (B) experimental culture tank, the black bar is approximately 1cm for scale (Source: Hosono et al., 2014)

Beach nourishment with self-produced coral gravel and sand was implemented on Fongafale as the first trial of an eco-friendly type of coastal conservation measure in the South Pacific region in 2016 (Onaka, et al., 2017). Using self-produced materials in Tuvalu is highly innovative and addresses the lack of availability of common construction materials like armour rock and concrete (Onaka, et al., 2017). After a year of monitoring the site, results showed that the executed beach nourishment can maintain stability under seasonal and extreme condition of wave actions.

During WWII large holes (borrow pits) were excavated in several areas in Funafuti to source material for reclaiming land to construct the runway. These borrow pits were effectively ponds, restricting land availability and increasing risk of water-borne and mosquito diseases such as dengue. The Tuvalu Borrow Pits project successfully dredged locally available carbonate sands from the lagoon and infilled the borrow pits. This raised land levels to provide additional land and increased resilience against climate change as shown in Figure 3.3.

Figure 3.3: Tuvalu Borrows Pits project before and after photos (Source: Ollivier, n.d.)

In 2017, the Tuvalu Coastal Adaptation Project (TCAP) implemented by the Government of Tuvalu (GoT) and United Nations Development Programme (UNDP) was launched (TCAP, 2018). This project aims to strengthen coastal protection on three target atolls of Tuvalu, including Funafuti. The project collected high resolution topographic and bathymetric 'light detection and ranging' (LiDAR) data for all nine islands in Tuvalu. This is a valuable dataset for multiple uses including modelling coastal hazards, planning, and designing adaptation measures. In Funafuti the project plans to reclaim 7.8 ha of land on the lagoon shore utilising locally sourced sediment from the lagoon to create new land at elevations relatively resilient to the impacts of climate change and coastal as shown in Figure 3.4. There is significant potential to incorporate this project into the proposed Geopark, such as erecting informative signage related to climate change adaptation on the reclamation and constructing a visitors' centre.

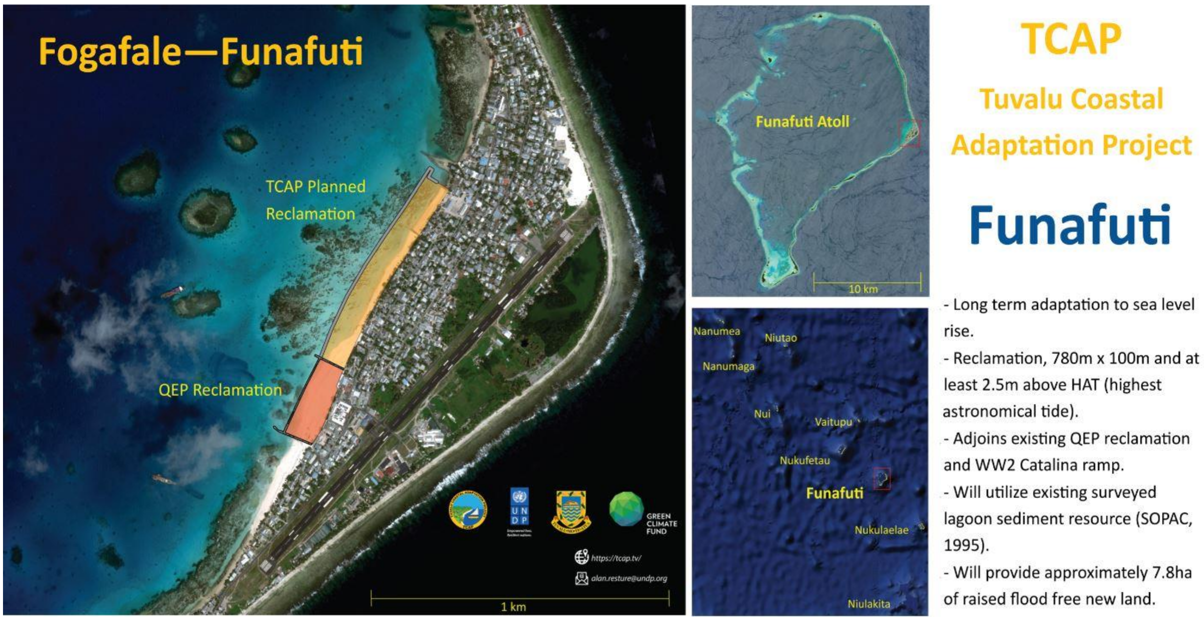

Figure 3.4: TCAP Reclamation in Funafuti (Source: TCAP, 2018)

Looking at adaptation solutions for water security in Tuvalu, the *Second National Communication of Tuvalu* by GoT (2015) lists the following measures that focus on both supply and demand for water:

- Improve water quality testing programs and sanitary practices for water management
- Carry out a complete national inventory and risk assessment of water resources
- Improve quality of current water resources
- Introduce water-saving devices
- Develop a watershed management strategy
- Include traditional practices for water conservation and management
- Using TEK to inform agricultural practices
- Proper land use planning and zoning
- Better disaster mitigation strategies – including the mapping of floodplains and other hazards
- Integration of climate change considerations into the day-to-day management of all sectors

Likewise, reverse osmosis desalination plants are already set up in Funafuti, this source was initially intended for emergency use but now serves as the main water supply on the atoll. However, it is an expensive method of acquiring freshwater, so GoT is exploring more cost-effective methods to gradually reduce the dependence on desalinated water supply (Government of Tuvalu, 2015). Communal water cisterns have also been built and are managed by the Falekaupule, churches and GoT (FCG ANZDEC Ltd, 2020).

Furthermore, the significance of TEK for weather forecasting and traditional mitigation and adaptation approaches to climate change have been highlighted by Dr. Lagi in a project documenting Tuvalu's traditional weather indicators (USP, 2020). An example of this knowledge includes the sighting of whales, dolphins and manta rays near the coast indicates strong winds and bad weather conditions (USP, 2020). When such indicators are observed, Tuvaluans would prepare by using traditional shelters of coconut leaves around the house and burying root crops to be consumed during and after the adverse weather conditions (USP, 2020). While such knowledge has proved to be successful in safeguarding local communities during disastrous events, priority has shifted towards modern knowledge endangering the survival of this invaluable resource (USP, 2020). The proposed Geopark provides a platform to safeguard and raise awareness of TEK, indigenous practices and management systems.

As for establishing protected areas as an adaptation measure, the Funafuti Conservation Area (FCA) was set up as part of a conservation project in 1996 in response to increased fishing pressure and threats of deteriorating environmental quality in Funafuti lagoon (Berdach, 2003; Fisk, 2007). As shown in Figure 3.5, the FCA covers about 33 sq. km of reef, lagoon, and islets on the western side of Funafuti Atoll (Fisk, 2007; SPREP, 2016), and contributes significantly to the area's high fish biomass (Berdach, 2003). The islets in this area are also nesting sites for the endangered green sea turtle (*Chelonia mydas*) (Berdach, 2003). The FCA has already been declared in the national legal framework (Fisk, 2007) and provides significant scope for collaboration with the proposed Geopark.

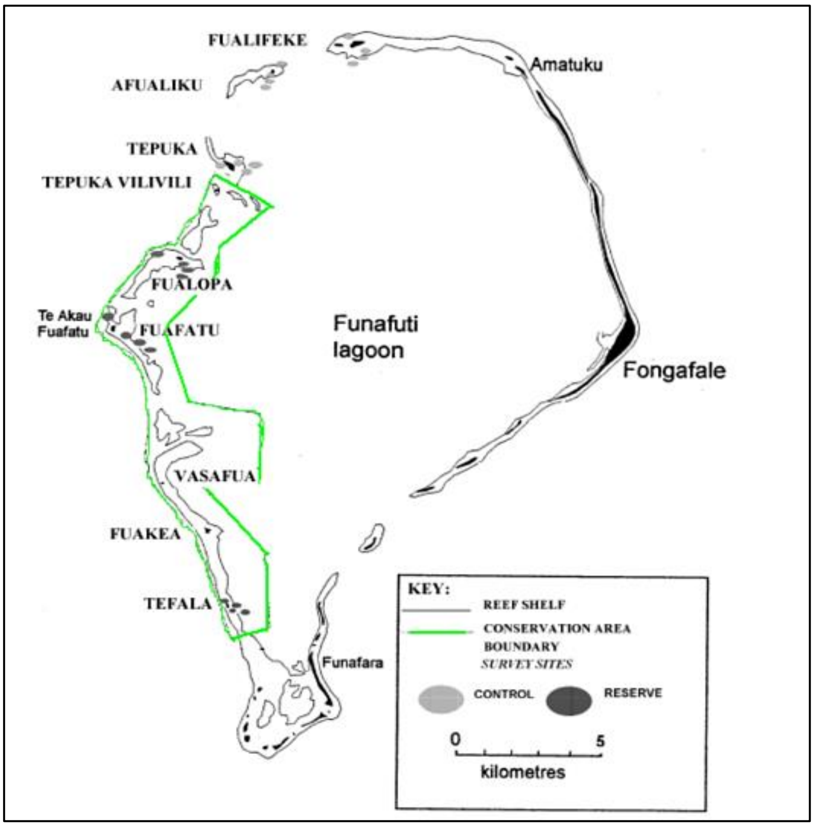

Figure 3.5: Funafuti Conservation Area (Source: Fisk, 2007)

3.7 Other Natural Hazards

3.7.1 Earthquakes

In 2010, a probabilistic seismic hazard model was developed for the South Pacific region (Rong, Mahdyiar, Shen-Tu, Shabestari, & Guin, 2010). Tuvalu had the lowest seismic hazard of the seven Pacific Island Countries (PIC) assessed in the model due to its position in the mid-Pacific plate away from the boundaries of the Pacific Ring of Fire (Rong, Mahdyiar, Shen-Tu, Shabestari, & Guin, 2010; FCG ANZDEC Ltd, 2020). According to the Global Facility for Disaster Risk Management, Tuvalu is classified as very low risk with a less than 2% chance of a potentially damaging earthquake in the next 50 years (FCG ANZDEC Ltd, 2020). Based on this information, the impact of an earthquake is not necessary in the design phases of this project. The relatively low risk of earthquakes in Tuvalu could be highlighted in the Funafuti Geopark as part of the cross cutting 'Pacific Ring of Fire' theme across a network on Pacific Geoparks.

3.7.2 Landslides

According to the web-based tool *ThinkHazard!* developed by Global Facility for Disaster Reduction and Recovery (GFDRR), there is also a very low susceptibility of landslides occurring in Tuvalu (GFDRR, 2020). With the existing rainfall patterns, terrain slope, geology, soil, land cover and earthquakes that make localised landslides are a rare hazard phenomenon (GFDRR, 2020). While climate change is likely to alter slope and bedrock stability through changes in precipitation and temperature, it is difficult to determine future occurrences of landslides as these depend on local geological conditions and other non-climatic factors (GFDRR, 2020).

However, in the past Tuvalu has experienced submarine landslides during atoll formation which have substantially influenced the modern shape of Funafuti, as discussed above in section '2.2 Island Formation' (Terry & Goff, 2012). The presence of these historic landslide scarps and their influence on the shape of Funafuti could be incorporated into the Geopark.

3.7.3 Tsunami

Tsunamis are long period waves generated by disturbance in the water column and may be caused by tectonic movement, underwater landslides, volcanic eruptions, or meteor impacts (FCG ANZDEC Ltd, 2020). An assessment in 2009 indicated that Tuvalu has the third lowest tsunami hazard of the PICs evaluated, with a maximum tsunami amplitude of 1.6m for a 2000-year return period (the highest is 5.2m for PNG, and the lowest is 1m for Nauru) (FCG ANZDEC Ltd, 2020). The assessment found that the major source of tsunami hazard in Tuvalu is the New Hebrides trench, with some contribution from the Tonga subduction zone. Most of the energy originating from a tsunami on the New Hebrides trench is likely to be directed towards the southern islands of the archipelago due to the orientation of the trench (FCG ANZDEC Ltd, 2020). Besides subduction zones, submarine landslides also provide a mechanism for identifying a vast number of potential tsunamigenic sources, which is critical for advancing modern understanding of tsunami hazards in oceanic environments (Terry & Goff, 2012). The varying tsunami risk across the Pacific region (and site-specific risk) could be highlighted as part of the cross cutting 'Pacific Ring of Fire' theme across a network on Pacific Geoparks, contributing to awareness and community resilience.

4 Biology

4.1 Marine Biology

Funafuti's local geology is strongly linked with its marine biology. Funafuti's landmass is almost entirely composed of the skeletons of marine organisms such as coral, shells, and foraminifera. Marine biology continues to play an important role in terms of sediment generation, contributing to the construction processes of coastal areas, as well as determining the distribution and diversity of species in an area. The Geopark has potential educate people and help to conserve certain ecosystems which play particularly important roles in sediment generation. Production of sediments by marine organisms is complex and interesting (for example parrot fish eating coral and producing coral sand), with great potential for education as part of a Geopark.

Tuvalu's marine biodiversity has previously been documented in comprehensive studies by Fisk (2007), Job and Ceccarelli (2012), and Thaman (2016). According to their reports, Tuvalu's marine environment comprises of five main ecological zones based on depth and location in relation to the atoll, including mangroves, intertidal flats, subtidal lagoon areas, subtidal oceanside reefs, and open waters (Thaman, et al., 2016). Within these ecological zones are other habitat types, such as agal flats, coral reefs, channels, soft sand and hard substrates, and seamounts, each with their own characteristic communities of phytoplankton, zooplankton, seaweeds, corals, molluscs, crustaceans, other marine invertebrates, finfish fauna, sea turtles and sea birds (Thaman, et al., 2016). This biodiversity is essential in terms of food, revenue, culture, and environmental security for Tuvaluan communities (Thaman, et al., 2016).

On Funafuti, there is a greater variety of marine species compared to outer atolls due to the larger size of the area being able to cater for more complex habitats (Job & Ceccarelli, 2012), as illustrated below in Figure 4.0. At least 1,276 species have been recorded within Tuvalu's marine systems, with 203 classified as *endangered*, *vulnerable*, and *near threatened* on the IUCN Red List (Pagad, 2019). Finfish fauna (sharks and rays) in particular, have been identified as being in need for some degree of protection (Job & Ceccarelli, 2012). Figure 4.0 highlights places of marine conservation interest in Funafuti. Incorporating well-enforced conservation sites such as FCA into the Geopark, will promote the safeguard of Tuvalu's diverse marine biology (Fisk, 2007; Job & Ceccarelli, 2012).

Therefore, the Geopark has significant potential to incorporate marine biology. Signage, tours, and educational programs can highlight the critical links between marine biology and geology in Funafuti. Certain areas could be protected and developed as snorkel or diving attractions, including education of how the habitats are linked to geological history such as coral pinnacles in the lagoon being related to the remnant weathering profile during the last ice age. Therefore, the Geopark has potential to help marine conservation efforts via both direct protection, and education. Further mapping of existing and potential snorkel/dive sites is highly recommended.

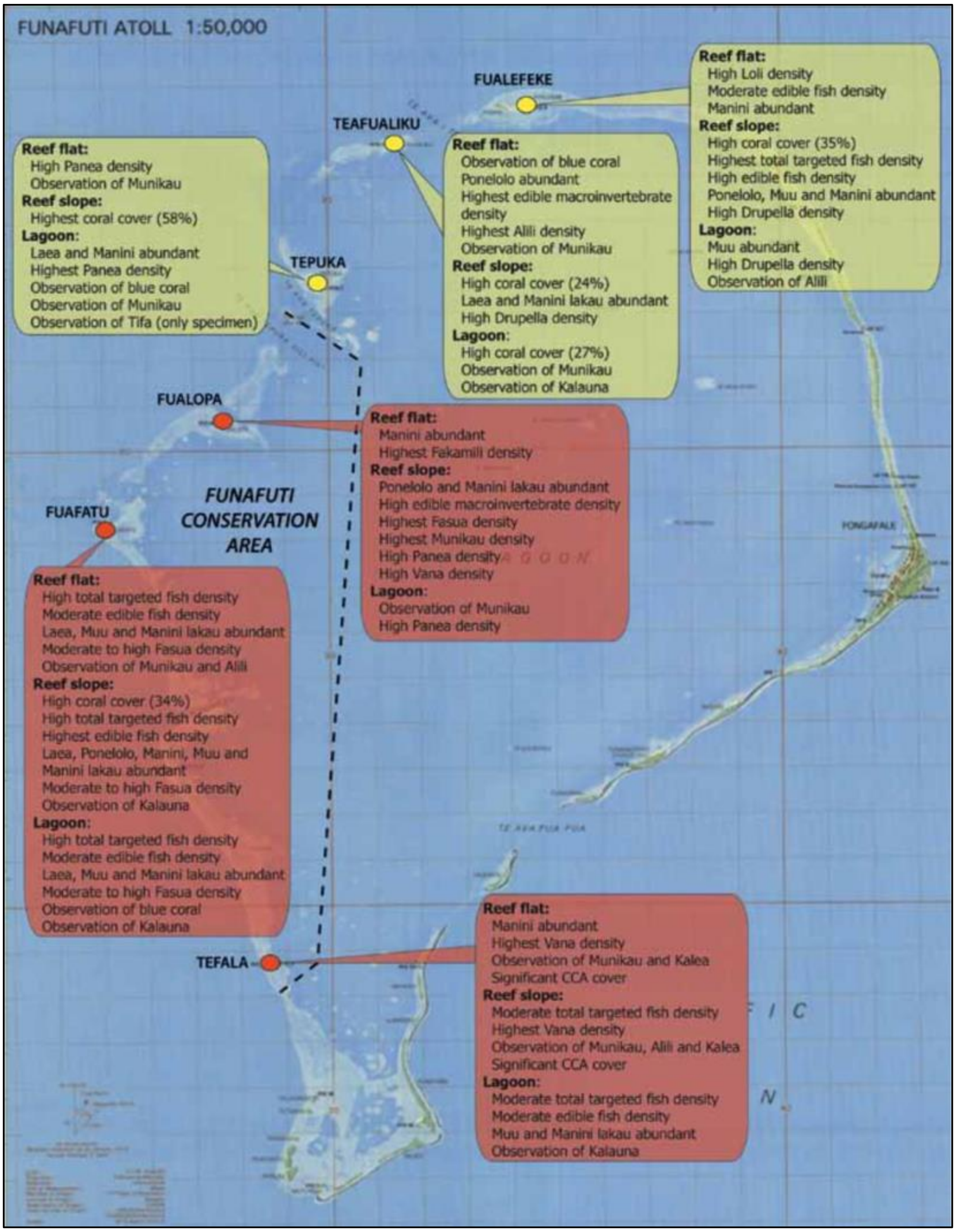

Figure 4.0: Points of marine conservation interest in Funafuti lagoon (Source: Job & Ceccarelli, 2012)

4.2 Terrestrial Flora & Fauna

Tuvalu's *Fifth National Report to the Convention on Biological Diversity* by Thaman, et al. (2016) provides descriptive documentation on the atoll's terrestrial flora and fauna. Unlike the marine biology, Tuvalu's terrestrial flora is less diverse, greatly disturbed, and dominated by introduced exotic species (Thaman, et al., 2016). This was influenced by the removal of indigenous vegetation to make space for human induced development, together with the deliberate and accidental introduction of exotic plants, some of which are invasive alien species (IAS) while others have become culturally significant (Thaman, et al., 2016). The total number of terrestrial plants recorded on Funafuti is about

356 species, only 16% of which are indigenous (Thaman, et al., 2016). The low abundance of indigenous species is an indication of the lack of habitat diversity on atoll islands compared to higher islands, as well as the difficulty of long-term survival in existing harsh environmental conditions (Thaman, et al., 2016).

Similarly for the terrestrial fauna, there are no indigenous land mammals, amphibians, or freshwater fishes occurring in Tuvalu. However, there are 28 species of indigenous birds and other terrestrial invertebrates including land crabs (e.g., coconut crab) and snails. There is only one record of an endemic vertebrate, i.e., the Tuvalu forest gecko (*Lepidodactylus tepukapili*), which can be found on Tepuka Islet in Funafuti (Thaman, et al., 2016).

Besides the coconut crabs and endemic forest gecko, Tuvalu's terrestrial biology suggests limited opportunities for this project. In terms of the cultural element of the Geopark there is scope to showcase how traditional flora and fauna is utilised in Tuvaluan culture, such as cuisine, building materials, traditional fishing practices, and handicraft. It is suggested that fieldwork explore the possibility of incorporating terrestrial flora and fauna into the proposed geopark.

4.3 Invasive Alien Species (IAS)

Over 200 species have been intentionally introduced into Tuvalu for ornamental use, landscaping, and as a food resource (Thaman, et al., 2016). In the instance of landscaping, alien plant seeds were introduced as soil contaminants during the movement of soil from Fiji for development purposes (Pagad, 2019). IAS pose serious problems to the environment in Tuvalu, including threats on the survival of bird species, habitat degradation caused by mammal predators, and the decline of Micronesian skink and coconut crab populations by yellow crazy ants (Pagad, 2019).

Additionally, two well-known IAS threats documented for the marine areas of Funafuti include the occurrence of algal blooms and the Cryptogenic Crown-of-Thorns (COT) starfish (*Acanthaster planci*) (Pagad, 2019). These IAS endanger the productivity and survival of significant coral reefs in the area.

With the heavy influence of introduced exotic species in Tuvalu, there has been IAS management actions put in place focusing on the prevention of the spread and control of existing IAS populations (specifically the yellow crazy ant) (Pagad, 2019).

IAS are highlighted here as they are an important consideration in terms of Geopark management. For example, it would be important to have operational procedures in place to prevent the introduction of IAS to any outer islets of Funafuti which may be part of the prospective geopark. IAS could also potentially be incorporated into the educational aspect of the geopark.

5 Social Setting

This section aims to provide baseline data on the social setting of Funafuti. Topics will include education, culture, traditional knowledge, women, and youth which are part of the top 10 focus areas for establishing UNESCO Global Geoparks (UGGp).

5.1 Demographics

Funafuti's population has increased significantly over the years (FCG ANZDEC Ltd, 2020). The highest proportion change (during 1979-1991) was due to Tuvalu becoming independent from the UK administered Gilbert and Ellice Islands colony in 1978 (FCG ANZDEC Ltd, 2020; Macdonald, 2021). At this time people moved back to settle in Funafuti, where essential infrastructure (e.g., hospital, airport, deep water anchorage) existed and housing was being developed (FCG ANZDEC Ltd, 2020).

In the mini-consensus report prepared in 2017 by GoT, the following trends were observed:

- Total enumeration for Tuvalu was 10,645 people, 6,320 of whom reside on Funafuti.
- Funafuti's resident population increased from 1,941 to 2,257 people per sq. km between 2012 and 2017.
- Funafuti gained its share of resident population from 47% in 2002 to 60.2% in 2017, while the outer islands experienced a loss from 53.4% to 39.8% in the same period.
- The sex proportions of Tuvalu's population in 2017 was 51% for males and 49% for females.
- 57% of the population 15 years and over were recorded to be married.

The wide base of the population pyramid in Figure 5.0 indicates that the Tuvalu population is relatively young, with 32% under the age of fifteen years old (Anderson, Barnes, Raoof, & Hamilton, 2017). A distinct feature of the pyramid is the indent of age groups between 30 to 54 years which is a clear sign of out-migration for the working age groups (Government of Tuvalu , 2017). Prior to 2003, Tuvalu nationals could travel to New Zealand without an entry visa, and this contributed considerably to the indent feature on the population pyramid (Government of Tuvalu; UNDP , 2011).

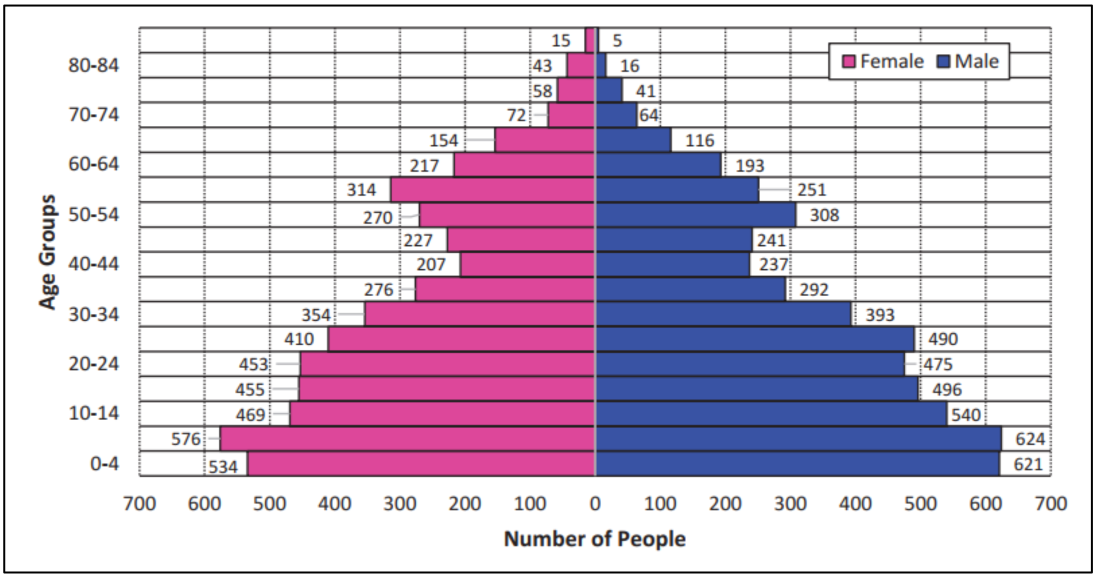

Figure 5.0: Age-sex structure of resident population in Tuvalu, 2017 (Source: Government of Tuvalu, 2017)

In terms of religion, the Ekalesia Kelisiano Tuvalu (EKT) is the main denomination in Tuvalu, made up of 86% of the population (Government of Tuvalu , 2017). The population of Tuvalu is ethnically Polynesian and is very homogenous with 97% being of Tuvaluan descent. The other 3% being dived among 3 ethnic groups – Tuvaluan/I-Kiribati, Tuvaluan/other, and other ethnicities (Government of Tuvalu , 2017).

5.2 History

The vibrant history of Tuvalu began with the first settlers arriving from Samoa, possibly by way of Tokelau, while others came from Tonga and Uvea about two thousand years ago (Faaniu, et al., 1983). As a result, the local language is a Polynesian tongue closely related to that spoken in Samoa (Government of Tuvalu; UNDP , 2011). The nation was formerly known as the Ellice Islands while under Great Britains control in the late 19th century, then became officially known as Tuvalu during independence on October 1st, 1978 (Macdonald, 2021). The name 'Tuvalu' originated from the term 'Cluster of Eight' as only eight out of the nine islands were inhabited by the 18th century (Faaniu, et al., 1983; Macdonald, 2021). The ninth island, Niulakita, is the smallest and southernmost atoll that was uninhabited until European contact.

In the context of this project, an important historical event to mention is WWII. Tuvalu was a strategic location during WWII due to its geopgraphical location, which is ultimately a result of the geological history of the Pacific region. The U.S. forces were based on Funafuti during the war (1943-1945) and substantial changes were made to the island's geomorpholgy (Macdonald, 2021), as discussed in earlier sections of this report and shown in Figure 5.1 below. The Geological Map(s) produced by the Coral Reef Expidition 1896-1898 provide a useful baseline for comparing changes made to Fongafale, as shown in Figure 5.2. The structures that were built have since been repurposed to suit the everyday lives of Tuvaluans. For instance, the airstrip on Fongafale was developed into a commercial airport and due to limited space on the atoll it also provides an alternative space for social interaction, sports, and entertainment by local communites when there are no flights (Weisskopf, 2013). The control tower that was built stands where the Seven Day Adventist Church is now, and the cable that connected the radio station on Tepuka islet to the airfield has been dismantled by local fishermen who used it as sinkers for fishing lines and nets (Faaniu, et al., 1983). A well-preserved underground bunker can also be found on the islet of Tepuka (Timeless Tuvalu, n.d.).

WWII history could form an important component of the proposed Geopark. Infrastructure and artifacts from the war could potentially make interesting sites for the proposed geopark, including the potential for submarine dive sites. Details of how WWII altered the overall layout and functionality of Funafuti could be highlighted on informative signs and tours. The Geopark could also showcase the tectonic sectting and broader geology of the Pacific region, and how this gave rise to the strategic importance of Tuvalu during WWII.

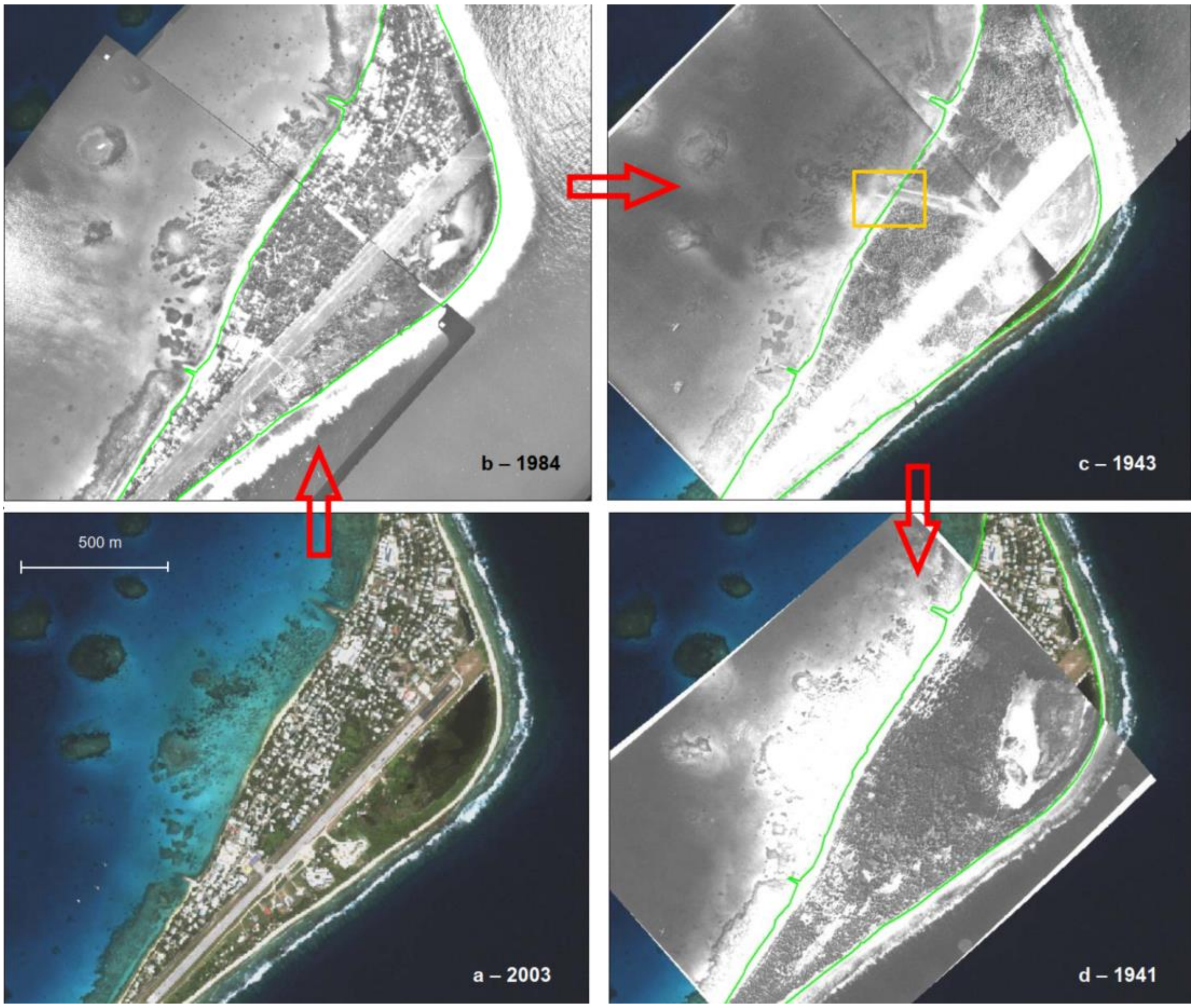

Figure 5.1: Historical imagery highlighting modification of modifications made to the central part of Fongafale islet during WWII, particularly construction of the runway (Source: Webb, 2006)

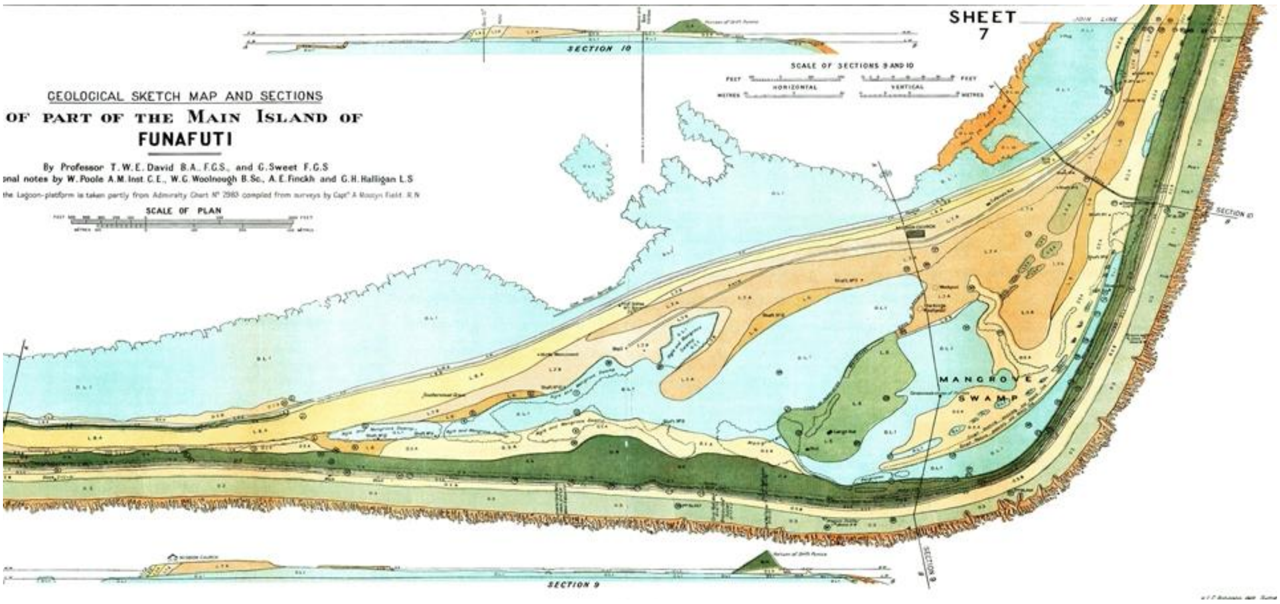

Figure 5.2: Geological map of Fongafale mapped during the 1896-1898 Coral Reef Expedition. This is a useful baseline to identify the significant geomorphological changes made to the area (Source: Edgeworth & Sweet, 1898)

5.3 Cultural Heritage and Traditional Knowledge

An objective of UGGp's is to celebrate the relationship between the Earth and indigenous communities. This relationship reflects how Earth's diverse geology has played a major role in influencing where in the world communities settle, thereby shaping their fundamental cultural heritage. Cultural heritage refers to the inherited physical artifacts and intangible attributes of a society that have been passed down from generation to generation (Nemani, 2012).

In Tuvalu, each of its atolls consist of its own distinct identity, dialect, and in one case language, due to several islands being settled at different times and by different communities (Stratford, Farbotko, & Lazrus, 2013). According to the *Tuvalu National Culture Policy Strategic Plan (2018-2024)*, Tuvalu aims to build its national system for safeguarding, protecting, and transmitting its cultural heritage with the involvement of local communities and other relevant stakeholders (Government of Tuvalu, 2018). The Culture Division have already conducted cultural awareness activities among communities, schools, and outer islands (Government of Tuvalu, 2018). In this section, Tuvalu's tangible and intangible cultural heritage are briefly reviewed.

Tangible cultural heritage (TCH) refers to physical heritage such as buildings, historic places, monuments, books, documents, and artifacts that are considered worthy of preservation for the future and are significant to the archaeology, architecture, science, and technology of a specific culture (Nemani, 2012).

In Tuvalu, several archaeological sites have been identified on the outer island of Vaitupu (Government of Tuvalu, 2018). There is also a possibility for Underwater Cultural Heritage (UCH) in the form of shipwrecks, sacred sites linked to its local communities, and underwater cultural landscapes (Government of Tuvalu, 2018). Moreover, the maneapa (island meeting halls) have served as an area for traditional teachings, community meetings, showing fatele (traditional dance), and displaying handicrafts (Government of Tuvalu, 2018). Tuvaluan communities are engaged in the creation of cultural handicrafts, such as mats, baskets, fans, shell necklaces, and costumes for traditional performances, which are made mostly from natural materials. The Tuvalu National Council for Women (TNCW) is the focal point for the promotion of these handicrafts (Government of Tuvalu, 2018). Likewise, the National Archive and Library of Tuvalu (located in Funafuti) safeguards documentary heritage and the Tuvalu Language Board is working on the production of a Tuvalu Dictionary (Government of Tuvalu, 2018).

Intangible cultural heritage (ICH) are the practices, representations, expressions, knowledge, and skills that communities recognize as part of their cultural heritage (UNESCO , 2003). These include oral traditions, performing arts, social practices, rituals, festive events, traditional craftmanship, knowledge and skills concerning nature (Nemani, 2012).

Tuvalu has a particularly rich ICH, with examples such as fatele, alofa (presentation of performing arts and gifts to visitors at the end of welcoming events), closed knowledge systems, traditional craftmanship (mat weaving, canoe making, shell necklace making), fishing skills, and traditional farming methods (pulaka pits) (Government of Tuvalu, 2018). In terms of festive events, each Tuvaluan community has its own annual day of feasting and faatele – a celebratory collective activity involving a combination of costume, song, dance, and percussion performed as a competition between villages which has been taking place since the pre-colonial period (Stratford, Farbotko, & Lazrus, 2013).

Tuvalu has a vast amount of traditional knowledge which has served and continues to serve as an important source of wisdom. For example traditional weather indicators are used by elders to forecast weather, plan daily activities, and have helped to save lives. Traditional knowledge is typically transferred between genrations via word-of-mouth. A Geopark provides a platform for Tuvalu to conserve traditional knowledge in different forms of media such a signs, educational programs, and tours. The research aspect of a geopark also has potential to intergrate and elevate the importance of traditional knowledge in the broader scientific community.

Additionally, there are various myths and legends that describe the creation and settlement of Tuvalu's islands, including the story of *te Pusi mo te Ali* (the Eel and the Flounder) where te Ali is believed to have formed the foundation of the flat atolls of Tuvalu (Faaniu, et al., 1983). Another legend describes how the current boundaries between each piece of land on Funafuti was created by a man called Levolo (Faaniu, et al., 1983). These stories and others are described in the publication by Faaniu, et al. (1983). This book is incredibly useful for understanding the history and culture of Tuvalu as it discusses past events and traditions specific to each of the nine islands in detail and was written by Tuvaluans interpreting their own history as they themselves have experienced it.

Moreover, Falekaupule is Tuvalus's local council system made up of councils (Kaupule) from each island. These councils maintain an important socio-cultural function for traditional governance and teaching (Government of Tuvalu, 2018), and are responsible for the safeguarding and protection of Tuvaluan culture (UNESCO, 2017). Falekaupule also plays a major role in managing the finances and maintenance of local services such as health and educaiton (Government of Tuvalu; UNDP , 2011).

With the escalating social impacts of climate change, it would be beneficial for Tuvalu to increase the implementation of programmes that focus on safeguarding their rich cultural heritage. It is also highly recommended that further documentation is made on the existing TCH (for example, archaeological sites and UCH) and ICH on Funafuti to expand the diversity of site options for the proposed geopark.

Culture is a key focus area of UGGp's, therefore the proposed Funafuti Geopark provides significant scope for the inclusion of Tuvalu's rich cultural heritage. Specifics of how the Geopark could best incorporate cultural heritage would be subject to mapping, creative thinking, and consultations, led and driven at the community level, respecting cultural sensitives. Therefore, it is inappropriate for the authors of this report to specify recommendations, however the following are general ideas to help stimulate further consideration at the community level:

- Signs documenting traditional culture such as legends of island formation and history.
- Establishment of a 'traditional village' (outdoor museum) to demonstrate Tuvaluan way of life prior to European influence, such as traditional houses, rainwater harvesting system (see Figure 5.3), agriculture, fishing etc. For example, on an islet which could be accessed for day tours, perhaps via traditional canoe.
- Education programs for Tuvalu youth.
- Cultural performances such as dance and music.
- Promotion of traditional handicraft such as the Women's Handicraft Centre.

Therefore, a Geopark has potential to form an important platform for conserving of Tuvalu culture and traditional knowledge. The local education dimension of a Geopark could facilitate intergenerational knowledge transfer to Tuvaluan youth. The tourism dimension of a Geopark could raise the awareness of Tuvaluan culture, history, and traditional knowledge on the international stage. The research dimension of a Geopark could elevate the importance and wisdom of traditional knowledge, and support integration with relevant scientific disciplines.

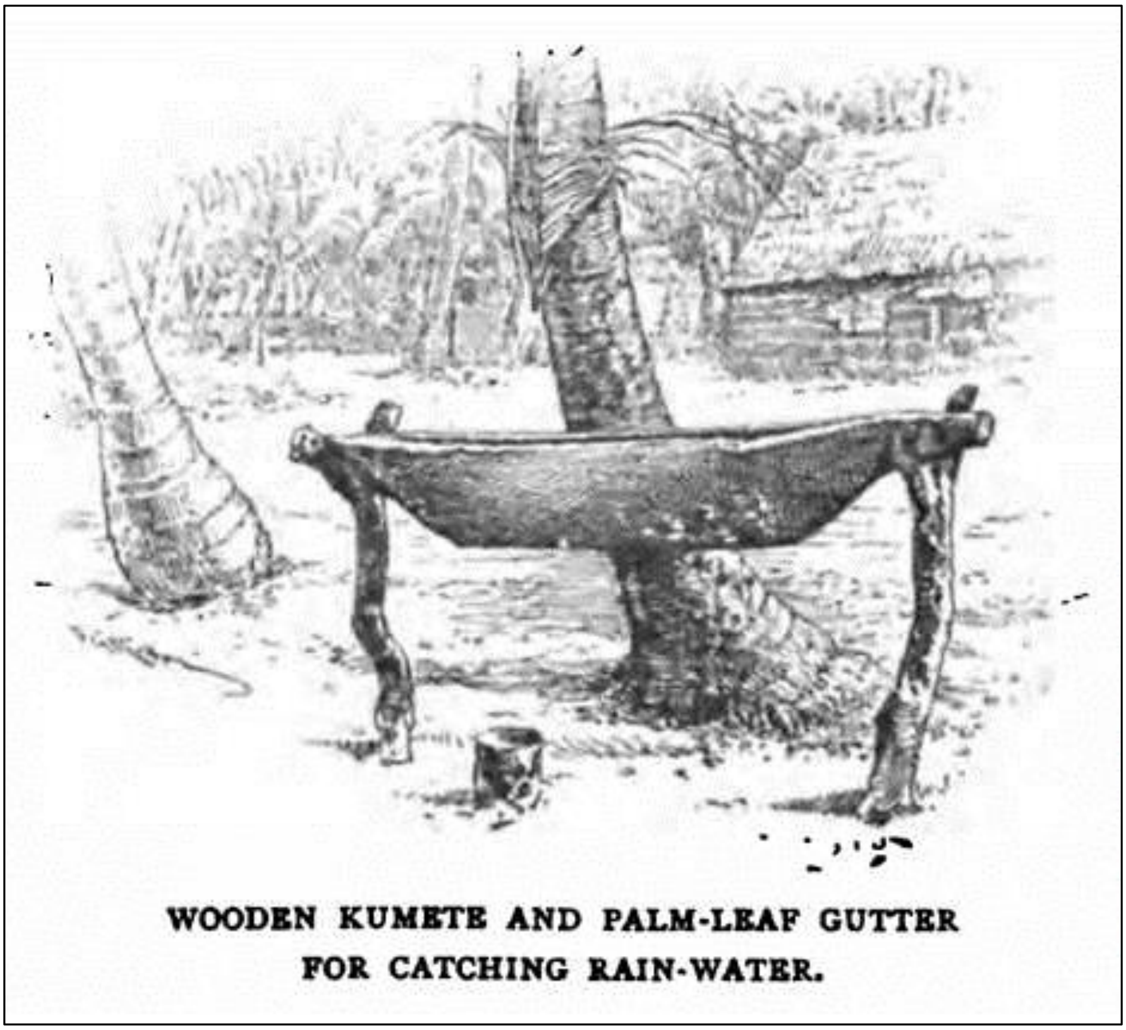

Figure 5.3: Sketch of a wooden Kumete and palm-leaf gutter traditional rainwater harvesting system; from the 1899 book 'Funafuti or Three months on a coral Island: An Unscientific Account of a Scientific Expedition' written by Caroline Martha David (Professor Edgeworth David's wife) during the Coral Reef Expedition (Source: David C. M., 1899)

5.4 Education

The GoT has prioritized education to enable its citizens to progress their knowledge and skills to a regional and/or international standard (FCG ANZDEC Ltd, 2020). Tuvalu's education sector uses the largest share of its national budget (18.4% in 2019) (The World Bank, 2020) to improve access to quality education by providing scholarship schemes and free education to those in primary and secondary levels (Brinkman, Sincovich, & Vu, 2017). Compared to the rest of the archipelago, Funafuti has the highest teacher-pupil ratio (1:27) and average student attendance (95%) (FCG ANZDEC Ltd, 2020). The atoll island also hosts one of Tuvalu's two secondary schools operated by the EKT Church, and the University of the South Pacific (USP) which is the only regional institute for tertiary education accessible and available to the public (FCG ANZDEC Ltd, 2020). Additionally, Tuvalu has strived to maintain and develop seafaring opportunities by setting up the Tuvalu Maritime Training Institute (TMTI) on Amatuku – an islet to the northwest of Fongafale. (FCG ANZDEC Ltd, 2020)

Cross cutting themes addressed by *Tuvalu's National Curriculum Policy Framework* includes language and culture, students with special needs, inclusive education, gender and equity, information and communication technologies, and education for sustainable development (Government of Tuvalu , 2013). These themes can provide opportunities for learning systems to integrate educational awareness on Tuvalu's geological heritage and its links to other aspects of their natural, cultural, and intangible heritages.

Education is a key focus area of UNESCO Global Geoparks. A Geopark in Funafuti could form the basis of an 'outdoor classroom' or 'natural museum' for students, members of the public, and tourists to engage in a variety of learning experiences. This could include learning experiences in a range of areas such as geology, climate change, coastal hazards, culture, indigenous knowledge, history, and marine biology. University students and researchers are a potential target market for Geopark visitors. This highlights the possibility of establishing an "atoll" or "climate change" research centre in Funafuti.

5.5 Women & Youth

There has been a recent shift in the roles of women in the Tuvaluan community. Spaces have been created that allow women to progress and partake in economic empowerment activities, for example women are now employed as lawyers, magistrates, patrol boat pilots, and carpenters (Ewekia, 2020). Tuvaluan women are also largely known for leading community fundraising drives. Funafuti has two women's associations (i.e., TNCW and Malosiga) which supports community development, women's political participation, women's handicrafts, legal literacy, and trainings on gender-based violence (FCG ANZDEC Ltd, 2020). Members of these associations also implement decisions made by the Falekaupule that concern women's roles and division of labour in society (FCG ANZDEC Ltd, 2020). On the outer islands, Kaupules are becoming increasingly progressive as women clan heads can now be a part of formal meetings (Ewekia, 2020).

Despite these positive developments, there are still opportunities to enhance equality and women's empowerment in Tuvalu. This can be achieved by raising awareness on gender issues, integrating women and their concerns into policymaking, and creating educational opportunities for women in all development areas (Kofe & Taomia, 2006). Geoparks emphasise women's empowerment whether through focussed education programmes or development of women's enterprises (as outlined by UGGp requirements), therefore the prospective Geopark has potential to support women's empowerment such as increased opportunities for the Tuvalu Women's Handicraft Centre.

Additionally, as discussed in section '5.4 Education' the GoT has invested heavily in their youths by improving access to quality education. This will allow youths (15 to 35 years old) to advance their knowledge and skills and apply them to support development in Tuvalu (UNESCO, 2017). The motive for this incentive is to build the capacity of Tuvalu's young population so that they can lead the country in creating solutions that address the impacts of climate change on their island (Taishi & Smith, 2018). Hence, involving youth groups in the planning and implementation of the proposed geopark is essential for long-term success.

6 Potential Geosites

UGGp's are defined as *single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education, and sustainable development* (UNESCO , 2017). Geosites are specific focus areas located within a broader geopark boundary, forming a network of sites for visitors and local communities to tour, admire and explore.

There are currently no UGGp in the Pacific, and no atoll UGGp's globally despite the fact that atolls are unique geological features with a rich scientific history. Additionally, the proposed Funafuti Geopark has linkages to all UGGp top ten focus areas, with particularly strong links to climate change. Therefore, the proposed Funafuti Geopark has several distinctive features.

Throughout this report there have been numerous suggestions for potential Geosites. A preliminary list of potential Geosites is presented below. It is important to note that this is a preliminary list, and we strongly recommend further investigations and consideration of additional Geosites:

1. **<u>Darwin's Drill site</u>**: as mentioned in section '2.2 Island Formation', this is where the Royal Society drilled cores to test Darwin's theory on atoll formation in 1896 -1898. This is a significant site in global scientific history which warrants conservation. The site could be upgraded, such as installing signage explaining the sites history, scientific significance and science of atoll formation, the signage should also include traditional legends on island formation.

Figure 6.0: Site of 'Darwin's Drill Site' (Source: Atkinson, 2019)

2. **<u>The 'Narrowest part of Funafuti'</u>** is a site which particularly highlights the risks posed by climate change, sea level rise, and coastal hazards in Tuvalu. This location could be one Geosite in a network of Geosites focusing on the risk and impacts of climate change in Funafuti. This is a sensitive area requiring respect and care at the local level; therefore, we do not recommend any other specific sites in this report, and in this regard, we recommend further fieldwork to identify such sites.

Figure 6.1: 'The Narrowest part of Funafuti' (Source: IFRC, 2007)

3. **<u>Climate change mitigation and renewable energy:</u>** signage could be installed at selected renewable energy sites to highlight the science regarding greenhouse gas emissions and climate change. This could focus on highlighting the fact that Tuvalu is a country contributing the least to global greenhouse emissions yet is at the frontline of the impacts of climate change, as well as showcasing Tuvalu's efforts to achieve 100% electricity generation though renewable energy.

Figure 6.2: Solar installations on Tuvalu Government Office roof (Source: solarZero, 2015)

4. **Climate adaptation:** the existing QEP reclamation and proposed TCAP reclamation could be showcased as adaptation efforts to combat the impacts of climate change using locally produced calcium carbonate sediment from the lagoon. There is potential to erect signage and construct a visitors' centre on the reclamation.

Figure 6.3: Fongafale's reclaimed coast (Source: TCAP, 2021)

5. **Fossil beaches** along Funafuti's coast indicate the gradual movement of the shoreline over hundreds of years. This site(s) could be developed with signage explaining the processes which form these features and the dynamic nature of Funafuti's shoreline. Associated signage could include shoreline change analysis highlighting how Funafuti's shoreline has changed over time, and explanation of the drivers of change. Fieldwork is recommended to identify specific locations.

Figure 6.4: Fossil beaches on Funafuti (Source: Webb, 2006)

6. **WWII history**: Multiple sites could be developed to showcase artifacts from WWII, signifying an important period in Tuvalu's (and the worlds) history. Also, various locations highlight the substantial changes made to Funafuti's overall geomorphology and functionality during WWII. Signage could be erected at these locations explaining the history, including the tectonic setting and geological history which gave rise to the strategic importance of Tuvalu during WWII.

Figure 6.5: WWII installation (Source: McLean, D, 2018)

7. **Borrow Pits:** Selected borrow pits sites could showcase the history of WWII when these sites were excavated to source materials for constructing the runway, and subsequent reclamation works to infill the pits, aligned with the climate change adaptation and WWII history themes.

Figure 6.6: Tuvalu Borrows Pits project before and after photos (Source: Ollivier, n.d.)

8. **Funafuti International Airport**: the airfield could be an interesting site in terms of how local communities maximize functional space on the island. It also has historical value in terms of construction during WWII and associated changes to Funafuti's geomorphology such as the borrow pits.

Figure 6.7: Social use of Funafuti's airstrip (Source: Løvschall, 2020)

9. **Dive and snorkel sites** at various locations around Funafuti atoll would create an attractive aspect of the geopark. The sites could showcase the rich marine biology in Funafuti and highlight the fundamental connection between geology and biology. Dive sites could also showcase WWII wrecks if any suitable locations exist. We recommended that fieldwork be carried out to identify suitable sites.

Figure 6.8: Funafuti marine life (Source: Job & Ceccarelli, 2012; Timeless Tuvalu, n.d.)

10. **<u>Funafuti Conservation Area (FCA)</u>**: There is excellent opportunity for collaboration and incorporation of the existing FCA with the Geopark. This area reflects pristine island geomorphology free from human modification, as well as showcasing Funafuti's rich marine biodiversity and offering educational experiences in terms of observing endemic (Tuvalu's forest gecko) and endangered (green sea turtle) species.

Figure 6.9: Funafuti Conservation Area (Source: SPREP, 2016)

11. **<u>Climate change instrumentation:</u>** the climate change instrumentation in Funafuti such as the state-of-the-art tide gauge could be developed as a site(s) with informative signage explaining the data collected and associated science, such as sea level records and projections.

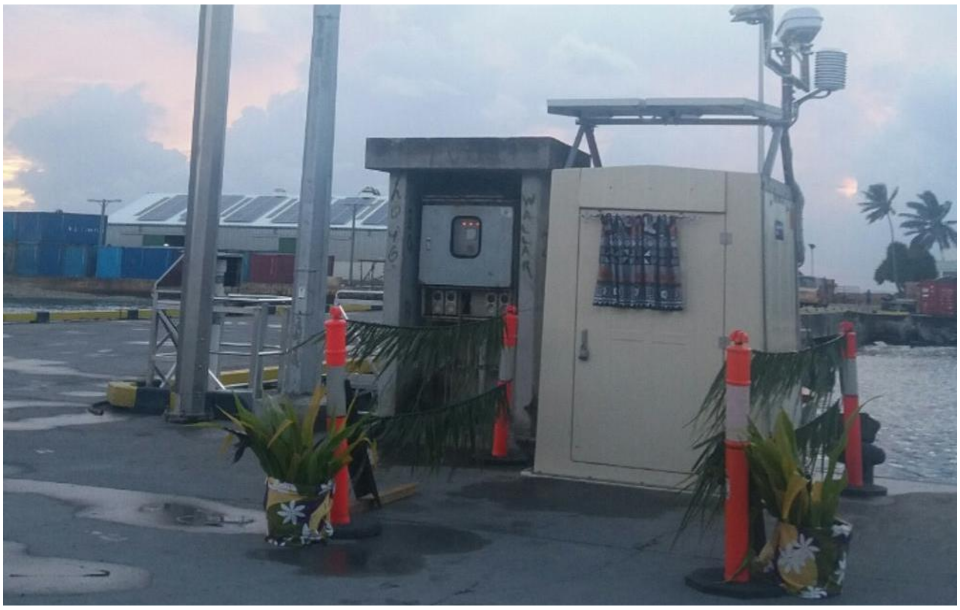

Figure 6.10: Funafuti tide gauge (Source: Mani, 2017)

12. Traditional village/ outdoor museum: a model ‘traditional village’ showcasing and conserving traditional Tuvaluan culture could be established as an ‘outdoor museum’ highlighting how traditional Tuvalu culture thrived in the atoll environment (prior to modern-day influence). This site could perhaps be on a nearby islet where visitors could tour via traditional canoe (note the island on the image below is for illustrative purposes only). There is scope for such a site to incorporate a range of cultural elements such as traditional knowledge, stories, cuisine, dance, and singing. Any cultural elements of the Geopark would require strong leadership from the local community.

Figure 6.11: Canoe and islet (Source: WANTSEE, 2019)

This is a preliminary list of potential Geosites to stimulate further imagination. We strongly recommend further work to identify additional Geosites that reflect the geoheritage, culture, education, sustainable development, sciences, traditional knowledge, and indigenous communities of Tuvalu.

7 Conclusion

In conclusion, the prospect of developing a National Geopark in Funafuti (with the intention to apply for UNESCO Global Geopark status) is a promising strategic opportunity which warrants further investigation.

8 Recommendations

For a Geopark to be successfully developed and managed in Funafuti it would require local leadership in Tuvalu with strong community involvement. SPC, SPTO and UNESCO are available to provide technical support and assistance, however local leadership is critical should Tuvalu wish to pursue a Geopark. The 'Funding with Intent' project has allocated a small amount of funding to financially support subsequent feasibility work implemented by the Government of Tuvalu. In this regard the following is a list of recommend actions to be led locally:

1. Identify relevant local stakeholders and establish a multi-stakeholder steering committee.
2. Conduct fieldwork to ground-truth the prospective Geosites outlined in this report and explore for new Geosites/ ideas for the Geopark.
3. Collect an inventory of cultural heritage and traditional knowledge, with specific focus on links to the prospective Geopark.
4. Conduct community consultations to gather ideas for the Geopark and gauge community support.
5. Consult the existing tourism sector to identify opportunities for collaboration with the Geopark concept and gauge support.
6. Consult education institutions such as schools and USP to gather ideas for the Geopark (particularly opportunities for educational aspects of the Geopark) and gauge support.
7. Identify requirements for infrastructure development such as signs, access paths, visitor centre etc.
8. Assess the legal and policy framework to identify existing protected areas, and legal instruments/processes for protecting new Geosites which aren't already protected.
9. Consider potential management body structures for the Geopark.

This is a preliminary list of recommendations to support further feasibility assessment. SPC is available to support this work remotely, including writing a feasibility report compiling collected data. Should the findings of this subsequent feasibility report yield positive results, SPC, SPTO and UNESCO are available to support with the development of a project proposal and attraction of funding to fully support the development of a Geopark in Funafuti, there may be potential to develop a multi-country proposal subject to findings of similar work in Fiji, Samoa, and Vanuatu.

The UNESCO 'self-evaluation checklist' and 'explanatory notes' attached in the Appendix 1 provide useful guidance for future work, including a framework of questions to consider.

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Appendix 1 – UNESCO self-evaluation checklist and explanatory notes

United Nations Educational, Scientific and Cultural Organization

UNESCO Global Geoparks

Self-Evaluation Checklist for aspiring UNESCO Global Geoparks (aUGGp)

In line with the Guidelines for UNESCO Global Geoparks and following the decision of the UNESCO Global Geoparks Council in its 4th session in Lombok, Indonesia (September 2019) **it** was decided to draft and finalize a checklist for aspiring UNESCO Global Geoparks.

101 questions are a quick self-evaluation checklist based on the quality criteria for UNESCO Global Geopark candidates (aUGGp) set out in the Operational Guidelines for UNESCO Global Geoparks, section 3 (viii).

Please note that the checklist and explanatory notes are intended as a quick and easy dashboard to measure the preparedness of an aspiring site on a regular basis and do not replace the application file and Form A, nor do they need to be submitted with the application file. They are strictly for internal use and do not need to be discussed in the evaluation mission if not wished so.

To complete this checklist you must tick either Yes or No for each question. The predefined traffic-light colour scheme (green/yellow/red) used together with the criteria detailed below will indicate your attainment level to submit/ or not a UGGp application**.**

- **All ticks in green boxes**: indicates that your aUGGp is in good condition to present a candidate file;
- **Up to 15 ticks in yellow boxes**: indicates that your aUGGp presents clear weaknesses with high probability that your candidature will be deferred or rejected;
- **More than 15 ticks in yellow boxes**: indicates that there is a high probability that your candidature will be rejected;
- **Two or more tick(s) in a red boxes**: indicates a breach of the Operational Guidelines for UNESCO Global Geoparks with a certainty of candidature rejection.

An (*) has been added to several questions, indicating that an explanatory note will provide further information, examples and guidance on how the UGGp Council has dealt with these issues in the past.

	Criterion i		
	(i) UNESCO Global Geoparks must be single, unified geographical areas(iA) where sites and landscapes of international geological significance (IB) are managed with a holistic concept of protection (iC), education (iD), research (iE) and sustainable development (iF). A UNESCO Global Geopark must have a clearly defined border(iG), be of adequate size to fulfil its functions and contain geological heritage of international significance(iH)as independently verified by scientific professionals.		
		Yes	**No**
	Unified territory (iA)		
1	Is your aUGGp territory a unified and single area?		
	Boundary (iG)		
2	Has your aUGGp a clearly defined boundary?		
3 (*)	Does your aUGGp boundary correspond to pre-existing limits? (i.e. administrative/state boundaries or protected area, etc.)		
	Adequate size (iH)		
4 (*)	Do you have a significant population living in your aUGGp territory?		
5 (*)	Does your aUGGp territory size provide the necessary conditions for appropriate sustainable development for the local population?		

	International value of the geological heritage (iB)		
6 (*)	Do you have clear evidence that your aUGGp has a geological heritage with an international value?		
7 (*)	Is there comparable geology at another UGGp located within your country? Or those countries you share a border with? **If Yes: Please complete question 8. If No: proceed to question 9.**		
8	If yes, have you carried out an independent geological study demonstrating the geological difference (and complementarity) between your aUGGp and the(se) other territory(ies)?		
	Conservation (iC)		
9	Do you have a aUGGp geological sites database and inventory?		
10	Do you have a map of the geological sites of your aUGGp?		
11	Do you have a geological map of your aUGGp?		
12	Do your most important aUGGp geological sites benefit from a conservation status?		
13	Do you announce the regulations to prevent misuse and damage?		
14	Do you provide regular maintenance and cleaning of these sites?		
15 (*)	If you have specific protected fragile geological/geomorphological sites, do you develop protective measures against erosion?		
16	Is your aUGGp involved in Cultural and Natural conservation?		
	Education (iD)		
17	Have you developed educational activities connected with your geological heritage (abiotic)?		
18 (*)	Have you developed educational activities connected with your natural heritage (biotic)?		
19	Have you developed educational activities connected with your cultural and intangible heritage?		
20	Do you operate specific educational programme(s) (i.e. for primary, elementary, secondary school and university students)?		
21	Do you have an educational hiking-path within your aUGGp?		
	Educational tools		
22	Have you developed different specific educational tools (publications, videos, slideshows, interactive elements, specific exhibits, puzzle, etc.)?		

	Research (iE)		
23 (*)	Does your aUGGp support and develop research in its territory?		
23bis	Do you have scientific publications about your aUGGp that are less than 5 years old?		
24	Have you had a scientific Institution or University involved in research in your territory?		
	Sustainable economic development (iF)		
	Visibility, infrastructure and facilities		
25 (*)	Do visitors to your area easily recognise and understand that they are in a Geopark? Is your aUGGp appropriately visible in the area?		
26 (*)	Do you have information panels at the entrance area(s) or in important sites of your aUGGp?		

27	Do you have panels or other systems providing information at your aUGGp sites?		
28	Do you have aUGGp signage along the roads or/and in important sites?		
29	Do you have public information infrastructure (i.e. an aUGGp information centre)?		
30 (*)	Do you have an exhibition room or a museum presenting your aUGGp?		
31 (*)	Is the presentation text displayed in your information centre or museum etc. available in English?		
32	Do you have a website?		
33 (*)	Is your website available in English?		
34	Do you have leaflets, publications, etc. presenting your aUGGp?		
35 (*)	Do you have leaflets, publications, etc. presenting your aUGGp in English?		
36	Do you have a aUGGp map which indicates your sites for visitors?		
37	Do you have car park facilities connected with the aUGGp sites?		
	Partnerships		
38 (*)	Do you have formal partnerships with local stakeholders (restaurants, hotels, etc.)?		
39	Have you developed a aUGGp branding policy with local products/producers?		
40	Have you developed a aUGGp partnership visibility with these different partnerships (partner panels, leaflets, etc.)?		
	Geotourism		
41	Do you have promotional material available for visitors as an incentive to visit your aUGGp?		
42	Do you have partnerships with Tour Operators?		
43	Does your aUGGp provide training for guides, or Tour Operators working with you?		
44	Do you have a monitoring system for your visitors?		
45	Have you created a general geotourism action plan for the minimum of the next four years?		
	Criterion ii		
	(ii) UNESCO Global Geoparks should use that heritage, in connection with all other aspects of that area's natural and cultural heritage, to promote awareness of key issues facing society (iiA) in the context of the dynamic planet we all live on, including but not limited to increasing knowledge and understanding of: geoprocesses; geohazards;		

	climate change (iiB); the need for the sustainable use of Earth's natural resources; the evolution of life and the empowerment of indigenous peoples(iiC).		
	Other natural heritage -biotic- (iiA)		
46	Does your aUGGp have natural protected areas? **If Yes: Please complete question 47 to 49. If No: proceed to question 50.**		
47	Does your aUGGp have a clear partnership with these protected areas?		
48 (*)	Do you promote these relevant sites of natural heritage within your aUGGp?		

49	Do you carry out actions or activities connecting geological heritage with other aspects of the natural heritage within your aUGGp?		
	Cultural heritage (iiA)		
	Tangible cultural heritage		
50	Does your aUGGp have protected cultural/historical monuments? **If Yes: Please complete question 51 to 53. If No: proceed to question 54.**		
51	Do you have an agreed partnership with these cultural/historical monuments?		
52	Do you promote these relevant sites of cultural heritage within your aUGGp?		
53	Do you carry out actions or activities connecting geological heritage with other aspects of the cultural heritage within your aUGGp?		
	***Intangible heritage* (iiA)**		
54 (*)	Does your aUGGp have intangible heritage? **If Yes: Please complete question 55 and 56. If No: proceed to question 57.**		
55	Is your aUGGp using and promoting its intangible heritage?		
56	Is your aUGGp linking intangible heritage with its geological heritage in its promotion, discovery, education or other activities?		
	Topics related to geoprocess, climate change and natural hazards (iiB)		
57 (*)	Is your aUGGp involved in climate change and natural hazards adaptation and mitigation related activities?		
58	Is your aUGGp developing education to mitigate climate change and/or natural hazards?		
	Needs for sustainable use (iiC)		
59	If legal mining is carried out inside your aUGGp, have you developed contact/partnerships with the enterprises for better sustainable use of Earth's resources?		
60 (*)	Do you promote awareness/action for the sustainable use of aUGGp natural resources?		
	Criterion iii		
	(iii) UNESCO Global Geoparks should be areas with a management body having legal existence recognized under national legislation (iiiA). The management bodies should be appropriately equipped to adequately address the area of the UNESCO Global Geopark in its entirety (iiiB).		
	Management body (iiiA)		

61	Does your aUGGp have a management body with a legal existence, recognized under national legislation?		
62	Are local decision-makers represented within the decision-making process of your Geopark		
63 (*)	Are the local population and local leaders represented on the management body?		
	Appropriate equipment (iiiB)		

64 (*)	Does your aUGGp have a permanent and professional working team?		
65 (*)	Does your team include a geoscientist working with your aUGGp on a daily base?		
66	Do you have a multi-disciplinary team (with e.g. specialists for education, culture, architecture, anthropology, marketing, tourism, etc.)?		
67	Do you have a clear and independent budget secured for the next four financial years?		
68 (*)	Do you have a aUGGp management plan or a main general concept for it?		
	Criterion iv		
	(iv) In the case where an applying area overlaps with another UNESCO designated site, such as a World Heritage Site or Biosphere Reserve, the request must be clearly justified and evidence must be provided for how UNESCO Global Geopark status will add value by being both independently branded and in synergy with the other designations (ivA).		
	Overlapping designations (ivA)		
69	Is your territory overlapping with other UNESCO designated sites (i.e. Biosphere Reserve and/or World Heritage Site)?		
	If Yes: Please complete questions 70-73. If No: proceed to question 74.		
70 (*)	Have other UNESCO designated sites been informed about the aUGGp existence and does it positively support, the development and concept of your aUGGp?		
71 (*)	Have you clearly examined the complementarity of your aUGGp with this other UNESCO designated sites?		
72	Do you have a formal partnership agreement with the other UNESCO designated sites?		
73	Do you have a clear, visible and independent branding of your aUGGp vis a vis these designated sites?		
74	Is your territory overlapping with international/national protected areas (i.e. Ramsar, National Park, Natural Park, National Reserve, Natura 2000)? **If Yes: please complete questions 75-77. If No: proceed to question 78.**		
75 (*)	Do you have a formal partnership agreement with the other designated site(s)?		
76	Do you organize mutual training between your aUGGp and the other protected areas?		
77	Do you have a clear, visible and independent branding of your aUGGp vis a vis these areas?		
	Criterion v		
	UNESCO Global Geoparks should actively involve local communities and indigenous peoples as key stakeholders in the Geopark (vA). In partnership with local communities, a co-management plan needs to be drafted and implemented (vB) that provides for the social and economic needs of local populations, protects the landscape in which they live and conserves their cultural identity. It is recommended that all relevant local and regional actors and authorities be represented in the management of a UNESCO Global Geopark (vC). Local and indigenous knowledge, practice and management systems should be included, alongside science, in the planning and management of the area (vD).		
	Local communities (vA) + (vB)		

78	Are your local community and local leaders actively and formally involved in your aUGGp?		
79	Is your local community represented inside the aUGGp management structure and participates in the drafting and implementation of aUGGp actions and projects?		
	Indigenous peoples (vA) + (vB)		
80	Do indigenous peoples live in your aUGGp? **If Yes, please complete question 81 and 82. If No: proceed to question 83.**		
81	Are your indigenous peoples actively and formally involved in your aUGGp?		
82	Is the indigenous population represented inside the aUGGp management structure and participates in the drafting and implementation of aUGGp actions and projects?		
	Local and indigenous knowledge, practice and management systems **Intangible heritage/cultural identity** (vD)		
83	Does your aUGGp have local and indigenous knowledge, practice and/or management systems? **If Yes: please complete question 84-85. If No: proceed to question 86.**		
84	If yes: Does the aUGGp have an inventory (even incomplete) of its intangible heritage?		
85	Is your aUGGp working to transfer knowledge, practice and management systems to the younger generation?		
86	Does the local population have their own indigenous language and/or a local dialect? **If Yes: please complete question 87-88. If No: proceed to question 89.**		
87	Is the aUGGp undertaking actions to ensure the appropriate transmission of this language?		
88	If this language is a written language, does the aUGGp systematically use the local/indigenous language on panels, promotional materials, etc?		
89	Is part of the aUGGp's intangible heritage classified at regional/national/UNESCO level? **If Yes: please complete question 90. If No: proceed to question 91.**		
90	Does the aUGGp integrate this classified intangible heritage in its resources, promotion etc?		
	Criterion vi		
	UNESCO Global Geoparks are encouraged to share their experience and advice and to undertake joint projects within the GGN (ViA). Membership of GGN is obligatory.		
	Networking (ViA)		
91 (*)	Has your aUGGp Team already visited an existing UGGp outside your country?		
92	Has your aUGGp developed contact/partnership with other UGGps on a national or international level?		
93	Did your aUGGp Team participate in national, regional or international GGN meeting(s)?		
94	Has a member of your aUGGp Team undertaken an UGGp intensive course or training supported by UNESCO/GGN?		
	Criterion vii		

	A UNESCO Global Geopark must respect local and national laws relating to the protection of geological heritage. The defining geological heritage sites within a UNESCO Global Geopark must be legally protected in advance of any application (ViiA). At the same time, a UNESCO Global Geopark should be used as leverage for promoting the protection of geological heritage locally and nationally. The management body must not participate directly in the sale of geological objects such as fossils, minerals, polished rocks and ornamental rocks of the type normally found in so-called “rock-shops” within the UNESCO Global Geopark (regardless of their origin) and should actively discourage unsustainable trade in geological materials as a whole (ViiB). Where clearly justified as a responsible activity and as part of delivering the most effective and sustainable means of site management, it may permit sustainable collecting of geological materials for scientific and educational purposes from naturally renewable sites within the UNESCO Global Geopark. Trade of geological materials based on such a system may be tolerated in exceptional circumstances, provided it is clearly and publicly explained, justified and monitored as the best option for the Global Geopark in relation to local circumstances. Such circumstances will be subject to approval by the UNESCO Global Geoparks Council on a case by case basis.		
	Conservation (ViiA)		
95	Do illegal mines or quarries exist within your aUGGp's territory?		
96	Are the most important geological sites of your aUGGp already legally protected?		
	Selling of geological material (ViiB)		
97	Are fossils, minerals, polished rocks and ornamental rocks of the type normally found in so-called “rockshops” on sale close by or inside the aUGGp sites?		
98 (*)	Is the selling of geological material occurring inside your aUGGp infrastructure or in an aUGGp partner infrastructure?		
99	Do any stakeholders or partners in your aUGGp sell geological material?		
100	Do any stakeholders or partners of your aUGGp Management Board sell geological material?		
	Guidelines 5.2		
101	Is your aUGGp already functioning as a *de facto* national Geopark for at least one year before you present the actual candidature?		

United Nations Educational, Scientific and Cultural Organization

UNESCO Global Geoparks

Self-Evaluation Checklist

Explanatory Notes

For aspiring UNESCO Global Geoparks

(aUGGp)

Q3 - Does your aUGGp boundary correspond to pre-existing limits? (i.e., administrative / state boundaries or protected area, etc.)

An aUGGp territory must reflect both its geographical and local cultural identity, providing a clear territorial view of the area. If you are unsure whether your territorial area qualifies, please consult the UGGp Secretariat at UNESCO before preparing your application.

The combination of different kinds of pre-existing limits (i.e., administrative and protected area) is acceptable.

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a) <u>For exclusively terrestrial aUGGps:</u>
An aUGGp boundary cannot be arbitrarily connected with a geological or a geographical context (Fig. 3.1). UGGps are sustainable development areas and must consider their existing local territorial identity (Fig. 3.2). The definition of an aUGGp territory needs to take into account pre-existing boundaries such as:

- Administrative limits (region, province, communes, etc.)
- Existing legal protection area boundaries (National Park, National Reserve, etc.) - Other official territorial boundaries.

- Some territories have to deal with specific issues like industrial exploitation, or municipalities that explicitly do not want to be part of the aUGGp project; and in these cases, the aUGGp has to provide an explanation and justification.

b) <u>For aUGGps that include maritime areas and Islands:</u>
To be a unified territory (criteria i), an aUGGp must integrate maritime parts where applicable (Fig. 3.3 and 3.4). This integration is an important asset for a terrestrial-maritime aUGGp to consider its marine environment including elements like biodiversity, submarine geology cultural relations to the sea (sailing, sea related mythology, cosmology etc.) and marine protected areas.

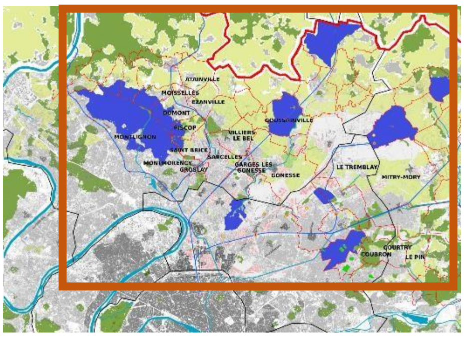

Fig. 3.1. *Wrong aUGGp boundary not taking into account administrative and cultural limits.*

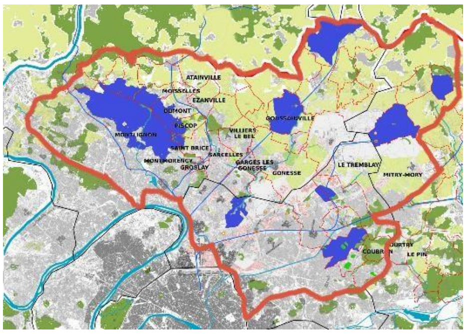

Fig. 3.2. *Correct aUGGp boundary following existing administrative limits.*

Fig.3.3. *Wrong island aUGGp boundary*

Fig. 3.4. *Correct island aUGGp boundary*

Q4 – Do you have a significant population living in your aUGGp territory?

An aUGGp is a sustainable development territory and should exist to support its local population. For this reason, a territory (often a conservation area) without a local population or a significant number of inhabitants cannot become a UGGp.

The definition of a "significant population" should at least present the lower population density for desert areas, equating to around ten inhabitants per kilometre square[1]. In some rare situations, for example, in an island context (or desert area), this population density could be even lower; and in this case, please consult the UGGp Secretariat at UNESCO early in your planning phase, before preparing your application.

[1] *United Nations Decade for deserts and the fights against desertification.*

Q5 – Does your aUGGp territory size provide the necessary conditions for appropriate sustainable development for the local population?

Currently, the average surface area of a UGGp is between 1 000 and 2 000 km^2.

The biggest one is Alxa UGGp (desert area, China) with 68 374 km^2. Huge areas are difficult to manage and require considerable effort to demonstrate a coherent image to visitors who may just visit a small part of it.

Among the intermediate UGGps are:

Hexigten, China	1 750 km^2
Toya Usu, Japan	1 180 km^2
Hateg, Romania	1 023 km^2
Gea Norvegica, Norway	3 010 km^2
Rocca di Cerere, Italy	1 279 km^2
Qinling, China	1 074 km^2
Shetland, United Kingdom	1 468 km^2
Kütralkura, Chile	8 053 km^2

While the smallest one the English Riviera UGGp (UK) with a land area of 62 km^2 and sea area of 41 km^2, it has significant population contributing to sustainable development.

Q6 - Do you have clear evidence that your aUGGp has a geological heritage with an international value?

We encourage candidates to work closely with their own national scientists (e.g. Universities, Geological Survey, IGCP National Committee, Geological Institute of Academy of Science and other research institutions) during the early stage of their application. This is necessary to assess the probability of recognition of the international importance of their geological heritage, to provide a sound basis for the desktop analysis to be undertaken by the International Union of Geological Sciences (IUGS)[2].

A complete and comprehensive bibliography of a territory's international and national publications and research evidence in Earth sciences is fundamental in helping an aUGGp to establish geological heritage of international value. An aUGGp that is unable to provide a complete and comprehensive bibliography is less likely to demonstrate international value.

To support the IUGS desktop analysis, candidates need to prepare:

- Annex 2: an additional and separate copy of section E 1.1 5 relating to geological heritage and conservation.
- Annex 6: a complete bibliography of the territory's Earth sciences publications divided into two sections:
  a) International publications and research;
  b) National publications and research (in the case the publications and research are not in English, please provide an English summary or Abstract if possible).

[2] https://geoheritage-iugs.mnhn.fr/

Q7 - Is there comparable geology at another UGGp located within your country? Or those countries you share a border with?

Aspiring UGGps submitting an application and located close[3] to an UGGp with comparable geological characteristics, must commission a comparative geological study. This study should determine major differences between the Earth heritage of the areas, identify how the aUGGp can position itself with respect to the existing UGGp and identify ways how to best promote and interpret the territory, focusing on its unique assets.

To guarantee objectivity, a comparative geological study cannot be undertaken directly by the aUGGp due to conflict of interest. Instead, an independent study should be commissioned through a local University or relevant research institution, Geological Survey, IGCP National Committee, Geological Institute of Academy of Science or independent qualified (geology-related) company. The study should synthesise and clearly highlight similarities, differences and complementary or even synergic aspects between the two territories, including natural and cultural heritage aspects.

Q15 - If you have specific protected fragile geological/geomorphological sites, do you develop protective measures against erosion?

Aspiring UGGps promote geological heritage but also need to be involved in its preservation, particularly when this heritage is being threatened by natural or anthropogenic damage. Erosion is a common natural process, affecting and changing geological heritage and as such does not need to be controlled everywhere. However, protective measures must be developed for geological sites of recognized value, especially if they are part of the internationally important geological heritage of the territory, or with a particular threat, which can be resolved or slowed down by physical protective measures (Figure 15.1, 2, 3, and 4). For the anthropogenic damage, the effective protective measures (such as protective facilities, monitoring systems, visitor code of conduct, etc.) should also be adopted.

Many technical solutions exist, and aUGGps need to consider when physical conservation measures are necessary and determine the most appropriate action, given the severity of the situation and financial implications. Some of the more common techniques used are on-site museums, protective shelters, using conservation techniques and methodologies, which are following the Venice Charter. Besides physical conservation, another important option to consider would be 3D scanning of the geological site, which is highly recommended for paleontological sites (especially fossil footprints, fossil skeletons, etc.). 3D scanning allows for comprehensive site recording and potential reconstruction by 3D printer.

[3] *this is relative to the country size, population density and geodiversity. If your aUGGp is less than 100 km away from another UGGp, please consult the UGGp Secretariat at UNESCO before preparing your application.*

Fig. 15.1 - *On-site museum built around a fossil tree, Lesvos UGGp, Greece*

Fig. 15.2 - *On-site museum on sirenian fossils, Haute Provence UGGp, France*

Fig. 15.3 - *Placing a protective coating on dinosaur fossils, Yanqing UGGp, China*

Fig. 15.4 - *On-site museum on dinosaur footprint Terra.vita UGGp, Germany*

Q18 - Have you developed educational activities connected with your natural heritage (biotic)?

The educational mandate of an aUGGp is to teach local students, its community and visitors about the intrinsic nature of its territory and all its potentials. Therefore, an aUGGp must develop suitable educational activities to make better understood and explain the aUGGp's natural heritage, climate change, natural hazards, paleo-environments, the evolution of life, and at a large scale our living and moving planet and the necessity for its preservation.

Shennongjia Establishes Golden Snub-Nosed Monkey Conservation Foundation

Shennongjia UGGp China

On April 26, 2019, the Shennongjia Golden Snub-Nosed Monkey Conservation Foundation registered by Shennongjia UNESCO Global Geopark (UGGp) was established. The first donations from enterprises and individuals, totalling US$600,000, will be used for conservation and research of the Golden Snub-Nosed Monkey population and the bio-diversity in Shennongjia UGGp.

- Press Conference on the Establishment of the Foundation
- Deputy Director General of Shennongjia UGGp Hosting the Ceremony
- Unveiling the Foundation

Fig. 18.1 - *Establishment of a monkey conservation foundation, Shennongjia UGGp, China*

Fig. 18.2 - *Imbabura UGGp conservation plan for the Andean Condor (©EFEverde)*

Q23 - Does your aUGGp support and develop research in its territory?

UGGps are living and active territories, which should support the enhancement of scientific research within their areas (i.e. Master's degree, PhD, Postdocs, research projects, etc.). Aspiring UGGps should define and organise their research strategy and activities with the support of, for example, local Universities, Geological Survey, IGCP National Committee, Geological Institute of Academy of Science and other Academic Institutions, using formal research agreements, research contracts, organised field research camps and logistic support, to form active working partnerships. The scientific research developed in an aUGGp should not exclusively focus on Earth sciences but should look into other territorial specificities including biodiversity, intangible, cultural heritage, natural hazards (landslides, earthquakes, etc.), and climate change. All aUGGps should pay attention to transferring the scientific results into accessible science, which can be understood by the public.

Q25 - Do visitors of your area easily recognize and understand that they are in a Geopark? Is your aUGGp appropriately visible in the area?

An aUGGp must develop its own brand identity connected to a logo and specific branding, which is present on visibility tools. This point must be clear before an aUGGp can design or modify panels. *Please refer to Question 26* for examples of branding and panels.

To be visible, an aspiring area must have a name. As a general guideline, an aUGGp, during its preparation phase can use “XX Geopark”. In connection with the application, it also could use “XX Aspiring UGGp”. After successful designation by UNESCO the name will be “XX UNESCO Global Geopark”. This must be kept in mind while designing the visibility tools.

Q26 - Do you have information panels at the entrance area(s) or in important sites of your aUGGp?

An aUGGp must have a **brand identity** through which it promotes itself, its heritage and its activities and services in the frame of sustainable development. This includes the provision of easily identifiable signage that informs visitors and the public that they are entering or inside the Geopark territory. (Examples of Geopark logos are given in Figs. 26.1, 2, 3, 4).

The appropriate mechanisms for territorial visibility are not the same everywhere and may depend on local legislation in terms of what kind of display panels and information is allowed and on what places. The conformity to local legislative context must be kept in mind while reading the proposed examples below. To achieve the necessary visibility, each aUGGp needs to combine different communication tools and adapt them to their local context.

Panels are only one of the many examples of how visibility can be reached. As an interim measure after accreditation, existing panels can be customized by adding the aUGGp logo and information (possibly by using stickers, etc.). This interim measure should be replaced at the earliest opportunity but not at the expense of appropriate sustainability considerations. The main tools used (although not exhaustive) are entrance gates, road signs, parking signs, partnership panels, products, communication tools.

Further clarification on what kind of logo should be used and for what purpose

During the preparation and application phase (but also later), the Geopark uses its own logo and brand identity, which demonstrates in smart a graphic way the characteristics of the area, as to be seen in the example below.

Fig. 26.1 - *Geopark logo, Mexico (showcasing indigenous cultural setting)*

Fig. 26.2 - *Geopark logo, France (showcasing a wine leaf)*

Fig.26.3 - *Geopark logo, China (showcasing the important geological structure)*

Fig. 26.4 - *Geopark logo, Germany (showcasing the important geomorphological structure)*

Only after the official designation as UGGp, will the Geopark be allowed to use the UNESCO

Global Geoparks “combined logo” (see Fig. 26.5) in their activities in order to promote the visibility and outreach of the UGGp network. The logo is composed of five unchangeable elements: the temple symbol, the full name of UNESCO, a vertical dotted line, the emblem of the UNESCO Global Geoparks Programme and the name of the individual UNESCO Global Geopark.

The logo will be prepared by the UNESCO Secretariat upon request after the official designation in the 6 official languages of UNESCO (English, French, Spanish, Russia, Arabic and Chinese), and/or in a national language. It can only be used after the official written authorization from UNESCO. The logo must not be used for commercial purposes. The sale of goods and services for profit is considered as commercial use, in that case, the Geopark can use the own Geopark logo as shown in the example of Geopark products in Figs. 26.1, 2, 3, 4.

UNESCO
Organisation des Nations Unies pour l'éducation, la science et la culture
Famenne - Ardenne
Géoparc mondial UNESCO

UNESCO
Organisatie der Verenigde Naties voor Onderwijs, Wetenschap en Cultuur
Famenne - Ardenne
UNESCO Global Geopark

UNESCO
United Nations Educational, Scientific and Cultural Organization
Famenne - Ardenne
UNESCO Global Geopark

Fig.26.5 - *Example of the combined logo Famenne – Ardenne UGGp (Belgium) in English, French and Dutch*

UGGp Entrance:

The UGGp entrance is usually located along different access roads into the UGGp. It aims to inform travellers that they are entering the UGGp from this point on. These UGGp entrance ways are often identified by the presence of large advertising panels, big rock signage, signposts, etc.

Fig.26.6 - *Entrance panel before designation, Rio Coco aUGGp, Nicaragua*

Fig. 26.7 - *Entrance road panel after designation, Leiqiong UGGp, China*

Fig. 26.8 - *Entrance panel after designation, Muroto UGGp, Japan*

Fig. 26.9 - *Entrance panel after designation, Luberon UGGp, France*

Fig. 26.10 - *Entrance gate after designation, Papuk UGGp, Croatia*

Fig. 26.11 - *Entrance gate before designation, Rinjani-Lombok UGGp, Indonesia*

Advertising Road Signs:

These signs are generally placed inside the UGGp, along main roads and are often placed on large advertising panels. These signs are also necessary along the main roads (highways) leading to the UGGp.

Fig. 26.12 - *Road panel after designation, Araripe UGGp, Brazil*

Fig. 26.13 - *Road panel during application period, before designation, Estrela UGGp, Portugal*

Fig. 26.14 - *Geopark land-mark before designation, (World heritage logo + Geopark logo) Ngorongororo-Lengai UGGp, Tanzania*

Fig.26.15 - *Road panel, Toya Usu UGGp, Japan*

Direction Signs/Orientation signs/Indicators:

On the roads leading from the main access into the UGGp direction, signs should be put up in order to orient visitors and tour operators from the main road to specific sites. All orientation panels need to carry the aUGGp logo/branding. Make sure that they are in a safe place where visitors can stop and not hindering traffic.

Fig. 26.17 - *Directional panel, English Riviera UGGp, UK*

Fig. 26.16 - *Directional panel, after designation, Dong Van UGGp, Vietnam*

Fig. 26.18 - *Directional panel, Katla UGGp, Iceland*

Fig. 26.19 - *Directional panel, Sobrarbe UGGp, Spain*

Parking Signs:

For visitor security, safe areas need to be created to be used as parking and/or observation points.

Parking signs are therefore required which again need to carry the aUGGp logo/branding.

Fig. 26.20 - *Parking area, North West Highlands UGGp, UK*

Fig. 26.21 - *Advertising and parking panel, Cao Bang UGGp, Vietnam*

Information/Interpretation Panels:

To explain a site of interest, interpretation panels are usually placed in their vicinity. Such panels need to provide easily understandable information and carry the aUGGp logo/branding.

Fig. 26.22 - *Information panel, Satun UGGp, Thailand*

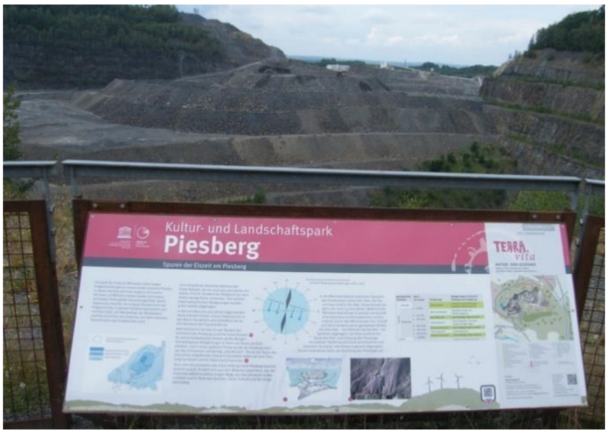

Fig. 26.23 - *Information panel after designation, Terra.vita UGGp, Germany*

Fig. 26.24 - *Information panel after designation, Burren and Cliffs of Moher UGGp, Ireland*

Fig. 26.25 - *Information panel after designation, Zhijidong UGGp, China*

Fig. 26.26 - *Information panel, Cliff of Fundy Canada*

Fig. 26.27 - *Information panel, Imbabura UGGp, aUGGp, Ecuador*

Aspiring UGGp Products:

Aspiring aUGGps need to promote local products using clear criteria and formal partnerships. Partner aUGGp products need to be identifiable via its branding and the aUGGp logo. (Sales products can only use the Geoparks logo, not the UGGp combined logo.)

Fig. 26.28 - *Sales product: Local rice wine, Izu Peninsula UGGp, Japan (Geopark logo)*

Fig. 26.29 - *Tea Product from Muroto UGGp, Japan (Geopark logo)*

Fig. 26.30 - *Sales products from Katla UGGp, Iceland (Geopark logo)*

Fig. 26.31 - *Ammonite cookie from Swabian Alb UGGp, Germany (Geopark logo)*

Fig. 26.32 - *Sales product: cookies Langkawi UGGp, Malaysia (Geopark logo)*

Communication Tools:

In addition to the physical tools discussed above, aUGGp visibility needs to include communication tools such as a website, leaflets, site maps and publications, etc.

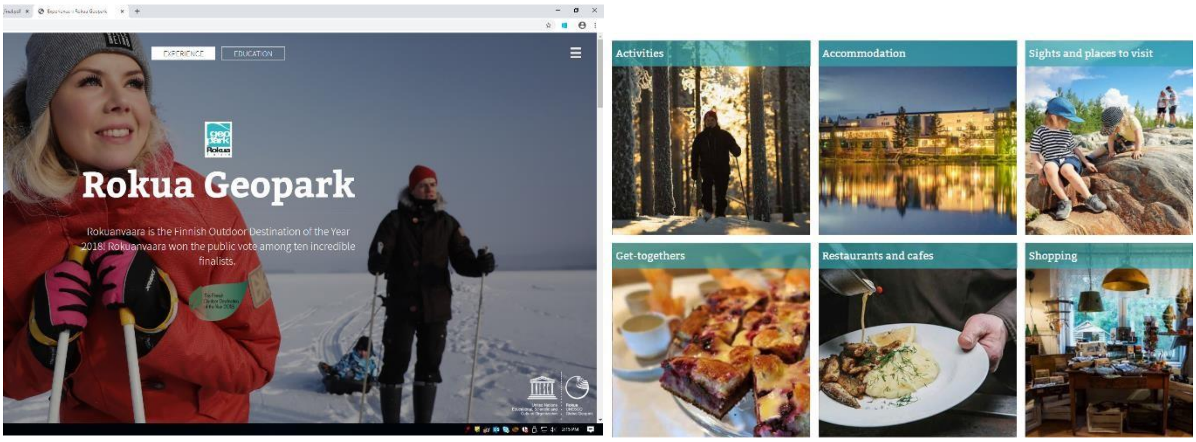

Fig. 26.33 - *Website after designation Rokua UGGp, Finland*

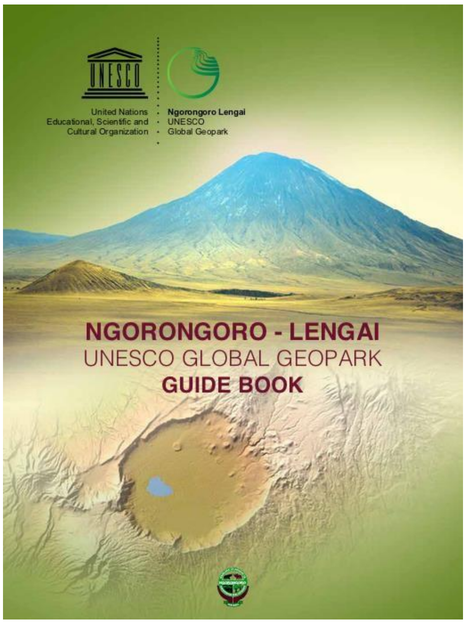

Fig. 26.34 - *Ngorongoro – Lengai UGGp guide book, Tanzania, after designation*

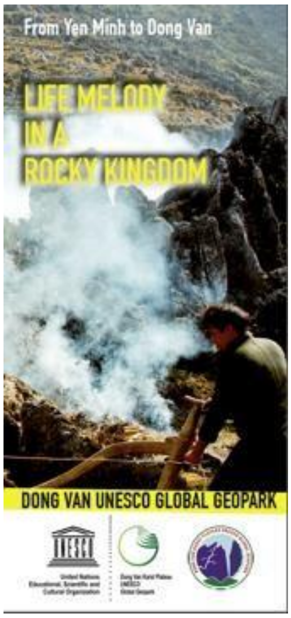

Fig. 26.35 - *Route leaflets after designation, Dong Van UGGp, Vietnam*

Fig. 26.36 - *Promotional leaflet after designation, Itoigawa UGGp, Japan*

Fig. 26.37 - *Route leaflets after designation, Dong Van UGGp, Vietnam*

Fig. 26.38 - *Geopark app, Magma UGGp, Norway*

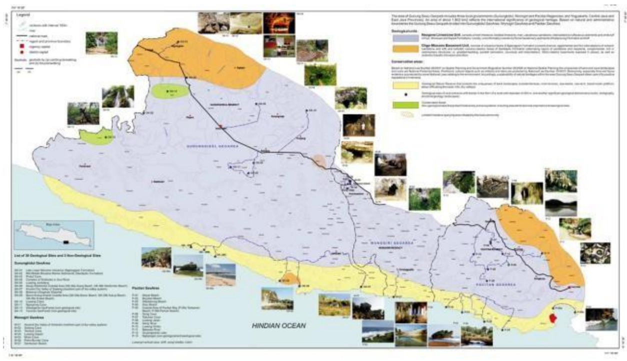

Fig. 26.39 - *Geopark map, Gunung Sewu UGGp, Indonesia*

Q30 - Do you have an exhibition room or a museum presenting your aUGGp?

Aspiring UGGps should provide visitors and the general public with comprehensive information relating to the aUGGp (e.g., its territory, mission, sites, heritages, products), explaining the variety of potential visits to the points of interest of the area as well as activities, and showing the attractiveness of the area for visit potential. The aUGGp museum (or exhibition room) should be a story-teller for the territory (telling the stories of the past, present and future of the aUGGp and interconnecting its geological, natural and cultural heritage). The examples below demonstrate how established UGGps provide this information while targeting different audience and public.

UGGp Museum:

In many cases, this is a specific building, which can be focused on the specificities of the location presenting comprehensive information on the aUGGp.

Fig. 30.1 - *Museum, Qeshm UGGp, Iran*

Fig. 30.2 - Museum, Leye Fangshan UGGp, China

Museum Partner:
This can be either a new or pre-existing partner or a facility within a aUGGp territory focusing on a specific thematic. A formal partnership must be established with such a partner, the aUGGp should set up a permanent exhibit with this partner or facility.

Fig. 30.3 - *Gassendi Museum, partner of Haute Provence UGGp, France*

Fig. 30.4 - *Lamminahon talo Museum, partner of Rokua UGGp, Finland*

Information Centre:

Frequently, aUGGps establish a designated information centre to provide comprehensive information on the aUGGp to visitors and the general public. The centre and its facilities are generally of limited size and investment and act as an information focal point for visitors allowing them not only to acquire a whole range of information on the UGGp but also to benefit from direct contact with the aUGGp team.

Fig. 30.6 - *Info centre Cilethu-Palabuhanratu* Fig. 30.7 - *Info centre, Mount Apoi UGGp, Japan UGGp, Indonesia*

Q31 - Is the presentation text displayed in your information centre or museum, etc. available in English? Q33 - Is your website available in English? Q35 - Do you have leaflets, publications, etc. presenting your aUGGp in English?

UGGps are an international designation open to international visitors. As such, aUGGps should provide English translation for visitors and the general public in their Information Centres and Museums. There is also a need to provide translation in other relevant international or local languages, which can be determined by the aUGGp management body. The requirement for English translation also extends to other forms of communication such as the aUGGp website, maps, essential leaflets and key publications.

Q38 - Do you have formal partnerships with local stakeholders (restaurants, hotels, tour operators, etc.)?

To be able to provide sustainable development in a territory an aUGGp needs to establish multiple partnerships with local stakeholders such as hotels, restaurants, guest houses, outdoor activities, tour operators, guides, museums schools and universities, local communities and regions, protected areas authorities, NGOs and other relevant institutions. These partnerships need to be formalised through a standard signed agreement, which clearly defines the partnership criteria and commitments between the partner and the aUGGp. *As indicated in Question 26, all partnerships need to be visible and promoted within the aUGGp*.

Partnership Panels:

Aspiring UGGps need to develop formal partnerships with their stakeholders, like hotels, restaurants, guest houses, outdoor activities, tour operators, guides, museums, etc., outlining clear partnership criteria and common commitments. If applicable, these partnerships should be promoted on the internet and physically by using "partner plaques" which are often placed in the entrance of a partner's premises (for example A4 or A3 size plaques) and carry the aUGGp logo/branding.

Fig. 38.1: *Partner plaque, before or after designation, Famenne Ardenne UGGp, Belgium (Geopark logo)*

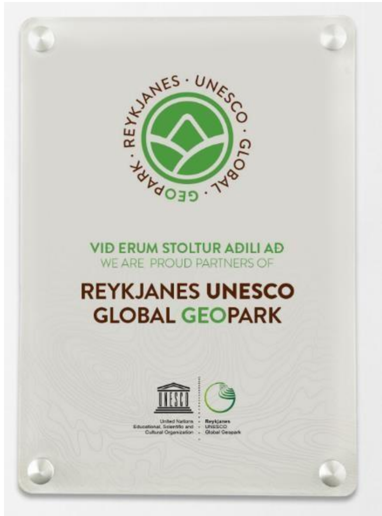

Fig. 38.2 - *Partner plaque, after designation, Reykjanes UGGp, Iceland (UGGp combined logo)*

Fig. 38.3 - *Partner plaque, Hondsrug UGGp before and after designation, Netherlands*

Q48 - Do you promote these relevant sites of natural heritage within your aUGGp

Aspiring UGGps must promote their natural heritage sites connecting them to the biotic natural heritage, by, for example, organizing joint events, and information, communication, and education activities.

Q54 - Does your aUGGp have intangible heritage?

Intangible heritage definition (Convention for the safeguarding of the Intangible Cultural Heritage, 2003): Practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their cultural heritage. This intangible cultural heritage, transmitted from generation to generation, is constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, and provides them with a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity.

It is manifested inter alia in the following domains:

- Oral traditions and expressions, including language as a vehicle of the intangible cultural heritage;
- Performing arts;
- Social practices, rituals and festive events;
- Knowledge and practices concerning nature and the universe including stories on natural hazards;
- Traditional craftsmanship;
- Local architectural techniques.

Q57 - Is your aUGGp involved in climate change and natural hazards adaptation and mitigation related activities?

Climate change and questions around natural hazards should be a high priority for all aUGGps. The geological record shows the consequences of the past climate change on the development of our environment and biodiversity, as well as evidence for natural hazards. An aUGGp, therefore, can undertake educational activities related to both thematics, organize exhibitions, seminars, as well as work jointly with schools and educators.

Climate Change:

Aspiring UGGps have to play a vital role in promoting sites, which have been affected historically by climate changes and in explaining them to their visitors and the broad public. In areas where the local geology does not allow for this kind of geological interpretation, an aUGGp can still assume an active role by developing more general awareness and educational programmes related to climate change and environmental best practice. Like all areas of the world, aUGGps have to deal with environmental issues whilst also looking for green energy solutions, waste reduction schemes and carbon-neutral activities. They could, for example, organise awareness days, collect and recycle plastic waste, etc..

Fig. 57.1 - *Picking up trash day in Hong Kong UGGp, China*

Fig. 57.2 - *Beach cleaning, Katla UGGp, Iceland*

Fig. 57.3 a) - *Exhibition and activities using geological record to understand the consequences of climate change, Lesvos UGGp, Greece*

Natural Hazards :

The aUGGp should take on the responsibility to initiate the development of research, surveys, monitoring and mitigation of natural hazards (landslides, earthquake, floods, volcanic risk, tsunamis, etc.) within its territory. Where relevant, this should be done in partnership with national or regional specialised agencies and be used in the aUGGp's visitor experience activities, educational programs, through specific publications and other media.

Fig. 57.4 - *On-site museum protecting houses damaged by last volcanic eruption- Unzen UGGp,*

Fig. 57.5 - *Volcanic risk education, Toya Uzu UGGp, Japan*

Fig. 57.6 - *Earthquake educative table, Lesvos UGGp, Greece*

Fig. 57.7 - *UGGp activity connected with natural hazards, Azores UGGp, Portugal*

Q60 - Do you promote awareness/action for the sustainable use of aUGGp natural resources?

Sustainable development of a territory must include the sustainable use of natural resources. Aspiring UGGps need to promote awareness, action and/or educational programmes. For example, special attention should be given to the use of territorial water resources by establishing action and educational programmes to provide adapted initiatives on water management and use in each territory. Aspiring UGGps can also be innovative models for sustainable use of other natural resources.

Q63 - Are the local population and local leaders represented on the management body?

Aspiring UGGps should be established using a bottom-up approach, closely involving the local and indigenous population and their leaders. Policies concerning the future development of a territory, as well as territorial facilities, cannot be achieved and will not be sustainable without the participation and agreement of local authorities and key stakeholders.

It is essential that within the aUGGp decision-making processes of the management body, local leaders are represented (mayors, chiefs of the tribe or community, or elders, etc.) to participate in decision making regarding the development strategies of the aUGGp. The local and indigenous population (associations, interest groups) also need to be represented within the management body and should be able to participate in aUGGp decision making.

Q64 - Does your aUGGp have a permanent and professional working team?

An aspiring UGGp cannot achieve its mission and purpose without a unified permanent and professional team dedicated to its activities. The aUGGp team can be directly employed by the management body or the team can be constituted from individuals from different institutions or departments with a percentage of working time dedicated to the aUGGp. In the latter case, a formal partnership agreement should exist specifying the number of staff concerned, names, areas of specialization as well as the percentage of time dedicated to working for the aUGGp.

All aUGGp teams should have well-defined roles and responsibilities with professional skills that can be adapted to the needs of the aUGGp. Adequate training should be provided to ensure professional management and operations. Specific UGGp training is highly recommended through the UNESCO intensive course, UGGp workshops and the UGGp mentorship and knowledge exchange programmes.

Q65 - Does your team include a geoscientist working within your aUGGp on a daily basis?

Geoheritage of international geological value is the core of an aUGGp. It is therefore important that at least one geoscientist is included in its staff, available on a daily basis, in support of the management and interpretation of geological sites and related activities.

Q68 - Do you have an aUGGp management plan or a main general concept for it?

For management bodies to be properly equipped, all aUGGps need to have a vision document, setting out their strategy and main concept for future development.

Management plans take time to develop and establish and need to be realistic and achievable. Therefore, a fully elaborated management plan will be checked in detail during the first revalidation of a UGGp.

A management plan can, for example, follow the formal structure of the candidate dossier or UGGp progress reports in order to provide a clear outline for actions and planned targets in a clear structured manner for at least a period of four years. In that sense, the management plans could include:

- Geopark personnel and capacity building
- Geoconservation strategy including protective and conservation measures and activities
- Heritage interpretation infrastructure, tools and publications
- Geoeducation strategy including partners, educational programmes and tools
- Geotourism[4] strategy including services and activities
- Sustainable local development, partners and activities[5]
- Geopark promotional activities and tools
- Networking and Partnerships

Q70 - Have other UNESCO designated sites been informed about the aUGGp existence and does it positively support the development and concept of your aUGGp?

An aUGGp needs to be mindful that it is part of the UNESCO designated sites (World Heritage Sites, Biosphere Reserves, UGGps) and therefore should have policies and mechanisms in place to work collaboratively with any other of the UNESCO designated site present within its territory.

Q71 - Have you clearly examined the complementarity of your aUGGp with this other UNESCO designated site?

If a UNESCO designated site exists within an aUGGp territory, the aUGGp should meet the management team of this site before applying for candidature, to explain how their project will operate and reflect jointly on how the aUGGp will provide complementary activities with the other designated site. In such cases, a letter of support should be provided by the other UNESCO designated site(s) to acknowledge general support for the aUGGp candidature.

Q75 - Do you have a formal partnership agreement with the other designated site(s)?

Cooperation and partnerships between different UNESCO designated sites within the same territory should be subject to a formal partnership/cooperation agreement. Formal agreements define and clarify the different territorial responsibilities between the UNESCO

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[4] *Arouca Declaration on Geotourism :* http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/Geopark_Arouca_Declaration_EGN_2012.pdf

[5] *(accompanied by a co-management plan, setting out the partnership with local and indigenous communities where relevant)*

designated sites and will establish the common commitments between them like shared training, collective actions, partnered activities, etc..

Q91 - Networking

Networking among UGGps and with the GGN community helps exchange good practice and joint programmes and projects, among others. By visiting other UGGps one can see not only how a UGGp is operating but also what type of networks exist, with their different partnerships. *(Please note the difference to UGGp partners located within the UGGp territory, dealt with under question 38. These partners are part of the UGGp stakeholder group.)*

Q98 - Is selling of geological material occurring inside your aUGGp infrastructure or in an aUGGp partner infrastructure?

UGGp guidelines (vii) clearly define the UGGp responsibilities concerning the selling of geological material. Therefore, the aUGGp cannot support, promote or sell geological material in any of its facilities like Museums, Info Centres and shops. This also extends to aUGGp partner premises and buildings.

An aUGGp should be used as leverage for promoting the protection of geological heritage locally and nationally. The management body must not participate directly in the sale of geological objects such as fossils, minerals, polished rocks and ornamental rocks of the type normally found in so-called “rock-shops” within the aUGGp (regardless of their origin) and should actively discourage unsustainable trade in geological materials as a whole. Where clearly justified as a responsible activity and as part of delivering the most effective and sustainable means of site management, it may permit sustainable collecting of geological materials for scientific and educational purposes from naturally renewable sites within the aUGGp. Trade of geological materials based on such a system may be tolerated in exceptional circumstances, provided it is clearly and publicly explained, justified and monitored as the best option for the aUGGp in relation to local circumstances. Such circumstances will be subject to approval by the UNESCO Global Geoparks Council on a case-by-case basis and should be clearly indicated in the application file.

Abbreviations	
aUGGp(s)	Aspiring UNESCO Global Geopark(s)
UGGp(s)	UNESCO Global Geopark(s)

Appendix 2 – Bibliography of International Geological Significance

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