Climate Change Education in Tongan secondary schools

A thesis

submitted in partial fulfilment

of the requirements for the degree

of

Doctor of Philosophy in Education

at

The University of Waikato

by

‘ELISAPESI HEPI HAVEA

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

2020

Abstract

Children are among the most vulnerable groups to the adverse impacts of climate change. They can be psychologically disturbed and rendered powerless by the magnitude of its impacts. Tonga and its island groups are extremely vulnerable to the impacts of climate change and these impacts affect the environment, the people and their livelihoods. Article 6 of the United Nations Framework Convention on Climate Change (UNFCCC) directs countries to consider education, training, and public awareness as integral responses to climate change. Climate change education empowers children to learn about how to minimise the impacts of climate change and learn to adapt and live sustainably in an environment already affected by climate change. In order to plan and design effective climate change education, it is crucial to determine students' and teachers' conceptions and misconceptions of climate change, their attitudes and motivations to act about climate change, and the climate change curricula in schools. This research then explored secondary school teachers' and students' awareness, knowledge, attitudes about climate change and their motivations to act upon it. This research also explored the place of climate change in the school curriculum in Tonga. This research also examined how talanoa as a form of interactive engagement and communication could help students to learn to understand and address climate change and its impacts.

Talanoa, which is a Pacific research methodology, was used in this research to inform and guide its data collection. This study adopted a mixed method approach, in which culturally appropriate methods such as talanoa fakataautaha (one-on-one talanoa) and talanoa fakatokolahi (group talanoa) and vakavakai'i (observation) were mixed with Western methods, including questionnaires and document analysis. Talatalanoa and tālanga were the two methods of talanoa used to conduct the talanoa fakataautaha and talanoa fakatokolahi. Data were collected in two phases. Phase One involved questionnaires and talanoa fakatokolahi with Class 10 teachers and students from two secondary schools in Tonga, and talanoa fakataautaha with officials from the Ministry of Education and Training (MET) and the Ministry of Meteorology, Energy, Information, Disaster Management, Climate Change and Communications (MEIDECC) in Tonga. The document analysis included documents such as the current school curriculum and syllabuses.

The findings indicated that students and teachers are aware of and worried about climate change, but they lacked a rich conceptualization of the issue and held misconceptions. Data indicated that both students and teachers in Tonga were unsure of causes of climate change but were aware of impacts. Students expressed concern, and a desire to learn more, about climate change. The findings also indicate that Tonga is lacking curriculum integration of climate change education. Teachers stated that climate change issues are not addressed by the syllabus effectively, and reported that they needed professional development to enhance their knowledge and understanding about climate change-related issues.

A climate change education intervention was then designed based on theoretical principles of climate change education, students' and teachers' perceptions, recommendations from Government officials and recommendations from literature. The climate change education intervention was trialled with one class and their teacher at a secondary school in Tonga. Talanoa was employed as a teaching and learning approach using ideas of talanoa fakatoka, talanoa felāfoaki, and talanoa kavekavehoko. Firstly, a professional development was conducted with the teacher through talanoa and was effective in using talanoa felāfoaki or co-construction to help improve the teacher's knowledge about climate change. Secondly, the talanoa approach sought to build relationships within the classroom, recognise students' experiences and understandings and give voice to their concerns.

The outcomes of the intervention indicated that climate change education could enhance and improve students' and teachers' knowledge about climate change-related issues, high student engagement, successful learning and a motivation to play a part in their own futures. Students and the teacher who implemented the climate change intervention recommended talanoa as an effective approach to teach and to learn about climate change in Tonga. The implementation of the three types of talanoa contributed to their successful learning of the topic. They helped to create an environment for learners to interact and communicate effectively. They also helped to explore learners' existing knowledge about climate change, and areas that were needed to be addressed during the teaching and learning process. Students indicated that talanoa helped them to co-construct ideas and helped them learn more from their peers.

This research contributes to an understanding of how climate change education, and use of talanoa could enhance students' and teachers' awareness of, knowledge and attitude

about climate change, and their motivation to act upon climate change. In addition, this research indicates that climate change education could address and correct alternative conceptions that are commonly held among students and teachers in Tonga about climate change. The outcomes of this research could give urgency to the Tonga Ministry of Education and Training to re-consider the importance of including climate change education in the school curriculum and across various disciplines.

Acknowledgements

> ‘Oku ou hau’alofa’ia ki he ‘Afiona, ‘a hoku malohinga ko Sihova. Ko hoku mo’unga ‘a Sihova, mo ‘eku kolo, mo hoku hao’anga; Ko hoku ‘Otua ko hoku makatu’u ia, ‘aia ‘oku fai ki ai ‘eku hufanga: Ko ‘eku pa, mo hoku nifo fakamo’ui: Ko hoku fu’u taua (Saame 18: 1&2).

‘Oku ou fakamalo ki he ‘Otua ko e Tamai, ‘Otua ko e ‘Alo, ‘Otua ko e Laumalie Ma’oni’oni ‘i he tapuaki kuo u lave ai mo hoku ki’i famili. Ka ne ta’e’oua ‘a Ho’o kau mai ‘Eiki, he’ikai ‘o’oku ‘a e faingamalie ni. ‘Oku ou fakafoki ‘a e langilangi kiate KOE tokotaha pe Sihova.

The success of this journey is attributed to the constant support that everyone offered me and my family during the course of my study. My sincere appreciation and thanks to:

- My Supervisory team - My Chief Supervisor, Associate Professor Chris Eames. Thank you for your wisdom and your knowledge, your continued support since Day 1, and your faith in me. I wouldn’t be able to complete this thesis without your guidance – Malo ‘aupito. I would also like to express my sincere thanks to Dr Philippa Hunter for the guidance and shared your pedagogical knowledge with me. Your amazing contribution in designing the CCE intervention is highly appreciated – Malo ‘aupito. ‘Oku ou fakamalo mavahe kia Dr Timote Vaioleti, ka koe Paionia na’a ne fofoa’i ‘a e ‘Talanoa’ ke hoko ko e Founga fekumi pe fakatotolo ‘a e kainga mei he Pasifiki (Talanoa Research Methodology). ‘Oku ‘ikai ha lea ke fakatataua ho’o tokoni lahi ‘o malava ke ikuna ai e feinga ni. A special acknowledge goes to Dr Timote Vaioleti who is the Founder of the Talanoa Research Methodology. You paved the way for all the Pacific emerging researchers including myself and it was a huge privilege for me to have you as a supervisor. To my three supervisors - This thesis would not come to fruition without your guidance and your support. It is an end product of a huge sacrifice that we all made as a team – Malo ‘aupito mo e loto hounga’ia mo’oni.
- My mother in law, ‘Akosita Vea Havea Snr who was called by God during the final year of my study. I know how you how you used to be proud of me and I am deeply saddened that you did not get to witness this very last achievement, but I know you’re smiling from Heaven.
- Ki he’eku Fa’e – Malaea Tu’uholoaki Similai, ko e ikuna ko ‘eni ‘oku ou foaki ia ma’au. Malo ho’o lotu moe fua tokotaha e fatongia he la’a mo e ‘uha. Na’a ke katekina e mamahi mo e faingata’a pea koe ‘aho ‘eni – kuo mau si’i taa’imalie ‘i ho’o ‘ofa mo ho’o tauhi. ‘E tanaki ‘a e koula, siliva moe maka mahu’inga kotoa, ka ko koe pe Fa’e ‘oku mahu’inga taha. He’ikai te ke ngalo si’eku fa’e. Malo ‘i he me’a kotoa pe.

- My dad, Maile Similai, thank you for your endless support especially supporting us financially during my study. Thank you for your words of wisdom, I will treasure them always.
- My two brothers, Sili and Nu'u, thank you for being the best brothers. You continued to showcase the 'Ofa, Faka'apa'apa, Loto Tō and Tauhi vaha'a. My two sisters in law, Losana and Eleni, my twin nephews, Maile Jr and Manako Jr, and my niece who is also my namesake, 'Elisapesi Jr, you teamed up well to give me the best support I ever needed – Malo 'aupito.
- Ki hoku kainga lotu Sā Sione, 'Eiki 'Anaseini Tupouveihola Fusitu'a, 'Eiki Laifone Vaea, Setuata, Paunga Tupou pea mo e ngaahi famili kotoa pē 'o Sā Sione, mālō ho'omou lotu mo e tokoni kotoa pē.
- The Ministry of Education and Training (MET) in Tonga and the Education Department of the Free Wesleyan Church of Tonga for granting me permission to conduct my research in the schools that I chose for this study.
- The principals, staff and students of the two schools that kindly welcomed me with open arms and to allow me to conduct my research at your schools, I am deeply grateful for the love and support that I received from you.
- All the participants who were willing to take part in the Phase One and Phase Two of my study, I would not be able complete this journey without your contributions. The science teacher and 40 students who made a hard decision and agreed to participate in the implementation of the intervention in the Phase Two of my research, I am forever indebted to you. You will always have a special place in my heart, malo mo e loto hounga'ia mo'oni.
- Fakamalo lahi ki he famili 'o Siaosi mo 'Utulamataki Tonga mo ho'omo ki'i fanau, malo 'i he tokoni kotoa pe lolotonga e taimi ne u fakapaea ai 'i he Fo'i 'One'one. Ki he famili 'o Tupou Lavulavu, pehe ki he famili 'o Solomone mo Fiona Pule, malo 'i he 'ofa mo e tokoni 'i he taimi na'e fakahoko ai 'a e feinga 'i Ha'apai. Fakamalo lahi kia Sela Telefoni pehe ki he famili he tokoni kotoa pe na'a ke fai 'o ikuna ai e feinga ni.
- To all staff and my fellow colleagues at the TEMS Research Centre, thank you for the amazing support and encouragement, that was such a great experience.
- The New Zealand Aid Programme-Postgraduate Field Research Awards, thank you for your generosity to provide a substantial financial support to fund my research project, this research would not be possible without your help. The 'Pacific at Waikato' for the TAPA Awards, Malo 'aupito for the financial support during my studies.
- To Melanie Chivers and Alistair Lamb, you have helped me in so many ways, malo 'aupito. To Aunty Kitty from the students learning support, thank you for all that you do.
- Thank you to Dr Louise and Colin for helping us during the difficult time, highly appreciated.
- Malo 'aupito to Associate Professor Alice Te Punga Somerville, for your ongoing assistance over the last few years, highly appreciated.

- Lupe ‘Oliveti, Semisi and Lesieli ‘Oliveti, Semisi Jr, Mele and Nomani ‘Aho and rest of the family – thank you for the help and support during my ongoing visits to Tonga.
- Lola Baker Tokotaha and family, thank you for always helping me out and cater for my ongoing requests, highly appreciated.
- My husband’s siblings, Sioeli, Sinai, Laumanusiu, and Samuela and your families, thank you for always supporting us.
- Fakamalo lahi kia Paunga mo Monalisa Tupou ‘i he tu’u tafa’aki ‘i he taimi kotoa pe. Ko e lotu moe tokoni kotoa pe na’a mou fakahoko ‘oku lau koe koloa mo e tapuaki.
- Kalolo and Liliō Havea, our children’s second parents, you guys have done a lot and helped us in so many ways. You have played a big part in my academic journey, I will be forever grateful, thank you so much.
- To ‘Asenafau, Feleti, and Gerizim, thank you for always being there for me and the support that we continue to receive from you at all times – malo ‘aupito e lotu mo e tokoni.
- Sione and Saane Molitika, Nena Moala Lahi Molitika, and rest of the family – I thank you for all the words of encouragement, and your ongoing support, highly appreciated.
- Late Rev Melema’u Molitika (R.I.P), I’m glad that you have joined our Heavenly Father - You have been a crucial part of this journey, your words of encouragement and your prayers will always stay with me.
- Thank you to the Carter family, Frank, Maile and Pelenaise for your love and support.
- To Rev Anne Preston and family, I can’t thank you enough for helping me out in many ways. Thank you Anne for always being a true friend.
- Tofavaha Vehikite Pule, thank you for sharing your knowledge with me during this journey.
- To Sitelimani Maile and Malumu, malo ho’omo ‘ofa mo e tokoni he taimi kotoa pe.
- ‘Ana Lose and Meleane Hopoi mo e famili, malo ho’omo ‘ofa mo e tokoni ‘i he taimi kotoa pe.
- Thank you Aunty Telekaki, Uncle Manako and Uncle ‘Aisea for all the love, help and support – I appreciate you all.
- My husband Penisimani Havea, who is my backbone, thank you for journeying with me. You have been by my side since Day 1, and in bad and good times. You worked and provided for our family without any single complaint – thank you for always being the best supporter. And to our three children, J, Penilahi, and Vea Jr, you were the reason why I took this journey - this thesis is for your future. In a very special and unique way, you helped running the race with me, and we finally made it. Thank you for trusting me and help making life easier and super enjoyable. I love you always, Mom.

Dedication

This thesis is dedicated to:

My maternal grandparents

Halatoa Tu'uholoaki and Kalolaine Mafi-Tu'uholoaki (R.I.P)

&

My beloved parents

Maile Similai & Malaea Tu'uholoaki-Similai.

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Glossary

This glossary includes the Tongan terms and phrases, and their interpretations. The definitions and interpretations of these terms and phrases were derived according to how they appear in the context of this research.

Ako	Learning, education, or schooling. It can refer to: to learn, to study or to receive education
Anga faka-Tonga	Tongan traditional customs and styles, rules of local etiquette
Anga fakatōkilalo	Humility
Famili	Family (both immediate and extended family)
Faa'i Kavei koula	Four Pillars that underpin the Tongan society
Fakatalanoa	To encourage discussion when people do not know each other
Faiako	School teacher
Faka'apa'apa	To show respect, deference or courteous.
Founga faka-Tonga	Tongan way/being
Fonua	Land, country, place
Fetokoni'aki	To help one another, reciprocity
Faikava	Cultural process of preparing and drinking of kava (beverage made from crushed roots of *Piper methysticum*) together with due form or ceremony
Fakafe'iloaki	Salutation, to greet or pay one's respects.
Feliuliuaki 'o e 'ea	Unpredictable, unstable or changeable weather and climate
Feveitokai'aki	To respect or honour one another, or to respect one another's feelings or scruples.

Fe'ofa'aki	To love or be kind to one another
Fa'a	A gardener, planter or farmer
Fatongia	Duty, obligation or responsibility
Fatongia 'o e Pule'anga	Responsibilities of the Government
Fatongia 'o e Potungaue ako - kau faiako moe fanau ako	Responsibilities or duties of the Ministry of Education and Training, teachers and students of Tonga
Fatongia 'o e ngaahi kolo mo e ngaahi komiuniti	Responsibilities of the village communities
Fatongia fakafo'ituitui - Matu'a moe fanau'i 'api	Individuals' roles – roles of parents and children's roles at home
Hangale	Tongan medicinal plant
Kai 'e he tahi e kelekele	Land is consumed by the sea
Koe to'ukai 'oku 'ikai pau, 'oku feliuliuaki. 'Oku 'ohofia e mahaki e to'ukai, pea 'oku 'ilonga lelei ia 'i Ha'apai ni	The seasonal produce are unpredictable, its changes regularly. Pests and diseases attack the seasonal food, and these are clearly the case here in Ha'apai
Kuo 'asi e nunu'a e feliliuaki'o e feliuliuaki 'o e 'ea	The detrimental impacts of climate change could now be observed
Ko e ngaahi poutuliki ki hono ako'i pea mo e ako fekau'aki moe feliuliuaki 'o e 'ea 'i lokiako	Framework for teaching and learning about climate
Kaungā fa'u	Two or more people create and make meanings or co-construct ideas together.
Kasa kona	Dangerous/toxic gases

Lahilahi ‘a e taimi ‘afu	High temperature periods are a regular occurrence now
Lū	Tongan dish of cooking taro leaves, coconut with meat
Māfana	An euphoric state where one is overcome by any reservations
Maheni	To be accustomed to or familiar with; to be on friendly or familiar terms with.
Mamahi’i me’a	To stand up for something, loyalty.
Mo’oni	Purest/ truest
Ngahi ngaue ke fakahoko	Activities
Polililili	Stunted and undeveloped
Poto	To be clever or skilful, one who knows what to do and does it well
Poto’i ngaue	An expert at something, skilful person.
Pō talanoa	A dialogue between two or more people who already know each other
Talanoa	Informal way of oral communication, talk, conversation or dialogue between people to tell stories or relate experiences.
Tā e lango kei mama’o	Cutting wooden cradles in time. It’s a Tongan proverb referring to the importance of being well-prepared
Talanoa fakataautaha	In-depth and meaningful talk and discussions between two people
Talanoa fakatokolahi	In-depth and meaningful talk and discussions between three people or more
Talanoa faikava	A dialogue taking place during faikava
Talanoa faka’eke’eke	Converse to inquire into or make repeated inquiries about

Talanoa fakatoka	Fakatoka refers to set or lay a foundation, or to give or devote an idea or thought to something. Talanoa fakatoka aims to identify students' and teachers' existing knowledge about climate change related-issues. This dialogue also intends to build and harmonise relationships among students and between teachers and students.
Talanoa felāfoaki	Felāfoaki derives from a Tongan traditional game where two or more players throw or toss disks, or a rope, fishing-line or net. Felāfoaki refer to tossing ideas about from one another. Talanoa felāfoaki is a platform that is used by Tongan people to tease out other people's thoughts, contribute and discuss ideas on a given issue.
Talanoa kavekavehoko	Talanoa kavekavehoko in this research refers to sharing new knowledge and presenting it to a large audience. It also involves students and teachers reporting their climate change actions and plans for their future.
Tauhi vā/Tauhi vaha'a	Maintaining integrity of all or harmonious relationship
Vā	Relationship, feeling, and attitude towards each other.
Vakavakai'i	To observe, consider, look at carefully or thoughtfully; to give attention or consideration to.

Chapter 1: Introduction

> The loss of small island states will affect us all. Climate change refugees will become a very serious issue for all countries…Our land is precious for us. It is our home. It is owned by our fathers and grandfathers, and we do not want to leave it; especially because change is something we did not cause. We want to continue to pass it on to our children and grandchildren. (Lord Ma'afu, 2009)

Tonga is on the frontline of the impacts of climate change. As of December 2015, the net sea level rise trend in Tonga was 7.3 mm per year (Ministry of Meteorological Energy Information Disaster Management Environment Climate Change and Communications, 2018 (MEIDECC)). The low lying areas throughout Tonga with an elevation below 2m, including the islands of Tongatapu and Ha'apai, will be affected by the increased sea level (Ministry of Environment and Climate Change and Ministry of National Emergency and Management Office, 2010). The increasing frequency and intensity of extreme weather events in Tonga is well documented and these have posed detrimental impacts on all sectors, including social, economic and environmental. The severe droughts of 1983, 1998, 2006 and 2015 had detrimental effects on the annual crops such as squash, vegetables, yams, sweet potatoes, root crops, and coconuts. The agricultural production was also gravely damaged by Tropical Cyclones Renee in 2011, Ian in 2014, and recently by Gita in 2018 (MEIDECC, 2018). The quote at the start of this chapter was a part of the script that was read by Tonga's Minister for Environment and Climate Change, Lord Ma'afu, at the 15th United Nations Conference on Climate Change in Copenhagen, Denmark, on December 15th, 2009. He wanted to emphasise to the world leaders that he does not want to see his home country, Tonga, be lost to cyclones and rising sea levels (Pulu, 2013).

The 5th assessment report by the Intergovernmental Panel on Climate Change (IPCC) identifies the Pacific as one of the world's most vulnerable regions to the detrimental impacts of climate change due to their geographical, physical, geological, and socio-economic characteristics (Nurse et al., 2014). This has been recognised by Pacific peoples, who note that "The projected increase in atmospheric and sea surface temperatures, changing rainfall patterns, prolonged drought periods, and increased

frequency of extreme weather events and rising sea levels will seriously affect the lives of Pacific Islanders" (Secretariat of the Pacific Community, 2013, p. 1).

There are two main strategies to address climate change: mitigation and adaptation (IPCC, 2014a). Mitigation focuses on interventions to reduce greenhouse gas (GHG) concentrations and adaptation refers to "…reducing the vulnerability of natural and human systems to the impacts of climate change and adapting to a changing climate through adjustments in social, ecological or economic systems…" (Anderson, 2010, p. 4). Article 6 of the United Nations Framework Convention on Climate Change (UNFCCC) directs countries to develop, promote and implement educational, training, and public awareness programs on climate change and its effects (UNESCO, 2012). Successful climate change mitigation and adaptation need relevant knowledge, skills and behaviour change that education can provide (Anderson, 2010).

Climate change education (CCE) is a key factor in the global response to climate change and is critical in supporting Pacific Island countries in adapting to the consequences of their vulnerability to climate change (Fernandez, Thi, & Shaw, 2014; Mochizuki & Bryan, 2015; UNESCO, 2014). It is paramount that people in the Pacific region are equipped with skills and knowledge so they will be able to respond to and address the impacts of climate change. Sound knowledge of causes and effects of climate change, the capacity to cope, and options to adapt and mitigate are crucial for the Pacific population (Hartmann, Hanna, Tagivakatini, & Ries, 2010). CCE seeks to help learners develop knowledge, skills, values, and action to engage and learn about the causes, impact, and management of climate change (Chang, 2014).

The significance of climate change impacts has been under-emphasised in most secondary school curricula, and there is limited integration of climate change science and the implications of associated environmental change across disciplines (UNESCO, 2009). There is a need to review and re-orientate the present educational and teaching and learning programs to address the causes and consequences of climate change (UNESCO, 2009). It has become necessary that the environmental and societal changes occurring and risks of these be incorporated into education (Bardsley & Bardsley, 2007). Mobilizing children in climate change education programs and encouraging child-led initiatives both in and out of school and at the community level is an area where major gaps persist and this can impact upon sustainable development (UNESCO, 2012). Dawson and Carson

(2013) highlight that students are not only our future but they are the future global citizens and they will hold responsibility for the Earth's environment.

Geographically, the Pacific region ranks high on people's levels of concern about climate change (Chua, 2010). However, these people are amongst those where least is known about the ways that climate change will affect them and how they can adapt to these effects (Barnett & Campbell, 2010). Ascertaining levels of climate change knowledge in different sectors of society is, therefore, an important aspect of dealing with future climate change, in order to understand how best to improve climate change awareness and adaptive capacity (Buggy & McGlynn, 2014).

Over the past several years, many international studies have been conducted to identify secondary school students' knowledge and conceptions of climate change, global warming, and the greenhouse effect. The research findings indicated the challenges facing teachers in developing students' conceptualizations of climate change. They indicate gaps between students' and teachers' conceptualizations and scientific perspectives on climate change (Boyes & Stanisstreet, 1997; Punter, Ochando-Pardo, & Garcia, 2011; Shepardson, Niyogi, Choi, & Charusombat, 2011). Even though young people in the Pacific Island Countries (PICs) are highly vulnerable to the impacts of climate change, very few studies have been carried out to explore their perceptions of the issue. The previous studies of students, teachers and climate change indicated that they can have significant misconceptions about climate change issues (Boyes & Stanisstreet, 1997). Identifying the students' perceptions about climate change in Tonga is therefore important.

1.2 The context of the inquiry

The Kingdom of Tonga is the only country in the Pacific region that has never lost indigenous sovereignty to a foreign power. Tonga consists of four main island divisions, Tongatapu and 'Eua in the south, Ha'apai in the middle, Vava'u in the north and Niuafo'ou and Niuatoputapu in the far north. Tonga is located between 15° and 23.5° south latitude just above the Tropic of Capricorn (Ministry of Meteorological Energy Information Disaster Management Environment Climate Change and Communications, 2018; Tonga Department of Statistics, 2013). Tongatapu is the largest island group where 70% of the population in Tonga reside. The majority of the islands in Tonga are of

coralline formation, and these islands are relatively flat. There are some high volcanic islands in Tonga, and they are located particularly to the west of Ha'apai, Niuafo'ou and Niua Toputapu. The south of Vava'u group is composed of high elevated limestone islands and surrounded by fringing reefs. The Ha'apai group has high volcanic and low limestone islands (Ministry of Environment and Climate Change and Ministry of National Emergency and Management Office, 2010).

The total population of Tonga is just over 100,000. Tongan life is all about 'Famili' or family. Each family member is brought up knowing how to love and respect one another. There are four core values that the Tongan culture is built on and these are expected to be upheld on a daily basis. These four core values, also known as the 'Faa'i Kavei Koula' or the Four Golden themes, are the pillars of Tongan society. They are: Faka'apa'apa (Respect); Loto to (Humility); Tauhi Vaha'a (keeping the relationship ongoing, alive and well); and Mamahi'i me'a (Loyalty).

Tonga's economy is largely dependent on foreign aid and remittances from Tongans working overseas (primarily in New Zealand, Australia, and the United States). Tongan families earn their income primarily from subsistence farming and handicrafts. The majority of households in Tonga, particularly on the outer islands, are self-sufficient, their basic food needs met from farming and fishing. Tonga is regarded as a Christian country, the people are religious and are churchgoers and church acts as the primary religious and social basis of the Tongan society.

Tonga is one of the Pacific Island Countries which are highly vulnerable to the impacts of climate change. Climate change is prioritised in its national agenda and it has partnered with the global community to address the detrimental effects of climate change. Tonga ratified the United Nations Framework Convention on Climate Change (UNFCCC) on July 20, 1998, and submitted its First National Communication in 2005 to fulfil its commitment to the UNFCCC (2005). Tonga submitted its Second National Communication (SNC, 2012) report in 2012 as a continuation and update of the work done in Tonga's initial report. Its main focus was to reinforce the national capacities and promote general knowledge and awareness on climate change and natural disasters and their impacts (Ministry of Environment and Climate Change, 2012).

Tonga was the first country in the region to develop a Joint National Plan on Climate Change Adaptation and Disaster Risk Management (Ministry of Environment and Climate Change and Ministry of National Emergency and Management Office, 2010). Lord Ma'afu (Minister for Environment and Climate Change) highlighted that this plan is an "entry point to a coordinated approach in assisting Tonga to timely adaptation and disaster risks mitigation, thus achieving its sustainable development goals and aspirations" (Ministry of Environment and Climate Change and Ministry of National Emergency and Management Office, 2010, p. i).

The Development of this plan complies with Tonga's National Strategic Development Framework 2009-2014 and the Pacific Islands Framework of Action on Climate Change 2006-2015. This plan comprised six priority goals and goal 2 directly addresses the education sector. The goal asks for: "Enhanced technical knowledge base, information, education, and understanding of climate change adaptation and effective disaster risk management" (Ministry of Environment and Climate Change and Ministry of National Emergency and Management Office, 2010, p. 5 (MECC & NEMO)).

The Joint National Action Plan 2 was established in 2018 and is consistent with the Tongan Strategic Development Framework. The mission of the policy for the JNAP 2 is: "To develop a resilient Tongan through an inclusive, participatory approach that is based on good governance, builds knowledgeable, proactive communities and support a strong, sustainable development pathway". The goal of the policy, for JNAP 2 is: "To achieve the vision of a Resilient Tonga by 2035. This will be realised through the achievement of specific targets" (MEIDECC, 2018, p. viii).

1.3 Historical overview of education in Tonga

Tongan society has been characterised by a three-tiered social system that comprised the king, nobles or chiefs, and commoners, whereby members of each social class were determined by birth (Koloto, 1998). Tonga is the only Pacific nation that has a traditional monarchy under a king and that social-political system has existed for many years based on the rules of the chiefs (Leyard, 1982). The Tongan people lived by the seasons, tides, planting and harvesting of crops, and fulfilment of their obligations to the chiefs and the royal dynasty, as well as individual events of birth, marriage, and death (Campbell, 1992). Activities were primarily fishing, house and canoe building, yam planting, weaving and

tapa making. A person's normal tasks would be determined by their place and function in society (Cummins, 1977; Paongo, 1990). The young generation grew up and witnessed this way of living, and followed the same pattern as that of their parents and grandparents. Therefore, traditional education was informal, flexible and based in the family and environment (Cummins, 1977; Paongo, 1990). The training and education provided for the children to gain skills and knowledge fundamental for their roles in society were carried out by extended family members. What was regarded to be important knowledge, who it was taught to, and how it was taught were directed and dominated by the chiefly groups (Mara, Foliaki, & Coxon, 1994).

In this system, people were trained and educated in informal ways wherein learning occurred through observing, listening, memorising and practical application. Children learned by observing their parents and relatives (Cummins, 1977; Mara et al., 1994; Paongo, 1990). Traditionally, the teacher was regarded as the person in possession of knowledge and skills and was viewed as superior to that of the learner. Therefore, the learner was expected to have a relationship of respect and deference towards the teacher (Mara et al., 1994).

Formal education, initially primary school, was first introduced to Tonga in the early 1820s by the London Missionary Society. One of the main objectives of the mission schools was to civilise and convert people to Christianity. The missionaries then developed a written form of the Tongan language and then translated the Bible into it (Ministry of Education, 1995). The curriculum was designed according to what knowledge the missionaries believed to be important and of value to them. The people of Tonga were educated not only on moral and religious issues but also in basic skills such as literacy and numeracy in order to communicate their understanding of the new faith (Ministry of Education, 1995). This period was an onset of the under-valuing of traditional knowledge and skills. The traditional knowledge which was a valuable possession of the local people was not taught in these schools. This was the period when the technological knowledge of the West started to take the place of traditional knowledge (Mara et al., 1994; Thaman, 1995).

With the establishment of a government in 1862 and an education system, the aim of formal education shifted from teaching children to read and write to that of preparing people for the workforce. The curriculum then extended to establishing mathematics and

other subjects. Tonga's first secondary school was established by the Wesleyan mission in 1866 and was called Tupou College (Koloto, 1998). The education system would provide free education to all primary school children and the majority of the primary schools are now administered by the Government. A majority of the primary students attend government schools. The church schools, however, still play a significant role in secondary school education. More than 90 percent of secondary students in Tonga attend church schools (Commonwealth Education Online, 2020).

In addressing the undervaluing of traditional Tongan skills and knowledge, Thaman (1995) advocated that educators in Tonga and across the Pacific analyse the curriculum that schools are communicating to the students. Thaman (1995) believed that the replacement of traditional knowledge by the technological knowledge of the West was an indication of loss of culture that may impact the people of Tonga. Aligning with the international movement by indigenous people to integrate indigenous knowledge and pedagogy in formal education, the challenge for Tongan educators was then to determine how this could be achieved in the Tongan formal education (Koloto, 1998).

1.4 Vision of education in Tonga

The national context in which Tonga is implementing its development plans is outlined in the Tonga Strategic Development Framework which defines the National Development Vision: "To develop and promote a just, equitable and progressive society in which people of Tonga enjoy good health, peace, harmony, and prosperity, in meeting their aspirations in life" (Ministry of Finance and National Planning, 2011, p. 10) to be achieved by delivering nine outcome objectives. Two of these outcome objectives relate specifically to education. The outcome objective 4 reads, "Sound Education standards, by emphasizing quality universal basic education" and the outcome objective 5 states that "Appropriately skilled workforce to meet the available opportunities in Tonga and overseas, by delivering improved Technical and Vocational Education and Training" (Ministry of Finance and National Planning, 2011, p. 6). This vision has been embodied by the Tonga Ministry of Education and Training (MET) and is aiming to achieve quality education that is unique for Tonga (Government of Tonga, 2015).

The Ministry of Education has responded to the Government Vision and Outcome Objectives by developing its Vision and Outcome objectives to align with and give

support to the achievement of the Tonga Strategic Development Framework. The vision of education in Tonga is that the "…people of Tonga will achieve excellence in education that is unique to Tonga" while its mission aims to "…provide equitable, accessible, relevant and sustainable quality education for all Tongans that will enable Tonga to develop and become a learning and knowledge society" (Ministry of Education and Training, 2012, p. 27). Quality education does not particularly focus on the students' achievements, but more on principles, values, and attitudes that characterise the student, which are then demonstrated when a student appreciates, respects, participates, cooperates, contributes and seeks to uphold Christ-like behaviours and relations with others (Ministry of Education and Training, 2014). Thaman (2013) also adds that for Tongans, quality education is based on their culture, their knowledge, their languages, and learning/teaching traditions.

There are five overarching themes that inform every subject in the Tongan education curriculum, and Education for Sustainable Development (ESD) is one of these themes (Ministry of Education and Training, 2016). ESD is an "inclusive 'life-skills' package" bringing together formal and informal education, and is growing in the Pacific (Vaka'uta, 2011, p. 3). In 2006, the Pacific Islands Forum Education Ministers endorsed the Pacific ESD Framework (PESDF) as a guiding document for ESD practice in the Pacific island region (UNESCO, 2006). The main goal of the PESDF was:

> To empower Pacific peoples through all forms of locally relevant and culturally appropriate education and learning to make decisions and take actions to meet current and future social, cultural, environmental and economic needs and aspirations (UNESCO, 2006, p. 3).

ESD therefore plays a significant role in the Tongan education context and indicates the importance of CCE for the school curriculum. This highlights the need to research how students and teachers understand the issue of climate change and its place in education. Anderson (2012) argues that it is vital to investigate the skills, attitudes, and behaviour of people in order to determine what works for formal CCE content. She also highlights that educational interventions are most successful when they focus on local, tangible, and actionable aspects of sustainable development, climate change, and environmental education, especially those that can be addressed by individual behaviour.

1.5 Aim of the study

This research aimed to ascertain Tongan secondary school students' and their teachers' current perceptions of climate change issues in their country: the causes; the impacts; and the possible actions to respond to climate change, and also to identify the existing status of climate change issues in the secondary school curriculum. Analysis of these perceptions and status enabled a climate change education intervention to be designed, implemented and evaluated for enhancement of climate change education in Tonga.

The research was guided by the following four key questions:

1. What are secondary school students' and teachers' perceptions of climate change in Tonga?

2. What is the existing status of climate change-related issues in the secondary school curriculum in Tonga?

3. How can a climate change education intervention be designed for Tongan secondary education?

4. What are the learning outcomes for Tongan students and teachers about the issue of climate change in response to the education intervention?

1.6 Significance of the research

Tonga and its island groups are extremely vulnerable to the impacts of climate change. The geographical location, geological composition and socioeconomic features of Tonga greatly determine its susceptibility to these impacts for they fundamentally affect the environment, its people and their livelihoods.

This research could be one of the first studies to explore students' and teachers' perceptions of climate change in Tonga, and for a climate change education intervention to be trialled in a secondary school. Therefore, the study could be a significant contribution to the knowledge in this area. The outcome of this study would benefit the students, teachers and the education sector in Tonga and may be applicable to the education sectors across the Pacific Island region. The evaluation of the intervention

could be instrumental in indicating how climate change education helps to enhance students' knowledge, awareness, attitudes, and motivation to act upon climate change.

Increased awareness of climate change issues can be facilitated by focusing on the education system, and particularly by enhancing school students' understanding of climate change (Buggy & McGlynn, 2014). It is crucial to determine students' conceptions and alternative conceptions of climate change, while also focusing on curricula content and on secondary school teachers' perceptions of climate change, in order to plan and design effective instruction that builds on these concepts (Buggy & McGlynn, 2014).

Most research and education interventions regarding climate change have focused on individuals' knowledge of, and alternative conceptions of, mitigation while ignoring the crucial construct of individuals' understanding of adaptation to climate change (Bofferding & Kloser, 2015). This study seeks to contribute to an emerging literature on students' understanding of climate change and their understanding, attitudes, and motivation towards mitigative and adaptive responses to climate change. Students' conceptions of adaptation to climate change are generally absent from the literature as studies focus primarily on mitigation (O'Connor, Bord, & Fisher, 1999), but in places like Tonga, where the sea level is rising, droughts parch the land, or floods inundate homes and fields, educating for adaptation is essential.

The research outputs may make it possible to develop or update a climate change perception instrument for proposed inclusion in the school curriculum (Buggy & McGlynn, 2014). This study has accommodated CCE in the context of ESD, and it may contribute to countermeasure the sense of helplessness and disempowerment that these citizens might feel in the face of climate change knowledge (Mochizuki & Bryan, 2015). ESD can position them as active change agents and equip them with a range of cognitive and analytical tools that can help them to deal with climate change. The teaching and learning methodologies in ESD enable learners to engage critically and productively with the complexities of climate science in ways that are dynamic, interactive and innovative (Mochizuki & Bryan, 2015). In addition, a key purpose for learning in the Tongan culture is to gain knowledge and understanding considered important for survival and continuity, which is the Tongan equivalent of sustainable living (Thaman, 2010; Vaioleti, 2011). An educated person is regarded as one who is poto, who knows what to do and does it well

(Thaman, 1988; Vaioleti, 2011), or has wisdom (Fua, Manu, & Takapautolo, 2008). Poto is achieved through the appropriate and beneficial use of ‘ilo, the appropriate combination of knowledge, understanding and experience, which has intellectual, emotional and spiritual connotations (Fua et al., 2008; Thaman, 1988; Vaioleti, 2011). One of the core values of Tongan indigenous education is tauhi vaha’a (maintenance of harmonious relationships), this is among people as well as in the relationship between people and nature (Thaman, 2010; Vaioleti, 2011). Thaman (2010) advocates that this indigenous education empowers knowledge and understanding of how people are related to one another, together with associated responsibilities and obligations.

1.7 Background and motivation of the researcher

My interest in climate change issues began when I was doing my undergraduate studies. At that time, climate change related-issues were gaining more public attention and have become one of the most debated issues. My attention, however, was attracted by the fact that the Pacific region was highly vulnerable to the detrimental impacts of climate change such as rising sea levels and increasing extreme weather events. Although I found climate change a relatively new topic, I was willing to learn more about it and to gain a better understanding about how it affects the people and the environment of Tonga, and also to explore any possible solutions to address climate change if it is happening in Tonga.

I was motivated to do this research as a result of my Master’s research, and also my experience as a Geography teacher in secondary school in Tonga. The findings of my Master’s research informed me that climate change affected the people and the environment of Tonga in many ways (Havea, 2015). This research also recommended education to be an effective way to help people address the consequences of climate change. With my prior background in education, I came to a decision that climate change education needs to be integrated in the school curriculum so that the young people in Tonga can be able to deal with the ongoing impacts of climate change.

Being a Geography teacher in Tonga for eight and half years before I migrated to New Zealand made me realise the urgent need of climate change education for students. Based on my experience as a teacher, I was aware that climate change issues had not been effectively addressed in the school curriculum. Climate change was not a topic of discussion at the time, and I could not remember a time that I included climate change in

my teaching. Knowing about the impacts of climate change on the people and the environment of Tonga, and understanding the importance of including climate change education in the secondary school curriculum, they strongly inspired me to think of how I could make a contribution. Therefore, it appeared to me that exploring the students' and teachers' perceptions of climate change, and the place of climate change in the school curriculum is an important need. This led me to find out how a climate change education intervention could be designed and implemented in Tonga, and how students and teachers responded to such an intervention.

1.8 Overview of the thesis

This thesis is organised into eight chapters. A brief outline of each remaining chapter follows:

Chapter 2 presents the literature review, which discusses the key elements of this study. Topics discussed are: The key ideas of climate change, which include the human-induced greenhouse gases, the impacts of and responses to climate change; Climate change in the Pacific region and Tonga; Perceptions of climate change; Climate change education, climate change in Tonga, and teaching and learning approaches for climate change education.

Chapter 3 describes the methodological approach used in the research, and methods used for data collection, and data analysis. It also includes a description of the research design, including sampling, and discusses the issues of validity and trustworthiness, and ethics.

Chapter 4 present the findings from Phase One of data collection based on students' and teachers' perceptions of climate change, and the existing place of climate change in the school curriculum. It provides the participants' background and characteristics and their connections to the place. It also presents the results of students' and teachers' perceptions of climate change focusing on Awareness, Knowledge, Attitude, and Motivation to act to reduce the negative impact of climate change. Findings on students' and teachers' desire to learn about climate change are also presented in Chapter 4.

Chapter 5 presents the findings on the existing status of climate change in the school curriculum. Students' and teachers' views about the place of climate change in their school curriculum are also presented in this chapter. The guiding principles for the climate

change education intervention are also outlined in this chapter, and they are informed by the key findings in Phase One of data collection, and key ideas from literature. The nature of the intervention is also discussed in this chapter and is followed by a description of the Professional Development that was conducted with the teacher who delivered the climate change education intervention.

Chapter 6 presents the findings of Phase Two of data collection which is the implementation of the intervention. It describes the background information of the participants and the context. This chapter also outlines the set of lesson plans that guided the intervention, and discusses Talanoa as the approach for teaching and learning about climate change in Tonga.

Chapter 7 presents the findings on the evaluation of the students' and teacher's learning outcomes in response to the climate change educational intervention. An evaluation of the community learning outcomes is also included in this chapter.

Chapter 8 presents the discussion, conclusions, and recommendations drawn from the research and presents suggestions for further research.

Chapter 2: Literature review

2.1 Introduction

This chapter presents a review of literature pertinent to this study. There are four main sections in this chapter. Firstly, a brief overview of the key ideas of climate change is presented and is followed by a review of existing literature around human-induced climate change. This section focuses on the literature that is relevant to causes and impacts of climate change and the solutions to address climate change at the local level in Tonga, in the Pacific and at the global level. Since education is recommended as an approach for climate change mitigation and adaptation, the next section explores literature around teachers' and students' perceptions of climate change. Literature on climate change education is discussed next and literature on education for sustainable development is also explored in this section. Recommended teaching and learning approaches for teaching and learning about climate change are also presented in this section. The last section of this literature review focuses on the theoretical position of talanoa in climate change education – talanoa as it appears in this literature review is a proposed approach for climate change education in Tonga.

2.2 Key ideas of climate change

Energy from the sun drives the Earth's weather and climate, by heating the Earth's surface. To balance this, the Earth radiates energy back into the space. Atmospheric gases such as water vapour and carbon dioxide (CO_2) trap some of the outgoing energy, so the Earth retains more heat it would without the atmosphere (Secretariat of the Pacific Regional Environment Programme, 2014) – this process is called the greenhouse effect (Le Treaut et al., 2007). Without the natural greenhouse effect, the Earth's temperature would be below the freezing point of water, and life on earth would not be possible (Le Treaut et al., 2007). The greenhouse effect occurs as certain atmospheric gases absorb longwave (terrestrial) radiation and hinder its transmission from the Earth's surface back to space. This energy is then emitted downward, back toward the surface keeping the Earth warmer than it would be if there were no greenhouse effect (Rohli & Vega, 2012).

The Earth's climate has always changed due to natural processes interacting with the sun, such as the water and energy cycle. In the past, these changes were natural and caused by phenomena such as slow shifts in the Earth's orbit and changes in solar and volcanic

activity, and natural release of so-called greenhouse gases (GHG) into the atmosphere. However, human activity has caused a sudden shift in the climate by releasing billions of tonnes of carbon dioxide and other greenhouse gases into the atmosphere and adding substantially to the greenhouse effect (Secretariat of the Pacific Regional Environment Programme, 2014). This is clarified by a recent report from the Intergovernmental Panel on Climate Change (IPCC), justifying that human activities contribute massively to the ongoing carbon emissions and is estimated to have caused approximately 1.0˚C of global warming above pre-industrial levels (IPCC, 2018).

It is clear from the above discussion that greenhouses gases occur naturally and are very important to the survival of humans and other living things. While natural processes affect the climate, and climate change on time scales both short and long, the human activities like driving cars, farming, burning coal and cutting down forests produce greenhouse gases – mainly carbon dioxide, methane and nitrous oxide – which gather in the atmosphere, and the more greenhouse gases we emit, the more the greenhouse effect warms the Earth. As pointed out by the United Nations Framework Convention on Climate Change (UNFCCC);

> … it's a matter of scale…A century and a half of industrialization, including clear-felling forests and certain farming methods, has driven up quantities of greenhouse gases in the atmosphere. As populations, economies and standards of living grow, so does the cumulative level of GHG emissions (UNFCCC, 2014a, p. 1).

2.2.1 Human-induced greenhouse gas emissions

The Intergovernmental Panel on Climate Change (IPCC) has indicated that high concentrations of atmospheric gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have resulted from anthropogenic greenhouse gas emissions since the pre-industrial era (IPCC, 2014b). The IPCC report (2007) stated that the:

> Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years (IPCC, 2007d, p. 2).

Global CO_2 emissions are mainly produced by fossil fuel burning and from cement manufacture, between them contributing to 75% of the increase in the atmospheric CO_2 concentration since the pre-industrial era (Denman et al., 2007). The observed increases in atmospheric methane concentration are directly associated with human activities such as energy production from coal and natural gas, waste disposal in landfills, raising animals such as cattle and sheep, rice agriculture and burning biomass. Human activities that produce nitrous oxide include the transformation of fertilizer nitrogen into nitrous oxide and its "subsequent emission from agriculture soils, biomass burning, raising cattle and some industrial activities, including nylon manufacture" (Denman et al., 2007, p. 513). This rise in greenhouse gas emissions and consequent levels in the atmosphere has warmed the Earth, leading to climate change.

2.2.2 Climate change: A global issue

Due to ongoing intense public debate about the urgency, feasibility, cost and responses to climate change and the risks it poses, governments and scientists identified the need for " robust, comprehensive, and unbiased information", so the Intergovernmental Panel on Climate Change was set up (Reisinger, 2009, p. 1). This panel put forward three goals: to assess available scientific information on climate change; to evaluate the environmental and societal impacts of climate change; and to formulate response strategies (Santer & Wigley, 2010).

The first assessment of the IPCC was published in 1990, which concluded that " unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more" (Houghton, Jenkins, & Ephraums, 1990, p. xxix), and six years later, the IPCC's second scientific assessment revealed a more definitive conclusion regarding human impacts on climate and stated " the balance of evidence suggests a discernible human influence on global climate" (Houghton et al., 1996, p. 4). This highlighted a "paradigm shift in scientific understanding of the nature and causes of recent climate change" (Santer & Wigley, 2010, p. 28). The third assessment was published in 2001, and made an explicit statement about the magnitude of the human influence on climate change and concluded that "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities" (Houghton et al., 2001, p. 4).

In 2007, the fourth IPCC assessment made an explicit statement about the magnitude of human influence on climate and concluded that "Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities" (IPCC, 2007c, p. 2). This scientific progress is due to "large amounts of new and more comprehensive data, more sophisticated analyses of data, improvements in understanding of processes and their simulation in models and more extensive exploration of uncertainty ranges" (IPCC, 2007c, p. 2). It concluded that "Human interference with the climate system is occurring…Climate change poses risks for human and natural systems" (Field et al., 2014, p. 37).

Assessments carried out by the IPCC show that the rise in global Carbon dioxide (CO_2) emissions originates in part from high emission rates from industrialized nations and largely from sharply increased emissions from developing nations. Industrialized nations' CO_2 emissions rose 4.3% from 1990-2004, while CO_2 emissions from developing nations increased nearly 70% during the same time period (Galpern, 2008, p. 192).

As mentioned earlier, the first IPCC assessment report was released in 1990, and within the same year, the IPCC and second World Climate Conference decided to call for a global treaty on climate change. The United Nations Framework Convention on Climate Change (UNFCCC) was then established in 1992 and ratified by 196 countries plus the European Union, and its aim was to develop cooperative strategies to stabilize greenhouse gas concentrations in order to prevent the dangerous impacts of climate change (United Nations, 1992). The UNFCCC recently added that the ultimate aim of the Convention was to stabilize the concentration of greenhouse gas at a level that would prevent human induced greenhouse gases interference with the climate system (UNFCCC, 2014b). It stated that "such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner" (UNFCCC, 2014b, p. 1).

Since climate change is a complex problem, it requires integrated responses (UN Development Programme, 2018). The UNFCCC meets at what is called the Conference of the Parties also known as the COP, to negotiate a range of issues from global reporting on national climate change efforts to systems for providing financing, and the COPs also

provide an opportunity to share knowledge and experiences (UN Development Programme, 2018).

2.2.3 Definition of climate change

The UNFCCC defined climate change to be "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods' (United Nations, 1992, p. 3). The UNFCCC makes a contrast between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes. This definition was developed in 1992, but the UNFCCC took effect in 1994, therefore, the definition was formed in a time where there was less scientific evidence than now (UNFCCC, 2014b). The IPCC has since defined climate change as "any change in climate over time, whether due to natural variability or as a result of human activity" (IPCC, 2001, p. 984) which also acknowledged multiple inputs to change. A more recent definition provided by the IPCC (2014c),stated that:

> Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014c, p. 5)

In this thesis, climate change is primarily referred to a change in the state of the climate over decades or longer due to natural internal processes or external forcings and man-made (anthropogenic) greenhouse gases. Due to the enormous evidence released by the IPCC report indicating that human activities are largely to blame for the rapidly-increasing concentration of greenhouse gases (IPCC, 2018), then climate change in this thesis is predominantly referred to as changes in the climate which are caused by human activities (anthropogenic).

2.2.4 Climate change or global warming

It is concerning that the terms ‘climate change’ and ‘global warming’ are sometimes used in an interchangeable way (Whitmarsh, 2009). Getting a better understanding of the definitions of, and differences between, ‘global warming’ and ‘climate change’ will help us understand why the threat caused by continued warming of the planet is so serious (Jeantheau, 2007). Global warming refers to an overall warming of the planet, based on average temperature over the entire surface. Climate change refers to changes in regional climate characteristics, including temperature, humidity, rainfall, wind, and severe weather events (Jeantheau, 2007). The term ‘global warming’ appeared to have been used more often perhaps because it is a more emotive term, in part because it suggests a clear direction of change towards increasing temperatures; while the evidence for, and implications of ‘climate change’ have been more ambiguous (Whitmarsh, 2009). Furthermore, ‘global warming’ may be seen as a more concerning and salient issue because of its previous currency in the mass media, which tends to dramatize and politicize science news (Hargreaves, Lewis, & Speers, 2003). By contrast, “climate change” is a more neutral term— there is no commitment implied as to the direction or cause of change. Indeed, this neutrality is demonstrated by the IPCC definition of climate change as current or projected changes in climate whether due to natural variability or to human activities (Whitmarsh, 2009).

Since research studies are increasingly focusing on public response to this issue, it is crucial to recognise that the terminology is not neutral and should not be used indiscriminately. In addition, the communicators should be aware of the distinct connotations of climate change and global warming amongst audiences (Whitmarsh, 2009). Whitmarsh (2009) highlights that public information about climate change may provoke a different, perhaps lower, response than information referring to global warming. On the other hand, global warming is more often associated with ozone depletion and heat-related impacts, and therefore may be misleading and reinforce widespread misperceptions (Whitmarsh, 2009).

Although the two terms global warming and climate change are used interchangeably, they refer to slightly different things (NASA, 2019). Global warming refers to the long-term warming of the planet and climate change embraces global warming but refers to a

wider range of changes that are happening to the planet including rising sea levels, accelerating ice melt in Antarctica, Artic, and Greenland (IPCC, 2018; NASA, 2019).

The next section presents the impacts of human-induced climate change which this thesis primarily focuses on.

2.2.5 Impacts of climate change

Impacts refers to the effects of climate change on natural and human systems - impacts on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system (IPCC, 2014c). Impacts are also referred to as consequences and outcomes. The physical impacts refer to the impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, (IPCC, 2014c). The Fifth Assessment Report (AR5) from the IPCC affirms that recent decades have seen warming air and ocean temperatures, altered precipitation patterns, rising sea levels, and changes in the frequency and intensity of some extreme weather events such as droughts, floods and storms (IPCC, 2014d)

In recent decades, changes in climate have posed impacts on natural and human systems on all continents and across the oceans (Field et al., 2014). These climate change impacts can either be direct or indirect. Direct impacts includes impacts such as inundation of different locations and infrastructure as a result of sea level rise (IPCC, 2007a). On the other hand, the indirect impacts of climate change can be identified in relation to poverty and health issues (Shaw, Pulhin, & Pereira, 2010) and can also include changes to market prices of agriculture and fisheries products (IPCC, 2007a). Climate change may contribute to various forms of natural disasters such as droughts, floods, and cyclones where people's lives and livelihoods are affected (IPCC, 2007a). Key environmental and social impacts that have potential to cause problems in Tonga are now discussed.

2.2.5.1 Rising temperature

Average global temperatures have increased about 0.7˚C since the late 1800's (Smith, 2001). The IPCC (2013a) declared in a report that the global mean surface temperature has increased since the last 19th century. The report also noted that each of the past three decades has been successively warmer than the previous decades, and the first decade of

the 21st century has been the warmest. Increasingly, it is recognized that current and future greenhouse gas (GHG) emissions have a significant likelihood of producing increased global temperatures above 2°C and concurrent climate change, which is likely to result in significant and dangerous physical, biological, and socioeconomic impacts (IPCC, 2007c).

> Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. (IPCC, 2007d, p. 5)

2.2.5.2 Sea level rise

The increase in global temperature is largely responsible for average global sea levels rising by 10 – 25 cm since 1900 (Smith, 2001). The rising of sea level is due to two main reasons. First, is the effect of the thermal expansion of the oceans and second, is the melting of the land-based ice (Field, 2014; Reisinger, 2009). These rising sea levels pose detrimental impacts on low-lying areas (Field et al., 2014). In many countries of the world, including New Zealand and Tonga, the impacts of sea level rise will vary around the coastline where low lying areas are prone to flooding. Some areas are exposed and susceptible to erosion. The impacts of sea level rise are evident during storm surges, and result in flooding (Parliamentary Commissioner for the Environment, 2014).

2.2.5.3 Extreme weather events

The IPCC third assessment report claimed some weather events and extremes will become more frequent due to global warming (Parry, Canziani, & Palutikof, 2007). Storms, heatwaves and fires are likely to increase in intensity and frequency. Floods, landslides, droughts and storm surges are very likely to become more frequent and intense. These extreme events already cause adverse impacts on human health through heat-related mortality, storm-related fatalities and injuries, and infectious diseases (Parry et al., 2007). Reisinger (2009) concurs with this by stating that a variety of systems and sectors are vulnerable to projected changes in weather and climatic extremes, namely water supply is negatively affected by droughts and the risk of flooding is increased with heavier rainfalls. Agriculture production is also affected by extreme temperatures.

The El Niño – Southern Oscillation phenomenon (ENSO) is the largest and best known mode of climate variability that affects weather, ecosystems and societies in large parts of the world (Van Oldenborgh, Philip, & Collins, 2005). The influence of increasing greenhouse gases on the properties of ENSO is a critical question in determining the impacts of climate change at the regional scale (Van Oldenborgh et al., 2005). Several climate models do indicate a more El Niño-like climate (greater warming in the tropical east Pacific Ocean and an eastward shift in convective activity in the Pacific) with increased greenhouse gases (Meehl & Washington, 1996). To some extent, successful long-term climate prediction rests on the issue of whether the unusual severity of these events was a consequence of rising global temperatures or was simply representative of natural variability (Cobb, Charles, Cheng, & Edwards, 2003). Tonga's climate pattern is highly influenced by the El Niño phenomenon. In 1983, 1998 and 2006 there were three major droughts in Tonga that were directly linked to El Niño events (MECC & NEMO, 2010).

These environmental impacts of rising temperatures, sea-level rise and extreme weather events can in turn have consequences for the economic, socio-cultural and sustainable development outcomes for Tonga, and these are discussed later.

2.2.6 Responses to climate change

In 2015 at COP21 in Paris, an agreement was made by the 197 nations present to establish a legal instrument that would govern climate change efforts; this is formally known as the Paris Agreement (UN Development Programme, 2018). The Paris Agreement's primary aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels, and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius (UNFCCC, 2018). To meet these goals, countries define their own contributions to the agreement through a bottom-up process and decide exactly what action they will take themselves (UN Development Programme, 2018). Since the Paris Agreement was ratified, research has evolved and the message from the climate science community is that we need to raise our ambitions further than expected. As indicated in a recent report on what a world with 1.5° C warming would look like, we will need to cut emissions in half by 2030 and reach zero net emissions by 2050 in order to avoid catastrophic climate impacts (UN Development Programme, 2018)

In December 2018, the COP24 was held in Katowice, Poland, and the core objective for countries at this meeting was to agree on the guidelines that govern the Paris Agreement, and to create a set of rules to help countries implement their national contributions and meet their targets (UN Development Programme, 2018). The IPCC's fourth assessment report (AR4) emphasized that climate change driven by human greenhouse gas (GHG) emissions is damaging natural and human systems, and without immediate response, it will "alter the planet's habitability" (Galpern, 2008, p. 192). The two main responses to the challenge posed by climate change are mitigation and adaptation (IPCC, 2018). Mitigation and adaptation are discussed next.

2.2.6.2 Mitigation

Mitigation is a human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2014a). That mitigation attempts to deal with the causes of climate change, and this can be achieved through actions that prevent the increase of atmospheric greenhouse gas concentration by limiting current and future emissions from sources of greenhouse gases and enhancing potential sinks (IPCC, 1996). Climate change mitigation is defined by the United Nations as a human intervention to reduce the sources of greenhouse gas emissions primarily linked to human actions of production and consumption (UNESCO & UNEP, 2011). Similarly, mitigation is referred to as measures to minimize the pace and magnitude of the changes in climate that will occur, such as emissions reductions, afforestation, and reforestation, and geoengineering to create cooling effects to offset warming by heat-trapping gases (Holdren, 2010). Mitigation efforts include a range of interventions to stabilize and reduce greenhouse gas concentrations such as: investing in renewable, non-polluting energies and designing greener technologies, promoting changed consumption patterns and lifestyles, fuel switching including the use of waste materials, heat and power recovery, feedstock changes including recycling, product changes, renewable energy, control of non-CO_2 gases, government leadership (for example in the United States, government agencies at many levels have established policies to build only Leadership in Energy and Environmental Design (LEED) – certified buildings), and changing behaviour (for example, turning off lights and appliances when not in use, ensuring doors and windows are closed in cold weather, and similar behaviours to significantly reduce building energy use) (IPCC, 2007b; Mochizuki & Bryan, 2015).

IPCC (2014a) highlights that effective mitigation will not be achieved if individual agents advance their own interests independently. They state:

> Climate change has the characteristics of a collective action problem at the global scale, because most greenhouse gases (GHGs) accumulate over time and mix globally, and emissions by any agent (e.g., individual, community, company, country) affect other agents (IPCC, 2014a, p. 5)

2.2.6.3 Adaptation

Adaptation refers to the process of adjustment to actual or expected climate change and its effects (IPCC, 2014b). The IPCC (2014b) states that, "In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" (IPCC, 2014b, p. 5). Climate change adaptation is also referred to as a process of building resilience and reducing the vulnerability of natural and human systems to the impacts of climate change (Mochizuki & Bryan, 2015). Mochizuki and Bryan (2015) argue that the adaptation dimension involves developing the knowledge, skills and dispositions to better cope with already evident and looming climate impacts. Smit, Burton, Klein, and Wandel (2000, p. 225) define adaptation as "adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli, their effects or impacts." Smit and Wandel (2006, p. 282) further define adaptation in the context of human dimensions of global change as "a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity".

Adaptation is comprised then of actions throughout society, by individuals, groups and governments, and it can be driven by many factors such as protection of economic well-being or improvement of safety (Adger, Arnell, & Tompkins, 2005). It can be indicated in various ways, either through market exchanges (Smit et al., 2000), through extension of social networks (Adger, 2003) or through actions of individuals and organisations to meet their own individual or collective goals (Adger et al., 2005). Adger et al. (2005) also state that adaptation can be initiated for individuals' benefit or it can be made up of actions by governments and public bodies to safeguard their people. The Article 3 of the UN Framework Convention on Climate Change urges governments to adapt to climate change,

and the Delhi Ministerial Declaration on Climate Change and Sustainable Development, issued at COP8 in 2002 emphasized that adaptation is of high priority for all countries and that adaptation requires urgent attention and action on the part of all countries (Adger et al., 2005).

Adger et al. (2005) argue that adaptation is an issue relevant at local, national and international levels, so adaptation strategy or decision-making will be effective if that action meets the objectives of adaptation and how it affects the abilities of others to meet their adaptation goals. In another words, success depends on "scale of implementation and the criteria used to evaluate it at each scale" Adger et al. (2005, p. 78). The Working Group II (WGII IPCC Fourth Assessment Report (AR4)) found that deliberate adaptation measures in response to anticipated climate change were being implemented by a range of public and private actors, on a limited basis in both developed and developing countries (Noble et al., 2014). These measures are undertaken through policies, investments in infrastructure and technologies, and behavioural change and they are sometimes initiated in response to climate change alone (Noble et al., 2014).

Adger et al. (2005, p. 79) outlined three cornerstones of adaptation: "reduce the sensitivity of the system to climate change; alter the exposure of the system to climate change; and increase the resilience of the system to cope with changes". Reducing the sensitivity of the affected system refers to measures such as planting hardier crops that can withstand more climate variability and ensuring that new buildings in flood plains are constructed with a floodable ground floor. Altering the exposure of a system to the impacts of climate change can be achieved, for instance, by investing in hazard preparedness and undertaking climate change mitigation activities. Increasing the resilience of social and ecological systems can be accomplished through actions aiming to reinforce well-being and increasing access to resources or insurance and also including measures to enable specific populations to recover from loss. These three dimensions of adaptation can be implemented at any scale (Adger et al. 2005).

Schipper (2007) argued that work on adaptation should focus on addressing the underlying factors that cause vulnerability instead of putting too much emphasis on responding to the impacts of climate change. Climate change brings new challenges, not only the rising in sea-level and temperature but also the current context of failure to address the causes of poverty adequately. Therefore, Schipper (2007) believes that policy

supporting adaptation is a profound strategy for responding to both climate change and supporting development. He notes that “a successful adaptation process will require adequate addressing of the underlying causes of vulnerability: this is the role that development has to play” (p. 2).

Societies have practiced various adaptation measures to reduce impacts of climate change such as irrigation, crop diversification and disaster risk management, but climate change, along with other drivers of change, poses novel risks often outside the range of experience (Noble et al., 2014). The IPCC WGII Assessment Report 4 accentuates that within all societies, there are individuals and groups that have insufficient capacity to adapt to climate change (Noble et al., 2014). There are factors that can hinder the capacity of a society to adapt to climate change, including economic and natural resources, social networks, institutions and governance, human resources and technology. The report notes the significance of the establishment of the National Adaptation Programmes of Action (NAPAs) and that some developed countries had established national adaptation policy frameworks (Noble et al., 2014).

Adger et al. (2009, p. 338) argue that in terms of adaptation, limits have emerged from inside the society rather from outside. They outlined four main domains that limit adaptations: “ethics (how and what we value), knowledge (how and what we know), risk (and what we perceive), and culture (how and why we live)”. They believe that these four propositions proclaim whether there are limits to societal adaptation to climate change. Some of these limitations are relevant to Tonga, for instance, a study that was conducted by Havea (2015) on the local people’s understanding about climate change in Tonga indicated that the people of Tonga were not willing to do anything about climate change as they thought God would save them from the consequences of climate change. Their religious beliefs constrained their abilities to act upon climate change, and how they could adapt to the risks that they currently encountered.

2.2.7 Education for Mitigation and Adaptation

UNESCO aims to make climate change education a more central and visible part of the international response to climate change (UNESCO, 2016a). The programme aims to help people understand the impact of global warming today and increase "climate literacy" among young people. It hopes to do this by strengthening the capacity of its member

states to provide quality climate change education; encouraging innovative teaching approaches to integrating climate change education in school; and by raising awareness about climate change, as well as enhancing non-formal education programmes through media, networking, and partnerships (UNESCO, 2016a). It is believed that CCE must be framed strategically to promote mitigation and adaptation with an emphasis on the causes and impacts as well as required "knowledge, skills, values and attitudes for effective mitigation using appropriate action-oriented pedagogies" (UNESCO & UNEP, 2011, p. 55). Climate change education explores mitigation and adaptation at both the local and global level (Kagawa & Selby, 2010) and the interrelationship between these levels (Stevenson, Nicholls, & Whitehouse, 2017). Boon (2016, p. 55) carried out a study on pre-service teachers, and findings indicated that pre-service teachers wanted to know more about mitigation actions, solutions and human impacts of climate change and "…areas less abstract and more clearly connected to their everyday life". It is further emphasized by Stevenson et al. (2017) that making connections to students' everyday life is hugely significant to effective learning. Barnett (2001) believes that the ability to learn is fundamental to the ability to respond and adapt climate change. He argues that education policy is a key to adaptation, and he believed that educated societies seem to be more resilient to environment change.

It is important to encourage and inspire individuals to take personal actions to mitigate climate change (Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007; O'Neill & Nicholson-Cole, 2009; Wolf & Moser, 2011). Gonzalez-Gaudiano and Meira-Cartea (2010) believe that there is a requirement for an education that challenges normative values that shape our worlds. Stevenson et al. (2017, p. 69) suggest that:

> Transition from unsustainable values and practices such as carbon-dependent forms of transportation requires students to assume responsibility and develop the capacity to become civically engaged in collective actions that can contribute to reducing greenhouse emissions and transforming communities and societies to enact more sustainable policies and structure.

Education is a critical component of adaptive capacity. This means that people are educated and the content of education can provide the knowledge and skills needed for

making informed decisions about how to adapt individual lives and livelihoods as well as ecological, social or economic systems in a changing environment (Anderson, 2012).

2.2.8 Section summary

Having discussed the key ideas of climate change, it is evident that the high concentrations of greenhouse gases can be attributed primarily to human activities. This high concentration of greenhouse gases is produced from various human activities such as agriculture, burning fossil fuels, deforestation and transportation. Impacts of climate change such as rising temperature, rising sea levels and more extreme weather events are already experienced and observed at local, regional and global scales. Mitigation and adaptation are two major responses being advocated to eradicate the detrimental impacts of climate change. Many countries have prioritised climate change in their national agenda.

The next two sections, section 2.3 and sections 2.4 presents literature on climate change in the Pacific Island Countries and specifically in Tonga. Section 2.3 briefly highlights the impacts of climate change and responses to climate change, and section 2.4 outlines Tonga's carbon emissions, impacts of climate change and the responses being utilized to address climate change.

2.3 Climate change in the Pacific Island Countries (PICs)

The Pacific Island Countries (PICs) are highly vulnerable to the impacts of climate change due to their physical, socio-economic and ecological characteristics. These places are at the frontline of climate change as the impacts such as rising temperatures, rising sea levels, shifts in rainfall patterns, and changing frequencies of extreme weather events are already felt and experienced by the people and the environment (Australian Bureau of Meteorology and CSIRO, 2011; Nunn, Aalbersberg, Lata, & Gwilliam, 2014; Nurse et al., 2014). Anderson (2012) echoes that vulnerable groups like children living in poverty in low-income countries with weak governance and poor education systems are the hardest hit by climate change. These changes are affecting peoples' lives and livelihoods, as well as important industries such as agriculture and tourism (Australian Bureau of

Meteorology and CSIRO, 2011) and these hazards increase vulnerability to disasters and result in widespread human, material, economic and environmental losses (IPCC, 2012).

Barnett (2011) highlights that climate change will affect food systems in the Pacific region, including the supply of food from agriculture and fisheries, the ability of countries to import food, systems for the distribution of food, and the ability of households to purchase and utilize food. Impacts of climate change on people's health are further discussed by McIver et al. (2015). PICs are among those most vulnerable to the health impacts of change (Hanna & McIver, 2014; Woodward, Hales, Litidamu, Phillips, & Martin, 2000). What challenges the Pacific island people the most are the impacts of climate change that threaten their way of life through increased climate variability, changes in the climate extremes, temperature rise and sea-level rise (Mimura, Nurse, McLean, & Agard, 2007; Nunn, 2009b; Nunn & Mimura, 2006).

2.3.1 Impacts

The economic impact of climate change is expected to be substantial because island economies generally depend on limited sources of revenue and are thus particularly exposed to external shock (Keener, Marra, Finucane, Spooner, & Smith, 2012). Climate-related environmental deterioration for communities at or near the coast, coupled with other socioeconomic or political motivations, may lead individuals, families, or communities to consider migrating to a new location. Depending on the scale and distance of the migration, a variety of challenges faces the migrants and the communities receiving them. Migrants need to establish themselves in their new community, find employment, and access services, while the receiving community's infrastructure, labour market, commerce, natural resources, and governance structures need to absorb a sudden burst of population growth (Keener et al., 2012). In addition, loss of local and traditional language associated with stresses to ecosystems may limit the effectiveness of adaptation (Adger et al., 2007; Burkett, 2011).

Climate change also poses serious consequences to the traditional life-styles and cultures of indigenous communities in all Pacific Island sub-regions (Keener et al., 2012). Inundation from sea level rise may destroy coastal artefacts and structures (Vitousek et al., 2004) or even the entire land base associated with cultural traditions (Henry & Jeffery, 2008). Drought threatens traditional food sources such as taro and breadfruit, and coral

mortality from bleaching will likely threaten subsistence fisheries in island communities (Maclellan, 2009).

Climate change may also have serious effects on human health, for instance by increasing the incidence of infectious diseases such as dengue fever (Lewis, 2012). Sea-level rise and flooding may also overcome sewer systems and threaten public sanitation (Keener et al., 2012). Psychosocial effects of stress from extreme weather events are likely to be gradual and cumulative (Keener et al., 2012). Increased incidences of resource conflicts may also affect mental and physical health, with a disproportionate impact on those of lower socioeconomic status (Swim et al., 2009).

2.3.2 Responses to climate change in the Pacific Island Countries (PICs)

In recognition of the adverse impacts of climate change on the PICs, leaders of the PICs developed the Pacific Islands Framework for Action on Climate Change 2006-2015 to guide the building of resilience to the risks and impacts of climate change (Australian Bureau of Meteorology and CSIRO, 2011). Nurse and Moore (2005) emphasised the need to implement adaptation measures in small islands with some urgency. They believe that adaptation in small island states is about building resilience. Lazrus (2012) concurs with Nurse and Moore by highlighting that adaptations and adaptive capacity enhance resilience. Previous studies of adaptation options for small islands including the Pacific region have been mainly focused on adjustments to sea-level rise and storm surges associated with tropical cyclones (SPREP, 2006).

Indigenous people play a significant role in the fight against climate change (Global Humanitarian Forum, 2010). Climate change issues are of particular interest to indigenous people for two interlinked reasons. First, they have a particular physical and spiritual relationship with land, water and associated ecosystems and tend to be among the most vulnerable to climate change. Second, they have a specialized ecological and traditional knowledge relevant to finding the best solutions to climate change (Gerrard, 2008). Indigenous knowledge systems and resource management practices are important tools for both mitigating and adapting to climate change (Mochizuki & Bryan, 2015). Households and community efforts in the islands are aligned with traditional practices and guided by local perceptions of risk and vulnerability. Rakova, Patron, and Williams (2009) use the example of planting mangroves, constructing sea walls and community-

initiated relocation plans and cooperation are vital mechanisms for resilience in the Pacific communities.

While the Pacific region must adapt to the impacts of climate change, their adaptive capacity is limited and is being hindered by factors such as internationalisation of economic activity and internal population pressures. Also, some traditional mechanisms for coping with environmental hazards are being lost in many islands (SPREP, 2006).

A community-based climate change project found that raising awareness is still a profound component of community climate change adaptation work in the Pacific. McNamara (2013a) states that in the Pacific, raising awareness of climate change at the community level is needed to be disseminated across the region, so that information and knowledge about climate change processes and impacts are continuing to develop. The levels of knowledge and awareness can influence people's perceptions about climate change, attitudes towards community adaptive capacity, and future responses to local environmental change (Barnett & Campbell, 2010). The awareness activities can also assist young generations in understanding the impacts of climate change, promoting voluntary changes in people's behaviour, and initiating public demand or support for actions (Lowe et al., 2006).

It is essential to recognise that the goal and all aspects of adaptation measures can only be understood in terms of the social context in which adaptation takes place; communities value things differently and these must be taken into account if adaptation is to be effective, efficient, legitimate and equitable (Barnett & Campbell, 2010).

2.4 Climate change in Tonga

The Tongan government considers climate change as a high priority in its National Strategic Planning Framework, 2009-2014 (MECC & NEMO, 2010). Tonga ratified the UNFCCC on 20th June 1998 and has submitted its Initial National Communication (INC) to the UNFCCC on 21 July 2005. Tonga's National Climate Policy was endorsed by government in 2006 and was followed by the establishment of the Ministry of Environment and Climate Change, which coordinates and implements all climate change activities in the country (Global Climate Change Alliance, 2013). The climate change policy identified key issues that affect the ability of Tonga to address climate change issues and concerns these key issues, including a:

> …lack of knowledge, a lack of physical and financial resources, a lack of comprehensive environmental legislation, inherent difficulties in discerning overlapping and unclear management powers, a lack of appropriate policy support, and a lack of public participation coupled with a basic lack of political will and commitment for sustainable development (Global Climate Change Alliance, 2013, p. 12)

Causes, impacts and responses to climate change in Tonga are now discussed.

2.4.1 Greenhouse gas emissions in Tonga

There are three main sources of energy in Tonga: Indigenous sources (especially biomass); renewable energy such as solar photovoltaic; and imported petroleum products (Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communication Ministry of Meteorological Energy Information Disaster Management Environment Climate Change and Communications, 2018). In 2016, indigenous biomass energy accounted for 46.5% and solar energy accounted for 0.2%, while imported petroleum products such as diesel and kerosene accounted for more than half, 53.3% of the total energy supply in Tonga (Ministry of Environment and Climate Change, 2012). The energy sector is a major greenhouse gas emitting sector in Tonga and the sector is highly dependent on imported petroleum products to meet Tonga's growing energy demand (Ministry of Meteorological Energy Information Disaster Management Environment Climate Change and Communications, 2018). Tonga aims to reduce its reliance on oil imports, and to respond to the Paris Agreement to reduce gas emissions and target to a much more cleaner energy through its nationally determined contributions and the Climate Change Policy.

2.4.2 Observed and projected impacts of climate change in Tonga

The climate of Tonga is reported to be changing and the adverse impacts of climate change on the environment are being felt (Pacific Australia Climate Change Science and Adaptation program, 2013). This thesis focuses primarily on the impacts of extreme weather events such as rising temperatures, drought and cyclones, and sea level rise. Literature on the socio-cultural and economic impacts of climate change is also reviewed. The Prime Minister of Tonga recently spoke at the Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC COP25) which was held in

Madrid, Spain from 2 – 13 December, 2019 and stressed the fact that the effects of climate change pose risks to the lives of people and the environment (SPREP, 2019). He stated:

> The effects of climate change continue to threaten the environment, land, the ocean and the marine resources, upon which, the livelihood and existence of our people, depend very much on. In the course of time, and as science tells us, these impacts are rapidly intensifying our vulnerabilities, and swiftly eroding our capacities for resilience
>
> (Hon. Pohiva Tui'onetoa, Prime Minister of Tonga (Source: SPREP, 2019, p. 1)

In his speech, the Prime Minister of Tonga also highlighted the impacts of rising sea level on the coastal environments, and that Tonga continued to experience record rates of coastal erosion, overflow and flash flooding. He also pointed out that the tropical cyclones in Tonga are increasing in intensity and at a rate that undermines their capacity to respond to and recover from (SPREP, 2019).

2.4.2.1 Extreme weather events

The intensity and frequency of days of extreme heat in Tonga are projected to increase over the course of the 21st century and this is physically consistent with rising greenhouse gas concentrations (Australian Bureau of Meteorology and CSIRO, 2011). Temperatures in Tonga change from season to season and are strongly tied to changes in the surrounding ocean temperature (Tonga Meteorological Service & Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Organisation, 2014). The projections for all emissions scenarios indicate that the annual average air temperature and sea surface temperature will increase in the future in Tonga. For example, "By 2030, under a high emissions scenario, this increase in temperatures is projected to be in the range of 0.3 – 1.1˚C" (Tonga Meteorological Service & Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Organisation, 2014, p. 6). Increases in average temperatures will also result in a rise in the number of hot days and warm nights in Tonga and decline in the cooler weather (Tonga Meteorological Service & Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Organisation, 2014). Similarly, the intensity and frequency of days of extreme rainfall are projected to increase over the course of the 21st century and this is attributed to an increase in the frequency and intensity of extreme weather which is consistent with larger-scale projections, based on the

physical argument that the atmosphere is able to hold more water vapour in a warmer climate (IPCC, 2007a).

2.4.2.2 Sea level rise

The effect of climate change and sea-level rise on coastal zones and resources would be significant. Thus land loss, shoreline retreat, coastal erosion and wave-overtopping would affect beach vegetation and mangrove forest which act as buffers against such extremes. Much of the infrastructure and socio-economic activities in Tonga are located near or on the coast which makes them highly vulnerable to effects of climate change and sea-level rise (SPREP, 2006). The mean sea level rise near Tonga measured by satellite altimeters since 1993 is over 6mm per year, and the mean sea level is projected to continue to rise over the course of the 21st century (Australian Bureau of Meteorology and CSIRO, 2011) This rise is partly linked to a pattern related to climate variability from year to year and decade to decade (Australian Bureau of Meteorology and CSIRO, 2011). According to the Australian Bureau of Meteorology and CSIRO (2011), there is a high confidence in this direction of change because sea level rise is a physically consistent response to increasing ocean and atmospheric temperatures, due to thermal expansion of the water and the melting of glaciers and ice caps. Coastal erosion is considered a severe issue facing Tonga, and sea level rise is one of the main causes. It affects the underground water supplies and agricultural production, particularly in low-lying coastal areas throughout Tonga (MECC & NEMO, 2010).

Coastal erosion has become a profound environmental issue, partially as a result of sea level rise. The low-lying coastal villages in Tongatapu, such as Kanokupolu (southern part of Tongatapu), and Lifuka island in Ha'apai, which is less than 2m above sea level, are highly vulnerable to the impacts of sea level rise (Ministry of Environment and Climate Change and Ministry of National Emergency and Management Office, 2010).

2.4.2.4 Socio-cultural impacts

Men, women, children, as well as people with disabilities, the poor, and the elderly are all affected by the impacts of climate change (MEIDECC, 2018). Women are considered as valuable contributors in both formal labour force and informal sector in Tonga. They are active in the production of handicrafts,, planting and sale of cash crops, and utilisation of coastal fisheries (MEIDECC, 2018). In the outer islands of Ha'apai, Vava'u and the Niua group, handicrafts (mainly weaving) make up at least 50% of household income.

Mats are also valuable for cultural obligations such as weddings, funerals, and birthdays. Following the natural disasters such as cyclones and droughts, which impact strongly on agriculture, there is a greater dependence on handicrafts to help them and their families (MEIDECC, 2018). However, mat weaving is impacted by climate change, as changing weather patterns affects the provision of weaving materials such as pandanus (MEIDECC, 2018).

For the people of Tonga, the loss of land to sea level rise means they have lost their connection to their ancestor's valuable possession. Land represents their identity and it has been passed down from generations to generations (Havea, 2015). People in Tonga were sad to see their land has been consumed by sea water. Losing their family land has affected them emotionally (Havea, 2015).

Changing in temperature and rainfall are likely to affect people's health in Tonga through incidences of vector-borne and water-borne diseases (SPREP, 2006). With the increasing rainfall and increased settlement of Tongans from outer islands to swampy areas of Nuku'alofa, which is the main town, the spread of dengue fever reached epidemic proportions in 2014 and 2016. While the majority of people in Tonga have access to safe drinking water, this could be affected during droughts, when water availability becomes limited, particularly in rural areas and outer islands. In addition, the rise in sea level will also cause sea water intrusion, especially in low lying coastal areas (MEIDECC, 2018).

2.4.2.5 Economic impacts

Tonga is affected by tropical cyclones and is susceptible to extreme climate events such as prolonged droughts associated with the ENSO events and coral bleaching and these cause severe damage to socioeconomic activities and infrastructure, agriculture and biodiversity (SPREP, 2006). In addition, since Tonga's source of living depends primarily on produce from land and sea for export, extreme weather events such as cyclones and drought affect the country's revenue and the livelihood of the people, food supply, as well as their socio-economic development (MEIDECC, 2018). A decrease in rainfall can affect agricultural production and perhaps the most significant impact on agriculture will most likely come from the effects of sea-level rise associated with storm surge and other extremes. It was projected that by 2100, a 1m sea-level rise in Tongatapu would effect the loss of 10.3km2 of land or 37.3km2 of land with storm surge. This would mean a total

loss of 14% of land area of Tongatapu . Increase in sea-level will also affect agricultural production and water resources through salination of freshwater and land loss (SPREP, 2006). Traditional root crops such as taro, yams, and cassava were badly affected during recent cyclones and droughts. This had impacts on food security and customary obligations, as well as the country's economy (MECC & NEMO, 2010). As noted, "Increasing trends in storm frequency and intensity threaten crops and the intensification of agriculture production in Tonga is only exacerbating this vulnerability" (MEIDECC, 2018, p. 21). Agricultural production was severely affected by Tropical Cyclone Renee in 2011, Ian in 2014, and recently by Gita in 2018.

Drought also affects agriculture in Tonga. The severe droughts of 1983, 1998, 2006 and 2015 had negative impacts on the growth of annual crops as squash, vegetables, yams, sweet potatoes, root crops and coconuts (MEIDECC, 2018). There was also a reduction in number of fruit set and size of fruit trees, including breadfruits and coconuts. Products of most traditional root crops in Tonga, such as taro, yams and cassava were also extremely reduced. There was also a significant reduction in the annual export volume of commercial crops, such as squash and pumpkins to Japan. The fisheries sector in Tonga remains productive and contributes significantly to Tonga's economy (MEIDECC, 2018). Coastal fisheries are at risk to climate change. The recent trend in sea temperature warming around Tonga's coastal waters have caused "wide spread coral bleaching and increased algae blooms, both of which impact on fishery species and importantly the complex of bays, inlets and coral reefs where they live" (MEIDECC, 2018, p. 10).

2.4.2.6 Impacts on Children

Children represent a uniquely vulnerable group but have received less research focus than adults. The predicted increase in severe extreme weather events is expected to be the primary way in which climate change will affect children's mental health and well-being (Burke, Sanson, & Van Hoorn, 2018). According to the World Health Organization, more than 88% of the existing burden of disease attributable to climate change occurs in children younger than 5 years (Sheffield & Landrigan, 2011). Many of the climate change impacts which affected children's physical health also lead to psychological and mental health consequences, but these are less well documented (Burke et al., 2018).

Knowing how children are affected psychologically by climate change is critically important for several reasons: (a) they will bear a larger burden of the negative

consequences of climate change over their lifetimes, and hence, we need to know how to reduce these impacts and protect them; (b) they are the next leaders of society and how they are responding psychologically now has importance for their current and future decision-making; and (c) they will need the capacity to adapt, psychologically and physically, to a climate-changed world, including a rapid transition to a low-carbon economy, and will require particular knowledge, attitudes, and attributes to facilitate this adaptation (Burke et al., 2018).

2.4.3 Responses to climate change in Tonga

The Kingdom of Tonga has prioritised climate change in its national agenda and it has partnered with the global community to address the detrimental effects of climate change. Tonga ratified the United Nations Framework Convention on Climate Change (UNFCCC) in July 20, 1998 and submitted its First National Communication in 2005 to fulfil its commitment to the UNFCCC (Ministry of Environment and Climate Change, 2005). Ratification of the UNFCCC is believed to be a step forward in terms of commitment to addressing climate change in Tonga (SPREP, 2006). A number of climate change programs, projects and activities have been conducted in Tonga since the entry into force of the UNFCCC (SPREP, 2006). In 2010, the Government of Tonga endorsed its first Joint National Action Plan for Climate Change Adaptation and Disaster Risk Management (JNAP 1) and it is the first country in the region to develop such joint approach (MECC & NEMO, 2010). This joint approach comprises six priority goals including: Improved good governance for climate change adaptation and disaster risk management; Enhanced technical knowledge base, information, education and understanding of climate change adaptation and effective risk management; Analysis and assessments of vulnerability to climate change impacts and disaster risks; Enhanced community preparedness and resilience to impacts of all disasters; Technically reliable, economically affordable and environmentally sound energy to support the sustainable development in the Kingdom; and Strong partnerships, cooperation and collaboration within government agencies and with Civil Societies, Non-Governmental Organisations and the Private Sectors (Ministry of Environment and Climate Change and Ministry of National Emergency and Management Office, 2010). Tonga submitted its Second National Communication (SNC) report in 2012 as a continuation and update of the work done in Tonga's initial report. Its main focus was to reinforce the national capacities, and

promote general knowledge and awareness on climate change and natural disasters and their impacts (Ministry of Environment Climate Change, 2012).

The Prime Minister of Tonga highlighted in his speech at the COP25 in Madrid, Spain that although Tonga contributes to less than 0.005 of the World's total greenhouse gas emissions, Tonga is dedicated to ensuring that it's Nationally Determined Contribution Target of 50% renewable energy is achieved by 2020. He said:

> Civil society, Academia, and the private sectors, must continue to be steadfast in their coordinated roles, in ensuring genuine accountability, by the state actors, and continue to be the solid drivers, in our search for further solutions, to the continuing adverse effects of climate change
>
> (Hon Pohiva Tu'i'onetoa, Prime Minister of Tonga (Source: SPREP, 2019, p. 1)

The above quote indicates that the Prime Minister of Tonga is calling upon genuine commitment and cooperation from all the related stakeholders in Tonga to cooperatively search for a solution for the impacts of climate change.

In 2016, the Tonga Climate Change Policy was established, providing a framework for climate action and a policy goal, for 'Resilient Tonga' by 2035. The climate policy strengthened the need for an integrated approach to mainstreaming climate change mitigation, adaptation and disaster risk management (Government of Tonga, 2016). In 2018, the second JNAP (JNAP 2) was established which will be a strategic plan for climate change and disaster risk management initiatives for the next 10 years (MEIDECC, 2018, p. viii). JNAP 2 aims to achieve the mission and goal of the Tongan Climate Change Policy. The mission is to 'develop a resilient Tonga through an inclusive, participatory approach that is based on good governance, builds knowledgeable, proactive communities and supports a strong, sustainable development pathway. On the other hand, the goal of the policy and for the JNAP 2 is: "To achieve the vision of a Resilient Tonga by 2035. This will be realised through the achievements of specific targets." (Ministry of Meteorological Energy Information Disaster Management Environment Climate Change and Communications, 2018, p. viii)

In 2010, the Government of Tonga released the Tonga Energy Roadmap (TERM) which is a ten year road map to reduce Tonga's vulnerability to oil price shocks and increase access to modern energy services in an environmentally sustainable manner (Ministry of Meteorological Energy Information Disaster Management Environment Climate Change and Communications, 2018). The JNAP 2 also indicates that Tonga is committed to reducing its greenhouse gas emissions from the energy sector primarily by increasing its utilisation of renewable sources of energy such as solar and energy efficient technologies. JNAP 2 states that,

> Tonga aims to achieve 50% of electricity generation from renewable sources by 2020 and 70% by 2030. Tonga also plans to improve energy efficiency through reduction of electricity line losses from 18% in 2010 to 9% by 2020 (Ministry of Meteorological Energy Information Disaster Management Environment Climate Change and Communications, 2018, p. 13)

Campbell (2006) indicates that Pacific peoples employ traditional practices to adapt to their environment, including resilient agriculture or famine foods, food storage and preservation. The traditional farming systems in the Pacific have a number of mechanisms that allow for sustainable production. For instance, Tongan farmers have their own calendar around which farming activities revolved. The Tongan calendar plays a role when smallholders make decisions about planning, harvesting and other farming matters (UNESCO, 2013). Campbell also stated that one vital traditional practice is the cooperation between people through ceremony and inter-island networks. This was further elaborated by Fua and Manu, identifying the values, skills, and knowledge to be significant aspects that are required to achieve sustainable livelihoods in the Tongan context (Fua et al., 2008). Sustainable livelihood is regarded as mo'ui fakapotopoto (acting wisely, prudently, and sensibly), which means a life that is able to use existing and limited resources wisely. Mo'ui fakapotopoto embodies spiritual, emotional, physical and intellectual capabilities. People who live lives considered as mo'ui fakapotopoto embrace a range of "skills, wide understanding of their environment and strong belief in maintaining relationships and fulfilling cultural obligations" (Fua et al., 2008, p. 12). Therefore, to live sustainably within the Tongan context, one must live and demonstrate mo'ui fakapotopoto (Fua et al., 2008). Fua et. al (2008) affirm that sustainability in Tonga depends on the attitude of the person, in which the right 'ulungaanga (characteristic habit

or quality) enables mo'ui fakapotopoto. Thus culture is a crucial principle to enabling sustainable processes in Tonga.

On the other hand, for the mitigation efforts to be successful, Stevenson et al. (2017) propose that individuals and communities will also need to adapt to future impacts that are unlikely to be avoided. They also echo that preparedness for current and potential consequences of climate change is increasingly being identified as paramount. Since the implications of a future shaped by climate change are not fully understood by people, climate change education is considered imperative to lower risk and vulnerability and build adaptive capacity and resilience (Krasny & DuBois, 2016; United Nations Educational Scientific and Cultural Organizations & United Nations Environment Programme, 2011). Chang (2014) highlights that education *is* a mitigation strategy for climate change. A study that was recently conducted on the people's understanding of climate change in Tonga indicated that Climate Change Education (CCE) was highlighted by almost 100% of the participants as a tool to enrich the people of Tonga with the knowledge and understanding about climate change and to empower them to address the negative impacts of climate change on their lives and on the environment (Havea, 2015).

2.4.4 Section summary

This section has discussed the impacts of climate change in Tonga. These impacts include rising sea levels, increasing extreme weather events such as tropical cyclones and drought, impacts on the economy, and on the socio-cultural aspects of the Tongan communities. It is also evident that Tonga has partnered with various global communities such as the UNFCCC to address climate change. It is highlighted in this section that traditional practices should be implemented as an adaptation measure to climate change. Sustainable livelihoods or mo'ui fakapotopoto in the Tongan context is also emphasized here as an effective way to adapt to climate change. Climate change education is recommended in this section to be an effective tool to help people addressing the impacts of climate change.

Prior to reviewing literature on climate change education, it is useful to explore students' and teachers' perceptions of climate change. It is suggested that an effective curriculum can only be designed and implemented successfully if we understand where the students are in terms of their knowledge and disposition about the issue (Chang, 2014). Therefore,

the next section (Section 2.5) presents literature on students' and teachers' perceptions of climate change, and then Section 2.6 reviews literature on climate change education

2.5 Perceptions of climate change

It is increasingly appreciated that perceptions of climate change and environmental risk influence the degree and nature of adaptation actions taken at the community level (Adger et al., 2005; Leiserowitz, 2006; Mortreux & Barnett, 2009). The definition of perception in this thesis refers to the ability to perceive climate change issues in the real world, based on memory and influenced by prior experience (Kuper & Kuper, 2005; Lindamood, 2001). There is a lack of research and knowledge on how different areas and groups in the South Pacific perceive climate change (Lata & Nunn, 2012). Responses to climate change are mediated by how individuals and communities perceive both the challenges and solutions of climate change (Mortreux & Barnett, 2009). The complex and diverse factors which contribute to perceptions include social networks and capital, media (Farbotko, 2005), personal experience, worldviews and values (Dessai et al., 2004; McLeman & Smit, 2006). Barnett and Adger (2003) also voice an additional influence on perceptions of climate change as the confidence in the community to successfully adopt adaptation strategies and actions. Therefore, perceptions are value laden, highly subjective and indivisible from the cultural and social context (Kunreuther & Slovic, 1996). Adapting to climate change without considering the knowledge and capacity that exists at the local level is likely to lead to failure and maladaptation (Mercer, Kurvits, Kelman, & Mavrogenis, 2014).

Walshe, Seng, Bumpus, and Auffray (2018) argue that in order to develop effective adaptation strategies, it is important to understand how different communities and groups in the South Pacific perceive climate change. In the Marshall Islands, climate change in interpreted in a holistic manner where a mixture of beliefs (such as loss of clan magic and biblical explanation) and local knowledge is blended with scientific knowledge within a narrative of the compromise and deterioration of modernity (Walshe et al., 2018). Walshe et al. (2018) point out that local spiritual beliefs on small island developing states (SIDS) can also influence perceptions of climate change. For example, in Tuvalu, sea level rise has been attributed to scripture, and consequently resulted in inaction (Mortreux & Barnett, 2009; Paton & Fairbairn-Dunlop, 2010). Similarly, Havea (2015) also found that the people's religious beliefs in Tonga can also influence their perceptions of climate

change. Her findings indicated that climate change is interpreted in Tonga as a punishment from God, and also, her participants believed that God could save them from the impacts of climate change (Havea, 2015). This is an indication that personal worldviews and even conservative political ideologies can negatively influence people's views about the seriousness of climate change, which may also hinder the process of addressing climate change (Cook et al., 2013; Kahan, Jenkins-Smith, & Braman, 2011; Stevenson, Nils Peterson, & Bondell, 2018).

Overlooking these perceptions, and the disconnect between national (top-down) and community (bottom-up) approaches to climate change adaptation in the South Pacific, is one reason why a prevailing top-down approach pursued by the government has not always been successful in generating appropriate and sustained adaptation (Lata & Nunn, 2012; Nunn, 2009a). Indeed, education and adaptation policies that enforce Western scientific concepts on rural communities, which lack formal or western education, have unsurprisingly failed (Berkes & Jolly, 2002; McNamara, 2013b), and may also undermine the traditional mechanisms for coping with change (Heyd & Brooks, 2009). Therefore, Barnett (2010) argued the plurality of perceptions and approaches within and between social systems needs to be recognized and reconciled to rise to the challenge of adaptation and create locally appropriate responses that are sustainable over time and space.

2.5.1 Students' perceptions of climate change

> Students in the classroom are the future citizens of the world, and it is in their power to mitigate the consequences of climate change, benefitting not only themselves, but the Earth itself (Dawson & Carson, 2013, p. 13).

Knowledge of a certain topic may enhance an individual's concern with it (Sunstein, 2006), however, an unfamiliarity with climate change science has been shown to be the single largest factor accounting for an individual's motivation to feel concerned about climate change (Tjernström & Tietenberg, 2008). By utilizing formal education environments, then there is an opportunity to assess where the current baseline of climate change science understanding is and how it can be influenced (Harker-Schuch & Bugge-Henriksen, 2013). Most studies have largely concentrated on simple drivers of climate change and to assess where knowledge deficits and misconceptions lie rather than to

determine where we stand now in terms of scientific knowledge, or to assess if knowledge can be improved and how this relates to opinions (Harker-Schuch & Bugge-Henriksen, 2013). It is significant that we must know what conceptions are already held by students (Munson, 1994) because the students' existing conceptions will affect their interpretation of the world and development of additional knowledge (Carey, 1985; Driver, 1985; Osborne & Freyberg, 1985; Posner, Strike, Hewson, & Gertzog, 1982).

Children have been shown to be aware of the consequences of global environmental problems and a range of pollutants which cause them, however, their thinking is over-generalized. It has been found that they also think that all pollutants contribute to all environmental problems (Batterham, Stanisstreet, & Boyes, 1996). Students can be often unaware that household energy contributes to greenhouse gases and therefore climate change (Kilinc, Stanisstreet, & Boyes, 2008). Students who misunderstand both climate change science and the consequences of personal choices are less likely to make pro-environmental decisions (Boon, 2009; Mason & Santi, 1998; McNeill & Vaughn, 2012; Sternäng & Lundholm, 2011).

Harker-Schuch and Bugge-Henriksen (2013) conducted a study to investigate the influence of knowledge on opinions about climate change in high school students in Austria and Denmark. Their study shows that the majority of students in these countries and schools have the opinion that climate change is a threat, is caused by humans, is happening now, and is the responsibility of both individuals and governments. They argued that increasing the level of knowledge in this demographic to better reflect the scientific consensus on climate change should be given highest priority by academic administrators and both regional and national governors. This study also shows that knowledge about climate change increases the likelihood of having the opinion that climate change is caused by humans and is the responsibility of both individuals and governments, and that knowledge can be improved by a lecture in climate change science (Harker-Schuch & Bugge-Henriksen, 2013). This is aligned with Niyogi, Choi, Shepardson, and Charusombat (2009), who believe that developing students' conceptions of climate change requires a curriculum that integrates the science disciplines. As has been explained elsewhere:

> Climate is an ideal interdisciplinary, integrating theme for education. Beginning with simple concepts and observations of weather and

> water, and building increasingly complex inquiries and investigation into the physical, chemical, biological, geographical, social, historical and even technological dimensions of climate, students and citizens have the opportunity to better comprehend the interconnectedness of this important topic and make use of this knowledge in their lives and in their communities (National Oceanic and Atmospheric Administration, 2007, p. 1)

Young people, particularly in the Pacific region, are exposed to environmental issues daily and they go to school with "pre-formed opinions and conceptions, many of which are incorrect" (Dawson 2012, p. 8), but children are regarded as a key audience for environmental messages, and they are seen as "tomorrow's opinion leaders and stewards of the Earth" (Uzzell, 1999, p. 397). Research conducted on students' understanding of climate change science illustrated that students have difficulty distinguishing between the ozone layer and the greenhouse effect (Boon, 2009). Greenhouse effect and global warming are two important concepts to understanding climate change (Lambert, Lindgren, & Bleicher, 2012), but research indicates that students express alternative conceptions about the two concepts (Mason & Santi, 1998; Rye, Rubba, & Wiesenmayer, 1997). The alternative conceptions that are commonly held among students include students confusing weather and climate, not understanding the greenhouse effect, the type and source of radiation involved, and thinking that climate change is caused by pollution or ozone holes. The greenhouse effect is explained by students as an environmental problem rather than a natural phenomenon (Koulaidis & Christidou, 1999; Myers, Boyes, & Stanisstreet, 2004). It is important to consider that students do not enter a classroom as empty vessels waiting to be filled with knowledge. They may possess prior or pre-instructional knowledge, often flawed, about the topic to be learnt (Chang, 2014).

2.5.2 Teachers' perceptions of climate change

A key aspect in climate education is teachers' knowledge, attitudes, and behaviour (Miler, Hollan, Valek, & Sladek, 2012). This is supported by Monroe, Oxarart, and Plate (2013) by stating that a teachers' knowledge of a topic can influence the degree to which he or she covers it in class. If teachers are key stakeholders in educating our young people about climate change, then it is significant that we determine teachers' readiness to deliver the climate change education curriculum (Miler et al., 2012). Given that students have

numerous alternative conceptions or lack of prior knowledge about climate change, it is significant that teachers need to have an understanding of the key science underlying climate change (Lambert et al., 2012). It is also important that teachers understand the natural and human-induced factors affecting climate change, and the potential consequences, and ways to mitigate and adapt to climate change (Lambert et al., 2012). Miler et al. (2012) also emphasise that teaching climate change topics require climate literate teachers in the first place. Providing an adequate climate literacy to the young generation remains a challenge and this is partly due to the complexity of its nature (Miler et al., 2012). It is believed that the role of teachers to promote understanding of climate change and the consequences of personal actions become part of the solution (Dawson and Carson, 2013).

Many school teachers do not demonstrate sufficient understanding of the concepts underlying climate change (Dove, 1996; Summers, Kruger, Childs, & Mant, 2000). In one study conducted with secondary and pre-service teachers in Australia, the subject knowledge, conceptual understanding and sources of information about climate change of teachers were examined. This study indicated the need to develop tertiary courses to improve the knowledge of student teachers about climate change (Boon, 2010). The findings also showed gaps in important school curriculum topics such as science and geography (Boon, 2010). Another study was carried out to explore teachers' understanding of climate change in Australian schools and findings show that although the teachers were well-informed about the issue, there appeared to be some misunderstanding about what climate change and the greenhouse effect are (Dawson, 2012). Dawson (2012, p. 9) then asks the question, "Do teachers themselves have the conceptual knowledge to teach climate change to students?" An earlier study indicated that they may not:

> Despite the evidence that teachers hold some of the same misconceptions as their students about global climate change, many place a high priority on the topic as part of their students' education (Fortner, 2001, p. 24)

Fortner and Corney (Unpublished work) conducted some studies among teachers in the Great Lakes region in the USA and they found that middle school science teachers rated global climate change as a priority 3 out of 4 and they indicated that their own knowledge

level about climate change was also at a level of about 3. A group of teachers in an in-service programme about global climate change felt strongly that their own behaviour serves as a model for their students (Rubba & Rye, 1997). Interview and journal data indicate that they were conscious of showing best practice regarding their personal responsibility for climate change. The teachers seemed to believe that "…if teachers show active interest and involvement in taking citizenship action, then students are more likely to do the same" (Rubba & Rye, 1997, p. 82).

A study was conducted by the United Nations Education, Scientific and Cultural Organization (UNESCO) on the community understanding of climate change in the islands of Samoa, Fiji, and Vanuatu. Findings illustrated that teachers perceived climate change as an important issue and worth teaching but they were left constrained by a "lack of training on the issue and insufficient resources to make it easy to communicate content on climate change in the local context" (UNESCO, 2014, p. 27).

2.5.3 The alternative conceptions about climate change

Studies of students' science conceptions have found that scientifically incorrect interpretations and responses to problems may be provided by students because they hold alternative understandings of the phenomena in question (Osborne & Freyberg, 1985). Munson (1994) stated that these alternative understandings are often referred to as misconceptions, and misconceptions do not simply signify a lack knowledge, factual errors, or incorrect definitions. Instead, these 'alternative' conceptions represent explanations of phenomena constructed by a student in response to the student's prior knowledge and experience (Hewson & Hewson, 1988; Strike & Posner, 1985). Fortner (2001) highlights that school students, as well as college students and pre-service teachers, frequently hold alternative conceptions about Earth system relationships, as well as how human activities impact those systems, and results regarding these are remarkably similar across education levels.

According to a survey conducted by Gowda, Fox, and Magelky (1997) on the students' knowledge and attitudes about climate change, the most common student alternative conceptions are: Inflated estimates of temperature change – students' estimates of the increase in average temperature resulting from global warming were dramatically higher than the IPCC; Confusion between CFCs, the ozone hole and climate change - ozone

layer depletion causes climate change; stop using aerosols to prevent global warming; Perceived evidence – warmer weather focus – students believe they could personally sense rising climatic temperatures, changes in long-term weather patterns, or the ozone hole; All environmental harms cause climate change – aerosols, acid rain, even solid disposal; and Confusing weather and climate (Gowda et al., 1997). They also believe that these alternative conceptions arise from low levels of information, reliance on the television news media, use of judgmental heuristics, confusion between weather and climate, and fuzzy environmentalism (Gowda et al., 1997). The same survey also indicated that teachers were mentioned much less frequently as a source of information than the news media. Classroom time devoted to a current issue like climate change was likely to be limited (Gowda et al., 1997). The authors stated that, "Often school curricula reflect traditional disciplines and are not multidisciplinary enough to provide coverage of topical, controversial, environmental problems that straddle disciplinary boundaries (Gowda et al., 1997, p. 2236). Their study also reported that students have a high level of trust in teachers. This suggests a role of educators through which they help correct alternative conceptions about climate change and ensure that people adopt effective environmentally measures (Gowda et al., 1997).

There are common alternative conceptions about climate change which occur amongst students in different countries (Dawson & Carson, 2013). Research shows that students commonly merge features of the greenhouse effect with those of the ozone layer (Boon, 2009; Gautier, Deutsch, & Rebich, 2006; Hansen, 2010; Lambert et al., 2012; Punter et al., 2011). A study conducted in Norway found out that 70% of the students were confused between the greenhouse effect and the ozone layer with almost one-third of students agreeing with the statement that the greenhouse effect is caused by ozone gas in the ozone layer (Hansen, 2010). Hansen also stated that this confusion which exists among students about the greenhouse effect and the ozone layer is most likely due to a propensity by students to group environmental issues together into a conflation of ideas (Hansen, 2010), and it has been shown elsewhere that students tend to often merge environmental problems together (Dawson & Carson, 2013).

Studies also indicate that students demonstrate a misunderstanding about the greenhouse effect and its processes. Students have been found to be unclear that the greenhouse effect is necessary for life on Earth and that climate change is caused by the enhanced greenhouse effect (Boon, 2009; Hansen, 2010). For instance, some students believe

climate change or global warming is due to an increase in solar heat reaching the earth through the hole in the ozone layer (Punter et al., 2011).

Another study on students' conceptions of climate change was conducted on three schools in the Midwest, USA, and similar to the other previous studies, the students lacked a rich conceptualization of the issue. For example, students were confused between pollution and greenhouse gases (Niyogi et al., 2009). Some researchers believed that this lack of knowledge about climate change is due to the difficulty of teaching students about climate change in a thorough and practical manner (Boon, 2009).

Climate change is identified to be difficult to communicate by its nature. For instance, greenhouse gases are invisible and their effects such as global warming and extreme weather events may take years before they are felt (America's Climate Choices, 2010). Dawson (2012) believes that climate change is topical and messy and chaotic, however, Sadler and Klosterman (2010) suggest that integrating socio-scientific issues such as climate change into the science curriculum is an advantageous teaching approach and has been identified to improve students' content knowledge. It is crucial for students to use higher order thinking skills to evaluate, analyse and synthesise information as they explore the chosen issue, thus, discussion of the issue with fellow students further facilitates their learning (Dawson, 2012).

Boyes and Stanisstreet (1993) suggest that a general problem is that children are aware of a range of environmentally 'friendly' and 'unfriendly' actions, and cognizant of a range of environmental problems, but that they do not link particular causes with particular consequences. Rather, children appear to think in a general way that all environmentally 'friendly' actions help all problems. They suggest that an understanding of major environmental problems is important because their solutions will require far-reaching changes in society, and that such education should begin early, before conceptions become embedded in alternative conceptual frameworks, and attitudes based on these framework become entrenched (Boyes & Stanisstreet, 1993).

A study carried out by Shepardson, Choi, Niyogi, and Charusombat (2011) discovered that although students held rudimentary concepts about global warming and climate change, they lack a rich conceptualization of the issue. Fundamentally, their conceptions of global warming and climate change are both limited in scope (narrow) and simplistic

(lacking complexity). Yet, the students' conceptions as a whole are similar to the IPCC findings, though less complex. The conceptual gap between these students and the IPCC scientific perspective calls for effective learning experiences that require a curriculum sequenced in a way that moves students toward scientific understanding (Driver, 1994).

2.5.4 Addressing alternative conceptions

Conflating climate change with ozone layer depletion is not restricted to students (Monroe, Plate, Oxarart, Bowers, & Chaves, 2017). Liu, Roehrig, Bhattacharya, and Varma (2015) discussed the impacts of a climate change-focused professional development workshop for secondary school science teachers in the United States. After a week-long workshop and a three one-day follow-up workshops on climate change, the participants demonstrated success in increasing concern regarding climate change and improved understanding of how humans affect climate (Monroe et al., 2017). However, some participants who expressed concern about climate change continued to see the ozone layer as a significant contributing factor to the problem (Monroe et al., 2017). In addition, a similar confusion was explored by Niebert and Gropengiesser (2013) in a group of 18-year-old German students. They reported success in changing student perceptions by directly addressing alternative conceptions with experiments that assist learners to visualize and understand faulty lines of reasoning. For instance, instructors developed lab experiments designed to illustrate the heat-trapping qualities of carbon dioxide (Niebert & Gropengiesser, 2013). By considering the results of these experiments, students were able to understand the role of atmospheric carbon dioxide in trapping heat (Monroe et al., 2017). A similar experiment was carried out in which students were asked to hypothesise about the impacts of using air or carbon dioxide to obstruct radiant heat and this case was to emphasize the importance of how the concepts are conveyed to students (Reinfried, Aeschbacher, & Rottermann, 2012). Results showed greater learning gains from materials designed based on Aebli's (1983) criteria for fostering constructivist learning than from more conventional materials. These criteria included: start with students' prior knowledge; untangle complex processes into successional steps; reduce the content to focus only on key ideas necessary to learn the new mental model being presented; and avoid technical terms (Reinfried et al., 2012).

Dawson and Carson (2013) suggest that Professional Development (PD) of pre-service and in-service science teachers can provide opportunities for teachers to understand not

only the science of climate change but also the confusion which exists amongst students about the greenhouse effect and climate change. Wise (2010) states that some teachers express concern about parents' responses to climate change, causing them to be hesitant to teach about the topic. There are also some educators who express concern that addressing climate change in their community could decrease their credibility and effectiveness (Morris, Megalos, Vuola, Adams, & Monroe, 2014; Tyson, 2014) and so they refrain from talking and teaching about climate change (Bowers, Monroe, & Adams, 2016; Sommer, 2014; Wojcik, Monroe, Adams, & Plate, 2014). Furthermore, some educators feel that they lack the necessary skills and knowledge to adequately deliver instruction regarding climate change (Monroe et al., 2013; Plutzer, McCaffrey, et al., 2016; Prokopy et al., 2015).

2.5.5 Section summary

Studies have identified factors that have contributed to the perceptions of climate change such as media, social networks, personal experience, cultural and social values and religious beliefs. This can be observed in places like the Pacific region where religious beliefs are key factors that can shape people's perceptions of climate change. Identifying individual and community's perceptions of climate change can possibly help to create appropriate mitigation and adaptation responses that are sustainable over time and space. It is crucial to explore the conceptions that both students and teachers already hold about climate change. Knowledge about climate change enhanced the likelihood of having the opinion that climate change is caused by human activities and is the responsibility of both individuals and government to address climate change. It is also vital to explore the teachers' conceptions of climate change because their knowledge of the issue can influence the degree to which they cover it in class. According to literature, both teachers and students are reported to have common alternative conceptions about climate change. Education and a clear curriculum in climate change are identified to be tools to address students' and teachers' common alternative conceptions.

2.6 Climate change education (CCE)

> Through education of emerging adults in climate change science, we may well find the road for mitigating future climate change we so urgently seek. We need to start expecting our students to think

> critically and we need to ensure our students are given precise instruction in climate change science covering all aspects of climate change (Harker-Schuch & Bugge-Henriksen, 2013, p. 764)

Climate change education refers to processes aimed at improving the degree to which an education system is prepared for, and is responsive to the challenges of climate change (Mochizuki & Bryan, 2015). Fernandez et al. (2014) also agree that education is a significant element in responding to the impacts of climate change, and a key factor in the global response to the increasing environmental challenges such as climate change (UNESCO, 2014). Climate change education is about helping learners to understand the concepts of climate change science and address the impacts of global warming today, while at the same time encouraging the change in attitudes and behaviour needed to put our world on a more sustainable path (UNESCO & UNEP, 2011). It equips individuals with the values, knowledge, and skills to make choices and decisions that minimize the use of natural resources, and reduce emissions, waste, and pollution, while supporting equitable socio-economic development and progress for all and contributing to the growth of new solutions (UNESCO & UNEP, 2011). Lehtonen, Salonen, and Cantell (2019, p. 364) state that "the goal of climate change education is to fully realize our humanity – a person, who thinks critically with rich information about a wide range of global situations".

Climate change education supports building societies that are characterized by flexible, creative, adaptable, well-informed and inventive sustainable well-being communities (Lehtonen et al., 2019). Climate change education aims at critical thinking about consumerism, human identity as a consumer, and prevailing ways of pursuing happiness pushed by globalization, capitalism and advertising. Barnett and Campbell (2010) highlighted that levels of knowledge and awareness can influence people's perceptions about climate change, attitudes towards community adaptive capacity and future responses to local environmental change. A community's acceptance of climate change, ability to make local sense of global controversies and willingness to adapt are all influenced by levels of awareness and in turn are critical to the success of community-led and sustainable adaptation projects (McNamara, 2013a). More specifically, awareness activities have assisted younger generations in understanding the impacts of climate

change, encouraged voluntary changes in people's behaviour, and generated public demand or support for policies and action (Lowe et al., 2006).

Education is as an untapped resource to alleviate climate change, however, the role of education in bringing about behaviour change for mitigation is often overlooked by the international community and particularly those within the climate change arena (Anderson, 2010). Educators are believed to have a long tradition of education for social change and can utilise their expertise on knowledge, skills and attitude and behaviour change to help reduce greenhouse emissions (Anderson, 2010). Education is a significant component of adaptive capacity (Anderson, 2010), and the way that people are educated and the content of education provide the knowledge and skills needed for making informed decisions about how to adapt individual lives and livelihoods as well as ecological, social and economic systems in a changing environment (Commission on Climate Change and Development, 2009).

Climate change education requires people everywhere to understand and respond to the nature, causes and consequences of climate change (UNESCO, 2009). Educational programmes should be reviewed and re-orientated in order to address the causes and consequences of climate change and solutions to climate change if the necessary changes in society are to be effected in time (UNESCO, 2009a). Communicating climate change through education helps to raise awareness, to confer understanding and to motivate action (Andrey et al., 2000). Climate Change Education (CCE) is crucial in supporting Pacific Island countries to adapt to the consequences of climate change which they are vulnerable to (UNESCO, 2014).

2.6.1 Learning new knowledge

Knowledge is defined in this thesis as a body of facts and principles concerning environmental issues that have been accumulated by humans in the course of time (Clarke, 1999). One of the realities of climate change education is to learn new knowledge and skills in order to manage the risks associated with climate change and reduce vulnerabilities to these risks by building adaptive capacity and resilient societies (Mochizuki & Bryan, 2015). Knowledge of climate science is obviously critical to coming to a deeper understanding of the causes and effects of climate change, and hence should be at the heart of any effort to educate citizens about climate change (Mochizuki & Bryan, 2015). Anderson (2012) notes that learners need a basic understanding of

scientific concepts with a deeper level of systems thinking such as: knowledge of the history and causes of climate change; knowledge and ability to distinguish between certainties, uncertainties, risks and consequences of environmental degradation, disasters and climate change; knowledge of mitigation and adaptation practices that can contribute to building resilience and sustainability; and understanding of different interests that shape different responses to climate change and ability to critically judge the validity of these interests in relations to public good. In addition, Bofferding and Kloser (2015) highlights that climate change education has the "potential to impact students' system knowledge – their understanding of the variables that affect the climate change – and action knowledge – their understanding of behaviours that can impact the system" (p. 275).

2.6.2 Raising awareness

In this thesis, awareness refers to the attention, concern and sensitivity of the respondents to environmental problems (McHenry, 1992; Soukhanov, 1992) such as climate change. Raising awareness has long been considered crucial to generate public support for government initiatives, encourage voluntary behavioural changes and assist those most sensitive to the issue at hand. As this commentary explores, the activity of raising awareness is not simply about increasing levels of knowledge about the impacts of climate change, but a wider frame of how to help involve community members in decisions that may affect their future (NcNamara, 2013). The current and projected impacts of climate change demonstrate the severity of this global, national and local issue. Raising awareness has therefore become a core component of climate change-related projects, policies and regulations (McNamara, 2013a).

Climate change education aims at increasing awareness of interconnectedness, post-material well-being, clarifying the goals of education and life as to meaning and purpose (Lehtonen et al., 2019). They also argue that climate change education applies systems thinking in order to understand how the word works. According to a rational systems view, it is clear that humans are part of natural systems first, living things second, human beings third, members of society and culture fourth, and particular individuals fifth. They believe that nature and culture should be considered as one, interrelated system. The eco-

social perspective helps to understand this interconnectedness and could be applied as the basic principle for all learning and educational practices.

In line with the broad topic area for this exploratory study, there is an expansive body of work on the value of education, interpretations and awareness-oriented activities in promoting environmental values, behaviours and management (Kollmuss & Agyeman, 2002; McNamara, 2013a). Klein, Nicholls, and Mimura (1999) argue that for climate change adaptation to be achieved, particularly in areas that are critical for sustainable livelihoods such as coastal resources, there has to be relevant and effective information exchange and raising awareness activities as core project outputs.

A number of studies have demonstrated how climate change awareness activities at the community level might generate positive outcomes. For instance, Barnett and Campbell (2010) point out how a level of knowledge and awareness can influence people's perceptions about climate change, attitudes towards community adaptive capacity and future responses to local environment change. A community's acceptance of climate change, ability to make local sense of global controversies and willingness to adapt are all influenced by levels of awareness and in turn are critical to the success of community-led and sustainable adaptation projects (McNamara, 2013a). More specifically, awareness activities have assisted young generations in understanding the impacts of climate change, encouraged voluntary changes in people's behaviour, and generated public demand or support for policies and action (Lowe et al., 2006).

2.6.3 Empowerment

Schreiner, Henriksen, and Hansen (2005) argue that climate change education empowers individuals for action by enhancing their content-specific knowledge and cognitive skills, motivational patterns and personal value orientations. They assert that in order to be empowered to meet the climate change issue, a person must be motivated for action towards the climate problem, have hope and visions for the future, have a general feeling that she or he can influence the future of the world. He or she will also be interested and engaged in the climate issue and think that environmental protection is important for society, and have sufficient knowledge about the science of climate change, possible adequate actions in terms of personal lifestyle, technical solutions and political measures, possible channels of influence through politics and organizations (Schreiner et al., 2005).

Increasing people's understanding of the process and activities driving climate change is an essential first step in motivating and empowering them to take action to alleviate it (Mochizuki & Bryan, 2015). Dobson (2006) echo that people are also more likely to feel responsible for the well-being of future generations and geographically distant others if they recognize that there is a visible causal relationship between day-to-day actions and the climate-induced harm that others will experience.

Introducing education on climate change through formal schooling and awareness activities can play a significant role in motivating the next generation to "demand, generate, interpret and apply information on current and future climate changes, and also help in bolstering people's abilities to cope with the challenges of global warming, as well as build adaptive capacity" (Vize, 2012, p. 221). Stevenson et al. (2017) concur with Vize (2012) by adding that mainstreaming climate change education throughout formal education systems can be one of the most important and effective means of developing capacities for addressing the climate change crisis. This is due to multiplier effects, where families and communities benefit when individuals share what they have learnt (Mochizuki & Bryan, 2015). CCE demands both immediate and longer term responses to climate change and central to this effort are the concepts of mitigation and adaptation, the two complementary actions that make up an overall strategy to reduce greenhouse gas emissions and climate change impacts (Mochizuki & Bryan, 2015).

Johnson (2013) suggests three key teaching strategies that can be utilised by a teacher who prepares to teach about climate change in the classrooms: Educate yourself – Teachers need to seek out professional development on climate change; Become data savvy – The stories that are told by the data is impressive and it offers students the opportunity to apply scientific skills. Students are also be able to discover the reality of climate change themselves without the teacher convincing it to them; and How to handle controversy. Teaching about controversial topics can be difficult, even for an experienced teacher (Johnson, 2013).

2.6.4 Motivation to Act

Literature indicates that climate change education can elevate people's motivation to act upon climate change. McNeal, Spry, Mitra, and Tipton (2014) conducted a study on how an educational program may impact on students' engagement, knowledge, confidence,

and perceptions of climate change. They found out that the educational program helped to improve students' content knowledge and perceptions, and students indicated a deep sense of commitment toward climate change.

Climate change education is suggested to be an effective strategy to overcome the influence of worldview and political ideology, particularly among young people (Stevenson et al., 2018). Even though worldviews and ideology have strong influence in shaping climate change beliefs and actions (Hornsey, Harris, Bain, & Fielding, 2016), climate change knowledge such as understanding climate change science, causes and impacts positively relates to climate change concern, even among those who are sceptical about climate change (Ranney & Clark, 2016; Shi, Visschers, & Siegrist, 2015; Stevenson, Peterson, Bondell, Moore, & Carrier, 2014). While adults' worldviews may indicate the strongest predictor of climate change perceptions (Hornsey et al., 2016), Stevenson et al. (2014) argue that the impact of this worldview disappears among adolescents as climate change knowledge increases. These findings indicate that through climate change education with adolescents, scepticism around climate change can be overcome and help in promoting behaviours and willingness to alleviate it (Stevenson et al., 2018).

Salonen and Åhlberg (2012) claim that the overall aim of education is to ensure that people takes care of themselves and their culture, the Earth and protecting possibilities for future generations. They add that the most important and fundamental target for lifelong learning is to expand the domain of human responsibility to cover people, animals and other organisms, plants, and life-supporting ecosystems as well as natural resources of the plant Earth. This responsibility requires a holistic vision consisting of changes in worldviews, ways of thinking, well-being paradigms and life orientations (Salonen & Åhlberg, 2012). Lehtonen et al. (2019) point out that climate change education enables students to understand the interconnectedness of planetary elements. They argue that without a well-functioning biosphere, society cannot exist, and without society, there cannot be societal functions, including the economy. Max-Neef (2010) echoes that the economy is a sub-system of the larger but finite Earth system. Lehtonen et al. (2019) emphasize that a main principle of climate change education is that taking care of the wellbeing of future generations does not constitute a sacrifice and this is because an individual's interest and the common good can be aligned.

2.6.5 Evidence-based curriculum for climate change education

> Research in misconceptions, attitude change, issue-based education, tolerance of different perspectives, and social learning may bring environmental educators to the forefront of understanding how to approach climate change education (Monroe et al., 2013, p. 5)

Gowda et al. (1997) point out that the significant alternative conceptions that students display in the context of climate change suggest the need for better educational materials focused on these major alternative conceptions. Designing a curriculum based on students' conceptions that builds toward a scientific perspective is essential (National Research Council, 1996) if students are to become more knowledgeable about global warming, climate change and environment health in general (Shepardson, Niyogi, et al., 2011). McNeill and Vaughn (2012) recommend that future climate change curriculum focus on supporting students' development of critical science agency by addressing common student alternative conceptions and by focusing on how students' actions can have significant effect on the environment. Buggy and McGlynn (2014) argue that it is crucial to determine students' conceptions and alternative conceptions of climate change, while also focusing on curricula content and on secondary school teachers' perceptions of climate change, in order to plan and design effective instruction that builds on these concepts.

Anderson (2012) adds that it is vital to investigate skills, attitudes and behaviour of people in order to determine what works for formal climate change education content. It is also important to understand the prior knowledge and attitudes of teachers and students before embarking on any programs to improve teacher readiness for CCE (Chang, 2014). Further research is required to gain a better understanding of students' ideas and models of climate change to plan the curriculum and design teaching materials in a way that challenge students' mental models allowing them to evolve towards those of science (Schraw, Crippen, & Hartley, 2006; Shepardson, Choi, et al., 2011). Bishop (2019) argues that schools and teachers can respond to diverse groups of students and develop teaching practices that promote learning for everyone. In this approach, students' prior knowledge, language and ways of making sense of the world are used to inform teaching practices rather than being seen as barriers to learning.

Educational strategies are best designed when they are based on knowledge of the learners' level of knowledge and preconceptions (Fortner, 2001). Information can be selected and experiences organized to fill known knowledge gaps, enhance understanding of relationships, and remediate alternative conceptions. The evidence indicates that education interventions are most successful when they focus on local, tangible, and actionable aspects of sustainable development, climate change and environmental education. Developing students' conceptions of global warming and climate change requires a curriculum that integrates the disciplines (Shepardson, Niyogi, et al., 2011). Planning curriculum and designing instruction is a difficult and challenging process made even more difficult by the essential requirement to start from students' mental models, considering that the progression in students' mental models is not a linear process (Shepardson, Niyogi, et al., 2011).

McNeill and Vaughn (2012) conducted a study to examine the impact of a four to six week urban ecology curriculum on students from three different urban high schools in the USA. A pre- and post-test written assessment from all students, and pre- and post-interviews from focal students were conducted to examine how students' conceptual understandings, beliefs and environmental actions changed. Their findings indicated that at the beginning of the curriculum, the majority of students believed that climate change was occurring, yet, they had limited conceptual understandings about climate change and were engaged in limited environmental actions. However, at the end of the curriculum, students had a significant increase in their understanding of climate change and the majority of students reported they were now engaged in actions to limit their personal impact on climate change (McNeill & Vaughn, 2012). They argue that these findings suggest that believing in climate change is not sufficient for critical science agency, rather, conceptual understanding and understandings of personal actions impact students' choices (McNeill & Vaughn, 2012).

2.6.6 Multi-disciplinary

The traditional thinking on climate change education (CCE) in formal educational settings is limited to teaching atmospheric composition and processes from a natural science perspective (Punter et al., 2011). Climate science has traditionally been taught in geography and earth science. Many now believe that climate change should be addressed by all subject areas, however, there is a tendency to include it in science-based subjects

(Punter et al., 2011). CCE is broader than climate science. It is cross-curricular and cuts across various disciplines. Mitigating as well as adapting to climate change is going to take far more than knowledge of the natural sciences (UNESCO & UNEP, 2011).

It is acknowledged that climate change is multidisciplinary, complex and difficult, but with some consideration, students would leave school equipped with an understanding of the enhanced greenhouse effect and how this contributes to climate change. This knowledge not only allows students to participate in the dialogue of climate change but empowers students to make personal choices and decisions to alter their behaviours (Dawson & Carson, 2013).

Guy, Kashima, Walker, and O'Neill (2014) argue that designing and implementing programmes about climate change may require a balancing act of increasing knowledge of climate change and acknowledging how cultural ideology plays a role in perceptions and learning. Monroe et al. (2013) emphasised the significance of making climate change education relevant to the children and youth. They argue that "Curricula with a purely scientific focus may not adequately convey to students how seemingly small temperature changes can have significant impacts of their lives" (Monroe et al., 2013, p. 5). In addition, (Monroe et al., 2013, p. 5) is concerned about how the Earth science curricular does not typically cover the impacts on human systems. They pointed out some significant questions such as "Who is most vulnerable to climate change impacts, and what is our responsibility to them?" and "How can coastal cities better prepare for rising sea levels?" (Monroe et al., 2013, p. 5). They highlight that these questions require the inclusion of multiple disciplines, such as geography, engineering, economics and policy. They also add that effective climate change education must not only cut across multiple disciplines, it must be sensitive to diverse opinions and carefully use strategies to help all students learn.

Many science educators have advocated using socio-scientific issues (SSI) as contexts for teaching science, but critics have long been concerned that using socially relevant curricula will threaten the integrity of traditional science curriculum and lead to a lapse in student understanding of basic science concepts (DeBoer, 1991). Sharma (2012) believes that climate change is a societal issue that needs a social response more than a technological one and science education is at the core of this change. It is therefore the role of science teachers to promote scientific understanding of climate change and the

consequences of personal actions and thus become part of the solution (Dawson & Carson, 2013).

Teaching students about global warming and climate change provides an ideal context for introducing students to complex and messy systems of the real world (Dahlberg, 2001). Sheppard (2012) suggests that rather than presenting abstract data and projections, communicators could use more intuitive scenarios, perspective taking, narratives and visualizations to make future environmental consequences of behaviour visible, and render global processes tangible in exploring their local effects. Schroth et al. (2011) further point out that making the invisible future visible represents a considerable advance over the simple provision of information, particularly where the agency and creativity of participants is engaged.

Researchers stress that a change in the curriculum in the high schools must work to support students' learning, addressing alternative conceptions and motivating students towards pro-environmental action (Chang, 2014).

2.6.7 Climate change education in the Pacific

Climate change education can play a crucial role in strengthening and motivating the young people in the Pacific island countries to interpret and apply information on current and future climate change and its impacts (Hartmann et al., 2010). Mainstreaming climate change within the education policy frameworks in the Pacific has been a small progress. There have not been sufficient plans to improve education sector capacities to integrate climate change in relevant programmes in the Pacific (Hartmann et al., 2010). There are numerous climate change educational resources available, and they focus mainly on the causes of climate change and ways to reduce the greenhouse gas emissions. However, there are very few educational resources that can specifically address adaptation measures to climate change in the Pacific.

In 2011, a regional Climate Change Education Planning Workshop was held in Nadi, Fiji. This workshop was a part of the Coping with Climate Change in the Pacific Island Region programme which was conducted by the Secretariat of the Pacific Community and the Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) on behalf of the German Federal Ministry for Economic Cooperation and Development (Secretariat of the Pacific Community and Gesellschaft für Internationale Zusammenarbeit, 2013). The workshop

consisted of education representatives from Fiji, Tonga, Samoa, Vanuatu, and Kiribati. As an outcome of the workshop, the representatives indicated a need to develop new educational resources to improve learning about climate in Pacific schools. A set of teaching resources were developed to help Pacific teachers when they teach their students about climate change. The resources consisted of a teacher guide - 'Learning about climate change the Pacific way: A guide for Pacific teachers', and a set of 16 colourful pictures showing the water cycle, Pacific and global climate, causes of climate change, the changing climate of six Pacific island countries who attended the workshop, and mitigation and adaptation in a town and in gardening, forestry and fishing (Secretariat of the Pacific Community and Gesellschaft für Internationale Zusammenarbeit, 2013; SPC, 2014). Table 1 illustrates the learning outcomes for this guide which was specifically designed for students at Years 7 and 8. The learning outcomes are derived from the pillars of education identified by the United Nations Educational, Scientific and Cultural Organization (Delors, 1998).

Table 1: *Learning outcomes for Years 7 and 8*

Pillar of education	Learning outcomes – students will be able to:
Learning to know	• describe the causes of climate change • link Pacific weather and climate to latitude, the water cycle, El Nino Southern Oscillation (ENSO), ocean currents and winds • describe the observed and predicted effects of climate change in their own country and in the Pacific region • explain how increasing levels of greenhouse gases and rising temperatures can affect local ecosystems
Learning to do	• differentiate between adaptation and mitigation activities • interpret maps, graphs and statistics on climate change • plan and participate in the implementation of an adaptation or mitigation activity with their class
Learning to live together	• discuss some possible adaptation and mitigation activities suitable for their community
Learning to be	Make a commitment to a personal adaptation and mitigation action

(Source: Secretariat of the Pacific Community and Gesellschaft für Internationale Zusammenarbeit, 2013, p. 3)

Kiribati is one of the Pacific nations that has developed a new national framework for climate change education as the Ministry of Education identified the need to improve students' understanding of climate change. The central target of their national programme on ESD is climate change education (Vize, 2012). It was also highlighted that Kiribati was not aiming at creating a subject called climate change but intended to identify relevant content on climate change that could be integrated with the existing subjects. Vanuatu has successfully developed a climate change curriculum and a teacher guide to deepen students' learning about climate change and this guide focuses on learning about climate in Pacific way (Lebars, Sabass, & Young, 2013a).

In relation to the New Zealand context, Eames (2017) argues that the New Zealand school curriculum does not explicitly address climate change as an issue. He analysed the achievement objectives (AOs) of the eight learning areas in the New Zealand curriculum – English, Arts, Health and Physical Education, Languages, Mathematics and Statistics, Science, Social Sciences, and Technology. He found out that "The phrase climate change does not appear once" (Eames, 2017, p. 101). However, he indicates that a number of AOs could directly or indirectly contribute to climate change education (Eames, 2017).

Education is a key factor in the global response to the increasing environmental challenges such as climate change (UNESCO, 2014). Education for Disaster Risk Reduction (DRR) and Climate Change is crucial in supporting Pacific Island countries to adapt to the consequences of climate change to which they are vulnerable (UNESCO, 2014). Thaman (2010) conducted research to highlight the significance of values and beliefs ingrained in non-Western cultures in implementing global education initiatives such as education for sustainable development (ESD) at the regional and local levels. She also wanted to assert the importance for educators to respect and use local and indigenous ways of life and knowledge systems in order to make teaching and learning more relevant and meaningful for Pacific students, in connection to issues like climate change. In agreement with Thaman (2010), Vize (2012), who was part of a team that redesigned. the Kiribati school curriculum to include CC, pointed out that in order for CCE and learning to be relevant and effective, it should be aligned with local contexts and experiences, and should prioritise traditional and indigenous knowledge in how to deal with changes. Vize (2012) also believed that another key issue for climate change education highlighted by Pacific countries is that it should be integrated across the curriculum.

Whereas climate change continues to be high on the international agenda, educationalists, climate scientists and those shaping or making climate or education policy still have limited understanding of what addressing climate change through education should entail (Mochizuki & Bryan, 2015). Meanwhile, Selby and Kagawa (2010) have argued that Educations for sustainable development can be seen as an holistic and transformational education towards a more sustainable world. Education for Sustainable Development (ESD) is referred to as a set of processes, pedagogies, and practices which seek to ensure that education systems are responsive to, and prepared for, current and emerging sustainable development challenges, such as climate change. This understanding recognizes the need for CCE to be approached from an interdisciplinary and systems perspective, so that the scientific, ecological, economic, political, ethical and social dimensions of climate change can more fully be appreciated (Mochizuki & Bryan, 2015).

2.6.8 Climate change education in Tonga

It appears that Tonga's education system is slowly progressing towards integrating climate change into the national curriculum. Training teachers and resourcing this integration in a systematic way is also considered crucial in this process. Climate change education was recently integrated into the primary (Class 1 to 6) science syllabus and the junior secondary science syllabus (Class 7 to 8) in an ongoing curriculum review in Tonga (Lebars, Sabass, & Young, 2013b). The science syllabus for Tongan secondary schools has recently been reviewed and it is evident that the concepts of climate change have just been integrated into the syllabus of Class 8 to Class 11 in 2016 (Ministry of Education and Training, 2016). Many of the advancements made to climate change education in Tonga to date are supported by targeted donor programmes (Ministry of Meteorological Energy Information Disaster Management Environment Climate Change and Communications, 2018). These programmes have focused on integrating climate change concepts and practices into primary or secondary schools' syllabi, and on targeting vulnerable children and communities with climate change information and resources (Ministry of Meteorological Energy Information Disaster Management Environment Climate Change and Communications, 2018). Further developing 'child-centred' approaches to education generally, and to climate change education specifically, can only be good for Tonga. Child-centred approaches offer a powerful pathway to lifting the knowledge and resilience, not only of children, but also of the entire community (Ministry of Meteorological Energy Information Disaster Management Environment Climate

Change and Communications, 2018). In the global education community, several stakeholders such as UNESCO and United Nations Environmental Programmes (UNEP) are incorporating elements of the climate change agenda in education and helping schools and communities integrate climate change education and environmental stewardship into the curricula (Anderson, 2010). However, Tonga's education system is slowly moving towards integrating climate change into the national curriculum, but there is still considerable work to do in training teachers and resourcing this integration in a systematic way (Ministry of Meteorological Energy Information Disaster Management Environment Climate Change and Communications, 2018).

Climate change has not been integrated into social science, because the Curriculum Development Unit (CDU) has recently changed social science to Tongan society and culture, where social science is focussed on how people live in specific Tongan traditional cultures (Lebars et al., 2013b). SPREP (2013) noted that Tonga emphasizes the importance of linking cultural awareness with climate change adaptation, disaster risk management and environmental sustainability in education in its Strategic Development Framework 2011-2015. It was stressed that cultural awareness is the traditional way of foreseeing and withstanding the impact of climate change and disasters, so that traditional practices could be further developed, including being placed in school resources.

2.6.9 Teacher Professional Development

Sections 2.5.2 and 2.5.3 presented literature on teachers' perceptions of climate change with the indication of alternative conceptions that are commonly held by teachers about climate change. To enhance the educators' understanding of climate change and how to integrate it into their existing practices, professional development programmes are required (Hestness, McDonald, Breslyn, McGinnis, & Mouza, 2014). "In preparing learners to make scientifically informed decisions related to climate change, teachers must be able to address complex scientific constructs" (Hestness et al., 2014, p. 320). Topics such as the relationship between greenhouse gases and radiation in the atmosphere, the effects of fossil fuel combustion on atmospheric greenhouse gas concentrations, and the ways in which the enhanced greenhouse effect influences Earth's energy balance should be included in the professional development program (Ekborg & Areskoug, 2012).

Walshe et al. (2018) conducted a study to investigate climate change perceptions of teachers in Samoa, Fiji and Vanuatu. Findings indicate that teachers in Samoa agreed that climate change was an important issue, however, lack of training and education resources restricted their ability to communicate or to teach climate change to their students effectively. They recommended training and workshops for teachers would be the best solution to enable effective teaching about climate change. Teachers also suggested that such workshops or training should be in both Samoan and English. It should also be locally contextualized and involve outdoor experiments and fieldtrips to connect scientific theory with local impacts and realities (Walshe et al., 2018). It was also expressed that education in schools needed to be streamlined with broader education initiatives outside of school, within families and communities. A forty one percent of teachers agreed that climate change should integrated in all subjects, however, 33% felt it should be part of geography, and only 17% believed it should be taught in science. Teachers in Fiji identified a lack of local examples with which to demonstrate impacts of climate change or practical applications for classroom lessons as the primary issue with teaching climate change, therefore, community-based workshops were suggested as a solution to locally contextualise lessons about climate change. Fijian teachers also believed that the curriculum did not adequately integrate climate change, and that this should be achieved by including it only in one subject. Teachers in Vanuatu and Fiji expressed that climate change education should start in primary school, however, in contrast to Fiji, teachers in Vanuatu believed that climate change lessons should be mainstreamed into all lessons and subjects, and that teachers should play a role in developing these materials via the sharing of best practices (Walshe et al., 2018). Teachers in Vanuatu felt that the curriculum was lacking in terms of its coverage of climate change, and this was a major barrier to teaching climate change as teachers were uncertain where to place materials within the existing subjects, and resources were not allocated. These teachers were particularly interested in the possibility of, and methods for, integrating traditional knowledge and culture with scientific methods and lessons. They also felt that they can and must do something about climate change (Walshe et al., 2018).

It is evident that professional development workshops are effective in addressing teachers' alternative conceptions, deepening understanding, stressing the topic's cross-curricular nature, and improving teacher's confidence and preparedness to teach climate change

(Hestness et al., 2014; Wise, 2010). Matkins and Bell (2007) found that teachers from across the United States did not only have limited knowledge about climate change, but they held several alternative conceptions about the science of climate change in general. A professional development workshop was held in which these teachers learnt about climate change as a vehicle to obtain a stronger scientific understanding. Matkins and Bell (2007) report that the teachers who attended the professional development indicated that they had a better understanding about climate change and the science of it.

2.6.10 Section summary

Sub-sections 2.6.1 – 2.6.4 delineate some of the key possible outcomes that can be achieved out of CCE such as learning new knowledge about climate change, raising awareness, empowerment and motivation to act. Sub-sections 2.6.5 – 2.6.7 discuss some of the ways that can potentially go about to achieve the possible outcomes outlined in the previous sub-sections. Sub-section 2.6.5 highlights the importance of exploring the student's existing knowledge about climate change which may help to design effective climate change curriculum. For instance, if students hold significant alternative conceptions, then the education providers need to provide better educational materials focused on those major misconceptions (Gowda et al., 1997)**.** Literature indicates that climate change mitigation and adaptation is going to take far more than knowledge of the natural sciences, so climate change is recommended to be taught from various disciplines but not only from science related subjects such as geography and earth science. However, the science syllabus for Tongan secondary schools has recently been reviewed and it is apparent that concepts of climate change have just been integrated into the syllabus of Class 8 to Class 11 in 2016.

2.7 Education or Ako in the Tongan context

Education equates to Ako in the Tongan language and the Tongan conceptualisation of education or Ako is based on the idea of poto or wisdom (Fua et al., 2008). In the past, the young generation grew up witnessing this way of living and followed the same pattern as that of their parents and grandparents. Therefore, traditional education was informal, flexible and based on the family and environment (Cummins, 1977; Paongo, 1990). The training and education provided for the children to gain skills and knowledge fundamental for their roles in society were carried out by extended family members. In this system,

people were trained and educated in informal ways wherein learning occurred through observing, listening, memorising and practical application. Children learned by observing their parents and relatives (Cummins, 1977; Mara et al., 1994; Paongo, 1990). Traditionally, the teacher was regarded as the person in possession of knowledge and skills and was viewed as superior to the learner. Therefore, the learner was expected to have a relationship of respect and deference towards the teacher (Mara et al., 1994).

The next sub-section presents the aims for secondary schools in Tonga, the Tonga curriculum framework, the curriculum guiding principles, and the overarching themes of education in Tonga.

2.7.1 Aims for secondary schools

The aims outlined in the secondary school education curriculum that are relevant to this study are to enable the boys and girls to:

- develop critical thinking skills and apply them to social issues in informed and responsible ways;
- develop a healthy self-concept, responsible independence, and social skills as young adults able and willing to contribute to community development;
- be proud of their Tongan identity and knowledgeable about Tongan cultures and values while being appreciative and respectful of the cultures and values of others;
- be prepared and able to participate in sustainable development by utilising and adapting new technologies and knowledge in ways that serve their own social and economic needs, and those of their community, as well as the needs of the environment; and
- be capable of adjusting to, or being resilient in a constructive way to rapid change.

(Ministry of Education and Training, 2016, p. 6)

2.7.2 Tonga Curriculum framework

The Tonga Curriculum Framework 2008-2019 drew from national policy consultations to provide the basis for the existing Curriculum Reform Programme. This framework consists of the nation's aspirations for education outputs, general aims for secondary education, guiding principles, over-arching themes, values, proposed best approaches for teaching, learning and assessment, and minimum subject allocation in the Tongan

classrooms, so that quality education unique to Tonga is enhanced (Ministry of Education and Training, 2016). Quality education does not particularly focus on the students' achievements, but more on principles, values and attitudes that characterize the student which are then demonstrated when a student appreciates, respects, participates, cooperates, contributes and seeks to uphold Christ-like behaviours and relations with others (Ministry of Education and Training, 2014). This in line with Fua et al. (2008) who agree that the purpose of education for Tongans is for their children to gain knowledge and skills that would enable them to lead worthwhile and useful lives in accordance with Tongan cultural behaviour. Tonga's desired education product is: "…to be a young man or woman who has made sound academic achievement, articulates possession of Christian principles and values, respects traditions and cultures, and above all contributes and actively participates in family and community activities" (Ministry of Education and Training, 2016, p. 5).

2.7.3 Curriculum guiding principles

There are ten educational principles guiding the curriculum in Tongan schools and three of these principles are particularly relevant to this research. These principles are:

- Learning that is relevant, meaningful and useful: The Tongan curriculum recognises that for learners to succeed, curriculum experiences must relate to learner's interests, needs, and learning styles. Wherever possible, learning is related to real life and lifelike contexts.
- Learning that relates to the wider world. The Tongan curriculum encourages an understanding of the place that Tonga has in the specific and globally, and the range of political, economic and social relationships and interactions that the country has in those settings.
- A high level of teacher professionalism and highly effective teaching: The curriculum framework recognises the importance of highly effective teaching in ensuring quality outcomes for learners. It will be implemented by schools in ways that are learner-centred and provide challenging learning opportunities and programs to enable all learners to achieve the learning outcomes to the best of their ability. Schools will provide teaching approaches, supported by high quality resources, that are relevant to learners and appropriate to their abilities and aptitudes, that are enjoyable, and that challenge them to strive to reach their full potential in all fields of learning. Effective

and quality teaching will develop in young people the capacity to be independent, yet collaborative, life-long learners.

(Ministry of Education and Training, 2016, pp. 7-8)

2.7.4 Overarching themes

There are five key themes that inform every subject in the Tongan curriculum, and they can be implemented through classroom activities. These themes are Tongan culture and values, Life skills, Education for Sustainable livelihoods, Enterprise, and Education for Sustainable Development (Ministry of Education and Training, 2016). These themes support the school curriculum to reinforce the commonly held values of respect, honesty, integrity, care and compassion, fairness, love, charity and fulfilment of mutual obligations of individual and collective responsibilities that underpin Tonga's traditional and modern society (Ministry of Education and Training, 2014). The Ministry of Education seeks to strengthen and develop the moral and cultural values that underpin Tongan society. These values include dimensions such as tauhivaha'a (caring), mamahi'ime'a (responsibility), faka'apa'apa (respect), and lototō (humility) (Ministry of Education and Training, 2016). The theme Education for sustainable livelihoods is about being able to manage existing resources, utilising context-specific skills and trusted knowledge guided by Tongan core values.

The theme Education for Sustainable Development embraces the connection of the Tongan people to nature. The Ministry of Education adopts a quote from Fua et al. (2008) which clarifies aspects of ESD in the Tongan context:

> One of the key features of the knowledge collected is Tongan people's closeness to nature and dependency on the land and the ocean. From women's weaving to men's plantation and fishing, to performing art, to medicine and natural disaster, it all reflects a concern with preserving the environment. In several cases, parents would ask that schools encourage the replanting of medicinal plants, flowers for garlands, plants for weaving, making 'ngatu', and trees for landscaping amongst crops and vegetables for food (Fua et al., 2008, p. 18)

The learning outcomes of the Tongan curriculum are based on the pillars of education advocated by UNESCO (Delors, 1998). The school curriculum aims together with Tongan families and the general community, school communities, religion communities,

employers and government to equip young Tongans to: Learn to know; Learn to be; Learn to do; and Learn to live together (Ministry of Education and Training, 2016).

2.7.5 Section summary

Tonga's traditional education was informal and flexible, and focused mainly on family and environment. Children used to learn through observation and listening to their parents and relatives. The extended family had the responsibility to train the children to become skilful and knowledgeable. Since this research focused only on secondary schools, it was important to review the literatures which indicate the aims for secondary schools, the overarching themes of the Ministry of Education and Training (MET), the Tonga curriculum framework, and some of the curriculum guiding principles. One of the aims for secondary schools in Tonga is to make sure the boys and girls could be able to be proud of their Tongan identity and knowledgeable about Tongan cultures and values while being appreciative and respectful of the cultures and values of others. The curriculum framework consists of 10 guiding principles, but only three guiding principles that are relevant to this study. One of these guiding principles requires learning to be relevant, meaningful and useful. The curriculum needs to be related to the learners' interests, needs and learning styles. Every subjects included in the Tongan curriculum are informed by these key themes: Tongan culture and values; Life skills; Education for Sustainable livelihoods; Enterprise; and Educational for sustainable development.

Having reviewed literatures on the education system in Tonga, the next section reviews literatures on teaching and learning approaches for climate change education.

2.8 Teaching and learning approaches for climate change education (CCE)

This section presents literature that review potential teaching and learning approaches for climate change education. The section starts with reviewing some literature on Pacific learning styles, then a review of some western learning and teaching approaches follow. Having discussed and considered the Pacific learning styles and the western learning and teaching approaches, then I propose an approach for teaching and learning about climate change in Tonga.

2.8.1 Pacific learning styles

> Cognitive style and learning style are not synonymous terms. The cognitive style relates to the thought processes, which are themselves related to the social-cultural-temporal milieu of the thinkers, where as learning style relates to the ways in which people endeavour to learn (Jarvis, 1987, p. 109)

Some of the generalisations made about the learning styles of Pacific learners including: Pacific students learn best in a group; and Pacific learners learn better from discussion (Jarvis, 1987). While the cultural emphases on communality and oral traditions are recognized, it is arguable that learning styles are directly related to cultural heritage. On the other hand, cognitive style is a product of socialisation (Jarvis, 1987).

Based on a study that was conducted by Pasikale (1996) on Pacific Island learners in New Zealand, they were asked to consider how they aspire to learn. Findings indicate that Pacific learners have a range of learning preferences and experiences (Pasikale, 1996). While the Pacific learners have a strong preference for teacher-facilitated learning, they also say that practice is an essential part of their learning experience (Pasikale, 1996). The Pacific Islands learners can often be taught and assessed by approaches which have theoretical foundations of little relevance to the learner's lives (Pasikale, 1996). Working in small groups was also a preference for the Pacific learners. Sharing, small group activities and peer tutoring were recommended by the participants to be some of the benefits of the group processes. They said it was easier for them to ask questions, they learn from each other, and they are not shy to share with a smaller group (Pasikale, 1996).

While western theories of teaching and learning are perhaps aimed at transforming, enlightening and preparing learners, the indigenous theories of learning and teaching were concerned with the continuity of the learner (Thaman, 1996). Thaman (2002) states that while traditional learning emphasized cultural continuity and survival, schooling shifted the priority towards models of thought highlighting economic, social and intellectual agendas. Tonga's desired education product includes a young man or woman who has made sound academic achievement, articulates possession of Christian principles, and values, respects traditions and cultures, and above-all contributes and actively participates in family and community activities (Ministry of Education and Training, 2016). The

assumption underlying indigenous notions of learning and teaching is one of nurturing (Pasikale, 1996). Learners are seen as developing products of their environment and the purpose of learning is to facilitate growth in ways that maintain harmony with the environment (Pasikale, 1996). Educational success for Pacific islands learners can be obtained if the cultural assets learners bring to the learning environment are not invalidated by the goals and practices of educational institutions. Culture provides the foundation for conceptualization as well as the context for learning (Pasikale, 1996).

2.8.2 Culturally Relevant pedagogy

Culturally responsible or culturally relevant teaching is a pedagogy that "empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills and attitudes" (Ladson-Billings, 1995, p. 382). Culturally relevant pedagogy is an avenue for students to ensure their cultural identity while succeeding academically (Ladson-Billings, 1995; Ogbu, 2003) while teachers make use of students' culture as a medium for learning (Ladson-Billings, 1995). According to researchers, culturally-responsive curriculum can impact student achievement by understanding the student's home-community culture, and integrating these cultural experiences, values and understandings into the teaching and learning environment (Au, 2007; Banks, 2004; Brown-Jeffy & Cooper, 2011; Gay, 2002; Ladson-Billings, 1995; Rhodes, 2013).

Education provision is likely to be more meaningful and participation in learning processes more active, when programmes deliver knowledge and skills which are relevant to local contexts and needs (Bangay & Blum, 2010). A number of studies have pointed to the unique potential of locally relevant, issues-based climate change education for improving students' climate change understandings (Anderson, 2012).

It is crucial to provide educational learning spaces that encourage young people to address issues in their local communities in meaningful and relevant ways, and we need to encourage them to use all the information, tools and resources that are available. It is through action that hopeful futures are created (Field, 2017).

Through observation, listening, imitation, participation and some direct instruction, young people obtain the necessary knowledge, skills and values of their cultures, elders from adults and sometimes their peers. Learning is practical and directly related to shared

values and beliefs (Thaman, 2010). For example, in Tonga, values include those of: ‘ofa (compassion), faka’apa’apa (respect), feveitokai’aki (reciprocity), tauhi vaha’a (nurturing inter-personal relations), and fakama’uma’u (restraint behaviour). The achievement of poto (wisdom) continues to be measured against these values, through people’s performance and behaviour in different social contexts (Thaman, 2010). One of the core values of indigenous education is relationship, this is in connection with relationship among people and relationship between people and nature (Thaman, 2010). Thaman advocates that this indigenous education empowers knowledge and understanding of how people are related to one another, together with connected responsibilities and obligations (Thaman, 2010). She believes that Pacific teachers do not acknowledge the existence and the potential contribution of indigenous education to ensuring relevance in the school curriculum. She highlights that this is common in urban schools where people continue to follow the requirements of traditions and elders and specialist teachers impart important knowledge, skills and values using a range of methods such as myths, legends, dance, poetry, songs, proverbs and rituals (Thaman, 2010). Fua et al. (2008) highlight that Tongan parents wish for their children to have an education so that they may have poto (wisdom). For the child to become poto, he or she must have ‘ilo (knowledge) and poto’i ngaue (skills).

2.8.3 Experiential approach

An experiential curriculum that teaches not just the causes of climate change but also the effects and locally appropriate actions is both rare and needed according to much climate/sustainability education literature (Caniglia et al., 2016; Plutzer, Hannah, et al., 2016; Wolf & Moser, 2011).

Anderson (2012) proposed Climate Change Education for Sustainable Development (CCESD) as an effective approach to combat climate change. She mentions that CCESD must not only include relevant content knowledge on climate change, environmental and social issues, disaster risk reduction, and sustainable consumption and lifestyle, but also a focus on the institutional environment in which that content is learned to ensure that schools and education systems themselves are climate-proofed and resilient as well as sustainable and green. She says:

> In order to ensure that educational gains are not lost as climate change-induced storms, floods, etc., destroy infrastructure, learning

> spaces should be made safe and climate resilient through the incorporation of disaster prevention, preparedness, response and recovery strategies for individuals, educational systems and communities (Anderson, 2012, p. 195)

2.8.4 Participatory approach

Climate practitioners from across the Pacific discussed ways to effectively build awareness and engage communities (McNamara, 2013a). These ideas are discussed in turn under the following themes that emerged from the focus group – approach (how), audience (who) and context (what). For the participants, how knowledge about the impacts of and potential solutions to climate change is shared is critical for delivering appropriate and effective awareness activities. They argued that participatory approaches are extremely effective, for example, to involve community members in the development of seasonal calendars, timelines or transect walks through the village, or for inviting people to partake in performances. Other examples included: communal storytelling; art, poem and song competitions; workshops and training; poem writing sessions; and the use of books and movies (McNamara, 2013a).

A stream of different ideas flowed from participants; use legends or myths to assist in the learning process; or use drama or puppet plays to deliver messages (McNamara, 2013). This reinforces the work of Klein et al. (2001), who provided a summary of a series of popular mediums to enhance community awareness, including workshops, conferences, training events, courses and technical assistance, along with series of technologies such as printed information, audio-visual media and interactive tools, such as board games and computerised simulation models.

2.8.5 Social constructivism

Constructivism in education is rooted in the work of Piaget and Vygotsky. Piaget (1970) highlighted the cognitive development and individual construction of knowledge, while Vygotsky (1978) emphasized social construction of knowledge. The emergence of this theoretical position has coincided with a shift in pedagogy away from teacher-centered information transmission models toward knowledge-centered and learner-centered approaches that focus on cognitive and social processes in learning (Kaufman, 2004).

The influence of social and cultural contexts on learning and knowledge construction is underscored in Vygotsky's social constructivist theory (Vygotsky, 1978). Vygotsky furthered the view that children's thinking and meaning-making is socially constructed and emerges out of their social interactions with their environment. Children's learning is facilitated by parents, peers, teachers, and others around them in the community and teachers too are learners in this context (Vygotsky, 1978). The constructivist approach sees learning not only as enrichment of information but also as reconstruction of what is already known (Mason & Santi, 1998).

Developed by Vygotsky, the concept of social constructivism emphasised collaborative learning environments and social interactions (Barker, 2008). Vygotsky claimed that people create meaning through interactions and learning is a social activity; "human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around them" (Vygotsky, 1978, p. 88). In a socio-constructivist classroom, in which the three Ts trilogy 'Teacher, Text, Test' is not undertaken, students can take on themselves the responsibility of their learning, using argumentation as a tool to critically evaluate the status of their own conceptions (Mason & Santi, 1998). Argumentative practice, stimulated in group discussions, allows students to transform their personal beliefs into reasoned views (Kuhn, 1993), learning gradually to transfer this way of thinking beyond the specific dialogical contexts (Mason & Santi, 1998)

Lehtonen et al. (2019) also highlight that the understanding and response to climate change is socially constructed; each person with a unique view. They note that in order to understand what to do about it, we need to become aware of cultural dichotomies and strive for interconnected thinking and better understanding about how we are connected to each other and nature, how we can reconnect to emotions and our bodies.

Having thought about the Pacific learning styles, elements of ESD, and all the teaching and learning approaches that were presented in the previous sections, and I also consider the fact that this thesis is based in Tonga, I propose talanoa which is a form of communication in Tonga and in the Pacific might be a better way to teach and learn climate change. The following sections review some literature which rationalises why this might be so.

2.8.6 Talanoa – An approach for teaching and learning about climate change in Tonga

A study that was conducted by Thompson, McDonald, Talakai, Taumoepeau, and Te Ava (2009) indicate that the Pacific students' lack of engagement in classroom discussions and with the school curriculum are due to factors such as unfamiliar educational pedagogies and the curriculum content. Therefore, it is suggested that appropriate teaching methodologies, and cultural contextualisation and customisation of teaching will enhance Pacific learner's engagement in the classroom discussion and with the class curriculum (Thompson et al., 2009). It is in the context of this research that I identify the need to employ talanoa as an appropriate pedagogy for teaching and learning about climate change in Tonga.

Talanoa is an oral form of communication which enables people in the Pacific to learn, relate to each other, narrate, and tell stories (Morrison, Vaioleti, & Vermeulen, 2002; Tavola, 1991). It is an activity used for creating and transferring knowledge (Vaioleti, 2013) and it also allows people to talk from their hearts (Halapua, 2005b). The Tongan system of supporting thinking, teaching and learning occurs through the verbal expression of talanoa (Halapua, 2005a). It is argued that traditional informal education was carried out through oral forms of communication and the key means of learning about behaviour, traditions, the past and also the present includes myths, legends, song, dance poetry, proverbs and rituals (Pasikale, 1996). People from the Pacific region were trained and educated in informal ways in which learning occurred through observing, listening, memorising and practical application, and children learned by observing their parents and relatives (Cummins, 1977; Mara et al., 1994; Paongo, 1990). Traditionally, the teacher was regarded as the person in possession of knowledge and skills and was viewed as superior to the learner. Therefore, the learner was expected to have a relationship of respect and deference towards the teacher (Mara et al., 1994). Talanoa can bring about a sense of maheni (familiarity) and fe'ilongaki (knowing each other's identity and place) among Tongan people (Manu'atu, 2000b). When a group of Tongan people gather they usually engage in different types of talanoa, including fakatalanoa (to encourage discussion when they do not know each other), pō talanoa (when they already know each other), or talatalanoa (in which they talk about selected topics or talk endlessly). Tongan people come together to talanoa about their experiences, express their aspirations, voice

their issues, and speak their different perspectives in forums, meetings, seminars, and radio programmes (Manu'atu, 2000b).

Vaioleti (2006) argued that talanoa will produce relevant knowledge and possibilities for addressing Pacific issues. Talanoa and its pedagogical and philosophical stances are an essential part of ako. Talanoa can be used constructively by a teacher and learner in order to make meaning and reach mutual understanding. In talanoa, there is a possibility that both teacher and learners can use diagnostic and formative assessment simultaneously to stay within a learning engagement in order to scaffolding one another to a mutual understanding or reach shared meaning (Prescott & Fua, 2016; Thaman, 1988; Vaioleti, 2011). This approach may ensure the learner understands concepts being learned and for the teacher to know that the learning has taken place. In talanoa (for ako), Talanoa is at its most powerful when used formatively to scaffold learners' current understanding to another level desired by the faiako (teacher) (Thaman, 1988; Vaioleti, 2011).

Talanoa is suggested as a pedagogy that best explores the knowledge, strengths and merits of using the Tongan language and cultural practices in teaching and learning of Tongan children (Lātū, 2009). Dilling and Moser (2004) recommend that teaching climate change has to be effective, concrete and doable, otherwise a message of fear will not produce reasonable responses to danger, but instead it will produce denial. In talanoa both participants share power and the responsibility for process and outcome discussion at hand. If it is used for teaching, learning will become the fatongia (responsibility) of both teacher and student and are likely to stay engaged in the learning relationship until the desired outcome is achieved. Therefore, if used for CCE, a good talanoa can be a platform for the participants to co-construct new solutions or knowledge (Vaioleti, 2013). Talanoa is a process used in many ways to obtain information and to find out people's feelings about things (Otsuka, 2006; Tavola, 1991).

It is also argued that talanoa is an established framework for generating discussion about complex topics used throughout the Pacific (Vaka, Brannelly, & Huntington, 2016). For instance, talanoa dialogue was brought into the Conference of the parties at its twenty-fourth (COP 24) iteration which was held in Katowice, Poland, with the purpose to "…share stories, build empathy and generate trust…" (UNFCCC, 2019, p. 6). Talanoa dialogue was acknowledged as an inclusive and participatory process that incentivized exchanges between Parties and non-party stakeholders, following the Pacific tradition of

talanoa (UNFCCC, 2019). It is also highlighted in the UNFCCC report (2019) that talanoa dialogue had the potential to generate greater confidence, courage, enhanced ambition and climate action (UNFCCC, 2019).

2.8.7 *Talanoa* as positioned in Western perspectives

Talanoa, as positioned in Western perspectives, can either be referred to as talk, dialogue or conversation. Vygotsky (1962) acknowledges the role of talk in organising our understanding of the world. Posner et al. (1982) explored the link between classroom talk, meaning construction and learning. They found that meaning making and understanding are dialogic processes. They noted that, "if the aim of the teaching is for students to develop an understanding of some topic, then those students must engage in some form of dialogic activity" (Posner et al., 1982, pp. 69-70). This is concurred by a statement given by Driver, Asoko, Leach, Scott, and Mortimer (1994) emphasising talk or dialogue as a social activity and that it helps individuals construct knowledge and understanding:

> Knowledge and understandings, including scientific understandings, are constructed when individuals engage socially in talk and activity about shared problems or tasks. Making meaning is thus a dialogic process involving persons-in-conversation, and learning is seen as the process by which individuals are introduced to a culture by more skilled members (Driver et al., 1994, p. 7)

The above quote aligns with an argument made by Mara et al. (1994) that in the Pacific classroom, a teacher is regarded as the person in possession of knowledge and skills and was viewed as superior to the learner. Therefore, the learner was expected to have a relationship of respect and deference towards the teacher. There is a growing body of empirical evidence to support the emphasis on the value of teacher-to-student and student-to-student interaction and its relationship to learning (Holthuis et al., 2012).

Spoken word is discussed by Alexander (2008) as an emerging pedagogy which exploits the power of talk to shape children's thinking and to secure their engagement, learning and understanding. Noddings (2015) stress the significance of open-ended dialogue between teachers and students, where real dialogue is a seeking for understanding, empathy or appreciation. Mercer (2000) and Alexander (2006) support that children learn through conversation that explore their thinking and understanding and children need

scaffolding and support in the classroom to interact in ways that optimize the processes of learning. Cazden (2001) explored many ways teachers use discourse as scaffold. She realizes that teachers use talk to introduce students into new perspectives and new ways of thinking about, reconceptualising, or re-contextualizing whatever issues or phenomena are being discussed. Executing scaffolding in the context of climate change education, teachers need to provide scaffolding that builds not only students' understanding of how climate systems work or the causes and effects of climate change but *how we know what we know*. For instance, what is the evidence for anthropogenic climate change and how sure are scientists about their claims (Holthuis et al., 2012).

Brown and Kennedy (2011) think that this places interaction and dialogue at the centre of the learning process, with the teacher in a pivotal role to enhance the interactive learning experience of children. They also argue that supporting teachers in reflecting on their interactional style with regards to the nature of the interactive context and the way conversations engage with children's ideas, can impact positively on children's participation and learning (Brown & Kennedy, 2011). Brown and Kennedy (2011) also believe that as children participated more in conversations, there was evidence of children connecting their ideas together giving more of a genuine dialogue.

2.8.8 Section summary

This section recognises the importance of an effective approach for teaching and learning about climate change particularly in the Tongan classroom. It is stressed in this section that Pacific island learners learn best in a group and they learn from discussion. Pacific learners prefer to learn in groups because it gives them confidence to share ideas when they are in a smaller group. Therefore, there is a need for integration of Tongan values and beliefs into global education initiatives. For a Pacific learner, culture provides a foundation and context for learning. In the Tongan context, learners used to learn from parents, peers and family members. The values that are practiced by a Tongan learner includes 'ofa (compassion/love), faka'apa'apa (respect) and tauhivaha'a (nurturing inter-personal relations). The learner's achievement of poto is measured against these values through the learner's performance and behaviour in all areas of the society.

Talanoa is used in this research as a Tongan way of teaching and learning about climate change. Its pedagogical and philosophical stances are an essential part of ako (learning).

Talanoa provides a space for students and teachers or for students and students to co-construct ideas and shared meaning.

2.9 Chapter Summary

Reports from the Intergovernmental Panel on Climate Change (IPCC) indicated that the high concentrations of Greenhouse gases (GHGs) in the atmosphere have resulted from human activities such as fossil fuel burning, and agricultural and livestock activities. This is leading to global warming and impacting on the Earth's climate. Climate change is a global issue and it poses impacts on natural and human systems on all countries and across the oceans. The Pacific Island countries including Tonga are on the frontline of climate change due to their physical, geographical and socio-economic characteristics. Tonga already observed climate change impacts such as sea level rise, high temperature and increased in the frequency and intensity of extreme weather events namely cyclone and droughts. While adaptation and mitigation are the two main responses to the detrimental impacts caused by climate change, education is recognised to be a key factor in the global response to the increasing environmental challenges such as climate change (UNESCO, 2014). The United Nations Educational, Scientific and Cultural Organization (UNESCO) intends to make climate change education a significant and visible part of the international response to climate change.

While children and young people in the Pacific are vulnerable to the impacts of climate change, it is apparent that most of them are going to school with very limited understanding of the issue. Students and teachers appear to hold common alternative conceptions about climate change. Literature insists that in order for students to become knowledgeable about climate change, the school curriculum should be designed based on students' perceptions of climate change. Not only that, but the education system should provide better educational materials in order to be able to address the students' significant alternative conceptions. Teachers in the Pacific nations think that there is lack of training on the issue and climate change resources are insufficient. While some Pacific nations have already integrated climate change into their school curriculum, Tonga appears to have made very slow progress in doing so.

Reviewing the literature sheds light to the role of climate change education (CCE) and the need to develop an approach which may assist teachers and students in teaching and

learning about climate change. CCE in this thesis refers to the processes aimed at improving the degree to which an education system is prepared for, and is responsive to the challenges of climate change (Mochizuki & Bryan, 2015). CCE is about equipping the young people with the values, knowledge and skills to make choices and decisions to reduce emissions, waste, and minimize the use of natural resources and the same time support socio-economic development and contribute to the growth of new solutions. This chapter outlines some potential outcomes that we may achieve out of CCE such as learning new knowledge, raising climate change awareness, empowerment and motivation to act. Literature indicates that climate change education may need to be evidence-based and multi-disciplinary in order to achieve those outcomes. An effective teaching and learning approach is imperative to ensure there is an effective climate change education.

Considering the fact that this study is based in Tonga, a review of literature around Pacific learning styles was crucial. However, a substantial literature on the western teaching and learning approaches was also reviewed to produce a balance in both perspectives as they may help guide the development of the learning and teaching approach for climate change in Tonga. Talanoa is proposed as an approach for teaching and learning about climate change in Tonga.

2.10 Conceptual Framework

Key ideas from the literature review help to inform a conceptual framework for this study and this is illustrated in Figure 1. This research aims to explore the students' and teachers' knowledge, awareness, attitude about climate change and their motivation to act upon climate change. The place of climate change in the secondary school curriculum in Tonga will also be examined. These findings and key ideas from the literatures inform a climate change education intervention that was designed and implemented in one of the secondary schools in Tonga. In this research, talanoa, was used as an approach for teaching and learning about climate change in Tongan secondary schools. This conceptual framework guides the scope of the research.

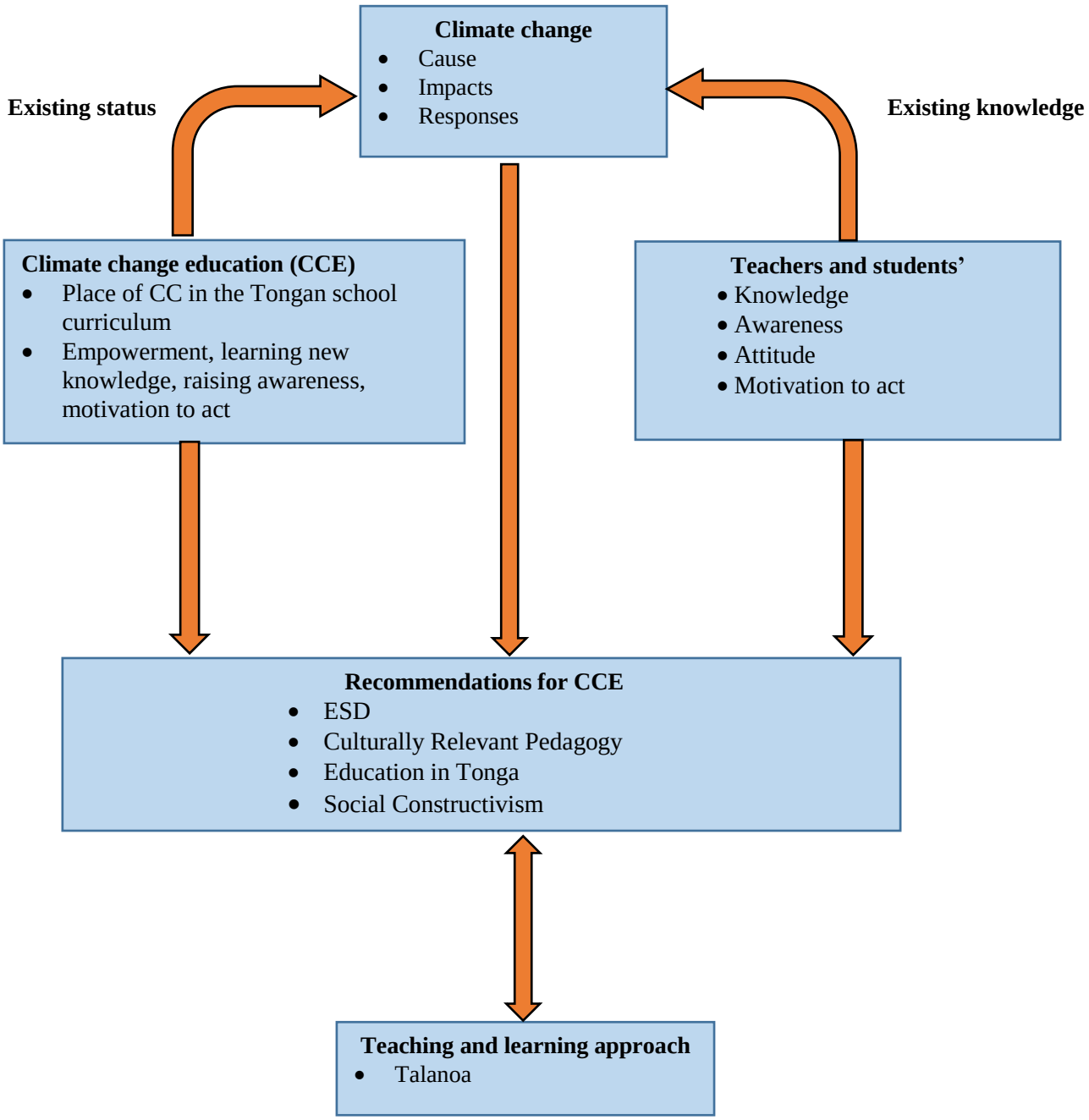


Figure 1 Conceptual framework of this research

The next chapter presents the research methodology and design.

Chapter 3: Research methodology and design

3.1 Introduction

This chapter examines the research principles and methodological framework used to conduct this research. The research uses methods that reflects phenomenological methodologies and cultural epistemologies that Vaioleti (2003, 2006, 2011) describe as Talanoa. The culmination of these two frameworks results in a culturally contextual, inductive approach. The methodology, Talanoa, draws on fundamental concepts and practices of founga faka-Tonga (Tongan way/being), requiring the researcher to be immersed within Tonga culture. The chapter begins with the research questions, and is followed by a discussion of the research methodology and the rationale for choosing this methodology. The research methods and stages of data collection are detailed. Finally, the chapter describes methods of sampling, data collection, analysis, and ethical considerations of the research.

3.1.1 Research questions

Research questions are important starting points to develop a research design because they provide important evidence about the subject or issue that a researcher is aiming to assess (Berry & Otley, 2004; Saunders, Lewis, & Thornhill, 2016; Yin, 2012). Conducting research entails the deliberate and methodical search for new knowledge and insights in the form of answers to questions that have been formulated in advance (Jonker & Pennink, 2010).

This research aimed to explore students' and teachers perceptions about climate change and its place in the school curriculum. Data collected helped to inform a climate change education intervention which was designed and implemented in a secondary school in Tonga. The research questions are as follows:

1. What are secondary school students' and teachers' perceptions of climate change in Tonga?

2. What is the existing status of climate change-related issues in the secondary school curriculum in Tonga?

3. How can a climate change education intervention be designed for Tongan secondary education?

4. What are the learning outcomes for Tongan students and teachers about the issue of climate change in response to the education intervention?

3.2 Methodology

It is significant in any research inquiry to position the research within a relevant methodology, as this implies a specific approach. To form the basis for understanding the underlying assumptions in the research approach, data collection, data analysis, and data interpretation, it is vital to determine what the researcher's methodological stance is (Lincoln & Guba, 1985). A methodology refers to a strategy or plan of action that links methods to outcomes and governs the researcher's choice and use of methods (Creswell, 2003). It is a "model to conduct research within the context of a particular paradigm" or worldview, and it "comprises the underlying sets of beliefs that guide a researcher to choose one set of research methods over another" (Wahyuni, 2012, p. 72).

This research aimed to explore secondary school students' and teachers' perceptions about climate change in Tonga, and the place of climate change education in their school curriculum. The research questions helped to determine the nature of a methodological framework for this study. In addition to that, there were some key questions that I considered such as "Who is this work going to be useful for?" (Vaioleti, 2006, p. 23), "Whose research is it? Who owns it? Whose interests does it serve? Who will benefit from it? Who has designed the questions and framed its scope? Who will carry it out? Who will write it up? How will its results be disseminated?" (Smith, 1999, p. 10).

To conduct research in the Pacific and on its people, it is important that the research development is influenced by Pacific thought (Sanga, 2004). Vaioleti (2006) emphasises the idea that Western, Eastern and Pacific knowledges do not have the same origins or construction, or that they grew out of the same contexts. He argues that researchers who have derived their knowledge from Western ways of being and origins are not likely to have the values and lived realities that allow meaningful understanding of "issues pertaining to knowledge and ways of being that originated from the nga wairua (spirits) and whenua of Samoa, Tonga, Fiji, Tuvalu or other Pacific nations" (Vaioleti, 2006, p. 22). Vaioleti argues that the research methodologies designed to explore issues and

provide solutions in non-Pacific cultures may not be appropriate when searching for solutions for Pacific peoples. Nabobo-Baba (2008, p. 143) contends that Pacific researchers need to use culturally appropriate framings and methodologies that recognise "Pacific world views, cultural knowledge and epistemologies, grounds the research and provides it with methodological integrity" (p. 143). This intent is mirrored in research methodologies that have been explored by a number of Pacific academics and researchers such as the Fonofale model (Pulotu-Endemann, 2001), the Fijian Vanua Framework for Research (Nabobo-Baba, 2008), and Talanoa (Vaioleti, 2006).

The Fonofale model embraces the structures of the traditional Samoan meeting house as it is interpreted in Figure 2. As a metaphor, it is used to represent important factors that should be considered in health development.

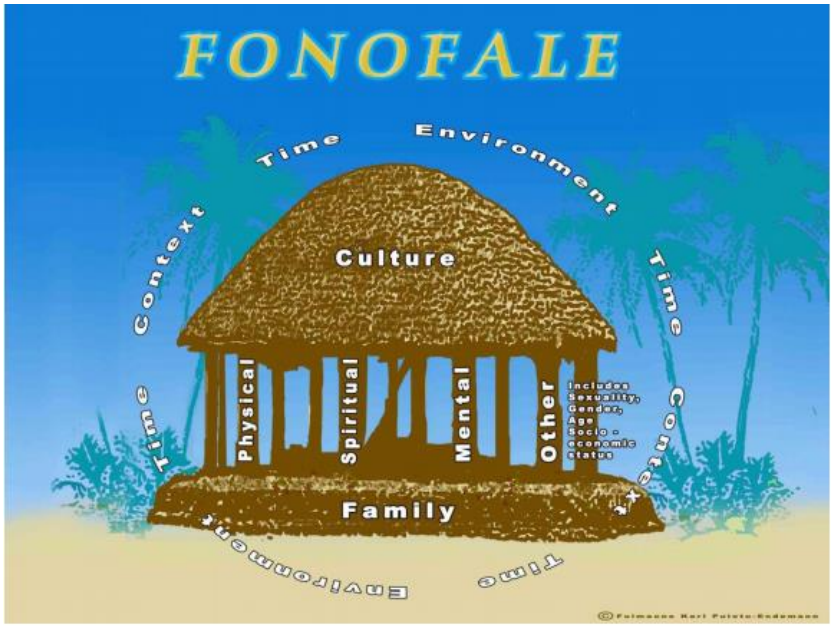


Figure 2 *Fonofale model* (Pulotu-Endemann, 2001, p. 3). Image used with permission from copyright holder.

The Fonofale model is used to guide research in other areas such as education research as well. In this framework, and as in the above interpretation, the foundation of the house represents the extended family. In the Fonofale framework above, the (extended) family is firmly situated in the fonua (whenua) that gives and sustains life, meaning, context and worldview.

From the outside, the roof in the above figure, represents the most identifiable influence of the whenua. That is, the culture. At the obvious level, they are the arts, be it

performance, visual or others. There are the political and spiritual, reflected in social hierarchies, nobility and their ties to villages and land (shown as extended family in the figure above). Within those ties are the rules, protocols and expectations to maintain the indigenous vā as in tauhi vā (maintaining integrity of all or harmonious relationship) understood in intrinsic rights and obligations of a culture. The roof then can also stand for language, ways of being that preserve gender protocols, indigenous spirituality and their complex interwoven tapu systems, that are intrinsic to maintaining order that are still part of their modern thoughts, even today.

It is to the metaphoric space between the roof and the foundation that I submit that researchers of Pacific issues must be invited into in order to truly tap into the authentic knowledge and views of a Pacific community. For researchers to gain acceptance into the intellectual and spiritual inside of an extended family (or community), researchers must follow the structures of appropriate research method and methodology, and have the competency to engage participants authentically and respectfully. Only in securing and maintaining the vā (tauhi vā) with the participants and their community does the researcher come to understand the community's issues from their own perspectives (Vaioleti, 2011).

It was in the study of Pulotu-Endemann (2001) and Nabobo-Baba (2008) theorising on researching Pacific issues that I arrived at arguing that Talanoa Research Methodology is the most situationally appropriate framework that allowed me to study the understanding of climate change by Pacific students in Ha'apai. Using Talanoa Research Methodology also support Nabobo-Baba's claim that Pacific researchers need to use culturally appropriate framings and methodologies that recognise that to use "Pacific world views, cultural knowledge and epistemologies, grounds the research and provides it with methodological integrity" (Nabobo-Baba, 2008, p. 143) when researching with Pacific participants to identify issue unique to them.

3.3 Talanoa research methodology

Talanoa was first introduced in the academic literature as a Pacific research methodology by a Tongan scholar, Dr Timote Vaioleti (2006). Prior to the introduction of talanoa research methodology, literature on talanoa emerged when Dr Sitiveni Halapua, also a Tongan scholar took this traditional Pacific philosophy of talk, and employed it within Fiji's post-2000-coup government. The talanoa helped to allow the opposing political

parties to speak from deep within their hearts and perspectives, so co-constructed solutions could be reached and lasting peace achieved (Halapua, 2000; Robinson & Robinson, 2005). In Tongan language, tala refers to telling stories, talking, informing, or talking about (Taleni, Macfarlane, Macfarlane, & Fletcher, 2018; Vaioleti, 2006, 2013) and noa meaning nothing, zero, free from constraint or pure. When talanoa is used for peace talks, noa can be the stage when reached that one is freed from negative constraints allowing authentic thoughts and information to flow straight from one's heart (Halapua, 2005b; Vaioleti, 2006).

Vaioleti (2011) in his later work on talanoa, says that an important goal or tala (talk, discussion, planning, instruction) is noa which means a state of balance, a state of total peace, a state of perpetual harmony as a spiritual goal for many, thereby within the concept is action and a philosophy, a method and methodology. Vaioleti (2006, p. 23) defines talanoa as "…a conversation, a talk, an exchange of ideas or thinking, whether formal or informal" (p. 23). Entrenched in oratory tradition, talanoa is commonly used as a mode of everyday communication for some Pacific islands including Tonga, Samoa and Fiji.

The Talanoa research methodology shares commonalities with phenomenology, where meaning is co-constructed. Phenomenology fits within an interpretive paradigm aiming at understanding the meaning of phenomena and how they fit within a social, cultural, and political context. The Talanoa research methodology shares commonality with the interpretive and flexible nature of phenomenology, blending it with cultural protocol and practices to obtain the most valid data of phenomena (Vaioleti, 2011). In addition, for talanoa, a researcher is not merely involved to interpret data, but to culturally co-construct it with participants. It is necessary for the researcher then to shed preconceived ideas when it may be appropriate and endeavor to interpret information received in their own integrity.

Talanoa is now arguably one of the most prominent research methodologies utilised across the Pacific (Farrelly & Nabobo-Baba, 2012). It provides a platform where researchers and participants engage in a "social conversation which may lead to critical discussions, knowledge creation or co-constructed stories" (Vaioleti, 2006, p. 24). Vaioleti (2003, 2006, 2011, 2013) claims that using the talanoa methodology in research with Tongan people can produce a more mo'oni (purer or real) view. Pacific scholars

claim that talanoa has the potential to explore issues regarding human relationships and for understanding the diverse views, needs, and expectations that exist among those interactions as experienced by Tongans, as well as other Pacific people (Manu'atu, 2000a; Otsuka, 2006; Prescott, 2008; Vaioleti, 2006).

Talanoa requires cultural connectedness between those involved (Vaioleti, 2006), and it is "undertaken with the understanding that is a culturally and emotionally embedded reciprocal exchange between researcher and participants" (Farrelly & Nabobo-Baba, 2012, p. 3). These cultural connections are central since the researcher and the participants are both involved in the 'kau ngā fa'u" or the co-construction of knowledge (Vaioleti, 2013, p. 194). While talanoa embraces the notion of kaungā fa'u, Morrison et al. (2002) realise how relationship can be a foundation in which most Pacific activities are developed.

Despite any prepared guiding questions to lead the discussions, and the pre-announcement of the topics or issues to be discussed, talanoa provides a space for the participants to talk openly and raise any aspect of the topic they feel is relevant or important. This is the natural progression of a talanoa (Prescott, 2008). Robinson and Robinson (2005, p. 17) state that "within the use of the philosophy of talanoa ideas are floated and discussed" (p. 17). While the researcher holds the responsibility to bring the discussion back in line, participants sometimes share some evidently irrelevant stories which are a fundamental part of their story. This reflects the benefit of giving an opportunity for the participants to contextualise their experiences through talanoa. These details are helpful for gaining an in-depth and a clearer understanding of the participant's character (Prescott, 2008).

Talanoa could be thought of as a research paradigm or worldview and these are established to address the philosophical dimensions of social science research (Wahyuni, 2012). Egbert and Sanden (2013) understand a paradigm to be a researcher's specific stance on how knowledge can be revealed. They are fundamental assumptions and beliefs as to how the world is perceived which then serves as a thinking framework that guides the behavior of the researchers (Jonker & Pennink, 2010). A philosophical dimension is important in research because it shapes how researchers formulate problems and research questions to study, and how to seek information to answer those research questions (Huff, 2009).

Prescott (2008) suggests that Talanoa aligns with the Western interpretive paradigm. He further suggests that Talanoa can place both the researcher and the participants in a position where they are regarded as equal and inseparable; both participate in, and contribute to the discussion. Hence both "benefit from the understanding gained from the experience" (Prescott, 2008, p. 131). Through interpretivism, a researcher also strives to "understand the subjective world of human experience" (Cohen, Manion, & Morrison, 2018, p. 19), and the truth is based on a person's subjective reality and constructed by each person's understanding of the world. (Cohen et al., 2018; Patton, 2002)

Talanoa shares qualities with qualitative research methodologies too as it that assumes that knowledge is known through the subjective experiences of people, and acknowledges the value-laden and biased nature of research whereby researchers make known their values in the study through positioning themselves in the research (Creswell, 2013). Talanoa aligns here too with the interpretive approach. Because of its interactive and participatory nature, the researcher can study things in their natural settings, making sense of, or interpreting phenomena in terms of the meanings participants bring to them (Creswell, 2013; Denzin & Lincoln, 2011).

The central aim of the interpretive paradigm is to understand the subjective world of human experience and to maintain the integrity of the phenomena being investigated, as efforts are made to get inside the person and to understand from within (Cohen et al., 2018). Given that this research revolves around students' and teachers' perceptions of climate change in Tonga, interpretivism fits because it is crucial for the researcher to understand the participants' worldviews and interpretations of climate change issues and also to describe them in detail through talanoa methodology. Since these human perspectives and experiences are subjective, social reality may change and can have multiple perspectives (Hennink, Hutter, & Bailey, 2011).

As Talanoa shares qualities with qualitative research methodologies, it shares qualities also with interpretivist approaches to research. In an interpretive study, the researcher recognizes that in order to understand the social world from the experiences and subjective meanings that people attach to it, therefore, it is crucial to interact and dialogue with participants (Wahyuni, 2012), in similar way that Talanoa expects. Researchers, myself included, should recognize the potential impact of our backgrounds mentioned in other parts of this thesis in shaping our interpretation, and to position ourselves in the

research to acknowledge how their interpretation and meaning of climate change flows from their personal, cultural, and historical experiences.

The acceptance of human understanding as socio-historically embedded leads to the assumption that all interpretations are temporal, located, and therefore always open to reinterpretation, and that the truth of an interpretation must be negotiated through continuous conversation and dialogue (Kvale, 1996). Prescott (2008) argues that Pacific methodology such as talanoa can do this in the same way as interpretivism. They are common in a sense that they both contribute to the discussion and they both benefit from the understanding gained from the experience (Prescott, 2008). Interpretive approaches focus on actions, and they are only meaningful to readers in so far as the researchers are able to ascertain the intentions of actors to share their experiences. A large number of peoples' everyday interactions with one another rely on such shared experiences (Cohen, Manion, & Morrison, 2011).

3.3.1 Rationale for using Talanoa methodology

From the Fonofale model (Pulotu-Andemann, 2001) used to guide research in the heath sector, one can see the importance of reflecting culture of the kaungā fa'u in all research activities. Nabobo-Baba (2008) also discusses how the culture of the fonua (whenua) and their spirituality must be understood and respected in order to work in a respectful way with the community which researchers are working in. These are also requirements of phenomenology and interpretive study. While Talanoa Research Methodology share many qualities with both phenomenology and interpretive study, Talanoa is a local, and for this study a, situational methodology.

Further, Talanoa is now arguably one of the most prominent research methodologies utilised across the Pacific (Farrelly & Nabobo-Baba, 2012). It provides a platform where researchers and participants engage in a "social conversation which may lead to critical discussions, knowledge creation or co-constructed stories" (Vaioleti, 2006, p. 24). Pacific scholars claim that talanoa has the potential to explore issues regarding human relationships and for understanding the diverse views, needs, and expectations that exist among those interactions as experienced by Tongans as well as other Pacific people (Manu'atu, 2000a; Otsuka, 2006; Prescott, 2008; Vaioleti, 2006).

Talanoa was considered the appropriate method for this study because of its interactive nature and its suitability to the Tongan cultural context. Nabobo-Baba (2008, p. 143)

contends that Pacific researchers need to use culturally appropriate framings and methodologies that recognise "Pacific world views, cultural knowledge and epistemologies". Since this research was conducted in Tonga where all participants were Tongans, talanoa appeared to be culturally relevant and appropriate because it also allowed (my kaungā fa'u and I) to communicate either in Tongan language or English (the second national official language of Tonga). One of the factors most likely to influence the responses of the participants would be the relationships maintained between me as the researcher and them. Vaioleti (2006) and Farrelly and Nabobo-Baba (2012), emphasise the importance of relationship in talanoa research methodology and in Pacific research in general.

3.3.2 A caution and response

Vaioleti (2006) stated that:

> The disparity between the objectivity base of much traditional research and the subjectivity of the participants is often not recognised in Pacific research contexts. For example, in a research situation in a Pacific community, the participants will behave differently depending on the age, gender, cultural rank or community standing of the researcher. These variables may significantly affect results (p. 22).

As a Western educated woman and a former high school teacher, the directive by phenomenology while researching is to shed preconceived ideas in order to understand discussions from the participants' perspectives. I constantly checked against what Bishop (1996) and Vaioleti (2003, 2011, 2013) assert in that we cannot separate who and what we are when carrying out research. To cope with these real conflicts, I followed the protocols of mateuteu (always well prepared), practice 'ofa (compassion), constantly displayed faka'apa'apa (humility) expected by the Tongan culture of a person of my age, gender and community standing, described by (Vaioleti, 2011, 2013) as protocol for talanoa research.

Furthermore, I used different methods of talanoa such as talatalanoa and tālanga through talanoa fakataautaha and talanoa fakakulupu to suggest and seek confirmation so I, as a Pacific woman and researcher aligns the quality of the participants' views and knowledge being studied. I also ensure that value of fetokoni'aki (reciprocity) was honoured to

minimize negative impact of my standing in the authenticity of the information being co-constructed.

Bishop (1996) and Vaioleti (2006, 2011) discuss the importance of koha (gifting) in indigenous research approaches. From these cultural perspectives, the koha by the kau ngā fa'u are their time, their knowledge and the disruption to their normal school work. In return, their koha will be utilised in a meaningful way which will hopefully benefit them in the future, my koha for the people of Tonga.

The koha offer to the kaungā fa'u (research participants) were both personal and professional. I offered and carried out professional development for teachers of the schools. I also designed and delivered lessons on climate change, interventions that contained new knowledge and pedagogies that involved field studies and community presentations. This was a welcomed and highly enjoyable experiential learning for the teachers as well as the students. A gift that was not obvious at the beginning was bringing talanoa methodology, a culturally relevant approach, one that used their language, their cultural and intellectual frameworks, one that "…always keeps at the forefront a respect for culture and meaning…" (Suaalii-Sauni & Fulu-Aiolupotea, 2014, p. 336) which brings the state of mālie regularly to them during the research engagements.

One of the benefits of talanoa is that it gives an opportunity for the participants to tell and share their stories in detail (Vaioleti, 2006) and provide the necessary context they feel appropriate (Prescott, 2008). Talanoa does not necessarily have a preconceived agenda, it is open and participants are free to tell their stories (Halapua, 2000, 2005b). It is a two way process – the researcher as a kaungā fa'u, must be prepared to share their own experiences and stories as part of the talanoa 'philosophy of openness, sharing and mutual respect' (Prescott, 2008, p. 139). These elements of talanoa benefitted my participants because it gave them the time and the space to tell their stories, things that were important to them, things that made them happy or sad. Instead of considering some of their information irrelevant, I'd say that those were the things that matter to them, that's how they create their stories. Halapua (2005b, p. 9) believes that "If you give people the opportunity, and they know you respect their voice, they will tell you their stories; that is a universal human phenomenon".

3.4 Research methods

Like phenomenology, Talanoa seeks to understand phenomena from within. The researcher's commitment to representing the perspectives of participants is at the core of understanding the phenomena. Within talanoa, there are several methods for data collection such as; talatalanoa (preparatory exchanges), talanoa faikava (focus groups), talanoa faka'eke'eke (interviewing), tālanga (interactive dialogue) (Vaioleti, 2011, 2013). For talanoa it is appropriate to hold both structured and unstructured conversations, both individually and within focus groups.

Methods are strategies used by researchers to collect and analyse data. This section presents the key methods employed for data collection in this research. Vaioleti (2016) contends that talanoa methods are "about the way talanoa is used as a tool, technique, or process to secure or co-construct knowledge" (Vaioleti, 2016, p. 5). However, since this study involved young people in Tonga, and from a Tongan cultural point of view, I believed not every student would be confident enough to participate in the talanoa. Therefore, a questionnaire was also used as a method of data collection in this study. A questionnaire was also considered an appropriate method since it has the potential to gather views from a large number of participants, which would be hard using talanoa. These methods are discussed next.

3.4.1 Talatalanoa and tālanga methods

There are two methods of talanoa that were employed in this research namely talatalanoa and tālanga. The details and application of these two methods in this research are discussed next.

3.4.1.1 Talatalanoa

In Tongan, talatala can mean consultative (Vaioleti, 2016) or can be described as talking to inform people about something (Manu'atu, 2000b) and noa means in this context flexible, or talking without the influence of predetermined agenda (Halapua, 2005b; Vaioleti, 2006). Therefore, talatalanoa can be defined as a consultative talk with a view to uncover something (Vaioleti, 2016). Talatalanoa involves speaking and listening. While a participant or the researcher is doing the talatala (talk), the other participant/s are expected to be silent (noa), listening attentively. As trust is vital for a good talanoa, talatalanoa is crucial to building trust, harmonious relationship, and respect, among

participants. Paea (2015) translates talatalanoa as a process of "maintaining warm relationships based on the good spirit of freely committing to one another's needs' (p. 56), through talanoa. Talatalanoa is normally carried out with positive spirit (Vaioleti, 2016).

3.4.1.2 Tālanga

Tālanga is a type of talanoa that involves a friendly discussion (Churchward, 1959). It is a "dialogical process that involves both the acts of speaking and listening, and they must always go together" (Vaka'uta, 2009, p. 129). Tālanga is interactive and purposeful (Ofanoa et al, 2015), it is an open-ended conversation which navigates numerous perspectives, options, solutions and/or meaning (Vaka'uta 2008). Tālanga in this study is therefore referred to as an interactive dialogue which involves discussions, exploring meanings, views and perspectives, options, and solutions about/for the issue researched.

3.4.1.3 Talanoa groups

Two talanoa groups were involved in the data collection: a talanoa fakataautaha (one-on-one talanoa) and a talanoa fakatokolahi (group talanoa). A talanoa fakataautaha refers to a talanoa that took place between the researcher and only one participant, and a talanoa fakatokolahi consisted of three or more participants.

Talanoa fakataautaha is similar to semi-structured interviews in a sense that it is flexible, and it gives the researcher or the participant the ability to explore the research subject in as much depth and from as many different viewpoints as necessary (Halapua, 2005b; Longhurst, 2009; Vaioleti, 2016). Interviews are one of the accepted modes of collecting data to gather information from participants (Matthews & Ross, 2010). However, the cultural values that underpin the talanoa fakataautaha including faka'apa'apa (respect), tauhi vaha'a (maintain good relationship), ofa (love), and lototō (humility) give talanoa an essence which interviews may not demand. These values are fundamental because they can yield a robust outcome in the one-on-one talanoa. Semi-structured interviews aim to collect data on people's experiences, behaviour, and understanding and why they perceive the world the way they do, however, a talanoa fakataautaha involves learning to live, tell, relive, and retell stories which are not owned but shared and co-constructed through relationship and conversation (Vaioleti, 2016). While semi-structured interviews are directed by an interview schedule by the researcher, and follow certain criteria but allow for flexible questioning (Dunn, 2005), talanoa fakataautaha is flexible, it provides opportunities to probe, challenge, clarify and re-align. "It should create and disseminate

robust, valid and up-to-a-minute knowledge because the shared outcome of what talanoa has integrated and synthesised will be contextual, not likely to have been already written or subjected to academic sanitisation (Vaioleti, 2006, p. 26).

The flexible nature of semi-structured interviews aligns with the aspects of talanoa. Vaioleti (2006) proposes that talanoa is flexible, it provides opportunities to probe, challenge, clarify and re-align. Talanoa has been used in education research (Manu'atu, 2000b; Otsuka, 2006; Vaioleti, 2003). One of the benefits for conducting one-on-one talanoa in this research is that it gives an opportunity for the participant to tell their story in detail, providing the necessary context they feel appropriate (Prescott, 2008). A 'one-on-one talanoa' would also be beneficial for participants who may not wish to participate in a group talk or a group talanoa.

A talanoa fakatokolahi is similar to a focus group discussion. Focus groups have typically consisted of 6 to ten people who discuss a particular issue provided by a researcher. However, focus groups with four to six participants are becoming more common due to the participants being more comfortable in small groups (Krueger & Casey, 2000). A talanoa fakatokolahi may not only focus on the researcher's topic but the discussion can be extended by participants to explore associated matters. This interactive feature of a talanoa fakatokolahi exposes participants to a wider range of views which can be used for a rich co-construction of knowledge sharing to improve the robustness of the data being made available. This talanoa fakatokolahi approach has ontological synergy with group-oriented Tongans who are naturally engaged in talking out issues that are important to them. Vaioleti (2011, 2013) refers to talanoa faikava as a talanoa that resembles the mainstream focus group. Faikava is the cultural process of making and drinking of kava in which a group that has a common purpose gathers and within the group, talanoa occurs and it is moderated by one or two persons depending on the topic. Talanoa "allows people to engage in social conversation which may lead to critical discussions or knowledge creation that allows rich contextual and inter-related information to surface as co-constructed stories" (Vaioleti, 2006, p. 24).

3.4.1.4 Application of talatalanoa and tālanga

In my research, talatalanoa and tālanga were both employed during the one-on-one talanoa and group talanoa. However, the time of their application during the talanoa varied due to the nature of each method. Talatalanoa was always conducted at the

beginning of the talanoa so that I could lay foundation for tālanga at a later stage (Vaioleti, 2016). Since, talatalanoa is done calmly and with a positive spirit, using simple language (Vaioleti, 2016), it brought clarity leading to maintenance of respect and humility (Halapua, 2003) within.

At the beginning of the talatalanoa, I did a lea fakafe'iloaki (salutation to welcome and to acknowledge) and to show my appreciation for the kaungā fa'u willingness to participate in my research. Instead of going straight to discuss the researched issues, we started by talking about how they were doing in terms of work and also with family. For me, it was crucial to build trust, and respect, between myself and my kaungā fa'u in the entire research relationship. Talatalanoa then has a vital role in ensuring that harmonious relationships were maintained and all exchanges are open and came from the participants' hearts (Halapua, 2005b; Prescott, 2008).

Since climate change has become one of the most discussed issues in Tonga, the nuances of talatalanoa provided an opportunity for the students and teachers to inform freely of their knowledge and feelings about climate change. Talatalanoa allowed the participants to talk from their heart (Halapua, 2005b) and show their emotions about how climate change impacted their lives and their environment. The application of talatalanoa provided a platform for the kaungā fa'u to share information that was helpful to answering my research questions. Starting off the talanoa fakataautaha and talanoa fakatokolahi with talatalanoa helped me to lay a foundation for tālanga which is discussed next.

Tālanga is often reached when both parties involved start to participate in a more in-depth discussion to navigate and make meanings together, and co-construct ideas about the issues of climate change. In tālanga, the talanoa is more empowering, interactive, collaborative, participatory, encouraging and purposeful (Ofanoa, Percival, Huggard, & Buetow, 2015). For these reasons, teachers and students in Tonga could use tālanga to co-create understandings on the impacts and solutions to climate change on the people and the environment. The credibility of the data will be high as they will be co-constructed from participants' life stories in good spirits, and in an environment of mutual respect.

In my observation, it was during the tālanga that the participants started to discuss their views about the status of climate change in their curriculum and how climate change could be better integrated in the school curriculum. The interactive and dialogic nature of

tālanga lead the talanoa to a state of heightened engagements, a state similar to euphoria caused by clarity of meaning that Tongan people call mālie, which Manu'atu (2006b) alludes to as an energising energy that uplifts spirits to a positive state of connectedness and enlightenment.

Tālanga is underpinned by the four pillars of Tongan society: faka'apa'apa (respect), tauhi vaha'a (maintaining relationship), mamahi'ime'a (loyalty and commitment), and loto to (humility) (Ofanoa, 2010). These values make tālanga culturally appropriate for researching sociocultural, economic and environmental issues such as climate change especially if the findings and recommendations are going to be situationally and contextually credible for my Tongan participants and their community.

3.4.2 Surveys using questionnaires

Survey is a method used in researching a large population. As this study involved 60 students and 10 teachers, survey was considered appropriate and used at the early stage to inform further stages of this study. The questionnaire used in surveys is a method in which data is gathered at a particular point in time to describe the nature of existing conditions. Principally, a questionnaire is employed to scan a wide field of issues, populations, and programmes to measure any generalized features (Cohen et al., 2011). Some of the advantages of using surveys are: they can be used to investigate different issues and collect information on people's demographic background, attitudes, values, beliefs, perceptions and opinions. Since this study involves exploring students' and teachers' perceptions of climate change in Tonga, survey is a potential method to be employed in this study.

Questionnaires are written in many different ways for many different situations and with many different data-gathering media. The role of the questionnaire is to elicit the information that is required to enable the researcher to answer the objectives of the survey. To do this, the questionnaire must not only collect the data required but collect the data in the most accurate way possible. Collecting accurate data means getting the most accurate responses, so a key objective in writing the questionnaire is to help the respondents to provide them (Brace, 2008).

The structures of surveys is similar to what Vaioleti (2011, 2013) called talanoa faka'eke'eke. Talanoa faka'eke'eke is a method used to bring to the fore a collective

view or a condition. Results of talanoa faka'eke'eke can be used to confirm/disprove hunches from a group of people. Talanoa faka'eke'eke can be carried out through face to face exchanges, by phone, other technologies or by other means of communications. The survey approach I used provided me with a macro view of the kaungā fa'u general understanding of climate change and where I may have to use other methods to develop further understand information shared in the survey. The questionnaires findings also provided additional information that were used for triangulation of other findings from the talanoa fakataautaha and talanoa fakatokolahi.

3.4.3 Document analysis

Document analysis refers to a systematic procedure for reviewing or evaluating documents (Bowen, 2009). A document can be defined as a record of an event or process that may be produced by individuals or groups and can take many forms (McCulloch, 2011). They can be personal or private documents such as letters, diaries, blogs, photographs, and autobiographies (Plummer, 2001). They can also be public and official documents including reports, memoranda, and committee minutes (Scott, 1990). These documents can be either primary documents or secondary documents (McCulloch, 2011). Primary documents are produced as a direct record of an event or process by a "witness or subject involved in it" and secondary documents are formed through an analysis of primary documents to provide an account of the event or process in question, often in relation to others (McCulloch, 2011, p. 249). For my research, I analysed some of the government documents that I found relevant to this research and would help in addressing the research questions. These documents included the secondary school curriculum, education policy, Class 10 Science syllabus, Class 10 Geography syllabus, Climate change policy document, and Join Action National Plan (JNAP) 1 and JNAP 2. These documents were analysed in order to find out the place of climate change in the school curriculum, and how it is addressed in the syllabus. Document analysis was used in this research in order to provide supplementary research data (Fereday & Muir-Cochrane, 2006). Information and insights obtained from documents can be influential additions to a knowledge base (Bowen, 2009). Documents can be analysed as a way to verify findings or corroborate evidence from other sources (Bowen, 2009) such as talanoa fakataautaha and talanoa fakatokolahi. Data derived from document analysis were analysed using thematic analysis. Thematic analysis is a form of pattern recognition within the data, with emerging themes becoming the categories for analysis (Fereday & Muir-Cochrane, 2006).

Thematic analysis was preferred because it involved a careful, focused re-reading and review of the data (Bowen, 2009).

3.4.5 Observation

Observation is a method of data collection in which the researcher takes field notes on the events, interactions, behaviour and activities of individuals at the research setting (Creswell, 2003). The researcher can engage in one of the following roles when conducting observations:

- Complete participant – researcher conceals their role and is a member of the group
- Observer as participant – role of researcher is known and is also a participant in the activities of the group
- Participant as observer – observation role secondary to participant role
- Complete observer – researcher observes without participating and is not noticed by the group.

(Cohen et al., 2011; Creswell, 2003)

In this research, I took the role of observer as participant as I was known to the students and the teacher. One of the benefits of using observer as participant is that it "demands first hand involvement in the social world chosen for study – the researcher is both a participant (to varying degrees) and an observer (also to varying degrees)" (Marshall, 2011). Being present in the setting allows the researcher to hear, see, and begin to experience reality as the participants do (Marshall, 2011). The observations were conducted in a semi-structured way, in which some prior questions that I was interested in the research site were used (Creswell, 2003). Details about the observations are presented in Section 3.5.4.1.

While I used the observation as a heading for this part of the study for clarity, in reality, a more contextual and situational method, I used was vakavakai'i, which shares similar qualities with observation. Vakavakai'i implies full attention paid to tauhi vā (maintenance of relational space) and competent use of protocols shared by Vaioleti (2006, 2011) which may allow engagement, without undue interference in an unfolding phenomena, being observed.

The five methods that have been presented in this section were used for the data collection in this research. The next section discusses the use of mixed methods and why it was considered as the appropriate approach in this research.

3.4.6 The use of mixed methods

Mixed methods refers to a combination of qualitative and quantitative data collection providing real answers to real questions (Cohen et al., 2011; Creswell, 2014). In this research, the idea of mixed method can be taken to another extent as in mixing culturally appropriate methods such as talanoa fakataautaha and talanoa fakakulupu with methods such as questionnaire. This mixed method would enable me to "better understand the complexity of the social phenomena being studied" (Greene, 2007, p. 20). This approach allowed the data to be collected and triangulated, which may result in a better understanding of the meaning and implications of the findings and a given context (Gogolin & Swartz, 1992). Gathering both quantitative and qualitative data can form a more complete picture of the issues rather than when either quantitative or qualitative data alone is used (Creswell & Plano Clark, 2007). Triangulating data could elevate the validity of the research (Cohen et al., 2011; Guba, 1989) or trustworthiness (Somekh & Lewin, 2004).

Furthermore, recognizing that all methods have limitations, researchers feel that biases inherent in any single method could neutralize or cancel the biases of other methods. From the original concept of triangulation emerged additional reasons for mixing different types of data from different methods. For example, the results from one method can help develop or inform the other method (Greene, Caracelli, & Graham, 1989). Alternatively, one method can be nested within another method to provide insight into different levels or units of analysis (Tashakkori & Teddlie, 1998).

3.4.7 Advantages of using mixed methods in this research

I planned to first survey 60 individuals (students), then follow up with a smaller number of them to obtain more detail and specifics of their perspectives and voices about climate change. In these situations, the collection of both closed-ended and open-ended qualitative data can prove advantageous to best understand the research issues (Creswell, 2003). Mixed methods design is useful to capture the best of both quantitative and qualitative approaches. For example, a researcher may want to both generalize the findings to a population, and develop a detailed view of the meaning of a phenomenon or

concept for individuals. Although mixed methods discourse can be a challenge to the broader qualitative interpretative community (Denzin, 2010), it is the preferred method due to the Tongan context I was researching.

To fully explore the perceptions of climate change by students and teachers, and the status of climate change-related issues in the secondary school curriculum in Tonga, it was necessary to use multiple methods. Researching with kaungā fa'u that are part of a complex social and cultural structure requires methods that respects the anga faka-Tonga (Tongan traditional customs and styles, rules of local etiquette). These will be different to methods used for analysing official documents such as the curriculum document from the MET. It is the skilful sum of those methods that should capture a more complete information that will help answer the research questions.

3.5 Research design

A research design plays a crucial part in connecting a methodology and an appropriate set of research methods to address the research questions. A research design situates researchers in the empirical world and connects them to specific sites, people, groups, institutions, and bodies of relevant interpretive material, including documents and archives (Denzin & Lincoln, 2018). For these reasons, talanoa research methodology, its methods and protocols were used to guide this research.

This section presents the context of the research, recruitment of sampling population and stages of data collection.

3.5.1 Setting of the research

This research was conducted in two schools in Tonga, one was a Government school and the other one was a Mission school. These two schools are both located in one of the main islands in Tonga. These two schools were selected to represent participants of both main types of schools in Tonga, the government and mission schools.

This research also included participants from the Tonga Ministry of Education and Training (MET) and the Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC). These two Government offices are both located on Tongatapu, the main island of Tonga.

3.5.2 Data collection

Before data collection, an application for a research permit was sent to the Prime Minister's Office in Tonga. My application was approved on the 5th of September 2016 (See Appendix A). I contacted the Ministry of Education in Tonga to inform them of my application's approval and to notify them that I wished to recruit my participants from one Government school and one Mission school in one of the outer islands in Tonga. The MET then contacted directly the principal of the Government school and advised her of my research.

I was also advised to contact directly the head office of the Mission school. A letter was sent to the head office of the Department of Mission Schools to ask for permission to conduct my research on one of their mission schools. The Department of Mission Schools approved my request, then they informed the principal of the mission school on the island about my research. In turn, the two principals selected the students and teachers to take part in my research. Since this research involved students, consent forms were sent to the parents seek their approval too (See Appendix I). The students who were to be kaungā fa'u were also given a consent form to sign and were given the option to opt out if they wished.

This research was carried out in two main phases. The sample and data collection involved in each phase are presented next.

3.5.3 Phase 1 (April-May 2017)

In Phase 1, both qualitative and quantitative data were collected to provide answers to the research questions 1, 2 and 3 (see Table 2). Table 2 provides a summary of the sample and data collection in both Phases and in relation to the research questions.

Table 2 *Sample, data collection process, and research questions*

Phase 1		
Research questions	Participants	Research methods
1. What are the students' and teachers' perceptions of climate change in Tonga? 2. What is the existing status of climate change-related issues in the secondary school curriculum in Tonga? 3. How can a climate change education intervention be designed for Tongan secondary education?	• 18 students (12 Government school, 6 Mission school) • 10 teachers (6 government school, 4 mission school)	Talatalanoa and Tālanga (Talanoa fakakulupu)
	• 60 students (40 government school, 20 mission school) • 10 teachers (6 government school, 4 mission school)	Questionnaire
	• 2 school principals • 3 officials (2 from MET, 1 from MEIDECC)	Talatalanoa and Tālanga (Talanoa fakataautaha)
Phase 2		
Research question	Participants	Research methods
4. What are the learning outcomes for Tongan students and teachers about the issue of climate change in response to the education intervention?	• 38 students	Questionnaire
	• 8 students	Talatalanoa and Tālanga (Talanoa fakakulupu)
	• 1 teacher	Talatalanoa and Tālanga (Talanoa fakataautaha)

3.5.3.1. Quantitative data - Questionnaires

The quantitative research approach is for "testing objective theories by examining the relationship among variables" (Creswell, 2014, p. 4). It utilises research questions and hypotheses to shape and specifically focus on the purpose of the study (Creswell, 2003). The quantitative research is associated with social survey techniques like structured interviewing and self-administered questionnaires, experiments, structured observations, content analysis, and the analysis of official statistics and the like (Bryman, 1995). The quantitative researcher uses claims for developing knowledge, that is: cause and effect thinking; reduction to specific variables and hypothesis and questions; and use of measurement and observation, "employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data" (Creswell, 2003, p. 18). I employed some of these features to help gain a broad picture of student and teacher perceptions of climate change education in Tonga.

There were 60 Class 10 students involved in Phase One of data collection, in which 40 students were to be from the government school and 20 students from the mission school. These students were between the ages of 13 to 15 years. I explored the students' perceptions of climate change and their views about the place of climate change in their school curriculum through a questionnaire (See Appendix D). The use of an anonymous questionnaire allowed participants to provide responses that they might be reluctant to say in talanoa fakataautaha and talanoa fakatokolahi. The questions were mainly closed with only a few open-ended questions. The student participants in the survey were allocated a coding system SQ1 to SQ60 for analysing and reporting their responses to maintain their anonymity.

The students' questionnaire contained nine sections: section A was on background information, section B was about awareness and attitude items, section C to section F were knowledge items, section G consisted of intention to act items, and sections H and I presented items on the status of climate change in the school curriculum. The background sections asked for students' age, gender, whether they had taken a subject at school where climate change was discussed, whether they have attended any climate change awareness program, and whether they have volunteered to do any activity which they thought might tackle climate change. In section B, there were 11 questions aimed to explore both the students' awareness of and attitude about climate change. The awareness and attitude questions were in 5-point Likert scale items, using strongly disagree, disagree, unsure, agree, and strongly agree. In section C, 6 knowledge questions consisted of 1 open-ended question and 5 multiple-choice questions. Section D to Section F also consisted of 18 knowledge questions with 5-point Likert scale items. Section D consisted of 5 items on knowledge about causes of climate change, section E had 8 items on knowledge about the impacts of climate change, and section F consisted of 5 items on knowledge about the solutions for climate change. Section G consisted of 5 intention to act items. In section H, there were 11 items based on students' views about the place of climate change education which consisted of 5-point Likert scale items and seven items consisted of 3-point Likert scale items, using not important, moderately important, and very important. There was one open-ended item in section H which was considered as qualitative data.

The questionnaire was piloted with 12 Year 10 Pacific Island students in Hamilton, New Zealand to test the feasibility of the questionnaire, and also to identify whether the

questionnaire was comprehensible and appropriate for the age group. The Year 10 students in New Zealand are comparable to the Class 10 students in Tonga for age and focus of learning. I decided to pilot the questionnaire in New Zealand due to the availability of resources. On the 27th March, 2017, 12 students (6 boys and 6 girls) of Pacific descent participated in the pilot test. These students took part in the Power Up Program that was funded by the New Zealand Ministry of Education and involved academic mentoring for Pacific students in Hamilton. I took part in this program as an academic mentor and this program provided me with an opportunity to pilot my questionnaires.

The students took from 30-40 minutes to complete the questionnaire. A copy of the questionnaires before the pilot test is shown in Appendix D. After the pilot test, I had a conversation with the students and they were asked to give their feedback on the questionnaires. The students indicated that they understood the questionnaires well and they really enjoyed answering the questions. However, four students believed that the word 'Deforestation' in Section D, number 25 was hard for them to understand. The phrase was replaced with 'Cutting down trees'. Six students found Section E number 28 was hard as they did not understand the term 'extreme weather events'. The phrase was replaced with the more specific 'cyclones and droughts' (See Appendix E for the final questionnaire).

I was also be able to print the whole set of the questionnaires on paper in New Zealand before my trip to Tonga. The sample island in Tonga had limited access to the internet and printing, therefore, an opportunity to pilot the questionnaire in a school in Tonga was not possible. The contents of the questionnaire were reviewed by my supervisory team to ensure they met the requirements of the research questions.

I recruited ten teachers to be involved in the teacher questionnaire. Six were from the government school and four were from the mission school. The ten teachers reported that their highest qualifications were as follows: 7 teachers held Diploma of Education (a teaching qualification), 3 held ~~a~~ Bachelor's degrees, and 1 held a Master's degree. The teacher cohort consisted of 5 science teachers, 4 geography teachers, and 1 Economics teacher. The teachers' ages ranged from 25 to 52 years old. The ten teachers who participated in the questionnaire were coded TS1 to TS10 for data analysis and presentation to maintain the anonymity of the participants.

The teachers' questionnaire contained 10 sections (See Appendix F). Section A consisted of 6 background items. It asked for their age and gender, their social role in the community, their formal education qualification, whether they included climate change in their teaching, and whether they have volunteered to do any activity which might help to address climate change. Section B consisted of 10 items on awareness and attitude, and they were in 5-point Likert Scale (Strongly disagree, disagree, unsure, agree, and strongly disagree). There were 18 knowledge items in Section C to Section F. There was one open-ended question (which was considered as qualitative data) and 17 5-point Likert scale items. Section G consisted of 5-point Likert scale items intended to explore the teachers' intention to act. In section H, there were four items focused on the teachers' perceptions about the place of climate change in the school curriculum, and they were presented using a 5-point Likert scale. Seven items on the teacher's desire to learn about climate change were given in Section I, and a 3-point Likert scale (Not important, moderately important, and very important) was used in this section. Section J consisted of one item which was an open-ended question and it was grouped as qualitative data.

On the 10th April 2017, I conducted ~~a~~ meeting with the teachers from the Government school. At this meeting, we talked about the questionnaires and their preferences for administering them. All teachers agreed to take the questionnaire with them and to find a time to complete it and hand back to me on the following day. On the 11th of April, each teacher handed in their questionnaires to me. None of the teachers showed any concern or raise any issues about the questionnaires.

The following week, I conducted a similar meeting with the teachers from the Mission school on the 18th April 2017. Again, the process of administering the questionnaires was discussed. These teachers also agreed to take the questionnaire with them so they could answer it overnight. On the 19th of April, I collected all the questionnaires from the teacher participants. When asked if they had any issues when they completed the questionnaires, no one appeared to have faced any issues. No piloting of this questionnaire was possible due to time constraints and the necessity of using teachers in Tonga for that purpose. The questionnaire was peer reviewed by my supervisors, who included a Tongan person.

2.5.3.2 Qualitative data - Talatalanoa and Tālanga

Qualitative research involves close attention to the interpretive nature of inquiry and locating the study within the political, social and cultural context of the research (Creswell,

2013). Qualitative research is conducted to gain a complex, detailed understanding of issues. It can empower individuals to share their stories, hear their voices, and minimize the power relationships that often exist between a researcher and the participants of a study (Creswell, 2013). These features would help me gain a deeper picture of student and teacher perceptions of climate change education in Tonga in Phase 1.

To gain an in-depth understanding of the student's perceptions of climate change and its place in their school curriculum, some students were randomly selected from the same cohort as the questionnaire participants to participate in a talanoa fakatokolahi. The three talanoa fakatokolahi that involved students were coded SFG 1, SFG 2, and SFG 3 for data analysis and presentation. Two talanoa fakatokolahi were held with students from the government school. One group consisted of 6 boys (SFG 1) and the other consisted of six girls (SFG 2). There was only one talanoa fakatokolahi held with students from the mission school (SFG 3). There were six students involved in this talanoa fakatokolahi, three boys and three girls. Talanoa fakatokolahi appeared to be relevant to this study because it had a potential to gain the most authentic information from both teachers and the students' groups. They were more comfortable with their peers in a group exchange and co-construction (Marshall & Rossman, 2006). The talanoa fakatokolahi provided an approach and opportunity for students to clarify and expand upon their perceptions and opinions on climate change as given in the questionnaire.

The same teachers who participated in the questionnaire also took part in talanoa fakatokolahi, and these talanoa fakatokolahi were coded TFG 1 and TFG 2. Two talanoa fakatokolahi were held with teachers, one in each school. The talanoa fakatokolahi (TFG 1) with the government school teachers was held at their school staff room on the 13th April, 2017 and with the mission school teachers (TFG 2) at their staff room on the 20th April, 2017. Each talanoa fakatokolahi was conducted over an hour and a half. One talanoa fakatokolahi consisted of 6 teachers, and the other consisted of 4 teachers. A talanoa fakatokolahi was an effective way of allowing these teachers to mention some key ideas that they could not mention in the questionnaire. It also allowed these teachers to expand or talk more in-depth about the responses they stated on the questionnaire.

The principals of the two schools were also invited to take part in a talanoa fakataautaha. The two principals would help provide in-depth information about the place of climate change in the school curriculum. The duration of the each talanoa fakataautaha was fifty

minutes, and they were both conducted after school. The school principals were also seen as potential participants who could indicate whether the school has joined or implemented climate change-related programs or not.

To gather relevant information about the place of climate change in the school curriculum, two officials from the MET were involved in a talanoa fakataautaha. These two officials were curriculum writers from the Curriculum Development Unit. One of them was responsible for designing the science syllabus, and the other was involved in designing the geography syllabus. In Tonga, the same curriculum is distributed among all secondary schools, which includes both government and mission schools. An official from the MEIDECC also took part in a talanoa fakataautaha. Views from this participant were considered significant as contributing ideas about the place of climate change in the school curriculum. This participant could provide data on the place of climate change education in their climate change policy or their action plans. These interviews could also help to indicate whether the MET and MEIDECC had any plans to consider or reconsider the place of climate change in the school curriculum. Cultural and other protocols such as faka'apa'apa and poto he anga (Vaioleti, 2006, 2011), such as introduction to these senior members of the community through senior members of my own family or supporters, were used to assist in making appointments with them. The talanoa fakataautaha were conducted between 40-50 minutes.

Moreover, the use of talatalanoa and tālanga to guide the talanoa fakataautaha and the talanoa fakatokolahi in this research potentially gave an opportunity for my participants to share their ideas openly. They were given time to talatalanoa about their work and their families, and that helped to create connections with me at a familial level. I also learned that creating a connection and good relationship with my participants through talatalanoa, could lead to a level that was not expected. For instance, the talatalanoa reached a level where these participants, including the student participants, were deeply emotional. This is a stage claimed by Manu'atu (2000b) as māfana, a euphoric state where one is overcome by a sense of pure spirit. In this stage, any information shared is usually not contaminated by any reservations. Halapua (2005b) alluded to this stage as a point that can allow the talanoa mei he loto (talk from one's heart) to flow freely.

This showed that using talatalanoanoa was effective and can be a phenomenologically authentic tool for co-construction of information in Tonga, and a trustworthy method to

collect authentic information about the participants' perceptions about climate change. These perceptions included their awareness, knowledge, and attitudes about the issue. Talanoa was also an effective method in this research because it explores issues regarding human relationships and for understanding the differing views and perceptions that exist among those interactions as experienced by Tongans (Halapua, 2003; Manu'atu, 2000b; Otunuku, 2011; Prescott, 2008; Vaioleti, 2006).

In the application of talanoa fakataautaha and talanoa fakatokolahi I started with a prayer; as in Tonga, saying a prayer before anything could happen is a norm. That was also a way of creating a warm environment for every participants to feel welcomed and connected. It was followed by a fakatapu or salutation, which is a Tongan way of acknowledging the land that we were present on, and also to acknowledge the presence of the participants. Fakatapu is an important part of the talanoa because that is when I paid my respect to the land and to the teachers who were willing to take part in the research. Prescott (2008) agrees that this part of the talanoa "establishes who is present as a mark of respect" (p. 139). Then a talanoa fakafe'iloaki was conducted, and this was when I welcomed the participants in the Tongan language.

It is during the talanoa fakafe'iloaki where I should start to build a close relationship with the participants. Talanoa at this time can act like an ice breaker, it removes the distance between the researcher and participants and provides the participants 'a human face that they can relate to' (Vaioleti, 2006, p. 25). Maintaining a mutual respect and a good relationship between myself and the participants were crucial (Morrison et al., 2002; Prescott & Fua, 2016; Vaioleti, 2006), therefore, talanoa would be the appropriate method to use. I started by asking how they were doing both at work and with family at home. When I realised that everyone was at ease and looked confident, then I started to ask the research-related questions. It was also very important that everyone who participated in the talanoa fakatokolahi would be given a chance to speak and the others to listen. The talanoa was conducted both in English and in Tongan. Some participants felt more confident in conversing in Tongan so I informed them to express their ideas in any language of their preference.

2.5.3.3 Documentary data

To obtain some triangulation to perceptions about the status of climate change in the school curriculum, access to relevant, official documents from the Tonga Ministry of

Education and Training was requested. These documents included the Tongan school curriculum, education policy, climate change policy, Class 10 science syllabus, and Class 10 geography syllabus. Documents from MEIDECC such as climate change policy, Joint National Action Plan 1 and Joint National Action Plan 2 were also analysed to come upon data that may be relevant to climate change education. These documents are significant to the data collection because governments, as well as organizations, produce documents in order to examine defined problems and to propose solutions (McCulloch, 2011).

The data obtained in Phase 1 were analysed and the findings are presented in Chapter 4. These findings were used to design a climate change education intervention. One of the two schools in Phase 1 was asked by the researcher to be involved in a climate change education intervention that was implemented in Phase 2. A detailed description of the intervention including its design and the implementation of the intervention are presented in Chapter 5 and Chapter 6. The Phase 2 research design of this study refers to the stage where the students and the teacher who took part in the intervention were involved in a questionnaire, a talanoa fakataautaha and group talanoa fakatokolahi conducted to explore their views about the effectiveness of the climate change educational intervention. During the intervention, I also kept daily observation records and a journal entry to help to record the students' and the teacher's reactions and their potential views about the intervention. The details of the sample and data collection in Phase 2 are outlined in the next sub-section.

3.5.4 Phase 2 (September-October 2017)

The climate change education intervention involved delivering a climate change teaching unit that was co-constructed by myself and the teacher who agreed to implement the teaching unit in Phase 2. The data collection in Phase 2 provided answers for the 4th research question which is – What are the learning outcomes for Tongan students and teachers about the issue of climate change in response to the education intervention? A detailed description of the participants, the setting, and the design and implementation of the climate change educational intervention are presented in Chapter 5 and Chapter 6. This sub-section describes the data collection that took place in Phase 2.

The intervention was conducted in the government school and with the same student cohort that participated in the data collection in Phase 1. The participants in the Phase 2 data collection included thirty-eight Class 10 students and one science teacher. Before the

start of the intervention, a consent letter was given to both parents and students to indicate their willingness for their child to participate in the study, and for the students to show their agreement to take part in the study. One science teacher from the teacher cohort in Phase 1 was keen to deliver the climate change education intervention. This teacher was given a pseudonym Lavinia to maintain her anonymity.

3.5.4.1 Observation records

The teaching part of the intervention commenced on the 26th September 2017 and ran until the 9th October 2017. After the 9th of October, students worked in their various groups on the 10th and 11th of October to prepare for the climate change expo that was planned to be conducted on the 12th October 2017. During this period of time, 26th September to 12th October 2017, I took the role of an observer as participant in order to have a first experience with the students and Lavinia, and be able to record observations during the teaching and learning process. It was important that I prepared an observation protocol for recording this observational data. While I engaged in observations during the teaching and learning process, I used the observation protocol for recording information (See Appendix L). An observation protocol helps in providing a useful way of organizing an observation (Creswell & Clark, 2011).

While Lavinia and the students were involved in teaching and learning process, I sat at the back of the classroom and responded to the requirements of my observation protocol. I also had a chance to take some photos of the students' work which were later used in my findings chapter. After every class, Lavinia and I conducted a talanoa so Lavinia could share her experience during her teaching in that particular class, and I also had a chance to share with her any relevant observations that I had made during my observation. Having talanoa and vakavakai'i (observation) concurrently utilised during the teaching and learning process helped to provide feedback and feedforward for Lavinia, so she could understand how the teaching went and it may also help her to ameliorate her knowledge and experience in teaching climate change. Playing a role of an observer as participant allowed me to hear and see what was going on in the classroom, and how the students were involved in the group activities. I had an opportunity to spend a considerable amount of time in the classroom and learn about daily life there (Marshall & Rossman, 2016).

During the climate change expo, I also conducted an observation to grasp the efficacy of the climate change educational intervention on the students. Students worked in their various groups, and observation helped me to see how students shared their knowledge with the audience. In this observation, I was able to record the impact of this expo on all the students and teachers who attended the expo. In addition, observation also allowed me to realise the impacts this expo on the members of the community such as parents.

Out of 40 students who attended the climate change education intervention, only 38 students participated in the post-intervention questionnaire as 2 students were absent on the day. These students constituted the two Class 10 classes at the school. Out of 38 students who participated in the questionnaire, 27 were girls and 11 were boys and they were all between the ages of 14-15 years old. Eight students (5 girls and 3 boys) were randomly selected from both classes so they could participate in talanoa fakatokolahi after the intervention. This talanoa fakatokolahi was conducted to obtain a more in-depth talatalanoa about the students' perspectives of the intervention. A talanoa fakataautaha was conducted with the teacher, Lavinia, to collect an insight into what she thought about the intervention. Talatalanoa was employed so that Lavinia could talk from her heart about her experiences during the Professional Development and during the teaching process.

3.6 Data Analysis

Data analysis is a crucial part of any research. "It involves preparing the data for analysis, conducting different analyses, moving deeper and deeper into understanding the data, representing the data, and making an interpretation of the larger meaning of the data" (Creswell, 2003, p. 190). The data collected must be triangulated and analysed in an unbiased and thorough manner which also contributes to ensuring the results and findings are valid and reliable or trustworthy (Cohen et al., 2011). Hence, it is paramount that the researcher decides on an appropriate method to analyse the data. As mentioned in Section 3.4.6, a mixed-method approach was used in this research to collect qualitative and quantitative data. After collecting both qualitative and quantitative data concurrently, I analysed the data separately and then merged them together in my data interpretation.

3.6.1 Qualitative data analysis

Qualitative data analysis involves organising, accounting for, and explaining the data provided by the participants (Cohen et al., 2011; Creswell, 2009). In this research,

thematic analysis was used to analyse the qualitative data that were obtained from the talanoa fakataautaha and talanoa fakatokolahi, document analysis, observation data, and the open-ended questions in the questionnaire. Thematic analysis refers to a strategy for identifying, analysing and reporting themes within data (Braun & Clarke, 2006). "Thematic analysis can examine how events, realities, meanings and experiences are the effects of a range of discourses operating within society" (Braun & Clarke, 2006, p. 81). Talanoa fakataautaha and talanoa fakatokolahi were mostly carried out in Tongan language, and where necessary the transcripts of the audio-recorded talanoa fakataautaha and talanoa fakatokolahi were translated by me, based on the context during the transcribing process. Although I am a Tongan native speaker, I sought cultural advice about my translations to ensure their accuracy.

The qualitative data were transcribed into a written form to conduct a thematic analysis. Some researchers argue that the transcribing process should be the 'key phase of data analysis within interpretive qualitative methodology' (Bird, 2005, p. 227) and considered as an interpretive act, where meanings are created rather than the mechanical act of putting spoken sounds on paper (Lapadat & Lindsay, 1999). During the transcribing stage, I started to develop a thorough understanding of my data. The close attention that I needed to transcribe my data helped to bring about the close reading and interpretive skills needed to analyse data (Lapadat & Lindsay, 1999). I familiarised myself with the data and I also compared the transcripts to the original audio recordings to ensure I transcribed accurately. To maintain accuracy, I contacted each participant who took part in the talanoa fakataautaha via email, and sent them a copy of their talanoa transcript. Only two of these participants informed me of their agreement with their transcript. The internet connection could be a factor that hindered their ability to receive or to respond back to my email.

Having read and familiarised myself with the data, coding was then used to identify features of the data that appeared relevant to the research questions. Coding is an important process (Huberman & Miles, 1994) because that was when I started to allocate my data into meaningful groups (Tuckett, 2005). Coding was performed through a software program called NVivo. Kelle (1995) suggests that computers are particularly effective at coping with the often-encountered problem of data overload and retrieval within qualitative research. Computers assist the researcher to use codes, memos, hypertext systems, and co-occurring codes. NVivo, as highlighted by Gibbs (2007), has various features such as the ability to import, work with and display rich texts; the ability

to code text into key codes (nodes) and to arrange codes and nodes into hierarchies and clusters; the ability to work with original documents using codes or to combine selected extracts from documents using codes and the ability to sort material using codes.

When data were coded, they were grouped into potential themes. Inductive analysis was conducted not only to gain a holistic understanding of what was said (Gale, Heath, Cameron, Rashid, & Redwood, 2013) but also to ensure that all key aspects of the data are captured (Charmaz, 2006; Gale et al., 2013). The research questions were also used as the lenses to identify the themes (Azungah, 2018). Deriving themes from the raw data using inductive approach averted the possibility of forcing a predetermined result (Bradley, Curry, & Devers, 2007; Braun & Clarke, 2006; Glaser, 1992). I used visual representations such as mind-maps to organise these themes and to start thinking about the relationship between themes. These themes were refined until I identified what aspect of the research questions that each theme captured. The findings of Phase 1 and Phase 2 are reported in Chapters Five, Six and Seven.

3.6.2 Quantitative data analysis

Quantitative data analysis is often associated with large-scale and statistical research, however, it can also serve smaller-scale investigations (Cohen et al., 2011). The quantitative data gained from the students' and teachers' questionnaire data in Phase 1 and students' questionnaire in Phase 2 of the research were analysed using descriptive statistics in Microsoft Excel. The main types of descriptive statistics are frequencies, measures of variability, measures of relationship, and measures of tendency (Gay, 2012). Frequencies were mainly used in this research to describe the numerical data.

Questionnaire data for items such as gender, age, social role in the community, highest formal education qualification, and all closed-ended questions were given scores. For instance, for closed-ended questions such as "Have you ever taken a subject at school where climate change issues were discussed?" a score of 1 was given for respondents who said yes and 2 for respondents who said no. Questionnaire items based on a 5-point rating scale corresponding to strongly disagree to strongly agree were coded as 1 = strongly disagree, 2 = disagree, 3 = unsure, 4 = agree, and 5 = strongly agree. Questionnaire items based on the 3-point rating scale corresponding to not important to very important were coded as 1 = not important, 2 = moderately important, and 3 = very important. The coded

and scored data were then compiled and manually entered into a spreadsheet in Microsoft Excel. Then the data were treated using descriptive statistics.

3.7 Trustworthiness: Issues of validity and reliability

Trustworthiness refers to when the research is valid, believable, trustworthy, transferable, dependable and authentic (Marshall & Rossman, 2006). Reliability refers to the dependability, consistency, and replicability of data over time, over instruments and over groups of respondents (Cohen et al., 2011; Creswell & Clark, 2011). Reliability in quantitative research concerns the research situation, for instance, the context of, or the conditions for a test, factors affecting the researcher or participants and the instruments for data collection themselves (Cohen et al., 2011). The data is considered as reliable if it is to be conducted with another, similar group of respondents in a similar context, then similar findings would be obtained (Cohen et al., 2011; Merriam, 2009). This measure can be applied to the closed question data in the questionnaire, and the reliability here was enhanced by standardising the conditions under which data were collected.

In qualitative research, ideas of dependability and confirmability are used instead of 'reliability' (Lincoln & Guba, 1985). The findings can be regarded as consistent with the data when the reader finds the data make sense and are consistent and dependable (Merriam, 2009). To enhance the dependability of findings in this research, data triangulation was employed. I triangulated different sources of information by examining evidence from the sources and using it to build a coherent justification of themes (Creswell, 2003). Triangulation was sought through the use of multiple sources of data collection, and member checking (Lincoln & Guba, 1985) was employed where possible in the data analysis to verify the accuracy of the data collected.

Using talatalanoa and tālanga methods in both talanoa fakataautaha and talanoa fakatokolahi yielded trustworthiness in the Tongan context. In talanoa, Pacific peoples, particularly Tongans, learn and share much during the talanoa, a form of cultural exchange underscored by mutual obligation and goodwill. A good exchange in talanoa can energise both the researcher and the participants' emotion and intellect elevating them to a higher level of enlightenment and spirituality as a stage called by Manu'atu (2000a, 2000b) māfana. This allows the exchange of knowledge to be in its purest form as they are exchanged with unreserved goodwill and with the best of intention. Vaioleti (2013)

argues that co-construction with Tongan kaungā fa'u (involved working together to co-construct) while at the stage of māfana should result in the most phenomenologically sound and trustworthy information.

Timoti Harris, a University award winner for teaching excellence, teacher educator and a former school principal claimed "that subtleties of talanoa are a window to the mind and hearts of Tongan… students and these subtleties are what makes it uniquely Pacific…" (in Vaioleti, 2011, p.150). It is important, however, that those using talanoa as a research methodology in a Tongan context are familiar with the culture and the deep spiritual assumptions of talanoa in maintaining the integrity of data and knowledge made possible and secured from talanoa. The usual way of honouring them is to preserve its integrity all in content, form and the spirit they were given in.

As a researcher who was brought up in the Tongan culture and spiritually, I am well versed in the subtleties of talanoa, in understanding the emotion, spirit and other ways in which holistic knowledge is shared by Tongan people in talanoa. I can capture the interconnectedness of utterances and cultural nuances that give their spoken words and data collected their total and contextual meanings. When talanoa is performed in its many forms, I am confident I undertook what Vaioleti (2003, 2006, 2011) terms laumalie (essence, spirit) of concepts, notions, emotions or expressions in the talanoa, making my observations and recording of the many talanoa with the participants trustworthy. Another quality of talanoa that elevated trustworthiness is that due to my sense of duty to make things better for Tonga and the expectation of me to carry out work that will make a positive difference to the young people of Tonga. Vaioleti (2006) comments that "The reciprocity embedded in Talanoa will raise the expectations that researchers and participants have of each other, promoting mutual accountability, which adds to the trustworthiness and quality of the research" (p. 26).

Validity is the ability of an instrument to measure what it is intended to measure (Cohen et al., 2011; Creswell & Clark, 2011), or whether the method investigates what it aims to investigate (Brinkmann & Kvale, 2018). Validity also refers to when the information collected is addressed with honesty, richness, scope, and depth (Cohen, Manion, & Morrison, 2000). The validity of quantitative data might be ensured through careful sampling, appropriate instrumentation and appropriate statistical treatments of the data (Cohen et al., 2011). To ensure validity in this study, a copy of the questionnaire was sent

to the experts in the field of my study. With their inputs, the questionnaire was modified to ensure validity. A pilot test was carried out with a group of Year 10 Pacific students in New Zealand before the data collection to enhance the validity of the questionnaire.

In qualitative research, there is more focus on validity to determine whether the accounts obtained by the researcher and the participants are accurate, can be trusted, and are credible (Lincoln & Guba, 1985). The use of triangulation can also help to improve the validity of a qualitative study (Merriam, 2009). Since the triangulation approach involves using multiple methods and multiple data to confirm findings, it allowed me an opportunity to compare the data I found from the talanoa fakataautaha and talanoa fakatokolahi, the observations and the document analysis.

3.8 Ethical considerations

Since this research involved collecting data from people and about people, then it was my responsibility to protect my research participants from harm, develop a sense of trust with them, promote the integrity of the research and protect against misconduct (Creswell, 2009). There are four main areas of ethical concerns in educational research with human subjects, and they are access to participants, informed consent, the right to privacy, and protection from harm (Cohen et al., 2011; Creswell, 2009). Approval from the University of Waikato's Human Research Ethics Committee to conduct this research project was obtained on 27th July 2016 (See Appendix A). An application for a research permit to conduct the research in Tonga was approved by the Government of Tonga on 5th September 2016 (See Appendix B). I was also informed verbally by the Prime Minister's Office in Tonga, that my application letter to do my research in Tonga will also be accompanied by a letter to inform the Prime Minister Office that I will also submit two copies of my thesis free of charge to the Government of Tonga. A copy of this letter is attached in Appendix C. Access to student and teacher participants was gained by permission from the Ministry of Education and Training, the head office of the Mission Schools, and the principals of the two schools.

I sought parents' consent (See Appendix I) before undertaking research with the student participants. Participants were informed that their participation was voluntary and if they participated, they had the right to refuse to answer any question. Participants who were keen to take part in the research were given an information letter that outlined their role

in the study and were asked to sign an informed consent form. The parents and caregivers of the students involved in the study were given a consent form to secure their child's participation in the research. Every participant, apart from those engaged only in the questionnaire, was offered a pseudonym to use if they wished, and their data are referred to only by that pseudonym.

The data collection procedure required the adult participants such as the school principals and the officials from MET and MEIDECC to allocate time for the talanoa fakataautaha and the teachers to allocate a time for the talanoa fakatokolahi. Student participants were also allowed whether to agree or disagree to participate in the talanoa fakatokolahi. Participants were assured of anonymity in the research and confidentiality of responses wherever possible. All statements made by the kaungā fa'u during the research were treated with confidentiality. Ethical processes also acknowledge talanoa values. As a Pacific researcher, I closely followed the Tongan protocols of doing research and applied the Tongan cultural values in order to create a respectful and culturally secure environment for the most mo'oni (purest, truest) information to be shared. Achieving this will enhance trustworthiness of the research.

During the talatalanoa and tālanga, research protocols such as: 'ofa (compassion); faka'apa'apa (respect); feveitokai'aki (reciprocity); tauhivaha'a (nurturing inter-personal relations); poto he anga (knowing what to do); and mateuteu (well prepared, culturally versed) were adopted and applied in order to ensure that the participants and their knowledge are respected culturally. These will create a sense of security and being respected in the minds and hearts of the participants leading them to the stage of māfana (Manu'atu, 2000a, 2000b) and in this stage they are likely to be generous with sharing of the deepest and most authentic information on the subject being studied (Fua et al., 2008; Vaioleti, 2006).

3.9 Summary

Talanoa, as a research methodology is specifically designed to conduct collaborative and reciprocal research with Pacific peoples (Vaioleti, 2006, 2011). As a methodology for studying human phenomena and understanding the human experience from a cultural perspective, it is based on Pacific epistemological and ontological perspectives. When

used for Pacific research, it seeks to reveal meaning from how Pacific participants experience their phenomena from their own worldview. Being a researcher competent in the culture of the participants, my approach in sharing of mutual history, culture, lived experience and language to co-construct meaning from their standpoints and experiences support my confidence in the mo'oni and trustworthy of my findings.

Talanoa methodology was considered a relevant methodology for this research because it was culturally relevant to the Tongan context. Talatalanoa and tālanga were the two methods of talanoa employed for co-construction and data collection in this research. The way they were applied were by talanoa fakataautaha and talanoa fakatokolahi. The situational and cultural application of the research protocols of faka'apa'apa (respect), anga fakatōkilalo (humility), fe'ofa'aki (love and compassion) and feveitokai'aki (care and generosity) described as paramount by Prescott & Fua (2016) and Vaioleti (2006, 2011) promoted the deep goodwill amongst myself, and the participants in the research relationship. The depth and quality of information co-constructed with and collected from the kaungā fa'u gave much meaning to their ideas and inspiration for their communities, climate change issues and their educational needs.

Since the data collection also involved quantitative data gathered through questionnaires, the benefits of using the mixed methods in this research were also discussed in this chapter. The detailed research design and the analysis of data were also addressed in this chapter. This chapter also considered the trustworthiness, validity, and reliability of the research instruments. The final part of this chapter addressed the ethical considerations of this study. Having discussed the talanoa research methodology, and methods of data collection in this research, the next chapter presents the findings of Phase 1 of data collection.

Chapter 4: Findings - Perceptions of climate change in Tonga

4.1 Introduction

This chapter presents the findings from Phase One which explored the perceptions of students and teachers about climate change education in Tonga. It has six sections and begins by discussing the demographic background of the participants. During the talanoa fakatokolahi, the participants were asked to explain their feelings about living in Ha'apai; their responses are discussed in the next section. This is followed by a discussion on the main themes that arose from the questionnaires, talanoa fakatokolahi and talanoa fakataautaha. These are awareness and sensitivity to the cause and impact of climate change; knowledge about causes, impacts of climate change and solutions; attitudes to the impacts of climate change; motivation to act; and students' and teachers' desire to learn about climate change.

4.2 Participant Background and Characteristics

The participants in Phase One of fieldwork consisted of 60 Class 10 students and ten secondary school teachers from two secondary schools located on the island of Ha'apai, Tonga.

The survey in April 2017 involved 60 students from the two schools; 25 (42%) were male, and 35 (58%) were female. The age group of the students ranged from 13 to 16 years of age as illustrated in Figure 3.

After the survey, three talanoa fakakulupu were conducted with students from this cohort. Two talanoa fakatokolahi were held with students from one of the schools, which had two Year 10 classes. One talanoa fakatokolahi consisted of six girls and the other consisted of six boys. These talanoa fakatokolahi took place on the same day as the questionnaire completion. The other school had only one Year 10 class, so only one talanoa fakatokolahi was conducted involving three girls and three boys.

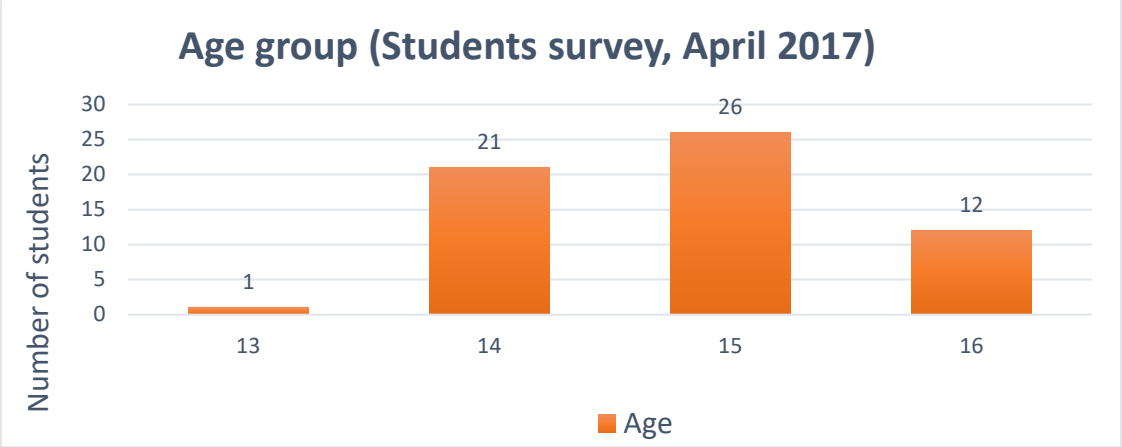


Figure 3 *Age groups of students who participated in the survey*

Ten teachers participated in both the survey and a talanoa fakatokolahi; 5 were male, and 5 were female. The ten teachers reported that their highest qualifications were as follows: 7 teachers held Diploma of Education (a teaching qualification), 3 held a Bachelor degree, and 1 held a Master's degree. From my own knowledge (up to date data is not readily available), it is typical for Tongan secondary schools to have more teachers holding Diploma than those holding university degrees. The teachers' cohort consisted of 5 science teachers, 4 geography teachers and 1 Economics teacher.

Two talanoa fakatokolahi were held with teachers, one in each school. One talanoa fakatokolahi consisted of 6 teachers and the other consisted of 4 teachers. The age group ranged from 25 to 52 years old and this is shown in Table 3. Although no recent data is available regarding all teachers in Tongan secondary education, this gender and age profile is expected to be fairly representative from my experience as a teacher in Tonga.

Table 3 *Age groups of teachers who participated in the survey*

Age	Total number of participants
25 – 29	3
30 – 34	1
35 – 39	2
40 – 44	1
45 – 49	2
50 – 54	1
Total	10

The student participants in the survey were allocated a coding system SS1 to SS60 to maintain anonymity of respondents in the data reported below. Likewise, the 10 teachers who participated in the survey were coded TS1 to TS10. The three students' talanoa fakatokolahi were coded SFG 1, SFG 2, and SFG 3 and the teachers' talanoa fakatokolahi were coded TFG 1 and TFG 2 and pseudonyms are used in reporting each participant's talanoa fakatokolahi data.

4.3 Participants' connection to place

Talatalanoa and tālanga were conducted to explore the participants' connection or their sense of place to Ha'apai island. In this study:

> Sense of place creates both a oneness or connection with the environment and with the people and local organisations who inhabit those places…It has to be built in the minds of the beholders and the dwellers in a particular place, and it has to be built over time (Carr, 2002, p. 28)

A Pacific island academic has previously stressed the relationship between the Pacific island people and nature, stating that "…we are part of Nature, …we are at one with Nature, … in Nature we find our roots" (Māhina, 1993, p. 113).

During the talanoa fakatokolahi, participants were asked to explain their feelings about living in Ha'apai in order to get a sense of how they connect to the place. There were four main points identified in regards to the participants' connection to Ha'apai. These were: sea as sustenance of life; recreation; family place; and serenity.

The sea as a source of sustenance was one of the main reasons why the participants connect to the island of Ha'apai. The participants believed that fishing is their primary source of food and essentially, their life is dependent on the sea. They also stated that fishing is the main source of income for most families in Ha'apai, and if the weather is rough, then the fishermen could not go out fishing and the family does not earn enough money. The participants manifested signs of appreciation for living in a place where they could catch seafood for the family, and some participants mentioned that they could also get free fish from neighbours and from friends. One teacher stated that he enjoyed living

in Ha'apai because there is plenty of seafood for the family to survive and he can also send some seafood to his parents who live in a different island. He said, "I like it here because there are heaps of seafood in Ha'apai, and my family in Vava'u always ask for seafood" (Samisoni, TFG1).

One student almost became emotional as he shared his stories about how people of Ha'apai have a lack of consideration about the significance of the sea to some families on the island. He said, "…what I don't like is that my family earns our living from the sea but there are too many people throwing rubbish into the sea and it saddens me" (Aisea, SFG1). When asking this student what he normally did when he saw people throwing rubbish into the sea, he said that he picked up the rubbish and his father helped him by taking the rubbish in the van to the landfill. This indicates the strength of care a family that is dependent on the sea has for looking after their place.

Recreation was also another popular reason why both teachers and students enjoy living in Ha'apai. A teacher who was born and raised in Ha'apai described her love for swimming, and how she is connected to the beaches. She expressed that, "I grew up in Ha'apai, and I like to live here…I like going to the beach, Ha'apai has got the most beautiful beaches in Tonga" (Salome, TFG1)

Student participants believed that living in Ha'apai is also special to them because they live close to the sea, so they can go swimming whenever they want to. They believed that living close to the sea is an opportunity for them to interact with the place, not only that they enjoy the beautiful beaches but they also enjoy swimming in the sea.

According to the participants, Ha'apai is a family place. Both teachers and students mentioned that living in Ha'apai had cultivated their connection to people. Some participants believed that the people's way of life is a bit conservative and laidback compared to other islands in Tonga and in that way, they feel able to connect to each other. One teacher described his connection to people as follows, "…I like hanging around with the people, they are a bit more conservative, and they have good attitudes" (Sekope, TFG2).

Most of the students who participated in the talanoa fakatokolahi noted that they were born and raised in Ha'apai, and they said that they are connected to Ha'apai because their

parents are with them and they are surrounded by family and friends. They said that they enjoy living in Ha'apai because they could hang out with the people they are really close to. One student explained how she is close to her cousins because she lives close to their houses and they can play every day. Another student indicated her disappointment with the fact that she would have to leave Ha'apai after secondary school to attend tertiary education in the main island of Tongatapu or in overseas institutions. She stated:

> I love this place because I was born and raised here in Ha'apai, and I am familiar with the lifestyle of this island, we got families here. What I don't like is that there's not enough higher level of education here, so when we finish from secondary school, we have to go to Tongatapu to attend higher institutions (Saunia, SFG 2)

Teacher participants claimed that Ha'apai island is a place of serenity. They stated that the peaceful ambience of the island made everyone feel safe and relaxed. Eight out of the ten teacher participants were living in Ha'apai for work, and they regarded Ha'apai as a safe place for raising children, because there are not many venues for potentially troublesome social gatherings. One teacher said, "It's peaceful in Ha'apai, and there is not much obligations. I would prefer a peaceful place like Ha'apai for my kids to live, there's no distractions from night clubs and such places…" (Siua, TFG 1)

One student who almost became very emotional stated that Ha'apai island does not have luxury materials like the main island of Tongatapu, and Ha'apai does not have factories to provide jobs for the people, but they still enjoy the peaceful life of living in Ha'apai. She said, "Although we are poor, we enjoy our simple and peaceful lives in Ha'apai" (Nau, SFG 1).

4.4. Awareness of climate change

This section presents data on teachers' and students' awareness of climate change. In this research, awareness refers to the attention, concern (mindful or heedful) and sensitivity of the participants (McHenry, 1992; Soukhanov, 1992) to climate change issues. The findings are drawn from the questionnaires and the talanoa fakatokolahi. In the questionnaire, the Likert Scale was employed and participants were asked whether they strongly agreed, agreed, were unsure, disagreed or strongly disagreed with each item. The talanoa fakatokolahi were conducted using the talatalanoa and tālanga.

4.4.1 Students' awareness of climate change

In the student questionnaire, two items were designed to identify students' awareness of climate change. The first item aimed to explore students' awareness of whether climate change is happening or not. They were given the statement, *I believe climate change is happening*. The results shown in Figure 4 indicate a very high level of agreement among the students. Ninety nine percent (99%) agreed that climate change is happening (67% strongly agreed and 32% agreed), and only 1% was unsure about the statement. The distribution of the data is illustrated in Figure 4.

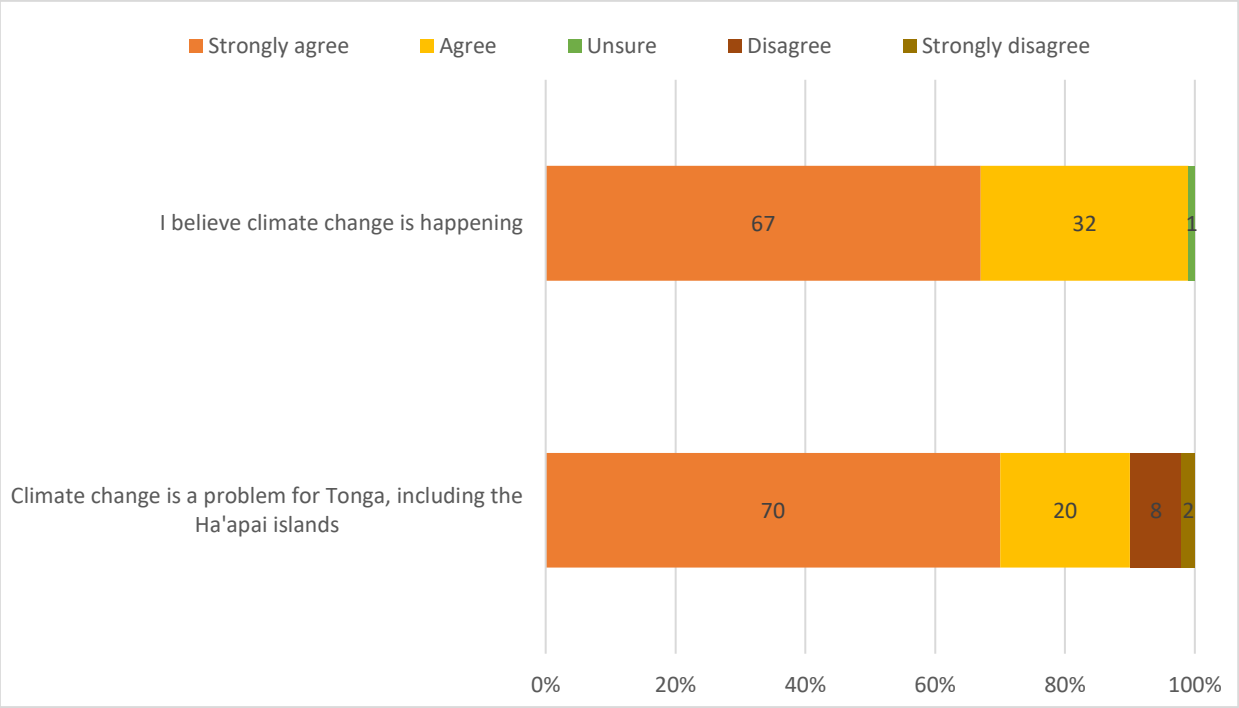


Figure 4 *Percentage and distribution of students' responses about awareness of climate change.*

To gain a better understanding of students' awareness about whether climate change is a problem for Tonga, they were given the statement, *Climate change is a problem for Tonga including the Ha'apai islands*. Similarly, a large majority of the participants (90%) either strongly agreed or agreed that climate change is a problem for Tonga including the Ha'apai islands, 7% were unsure, and 3% were either disagreed or strongly disagreed.

In order to get more insight into students' awareness of climate change, they were asked in the talanoa fakatokolahi, *Do you believe climate change is happening*? All of the students who participated in the talanoa fakatokolahi indicated their belief that climate change is happening in Tonga, and also in Ha'apai. When asked to give reasons for their answer, they said that the impacts were evident in several manifestations, particularly in terms of their everyday experiences and observations. The impacts of sea level rise was recognised by students as the most obvious sign of climate change in Ha'apai. One student who has been living with her family in the main town of Pangai, Ha'apai, shared her experience of the reality of climate change:

> When I grew up, there was a foreshore in front of the coastal area in Pangai, and I used to go swimming there. Today the foreshore is no longer there, and numbers of coastal plants have decreased as well, I think it is because of climate change (Akosita, SFG 3).

Students attributed the impacts of drought on the crops and their experience of it to their awareness about climate change issues. One student mentioned:

> Yes, when there's a long period of drought, the crops are not growing well. Crops can't survive because there is not enough water, the products are very poor quality. Climate change causes drought, therefore, there is not enough rain (Lupe, SFG 2).

The students also had a focus on their experience of Cyclone Ian which struck the island of Ha'apai in 2014. They believed that Cyclone Ian happened as a result of climate change. This awareness of climate change was built through experience, which was also reported by one student as a very sad experience. He said:

> When Ian struck, no one was prepared for it. *Ne mole 'emau 'amanaki* (All hope was gone). My neighbour's house was completely destroyed, and the whole family just stood there, so we helped taking them to another house (Nau, SFG 2)

When asked where they had heard about climate change, a majority of students said they heard about it from visitors to their primary schools. Four students said they heard about climate change from their science teachers, however, others also reported that at High

school, they do not hear much about climate change. Data from the talanoa fakatokolahi indicated that students' conversations with their parents at their homes also elevated their level of awareness about climate change. Some students mentioned that their parents are sharing their stories about their experiences of climate change. For example, one participant talked about his father's experience of sea level rise. He said, "My parents worked as church ministers in Mo'unga'one island and my father said in the past, the sea water was a bit distant from the land. Today, the sea water has reached the land already…" (Peni, SFG 1).

4.4.2 Teachers' awareness of climate change

Two items in the teacher questionnaire were designed to find out the teachers' awareness of climate change. The percentage and distribution of teachers' responses are illustrated in Figure 5. Teachers were given the statement, *I believe climate change is happening* to investigate their views on whether climate change is happening or not. All the participants (n = 10) strongly agreed that climate change is happening. To probe into teachers' understanding of whether climate change is a problem for Tonga, including the Ha'apai islands, the majority of the teachers (9 of the 10 teachers) strongly agreed and one agreed with the statement, *Climate change is a problem for Tonga, including the Ha'apai islands*, and only one of the teachers was unsure about the statement. Data from the questionnaires reported a high level of climate change awareness among the teachers.

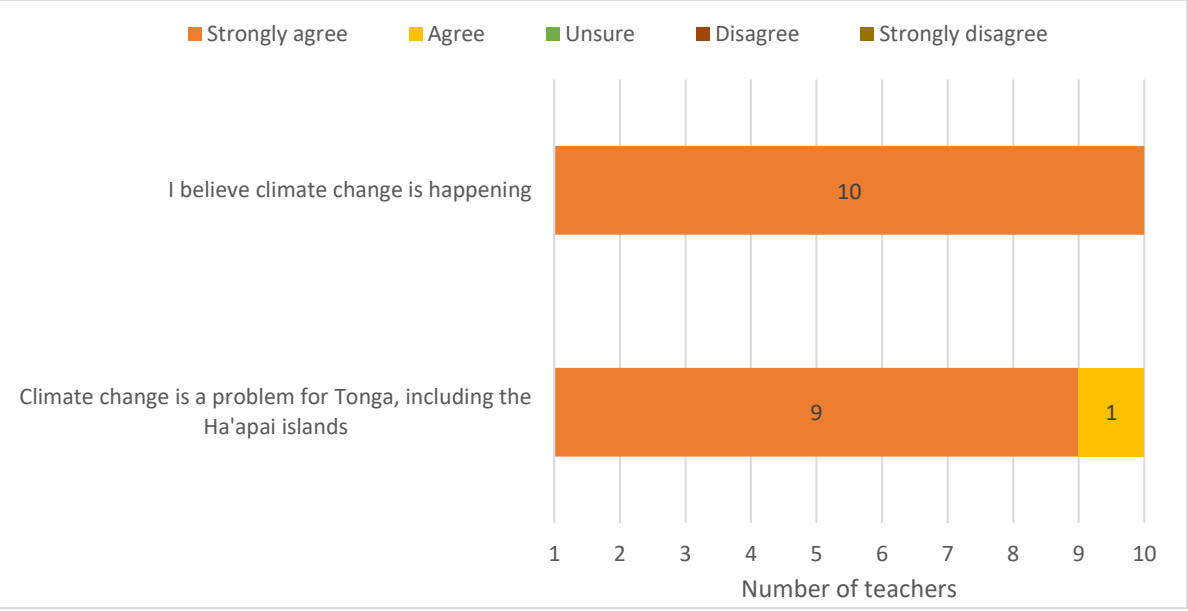


Figure 5 *Number of teachers' responses about their awareness of climate change*

To elucidate more on teachers' awareness of climate change, they were asked in the talanoa fakatokolahi to explain in depth whether climate change is happening or not. All teachers who participated in the talanoa fakatokolahi were much aware that climate change is already happening. Data from the talanoa fakatokolahi indicated that climate change manifests in diverse ways: teachers are already experiencing its impacts; it is a threat to the people of Tonga; and it poses risks to the environment of Tonga. The teachers' awareness of climate change seemed to have developed primarily from their personal observations and experiences. Three impacts of climate change that were frequently mentioned by the teachers in the taanoa fakatokolahi were: sea level rise, extreme weather events and temperature rise. Salome (29), a female teacher who was born and grew up in Ha'apai, stated:

> Climate change is happening because it is way too hot during summer time compared to the past…When I was little, we could differentiate between low and high tide. At low tide, we could walk on the sand and fish from the reef, but today, it is hard to identify low tide because the area is constantly under water (Salome, 29, TFG 1).

Changes that have been observed in weather patterns and in hurricane seasons were highlighted by one female teacher, Meleseini (48), as key indications of climate change. She acknowledged climate change is happening because she could witness these changes. She echoed her views by saying:

> I do believe climate change is happening. To me it means the weather pattern is different from what it used to be. For example, in the past, each season occurred at the right time; it's different today. The hurricane season was from November to April, but now, hurricanes can occur at any time. So I think it is true, climate change is happening (Meleseini, 48, TFG 2).

4.5 Knowledge about climate change issues

This section presents the students' and teachers' specific knowledge about causes, impacts and potential solutions to climate change. Data are presented from the questionnaires and the talanoa fakatokolahi. This section starts with presenting data on the students' definitions of climate change.

4.5.1 Students' definitions of climate change

In order to gain an understanding of students' meanings of climate change, students were asked the question, *Please explain what you think climate change is* in the questionnaire. The students' definitions were analysed according to the definitions provided by the Intergovernmental Panel on Climate Change (IPCC), that climate change refers to "any change in climate over time, whether due to natural variability or as a result of human activity" (IPCC, 2001, p. 984). A scoring rubric was used to delineate criteria to grade the students' definitions. A total score of four was given to the definitions that covered all four aspects: change in climate over time; result of natural process with one example; result of human activity with an example; and example(s) of impacts of climate change. A score of three was allocated if they mentioned three of the four aspects, two was given to those who mentioned any two of the four aspects and one if they mentioned only one aspect. Students who did not mention any of the four aspects, or provided irrelevant answers and alternative conceptions about climate change were given a score of 0. Table 4 illustrates the categories and the frequencies of the students' responses.

Table 4 *The Frequencies of student responses in comparing their definitions to the IPCC's definitions of climate change (n=60)*

List of aspects	Change in climate over time, Result of natural process, Result of human activity, Impact(s)				
Scoring Rubric	Students mention four from the list above	Students mention any three of the list above	Students mention any two from the list above	Students mention any one from the list above	Students mention none from the list above
Number of respondents	0	0	10	41	9

The data reports that out of 60 students who participated in the questionnaire, none mentioned four or three of the aspects in their definitions. Ten students included two aspects in their definitions, 41 students mentioned only one of the aspects and nine students mentioned none of the aspects. The nine students under the last category refers to students who either held alternative conceptions about climate change or provided answers that were irrelevant to what was required. An example of participants who held alternative conceptions about climate change defined climate change as "Changing

climate by pollute air that damage the ozone layer allow radiation of the sun to melt ice and increase sea level that eat up land, For example, Ha'apai." (Student 34).

This conception was elucidated during the talanoa fakatokolahi to gain a further understanding of students' meaning of climate change. The findings are reported later in Section 4.5.5 - the students' alternative conceptions.

Data in Table 4 are elaborated more in Table 5 to explore the aspects that were identified in the students' responses. The students' definitions were then categorised as: Impacts; Causes; Combination of impacts and causes; and Irrelevant or Alternative conceptions. Table 5 indicates the categories and the frequencies of the students' responses.

Table 5 *The Frequencies of students' responses to their definitions of climate change by category (n=60)*

Category	**Number**
Impacts	31
Causes	10
Impacts & Causes	10
Alternative conceptions & Irrelevant answers	9

Students' definitions of climate change appeared more focused on localised impacts of climate change. Thirty one students mentioned one or two impacts of climate change in their definitions. For instance, a student defined climate change as:

> Climate change takes much of our land and it is evident by sea rising over landward and changing and unpredicted weather (Student 51)

The impacts that were frequently mentioned and discussed in the students' responses were increased weather events, namely cyclones, and the impacts of sea level rise on the land. The Tongan phrase that students frequently used to describe the impacts of sea level rise was "Kai 'e he tahi 'ae kelekele" (Land is consumed by the sea). For example, one student defined climate change as:

> My thought about climate change, the climate change causes many great disasters, for example, the super king tides. At the current time, as time goes by, the land is being consumed by the sea as a result of climate change (Student 9).

Ten definitions were based on causes of climate change. For example, one student responded, "Climate change is caused by burning fossil fuel and the carbon dioxide released by the power stations" (Student 33). Ten students included both impacts and causes in their definitions. For example, a student defined climate change as:

> Climate change refers to flooding, land is lost to sea level rise, there is high number of cutting trees, when we burn rubbish, we produce carbon dioxide (Student 48).

The nine students whose responses are considered to be Alternative conceptions & Irrelevant answers are correlated to the data in Table 2. They were students who provided answers that were seemed to be irrelevant. For example, a student provided an answer that did not clearly respond to the question: "To study how climate change in the earth" (Student 38). Correspondingly, another student presented a definition which showed alternative conceptions.

> When the climate is changed it means there is a layer, and there are three types of sun's radiation, and two of these 3 radiations reach the earth while one radiation is reflected back into space. Today, these three radiations all reach the earth. When we burn fire, the smoke contributes to forming a hole on the ozone layer (Student 1).

4.5.1.1 Ko e feliuiuaki 'o e 'ea - Shaping students' definition of climate change

Ko e feliuliuaki 'o e 'ea (Unpredictable, unstable or changeable weather or climate) is the Tongan translation of climate change which was provided by the MEIDECC and the term is adopted by all stakeholders including the Ministry of Education, and it is also used to communicate climate change to the public. In the Tongan language, the term feliuliuaki refers to unpredictable, unstable or changeable, and climate is used interchangeably with the term weather. 'Ea in the Tongan language can be referred to either: weather; climate; or air. In the questionnaire, students were asked to explain what they thought climate

change is. It is evident from students' responses, that climate change was conceptualized as changes in weather on a daily basis, in other words, the Tongan language version of climate change may have had an impact on students' definitions about it. One student stated: "Climate change is the changing of weather, for example, it is sunny in the morning and almost come to the end of the day the weather changes to rainy" (Student 25). Climate change as a change in climate over time was one of the expected definitions which was not mentioned by the students in the survey.

4.5.2 Teachers' definitions of climate change

To further explore teachers' definitions of climate change, they were given the statement, *Please share your understanding of what climate change is*. Teachers' definitions were graded using the same scoring rubric that was used to grade the students' definitions as stated in Section 4.5.1. The four categories and the frequencies of teachers' responses are illustrated in Table 6.

Table 6 *The Frequencies of teachers' responses in comparing their definitions to the IPCC's definitions of climate change*

List of aspects	Change in climate over time Result of natural process. Result of human activity Impact(s)				
Scoring Rubric	Teachers mention four from the list above:	Teachers mention any three from the list above:	Teachers mention any two from the list above :	Teachers mention any one from the list above:	Teachers mention none from the list above:
Number of respondents	0	1	4	5	0

As illustrated in Table 6, out of the 10 teachers who participated in the questionnaires, none of them mentioned the four aspects in their definitions. Data reports that only one teacher (Teacher 4) mentioned three aspects in his or her definition, 4 mentioned two aspects and the majority (5) mentioned only one aspect in their definitions.

Teacher 4 defined climate change as:

> Climate change is the changing of climate in a long period of time. This is caused by human activities. Climate change affects people's daily

> lives, and the Government's economy, and land. Climate change is a big issue in the Pacific and in the world. All countries in the world are trying to overcome the problems that are caused by climate change… (Teacher 4)

The one aspect that was not included in the above definition, and also in the definitions of the other nine participants' was the 'Result of natural process'. These findings indicated that teachers seemed to only understand about human contributions to climate change and not understanding about the climate change as also a result of natural process. IPCC (2013b) reports that scientists' records of Earth's climate shows that the climate system varies naturally over a wide range of time scales. In general, climate changes prior to the Industrial Revolution in the 1700's can be explained by natural causes, such as changes in solar energy, volcanic eruptions, and natural changes in greenhouse gas concentrations (IPCC, 2013b).

Data indicated that only four teachers appeared to include 2 aspects in their definitions and the majority of the teachers included only 1 aspect. The frequencies of the teachers' responses are illustrated in Table 7.

Table 7 *The frequencies of teachers' responses to each aspects*

Teachers 1-10	Aspects mentioned in the teachers' definitions			
	Change in climate over time	Result of natural process (Cause)	Result of human activities (Cause)	Impact (s)
Teacher 1			✓	✓
Teacher 2				✓
Teacher 3			✓	
Teacher 4	✓		✓	✓
Teacher 5			✓	✓
Teacher 6			✓	✓
Teacher 7				✓
Teacher 8				✓
Teacher 9				✓
Teacher 10			✓	

As shown in Table 7, the impacts and causes of climate change were the two aspects that the majority of the teachers mentioned in their definitions. For example, a teacher defined climate change as:

> Climate change is when the average surface temperatures on Earth rise due to burning of fossil fuels. Burning fossil fuels release carbon dioxide and other dangerous gases. The impacts of climate change are sea level rise, severe weather events such as droughts (Teacher 6).

The five teachers who mentioned one aspect in their definitions consisted of four teachers who mentioned impacts, and one teacher who mentioned climate change as a result of human activities. This finding indicated that the majority of the definitions that were provided by the teachers focused mainly on the impacts of climate change.

4.5.3 Students' knowledge about causes of climate change

Students were given three multiple choice questions about the atmospheric concentrations of greenhouse gases and climate change and asked to circle the letter with the correct answer. These questions were designed to assess students' knowledge of enhanced greenhouse gases contributing to the cause of climate change. The data is presented in Table 8.

Table 8 *Multiple choice questions and percentage of students' of students with the correct answer*

Questions	Answer options (the correct answer is in bold)	Percentage of students with the correct answer
There is more carbon dioxide (CO_2) in the atmosphere now than in the past hundred years. What is the most likely cause of the current increase in carbon dioxide?	a) The sun is releasing more heat energy b) There is an increase in volcanic activity. c) **Humans are generating more air pollution** d) The Earth's orbit around the Sun is changing.	72
Scientists believe that global temperatures are rising primarily because of:	a) an increase in the use of toxic chemicals such as pesticides sprays. b) **increase in the amount of carbon dioxide (CO_2) from burning fossil fuels** c) a hole in the ozone layer allowing heat to enter the earth's atmosphere. d) excess heat given off from energy generation in power stations.	32

Certain gases in the atmosphere - water vapour, carbon dioxide and methane - can influence Earth's temperature and climate. They are called:	a) ozone gases b) solar gases c) **greenhouse gases** d) atmosphere gases	23

The data indicates that most students have an understanding of human contribution to the current increase of carbon dioxide in the atmosphere, with 72% of students reporting their understanding that increased carbon dioxide in the atmosphere is due to humans using more fossil fuels. However, most students did not fully understand why global temperatures are rising. Only 32% knew that global temperatures are rising because of an increase in the amount of carbon dioxide from burning fossil fuels, while the majority of the students (65%) chose the option that the rise in global temperature is due to a hole in the ozone layer allowing heat to enter the earth's atmosphere. The last question required the students to give the name of certain gases in the atmosphere, such as water vapour, carbon dioxide and methane, that can influence Earth's temperature and climate. Only 23% of the students correctly responded that these gases are Greenhouse gases, about 68% of the students thought that these are ozone gases, 6% responded that these are atmospheric gases and 3% believed that these gases are called solar gases.

None of the students who took part in the talanoa fakatokolahi reported a clear understanding of the concept of the enhanced greenhouse effect. The following conversation shows the students' responses during the SFG 2, in which they indicated a lack of understanding about the concept of the enhanced greenhouse impacts.

> **Researcher** – Can you please explain what you know about the concept of enhanced greenhouse effect?
>
> **SFG 2 -** We haven't done that sorry, and we do not know anything about it.
>
> **Researcher** – Did you learn about greenhouse effect last year or the previous years?
>
> **SFG 2 -** No, we haven't heard about Greenhouse effect

One of the Tongan terms that students often mentioned during the talanoa fakatokolahi was ‘kasa kona’ which means dangerous gases. The term greenhouse gases was not a familiar term to them; also they could not identify names of greenhouse gases such as methane and nitrous oxide. The only gas that they frequently mentioned during talanoa fakatokolahi was carbon dioxide. This data depicts students’ lack of understanding about the concept of enhanced greenhouse effect and they also lacked some understanding of names of greenhouse gases.

The next part of the questionnaire dealt with students’ knowledge about activities that contribute to the cause of climate change and this data is illustrated in Figure 6.

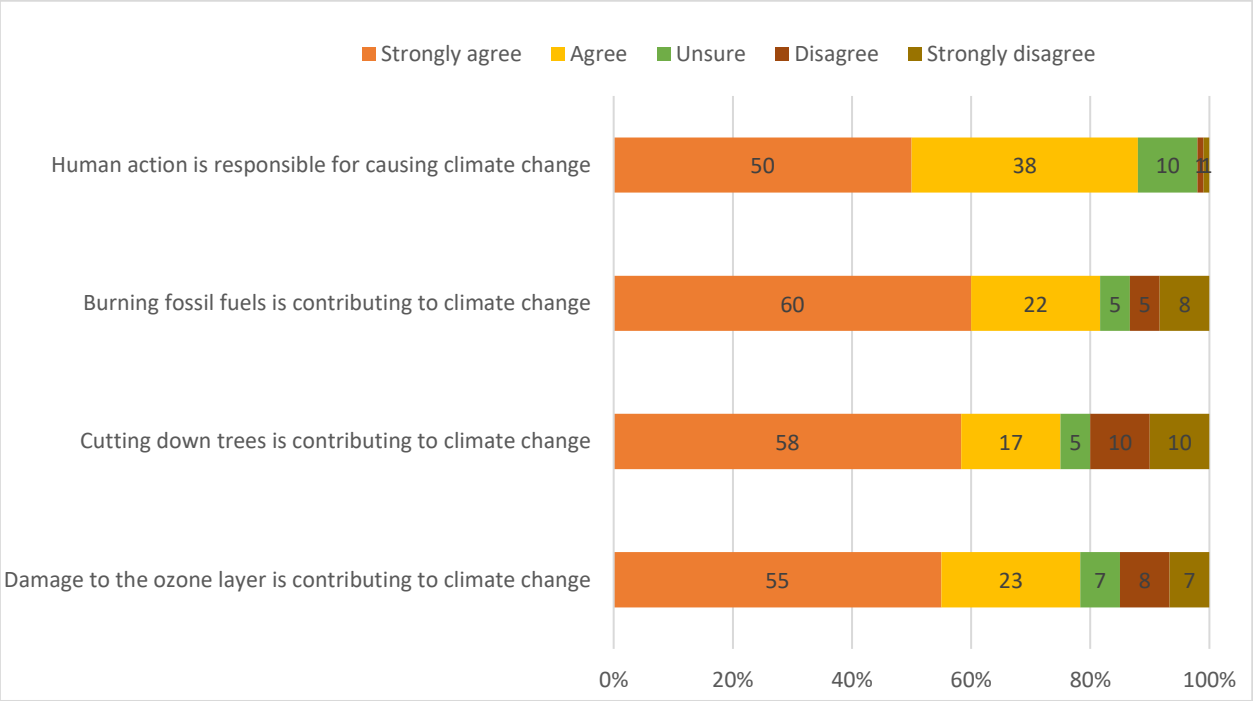


Figure 6 *Percentage and distribution of students’ responses about the processes contributing to the cause of climate change*

The data showed that a majority of the students (88%) either strongly agreed or agreed that human action is responsible for causing climate change and that burning fossil fuels is contributing to climate change (82%). When asked if cutting down trees also contributes to climate change, a very high proportion (75%) of the students either strongly agreed or agreed that cutting down trees contributes to climate change. On the other hand, a number of students (20%) either disagreed or strongly disagreed with only 3% who were unsure with the statement. In the last statement, students were asked to state whether they agree or disagree that damage to the ozone layer is contributing to climate change.

Surprisingly, a majority of the students (78%) either strongly agreed or agreed that damage to the ozone layer is contributing to climate change, 7% were unsure, and 15% either disagreed or strongly disagreed. This finding indicated that students who participated in the questionnaires held strong conceptualisations about the linkage of the ozone layer depletion to climate change.

The talanoa fakatokolahi indicated that students viewed local actions such as burning rubbish and cutting trees at their homes as main causes of climate change. They also mentioned burning plastics and fumes from vehicles as causes of climate change.

During the talanoa fakatokolahi, the students were asked if the industrial countries could be blamed for causing climate change. They stated that the people of Tonga should be blamed because their daily actions such as burning rubbish, burning vehicle tyres and plastics are what contributed the most to climate change. While the developed and industrial countries are generally believed to be the biggest contributors to global greenhouse emissions, for instance, Galpern (2008) stated that the industrialized nations' CO_2 emissions rose 4.3% from 1990-2004, while CO_2 emissions from developing nations increased nearly 70% during the same time period, the students barely mentioned it in their discussions, as their focus was mainly based on the localised activities and what they observed on a daily basis such as burning rubbish and cutting down trees.

4.5.4 Teachers' knowledge about causes of climate change

To explore teachers' understanding about the causes of climate change, four statements were given in their questionnaire to consider. The percentages and distribution of the teachers' responses to the four items can be seen in Figure 7.

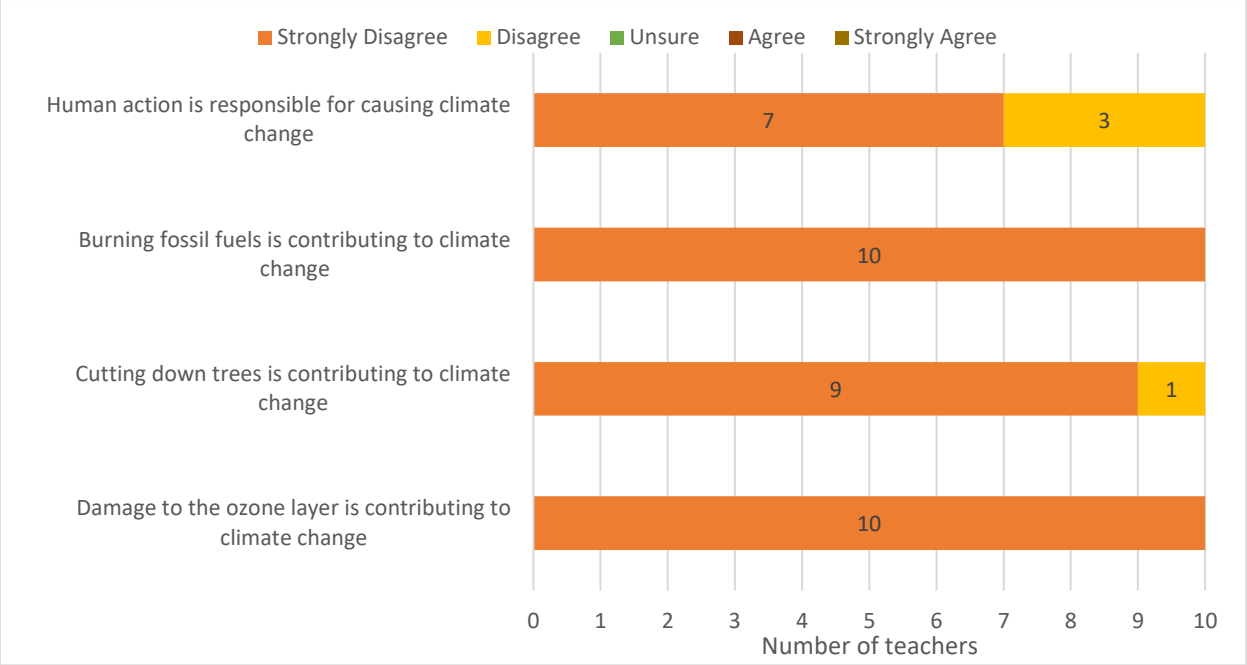


Figure 7 *Number of the teachers' responses about causes of climate change*

In responding to the first item, *Human action is responsible for causing climate change*, a majority of the participants (7, n = 10) strongly agreed and three agreed with the statement. The results of this item indicate that all teachers who participated in the questionnaires believe that human action plays a significant part in causing climate change. Similarly, burning fossil fuels was also reported by all teachers (10) to be contributing to climate change. All teachers (10) either strongly agreed or agreed that cutting down trees is contributing to climate change. To gain a deeper understanding of teachers' conceptions of ozone layer depletions and climate change, they were given the statement, *Damage to the ozone layer is contributing to climate change*. The data collected identified a high level of agreement among teachers that damage to the ozone layer is contributing to climate change. Ten teachers who participated in the questionnaires strongly agreed that the damage to the ozone layer is contributing to climate change. These results concurred with the students' data, that linking the concept of ozone layer depletion to climate change was commonly held by both teachers and students.

To get more insight into teachers' knowledge about the causes of climate change, they were asked in the talanoa fakatokolahi to talk about what they think causes climate change. A great diversity of answers was noted. Teachers' knowledge about causes of climate

change can be grouped into two categories: human activities, and selfishness and inconsideration.

4.5.4.1 Human activities

In general, although the participant teachers held good understandings regarding how human activities contribute to climate change, many of them were not precise in their description of the causes of climate change. Many teachers attributed climate change to burning fossil fuels without further explanation. Human activities such as cutting trees, burning rubbish and burning fossil fuels were commonly mentioned by teachers to be the causes of climate change. Siua, a male teacher aged 52, delineated that cutting of trees disturbs the carbon sink cycle. He went on to clarify his ideas by saying:

> Trees act as carbon sinks, so when we cut down trees, we disturb the carbon sink cycle. When trees are removed, the smoke travels up in the air, and that's how climate change tended to happen (Siua, 52, TFG1).

4.5.4.2 Selfishness and inconsideration

Teachers who participated in the talanoa fakatokolahi also reported that climate change is caused by human's selfishness and inconsideration. Some participants stressed that the industrialised countries contribute the most to climate change, for instance, they burn fossil fuels. The talanoa fakatokolahi participants thought that the industrialised countries are more concerned about improving their economic and living standards, and show little consideration of their actions that contribute to climate change, which in turn poses risks to smaller nations like Tonga. Lavinia (44) from the TFG1 stated:

> I do blame the industrialised countries because they are the ones that contribute the most to climate change. They are selfish, they do not consider small island countries like Tonga (Lavinia, 44, TFG1)

The industrialised countries were blamed by the teacher participants because they perceived these actions such as burning fossil fuels are driven by selfishness and lack of consideration.

4.5.4.3 Who is responsible for climate change?

Some teachers reported that people these days including the government of Tonga, are somewhat influenced and controlled by economic factors. One participant stated:

> I believe that when humans started to shift from the traditional ways of doing things to incorporate ideas of technology and development, that is when problems related to climate change started to emerge. Striving for economic standard and a convenient lifestyle is powerful these days, and it seems to control our daily lives. For example, yesterday, we used banana leaves for wrapping *lu* (taro leaves, coconut milk with meat), but today, we are shifting to using aluminium foil (Siua, 52, TFG1)

Some teachers thought that the government of Tonga imported far too many vehicles into the island without considering the negative impacts of their decisions. For example:

> …I do blame the government of Tonga. They trade a lot, and import vehicles and other goods that are not good for the environment of Tonga. Even though it is the industrialised countries that contribute the most to climate change, but we in Tonga, also contribute but in different ways (Siua, 52, TFG1).

4.5.5 Alternative conceptions

This section presents data which are considered to be alternative conceptions held by teachers and students. Alternative conceptions in this research refers to the concepts that may often run counter to currently held scientific views (Meadows & Wiesenmayer, 1999). Literature indicates that there are alternative conceptions commonly held by students and teachers, such as the confusion of the greenhouse effect with ozone layer depletion (Hansen, 2010). Consequently, some items in the questionnaires were designed to find out whether the Tongan students' and teachers' conceptions of climate change may mirror the types of alternative conceptions published previously. The findings from the students' and teachers' knowledge in the domains of causes, impacts and response to climate change showed that they lack deep understanding and in some cases reflect some alternative conceptions. This data draws from the questionnaires and the talanoa fakatokolahi.

4.5.5.1 Conflation between greenhouse effect and ozone layer depletion - Students' stories

Data from both the questionnaires and talanoa fakatokolahi reported that a majority of the students conflated the hole in the ozone layer with the greenhouse effect. As indicated in in Figure 6 (Section 4.5.3), a majority of the students (78%) either strongly agreed or agreed that damage in the ozone layer is contributing to climate change. Similar alternative conceptions were also identified in students' definitions of climate change in the questionnaire. Student 34 defined climate change as:

> Climate change is caused by air pollution, and it damages the ozone layer allowing the sun's radiation to melt the ice and cause the sea level to rise and eat up the land (Student 34)

These alternative conceptions also surfaced many times in the talanoa fakatokolahi. When asked in the talanoa fakatokolahi to explain what causes climate change, a male student responded:

> …Yes, the problem of ozone depletion, that the sun is getting hotter and cause ice melting at the two poles…Yes we know that the ozone depletion is the main cause of climate change (Sione, SFG 3).

The comment above indicates the common alternative conception this particular student held. However, this conception was not limited to only one student, as the majority of the students (90%) who participated in the talanaoa fakatokolahi thought that the ozone layer depletion is responsible as a cause of climate change. During talanoa fakatokolahi, the participants highlighted that human activity has been releasing kasa kona (dangerous gases). In their thinking, in some way, these gases degrade the ozone layer creating a hole through which solar radiation can penetrate further, heating the atmosphere and disrupting the climate. These alternative conceptions are commonly held among students not only in Tonga but also in other countries (Hansen, 2010).

4.5.5.2 Conflation between greenhouse effect and ozone layer depletion - Teachers' stories

To get insight into what teachers understood about the link between the process of greenhouse effect and climate change, they were given the question, *Scientists believe*

that the process of enhanced greenhouse effect does contribute to the cause of climate change. Nearly all of the talanoa fakatokolahi participants reported they did not know about the process of the greenhouse effect, and how the process contributes to climate change. The two teachers who responded to the question, however, only explained a little about greenhouse gases; and the rest of the participants said that they did not know much about the enhanced greenhouse effect. For example, one teacher who responded to my question stated that greenhouse gases are released from activities such as burning fossil fuels, but also held alternative conceptions about the process of enhanced greenhouse effect and its contribution to climate change. She stated:

> Greenhouse gases are released from burning fossil fuels and burning plastics. These gases are making holes in the ozone layer, and causing ozone layer depletion. The greenhouse that protects us from the sun has holes in it, and that is why the Earth's temperature is dramatically rising these days (Meleseini, 48 TFG2).

When asked whether they thought the ozone layer depletion causes climate change, Sekope (38 years of age, TFG2) concurred with Meleseini that humans release a high amount of chemicals into the atmosphere, which depletes the ozone layer causing climate change. Salome (28, TFG1) agreed with this idea by highlighting that the smoke which is produced by burning is what is causing the holes in the ozone layer, and the ultraviolet light that comes through the ozone layer holes causes climate change. Samisoni (29, TFG1), a Geography teacher who also taught Agriculture, added that he learnt about methane and nitrogen when he taught Agriculture, and he believed those two gases can cause climate change. Samisoni (29, TFG1) also added, "When people cut down trees, then the carbon is being removed, and it goes to the atmosphere, and goes to the ozone layer and it causes problems, so that is why the Earth gets warmer".

These findings indicate that teachers seemed to hold a strong conflation between the process of greenhouse effect and that of ozone layer. When asked questions about climate change, the majority were unable to disentangle the greenhouse effect from ozone depletion. They stressed that burning rubbish, plastics and fossil fuels made holes in this layer, so the solar rays enter the earth through these holes and that is why the Earth is hotter these days, thus contributing to climate change. These results mirror an array of

previous studies that point to the fact that school teachers believe the hole in the ozone links to the cause of climate change (Groves & Pugh, 1999; Papadimitriou, 2004)

The findings also showed that teachers have formed various images to explain the climate change phenomenon. These images were somehow confused with other environmental problems. In response to asking what they know about impacts of climate change, Salome (28, TFG1) seemed to perceive earthquakes as an example of climate change and stated:

> Climate change will bring more intense and frequent natural disasters, like Cyclone Ian. We have experienced quite a number of earthquakes recently. I think these are the impacts of climate change (Salome, 28, TFG1).

4.5.5.3 Industrialised countries are not major contributors to climate change

The data from the talanoa fakatokolahi reported that students and teachers believed that burning rubbish and cutting down trees especially at their various homes and villages are major contributors to climate change, but not the industries and vehicles. Giving the students and teachers prompts to consider if the industrialised countries may be the major contributors to climate change, they seemed to identify the local activities as contributing the most to climate change.

4.5.6 Students' knowledge about impacts of climate change

To ascertain students' knowledge about impacts of climate change, they were given eight statements about different impacts of climate change, and the 5 point Likert scale (1 – Strongly disagree to 5 – Strongly disagree) was employed to identify students' responses to each statement. The response distribution and percentages are shown in Figure 8.

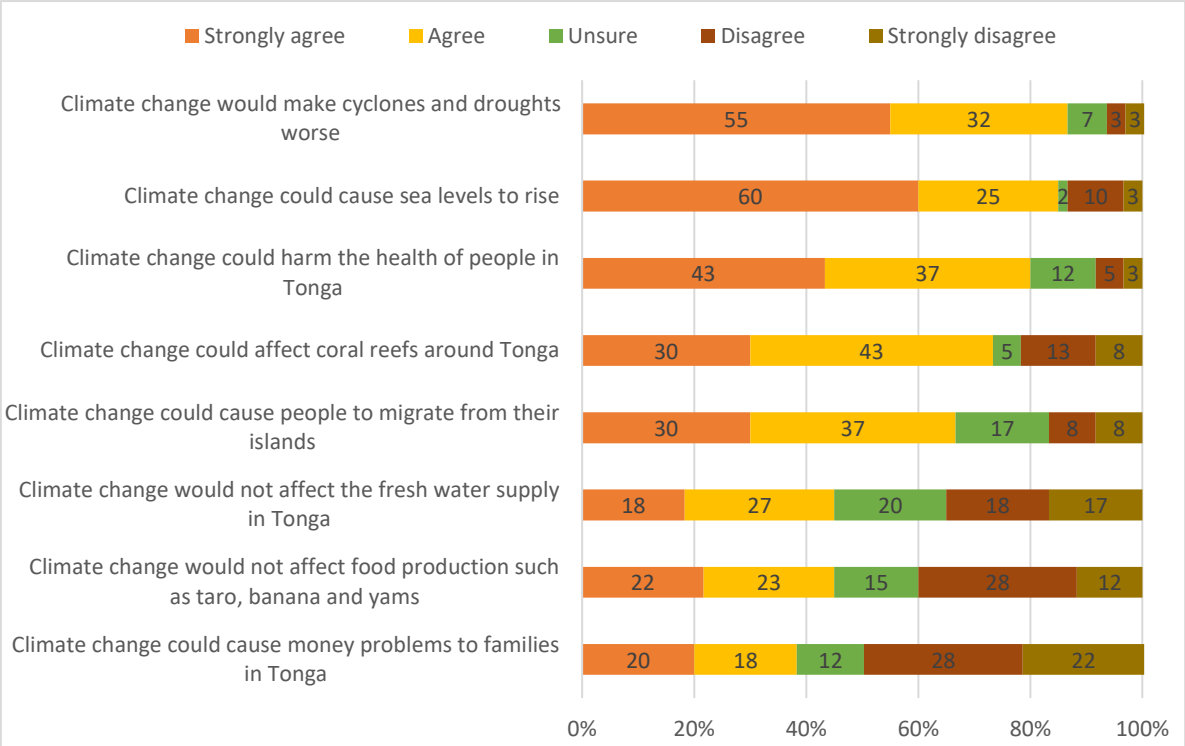


Figure 8 *Percentage and distribution of students' responses about the impacts of climate change*

The statement *Climate change would make cyclones and droughts worse* was perceived to be the most likely impact of climate change. Eighty seven percent (87%) of the students either strongly agreed or agreed, 7% were unsure, and 6% either strongly disagreed or disagreed that climate change would make cyclones and droughts worse. The second most identified impact was the sea level rise. Eighty six percent (86%) either strongly agreed or agreed, 2% were unsure and 13% were either strongly disagreed or disagreed that *Climate change could cause sea levels to rise*. Extreme weather events and sea level rise are two direct environmental impacts of climate change, and they are two of the major global effects of climate change which are not only commonly held around the world but they are well known in the scientific community (IPCC, 2007a; Sheppard, 2012).

More than two thirds of the students were in agreement with both the social and environmental impacts of climate change. Data indicates that eighty percent (80%) of the students either strongly agreed or agreed that climate change could harm the health of people in Tonga, 12% were unsure and only 8% were either strongly disagreed or disagreed. To find out students' awareness of the impacts of climate change on coral reefs, they were given the statement *Climate change could affect coral reefs around Tonga*. Seventy three percent (73%) either strongly agreed or agreed that climate change could

affect coral reefs around Tonga, 5% were unsure, and 21% were either strongly disagreed or agreed. Students were also asked to state whether climate change could cause people to migrate from their islands, and a total of 67% either strongly agreed or agreed, 17% were unsure, and 18% either strongly disagreed or disagreed that climate change could cause people to migrate from their islands.

The last three items in Figure 7 can be classified as secondary impacts or indirect impacts (Sheppard, 2012), and they refer to impacts of climate change on other areas such as economy, culture and traditions. Students were given the statement, *Climate change would not affect the fresh water supply in Tonga*. Data reported that 45% of the students either strongly agreed or agreed that climate change would not affect the fresh water in Tonga, 20% were unsure and 25 percent either disagreed or strongly disagreed, which illustrated a diversity of views and some uncertainty. To explore students' understanding about how climate change could affect the food production in Tonga, the students were given the statement *Climate change would not affect food production such as taro, banana and yams*. Some students (45%) either strongly agreed or agreed, 15% of the students were unsure, and 40% either strongly disagreed or disagreed and about the statement (See Figure 8). The result of this item indicates some real uncertainty about whether climate change would affect food production, perhaps reflecting a lack of understanding of connection between the climate and food production. The impact of climate change on the economy of Tonga seems to have received the least agreement among students. When they were given the statement *Climate change could cause money problems in Tonga*, data reveals that only 38% of the students either strongly agreed or agreed with the statement, 10% were unsure, and 50% either strongly disagreed or disagreed with the statement. These findings indicate that students showed less appreciation or concern about the indirect impacts of climate change namely, fresh water supply, food production and especially on the economy of Tonga.

To delve more into students' existing knowledge about impacts of climate change, they were asked during the talanoa fakatokolahi to explain what they knew about impacts of climate change. The two most discussed impacts of climate change in all talanoa fakatokolahi were sea level rise and the increasing extreme weather events. This data aligns with the data in the questionnaire. All participants of the talanoa fakatokolahi agreed that sea level rise is an impact of climate change. Their discussions were based

mainly on personal observations and experiences. Some families that used to reside along the coastal areas of Ha'apai island were relocated further inland due to sea level rise. Because students could see these situations, their understanding of the impacts of climate change was through first-hand experience for them.

Although sea level rise was indicated as one of the key impacts of climate change, the students could not explain the processes involved in such events. Only two students were able to give some explanations, while the rest of the students did not respond to the question. The students were expected to possibly discuss the concept of an increase in temperature as a result of the enhanced greenhouse effect which then leads to melting of the ice caps. However, the two students mentioned that the increase in temperature is a result of the thinning of ozone layer. The increased temperature then leads to melting of the ice on both Poles. These explanations indicated very limited and inaccurate understandings and also consisted of some alternative conceptions. One of the students responded:

> When I was at Primary school, I learnt that burning releases gases, and these gases contribute to thinning the ozone layer, and then the ice on both Poles melt. This melting ice is deposited in low lying areas causing sea level to rise (Akosita, SFG 3)

The majority of students who participated in the talanoa fakatokolahi had also experienced Cyclone Ian which hit Ha'apai island in 2014. The students who were in Ha'apai during this cyclone emotionally shared the impacts of Cyclone Ian on them personally and their families. One student mentioned:

> …in 2014, during Cyclone Ian, our neighbour's house was destroyed by the cyclone, it saddened me because they got nowhere to hide, so they all ran and hid inside an empty water tank (Nau, SFG 2).

The intensity of Cyclone Ian was also described by the students as "powerful and scary". All the participants who experienced Cyclone Ian mentioned that they felt scared and one person reported that he thought it was the end of the world.

The impacts of climate change on the economic life of families was discussed by only a few participants. Only one participant in SFG 3 stated that rebuilding houses after

cyclones will be a financial stress to all families affected. The rest of the participants did not comment on the impact of climate change on the economy.

4.5.7 Teachers' knowledge about impacts of climate change

To gauge teachers' knowledge about impacts of climate change, eight items were presented in the questionnaire, and teachers were asked to state whether they strongly agree, agree, unsure, disagree or strongly disagree with each statement. Figure 9 shows the percentage and distribution of teachers' responses to the eight items.

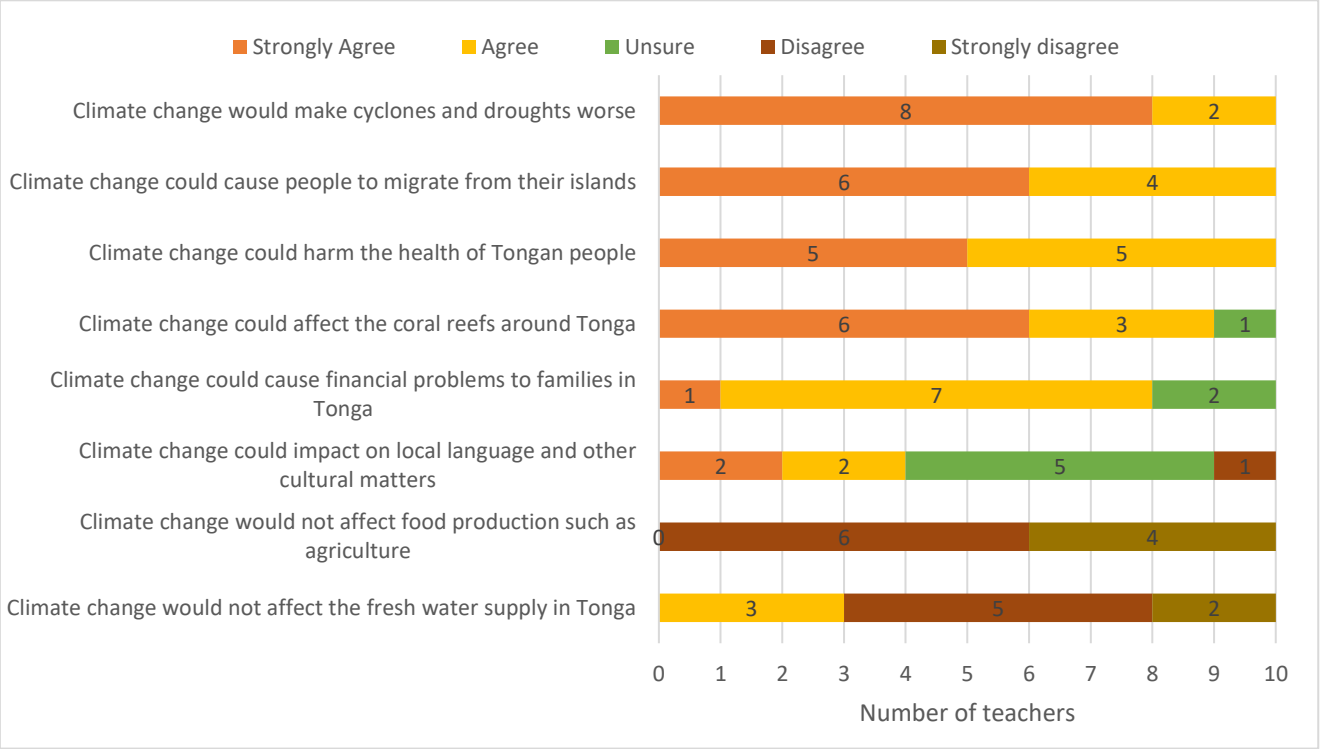


Figure 9 *Number of teachers' responses about the impacts of climate change*

When asked whether climate change would make cyclone and droughts worse, all of the teachers either strongly agreed or agreed with the statement. Similar findings were presented when teachers were given the statement, *Climate change could cause people to migrate from their islands*; six of the teachers strongly agreed and four agreed with the statement. The next statement in the questionnaire was, *Climate change could harm the health of Tongan people*. Findings were similar to the previous item, five of the teachers strongly agreed, and the other five agreed.

Unlike the last three items, where teachers reported to have either strongly agreed or agreed with all the given statements, the next statement, '*Climate change could affect the*

coral reefs around Tonga' was slightly different. Data showed that five of the teachers indicated they were unsure, four either strongly agreed or agreed, and one disagreed with the statement. When asked if climate change could cause financial problems to families in Tonga, only one teacher strongly agreed, seven agreed and two were unsure. A high proportion of teachers (5/10) indicated in the questionnaire that they were unsure about the statement, *Climate change could impact on local language and other cultural matters*, with only four reported to be either strongly agreed or agreed, and one disagreed with the statement. All teachers (100%) who participated in the questionnaires either strongly disagreed (6/10) or disagreed (4/10) with the statement, *Climate change would not affect food production such as agriculture*. In other words, 100 percent of the participants believed that climate change could affect food production such as agriculture. Thirty percent of the teachers stated that they agreed with the statement, *Climate change would not affect the fresh water supply in Tonga*, however, majority of the participants (50%) disagreed or strongly disagreed (20%).

To further explore teachers' knowledge about the impacts of climate, they were asked in the talanoa fakatokolahi to explain in depth about the impacts of climate change. The teachers' understanding about impacts of climate change can be classified into three main categories: impacts on nature; impacts on the environment; and impacts on the people. As one teacher said:

> "'*Kuo 'osi 'asi e nunu'a 'o e feliuliuaki 'o e 'ea*" - The detrimental impacts of climate change are already observed (Sekope, 38, TFG2)

4.5.7.1 Impacts on nature

Two main impacts of climate change on nature were discussed by the teachers during the talanoa fakatokolahi. Firstly, there is an increase in the frequency and the intensity of extreme weather events namely cyclones and droughts. Cyclone Ian, which hit and wiped out almost the entire island in 2014, was reported by many teachers as an obvious manifestation of the impact of climate change. In comparison to their experience of cyclones in the past, some teachers stated that the number of cyclone warnings are more frequent these days. In addition, the recent cyclones in Tonga such as Cyclone Ian were measured at Category 4 and Category 5, indicating that cyclones have become very strong. Salome (28, TFG1) said, "Natural disasters occur more frequently and more intense now in compared to the past…And we all experienced it when Cyclone Ian hit our island".

Drought was also an example of the extreme weather event that most of the teachers claimed to have happened as an impact of climate change. Teachers discussed that there are longer periods of drought these days compared with the past. The impacts of cyclone and drought on the people and the environment are further discussed later in this section.

The second impact of climate on nature is regarding the increase in temperature. "*Lahilahi e taimi 'afu*", this quote was given by Sekope, a male teacher aged 38, in which he declared that high temperature periods are regular occurrence now.

4.5.7.2 Impacts on the environment

Sea level rise was one of the environmental impacts of climate change that was commonly discussed during the talanoa fakatokolahi. Witnessing the problem with their eyes appeared to help boosting their understanding of it. Tilila, a female teacher aged 31 (TFG2), talked about her visit to Uoleva island. She stated:

> I went to Uoleva island, and I could observe very clearly the impact of sea level rise. The water has come inland and taken much of the land, and the roots of the trees are quite exposed, I could see them (Tilila, 31, TFG2).

Another teacher told a story about a family at her village who used to live near the beach but are now relocated further inland because their home was taken by the sea.

> *Koe to'ukai 'oku 'ikai pau, 'oku feliuliuaki. 'Oku 'ohofia e mahaki e to'ukai, pea 'oku 'ilonga lelei ia 'i Ha'apai ni.* The seasonal produce are unpredictable, its changes regularly. Pests and diseases attack the seasonal food, and these are clearly the case here in Ha'apai (Sekope, 38, TFG2).

Drought was mentioned by the teacher participants to have posed risks on crops and on fruit in Ha'apai and in wider Tonga. The above quotes stressed that the seasonal produce such as fruits and crops are inconsistent. Not only that but the pests and diseases damage the fruits and crops due to a prolonged period of no rainfall. The size of fruit was reported by one participant as "*polililili*" which can be described as 'stunt and undeveloped'. Some traditional plants such as "*hangale*" which was used by Tongans as a medicinal plant, are no longer existing as they could not resist the high temperatures.

The impacts of the tropical cyclones on the environment were well discussed and this may have been because the pictures of the damage that was done by Cyclone Ian to the environment of Ha'apai were still fresh in peoples' memories. One teacher who experienced cyclone Ian reported: *"After cyclone Ian, the environment of Ha'apai suffered. All trees were gone"* (Pauline, 47, TFG2).

4.5.7.3 Impacts on people

The impact of climate change on people's health was highlighted by the teacher participants during the talanoa fakatokolahi. Due to the prolonged period of no rainfall and increasing temperatures, people's health seemed to be affected. Tilila (31, TFG2) stated, "The outbreak of typhoid is due to lack of clean water. And this problem emerges due to a prolonged period of no rainfall, and I think it is the result of climate change". There is an increase in number of people suffering sudden death because of hot weather, and the participants thought that some people could not withstand high temperature.

A majority of people in Ha'apai earned their living from fishing and crops. According to the teacher participants, climate change has caused financial pressure on people. One participant said that:

> Economically, the Fa'a (a gardener, a planter or a farmer) of Ha'apai can no longer export their crops, they said the weather condition is unsuitable for the crops and they can't grow well. One man said to me that he used to export his crop products to overseas, that was his main source of income, but he does not do that anymore. He lost thousands of dollars, it is also a loss for his family's income. Not only it affects him personally, but it affects his family and the whole community, because the community could also get food from my garden (Sekope, 38, TFG2).

In addition to that, a teacher participant stated that in Ha'apai, a lot of women earned their living from weaving. However, the warm temperatures do affect the pandanus leaves and as a result, the weavers are be able to obtain sufficient good quality pandanus leaves. This has affected the economic life of many people in Ha'apai,

4.5.8 Students' knowledge about responses to climate change

In order to explore students' knowledge about solutions for climate change, they were given five items in the questionnaire to state whether they strongly agreed, agreed, unsure, strongly disagreed or disagreed with the statements. Figure 10 reports the students' responses to each statement.

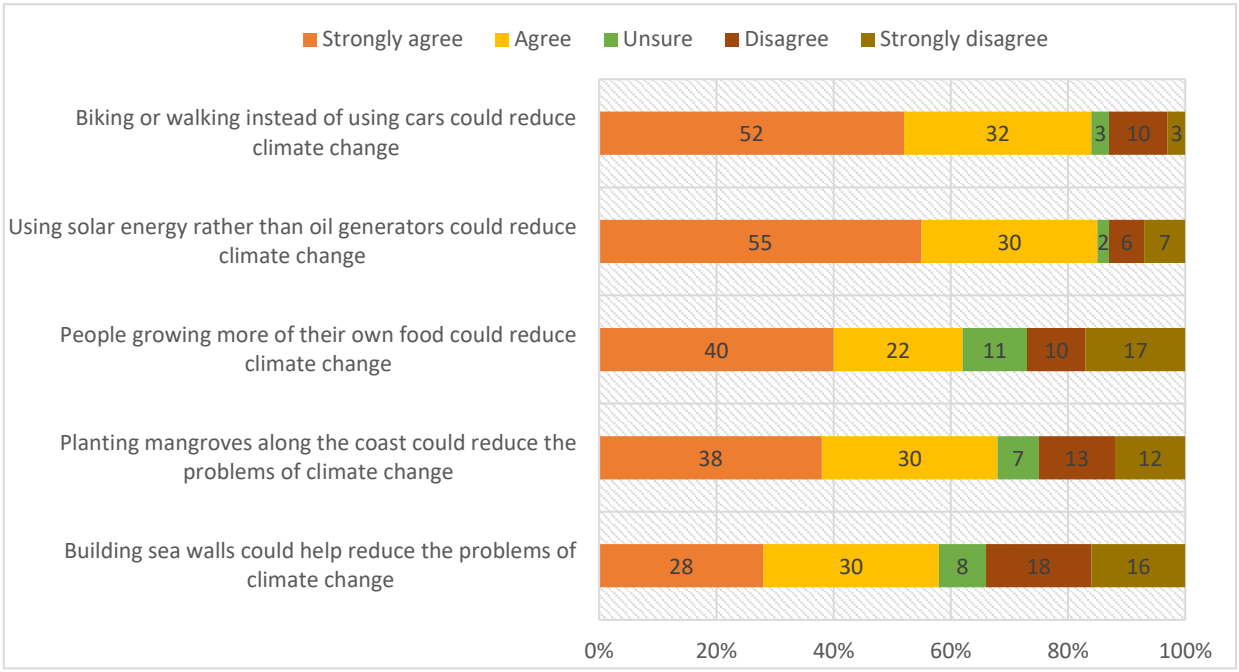


Figure 10 *Percentage and distribution of students' responses about actions to address climate change*

When asked about *Biking or walking instead of using cars could reduce climate change*, a majority of the students (84%) either strongly agreed or agreed, 3% unsure, 10% disagreed, and 3% strongly disagreed with the statement. Similarly, a significant proportion of students (85%) either strongly agreed or agreed that using solar energy rather oil generators could reduce climate change, 2% unsure, 6% disagreed and 7% strongly disagreed. Most of the students recognised these two main actions as likely to reduce climate change. Students were given the statement, *Planting mangroves along the coast could reduce the problems of climate change* and 68% of the students either strongly agreed or agreed with the statement, and slightly less students (62%) either strongly agreed or agreed that people growing more of their own food could reduce climate change. When students were asked if building sea walls could help reduce the problems of climate change, only 58% of the students either strongly agreed or agreed with the statement, 8% were unsure, and 34% either strongly disagreed or disagreed. Building sea walls can be classified as one of the adaptation measures to reduce the impacts of sea level rise

(McCarthy, Canziani, Leary, Dokken, & White, 2001), and this finding showed students' limited understanding about some key adaptation measures which could help reduce impacts of climate change.

To gain an in-depth understanding of students' awareness about climate change solutions, they were asked during talanoa fakatokolahi to discuss the actions they would take, and also solutions to reduce the impacts of climate change in Ha'apai and in Tonga. The students seemed to consider the concept fatongia (responsibility) as a crucial strategy when attempting to address climate change. This fatongia was highlighted by the students to be carried out by an individual person and by the Government as well.

Students emphasised the importance for everyone in Ha'apai to participate in action to reduce the negative consequences of climate change. Their concerns were for people to change their behaviours and also for people to act upon climate change. People in Tonga may have adapted to the behaviour of burning rubbish at their homes, which is also a very common activity for every household in Tonga. Students proposed that this behaviour should be stopped. Two students stated that people should not burn their rubbish but instead, bury it or take it to a landfill.

One of the actions that was frequently mentioned during the talanoa fakatokolahi to help climate change was replanting trees. This action was believed by most of the participants to be very significant and that everyone in Ha'apai and in Tonga should participate in replanting trees to help reduce the impacts of climate change. Akosita mentioned that students, for example, should play a role in acting upon climate change. She stated:

> I believe that students should pick the rubbish up and the Government can help stopping people from cutting down trees. And us students, we should stop littering and stop burning rubbish (Akosita, SFG 3).

A majority of the participants also think that the Government has an important fatongia in trying to address climate change. Sione from the students' SFG 3 suggested that:

> The Government should design a law to stop burning the rubbish that everyone should make it a priority. It is our 'fatongia', our responsibility to stop cutting down trees. By doing that, others will

see what you're doing, then they will do the same. We should be more responsible (Sione, SFG 3).

A very small proportion of students mentioned that 'building sea walls' is a way of adapting to the impacts of sea level rise. Only one student was able to discuss the importance of building sea wall in Ha'apai. She said: "*We should build foreshore high up to the sky*" (Saunia, SFG 2). This comment correlates with the findings in the questionnaire, which also indicated a small number of students considered building sea walls a significant adaptation measure in reducing the impacts of sea level rise.

4.5.9 Teachers' knowledge about responses to climate change

To examine teachers' knowledge about responses to climate change, five statements were given in the questionnaire. Figure 11 presents the percentage and distribution of teachers' responses to the five items.

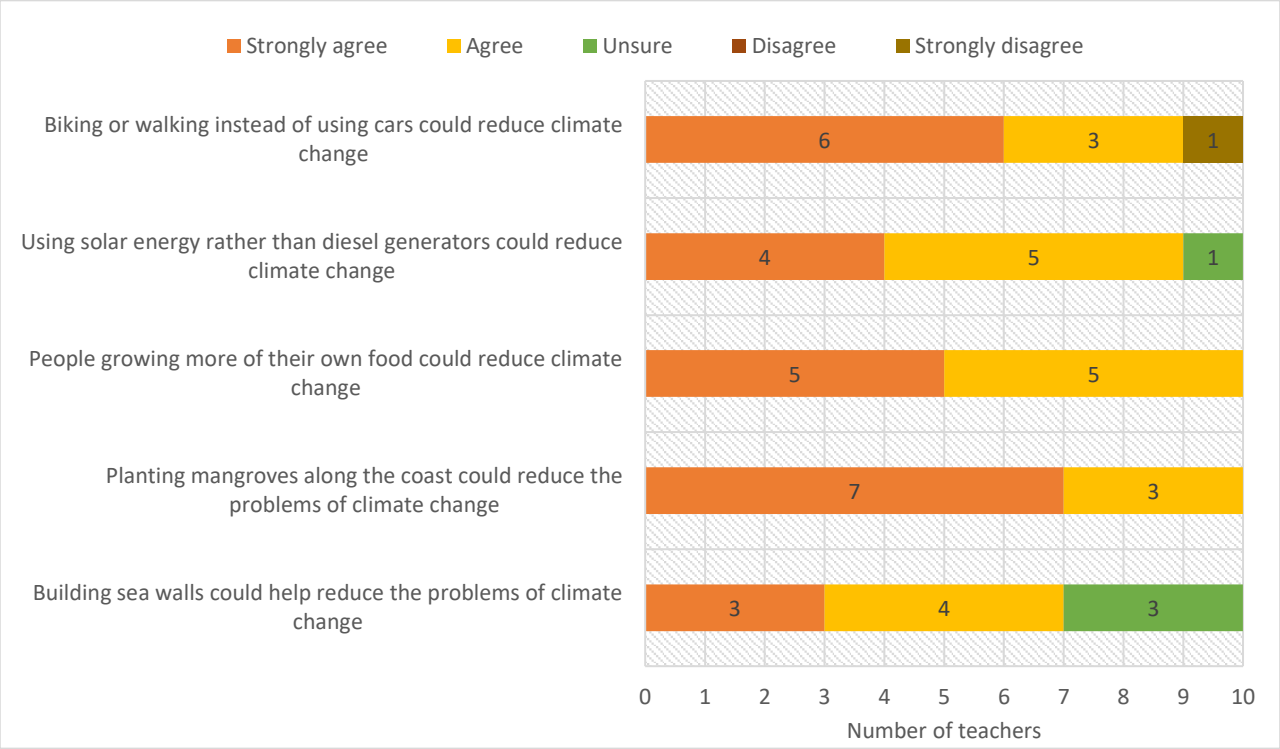


Figure 11 *Number of teachers' responses about actions to address climate change*

In responding to the first item, *Biking or walking instead of using cars could reduce climate change*, a majority of the teachers (9/10) either strongly agreed or agreed with the statement. Similar results were obtained for the statement, *Using solar energy instead of diesel generators could reduce climate change*. The proportion who agreed was still high [strongly agreed (4/10) and agreed (5/10)], and one of the teachers was unsure with the

statement. In the next item, dealing with the idea that people growing more of their own food could reduce climate change, the teachers unanimously agreed; 5/10 of the teachers strongly agreed and 5/10 agreed. The findings indicated that all teachers (100%) were positive that growing more of their own food could reduce climate change. Similar findings were found when students were given the statement, *Planting mangroves along the coast could reduce the problems of climate change*. Although the proportion who agreed was slightly higher than for the previous item [strongly agreed (7/10) and agreed (3/10), the frequencies of the "agree" participants remained the same as for the previous item (100%). The last item, *Building seawalls could help reduce the problems of climate change* was supported by 7/10 of the teachers, with only 3/10 strongly agreed and 4/10 agreed. The remaining 3/10 of the teachers were unsure with the statement. The findings showed that although building seawalls was considered by majority of the teachers to help reduce the problems of climate change, there were still some teachers who were unsure about this item.

To gain an insight into teachers' knowledge about ways to address climate change, they were asked in the talanoa fakatokolahi, *What can we do to solve or to reduce the impacts of climate change?* Teachers appeared to stress fatongia (responsibility/duty) to be carried out both at the local and national levels. Their answers can be grouped into four main categories: Fatongia 'o e Pule'anga (The Government's role); Fatongia 'a e Potungaue ako – Kau faiako moe fanau ako (The roles of the Ministry of Education and Training, teachers and students of Tonga); Fatongia 'o e ngaahi kolo mo e ngaahi komiuniti (Roles of the village communities); and Fatongia fakafo'ituitui - Matu'a moe fanau'i 'api (Individuals' roles – roles of parents and children's roles at home).

4.5.9.1 Fatongia 'o e Pule'anga (The Government's role)

To reduce the impacts of climate change in Tonga, teachers suggested the Government of Tonga should strengthen and reinforce laws and to establish new laws to ensure the people of Ha'apai and Tonga take good care of and value the environment. Teacher participants emphasized that the Government of Tonga should introduce a law to restrict people from cutting or destroying trees. They also noted that there is a law in place regarding burning rubbish, where households were advised by law not to burn rubbish, but to put their rubbish in rubbish bags instead. However, one participant stated that that law can only be observed in Tongatapu (the main island), whereas in Ha'apai, that law is

not strengthened by the Government so people of Ha'apai are still burning their rubbish at their own time.

It also appeared, from the talanoa fakatokolahi, that there is no specific landfill site in Ha'apai. Some teachers mentioned that the Government should consider building a landfill site for Ha'apai. This would encourage people to take their rubbish to the landfill instead of burning it.

4.5.9.2 Fatongia 'oe Potungaue ako – kau faiako moe fanau ako – (Roles of the Ministry of Education, teachers and students).

During the talanoa fakatokolahi, education was accentuated by the majority of the teachers as a way to respond to the detrimental effects of climate change. They felt that the Ministry of Education should review the current state of the curriculum in order to incorporate key aspects of climate change. One teacher highlighted the importance of teaching student values and knowledge about caring for their environment, and he also pointed out that it is the teachers' fatongia to teach those values and skills to the students. He mentioned:

> Disposition and knowledge…teach the child so s/he knows the factors that cause climate change…and students to value his/her environment and the sense of love…make responsibility and compassion for the environment her/his natural disposition… you may be 1% contribute to the cause of climate change, but if you are a teacher, your job is to instil values and skills into the child's mind, teach them not to litter… (Siua, 52, TFG1).

One male teacher stressed that the two main aspects of climate change that should be integrated in the curriculum and in the school syllabus are the causes of, and solutions for, climate change. A female teacher aged 31 also stressed that it is important for the Ministry of Education to integrate the Tongan traditional ideas in the curriculum as a way to address climate change in Tonga. She stated:

> …the Ministry of Education should introduce the traditional ideas of doing things, such as cooking, in the curriculum. For instance, instead of using aluminium foil for wrapping lū (traditional food made of taro

> leaves, meat and coconut cream), students should be taught and encouraged to use banana leaves, the olden days style should be re-introduced… (Tilila, 31, TFG2).

4.5.9.3 Fatongia ‘o e ngaahi kolo moe komiuniti (Roles of the village communities)

A community education was proposed by many of the teachers to be implemented in Ha’apai in order to educate the people about the issues of climate change. The elderly people, for example, should be provided with knowledge which is up to date about climate change. It was also discussed that people of this age group do hold some conceptions which may contradict scientific knowledge, so the teachers suggested that a community workshop to build awareness would be a great way to start. Some teachers also brought in the ideas of running village activities such as replanting trees.

Having posters all around the public places was also mentioned by one teacher to be an effective way of educating the community about the impacts of climate change and how to overcome the problems. Public speaking on climate change was mentioned by some teachers as a way to communicate climate change to the people in the community. Lavinia (44, TFG1) echoed:

> There should be workshops in the village community to educate the local people and build their climate change awareness. Some teachers including myself need to be trained. When I did your questionnaire, that was the first time for me to look up for any information about climate change…

4.5.9.4 Fatongia fakafo’ituitui – matu’a moe fanau ‘i ‘api (Individual roles – roles of parents and children at home)

It was argued by one participant that the parents at home need to educate their children at home. He believed that parents could play a role on re-emphasising some of the Tongan values to the children. He said:

> Parents should re-introduce the Four Pillars to be the foundation of every Tongan families: *Faka'apa'apa* (respect), *Anga fakatokilalo/loto tō* (humility), Tauhi vaha'a (reciprocation), *Mamahi'i me'a* (patriotism) (Siua, 52, TFG1)

Siua thought that if the young people are educated with the values of faka'apa'apa, anga fakatokilalo/loto tō, tauhi vaha'a, and mamahi'i me'a, then they would be likely to be willing to address climate change in Tonga. In this view, every individual is responsible for respecting the environment by not cutting down trees, show humility when engaging with the environment, and the value of tauhi vaha'a should be encouraged as well so that individuals keep a healthy relationship with their environment. When everyone is holding the value of patriotism, then they will develop a sense of belonging to the environment.

Teachers' knowledge about mitigation and adaptation measures were also examined. Mitigation refers to "efforts to prevent climate change, and thus prevent future climate impacts, through intentional alteration of the climate system" (Pielke, 1998, p. 161). Adaptation to climate change can be regarded as adjustments in natural or human systems in response to actual or expected climate stimuli and their effects, which moderate harm or exploit beneficial opportunities (McCarthy et al., 2001). The findings indicate that during the talanoa fakatokolahi, teachers focused on actions that are quite common in Tonga. When asked what they could do to stop climate change, planting trees and refrain burning rubbish were the two answers that most participants suggested. In addition to that was the concept of the fatongia. These may reflect the fact that teachers had limited understanding about other adaptation and mitigation measures to address climate change.

4.6 Attitudes about climate change

This section presents data on students' attitudes towards climate change. In this research, the meaning of attitude refers to a set of dispositions and feelings of concern about climate change (Dooms, 1995). Data are presented from the questionnaires and talanoa fakatokolahi.

4.6.1 Students' attitudes about climate change

Five items were designed in the questionnaire to explore students' attitudes about climate change. Concern about climate change was high among students. The majority of the participants (99%) either strongly agreed or agreed with the statement *I am concerned about climate change* and only 1% was unsure. These results are shown in Figure 12.

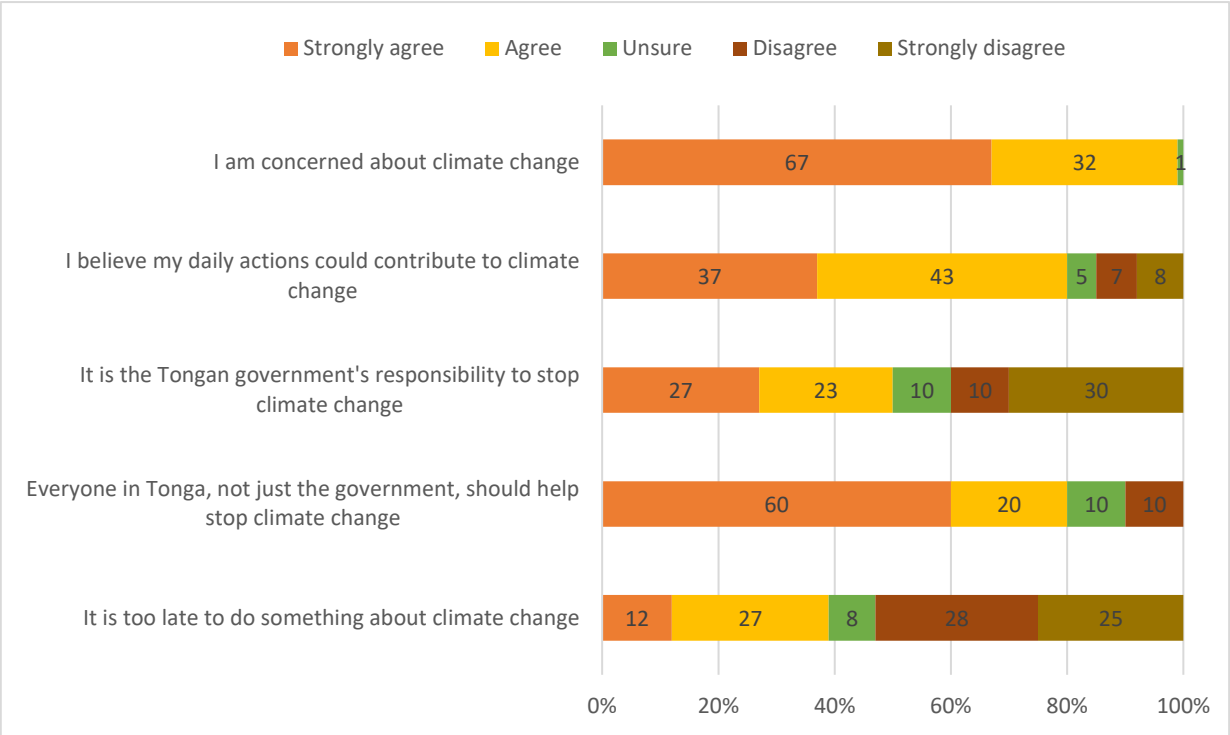


Figure 12 *Percentage and distribution of students' responses about their attitudes towards climate change*

To get insight into what students believe about their daily actions and their contributions to climate change, they were given the item, *I believe my daily actions could contribute to climate change*. A majority of the students (80%) either strongly agreed or agreed that they believe their daily actions could contribute to climate change, 5% were unsure, and 15% were either disagreed or strongly disagreed with the statement. A similar majority of students (80%) students also either strongly agreed or agreed that everyone in Tonga, not just the government should help stop climate change. In contrast, when students were asked to state whether it is the Tongan government's responsibility to stop climate change or not, only fifty percent supported this statement and a number of the students (40%) either disagreed or strongly disagreed that it is the Tongan government's responsibility to stop climate change, and 10% were unsure. In other words, these two items indicate that students appear to believe that it is not just the government's responsibility to stop climate change, but it is everyone's responsibility to stop climate change. Fifty three percent of the students either disagreed or strongly disagreed that it is too late to do something about climate change. In other words, a majority of the students (53%) agreed that it is not too late to do something about climate change. Eight percent were unsure, and 39% of the students were either strongly agreed or agreed that it too late to do something about

climate change. These findings indicate that although a slight majority (53%) believed that there was hope to do something about climate change, there was a sizeable proportion (39%) of students who did not have hope.

To gain more insights into students' attitudes about climate change, they were asked in the talanoa fakatokolahi, *Are you concerned and worried about climate change?* All students (100%) who took part in the talanoa fakatokolahi expressed concern about climate change.

The impact of sea level rise was a particular concern of the students. Two main reasons why students were so concerned about sea level rise were: fearing of losing their land to sea level rise; and fearing of losing family and friends due to relocation or migration. They shared stories about family and friends who were already relocated further inland due to their houses being taken over by sea water. Pulotu, a male student from the SFG 2, reported that:

> In my village, one family used to live near the sea, they have now moved and live further inland as their house is now flooded with sea water. It concerns me because we have lost a neighbour, and our connection with this family is distanced because their house is a bit further away (Pulotu, SFG 2).

The increasing extreme weather events that the people of Ha'apai currently experience was also a concern. For example, the category 5 Cyclone Ian that hit and destroyed about 90% of the island in 2014 was frequently mentioned by the students as one of the scariest cyclones they have experienced in their lives. One student mentioned that most families in Ha'apai could not afford to build strong houses to withstand strong cyclones, and that worried her a lot. She said:

> …it worries me because tropical cyclones are now increasing in frequency and intensity. What worries me the most is that, here in Ha'apai, there is not enough strong houses to protect the people. There is no safety hub for families whose houses were affected by the cyclone (Nau, SFG2)

Due to the impact of increasing temperatures, students were concerned about the health of their families. One student said that she thinks about her father every day when he is working in the plantation. On a very hot day, she was so worried about her father, whether he was feeling fine in the plantation or not.

4.6.2 Teachers' attitudes about climate change

To get insights into teachers' attitudes about climate change issues, five items were given in the questionnaire for teachers to indicate their agreement to each item. The percentage and distribution of teachers' responses to the 5 items are indicated in Figure 13.

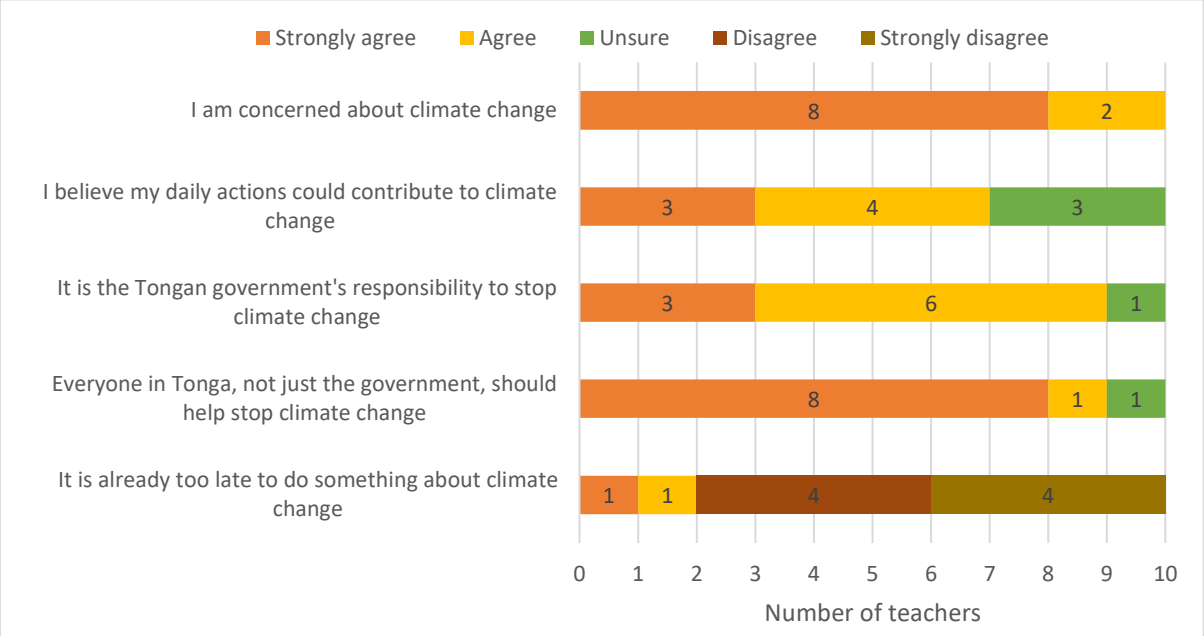


Figure 13 Number of teachers' responses about their attitudes towards climate change

To explore teachers' level of concern about climate change, they were given the statement, *I am concerned about climate change*. All teachers either strongly agreed (80%) or agreed (20%) with the statement. This result indicates a high level of concern among teachers about the issue. In the questionnaire, teachers were asked to state whether their daily actions could contribute to climate change. The proportion who agreed was relatively low compared to the previous item [strongly agreed (30%) and agreed (40%)]. Thirty percent were unsure. This result indicates that although 100% of the teachers were concerned about climate change and 70% believed that their daily actions could contribute to climate change, some teachers appeared less certain in their feelings about whether their actions contribute to climate change or not. When asked in the questionnaire if it is the Tongan government's responsibility to stop climate change, 30% strongly agreed, 60% agreed

and 10% were unsure. In contrast, when teachers were asked whether everyone in Tonga should help stop climate change, and not just the government, a high proportion strongly agreed (80%), 10% agreed, and 10% was unsure. The findings indicate that teachers believe it is everyone's responsibility to help stop climate change, not just the government. A majority of the teachers (8 out of 10) did not agree with the statement: *It is already too late to do something about climate change*. This data showed that almost all teachers who participated in the talanoa fakatokolahi believed there was hope for something to do about climate change which is a positive sign for education in this area.

To gauge teachers' attitudes about climate change, they were asked again during the talanoa fakatokolahi, *How concerned are you about climate change?*, nine teachers admitted to worrying about climate change. A majority of the teachers stated that climate change is now a concern since it affects everyone in Tonga. They have witnessed the consequences of climate change both on the environment and on the people and that worried them to a great extent. As one said:

> The environment suffers from Cyclone Ian. The trees were gone, and everything was gone. The environment was completely destroyed (Pauline, 47, TFG2).

The above quote illustrates Pauline's concern about the disastrous effect of Cyclone Ian on the environment of Ha'apai. There were also a number of teachers who were concerned about the quality of water. It was obvious from the teachers' discussions that the underground water in Ha'apai is starting to turn salty and now believed to be unsafe for drinking. Siua (52, TFG1) said that he is quite concerned about the water quality in Ha'apai. Asked why he felt that way, he stated that water tanks could currently provide sufficient clean water to the people of Ha'apai. However, he wanted to emphasize the fact that in about ten years' time, his concern about the water quality in Ha'apai is likely to be greater.

Climate change also became a concern when teachers started to think and to talk about their grandchildren and the future generations of Tonga. Without discussing in further details about how the future generation would be affected by climate change, it appeared from the discussions, that the teachers were concerned about this. For example, Siua (52, TFG1) reported his concern for his children and his grandchildren.

There was also a concern which emerged from the talanoa fakatokolahi data about the status of people's awareness and understanding about climate change, which may hinder concern about climate change. Salome (28, TFG1) verified this by saying, "I think I may be the only one in my village who is concerned about climate change, and it may be attributed to my background knowledge about climate change. The people in my village may not be concerned about climate change because they do not really understand about it". Siua (52, TFG1) concurs with Salome by stressing that some people in Ha'apai are already affected by the impacts of climate change such as rising sea level, but they do not want to really consider it a problem. He said, "…some people are affected…their houses are affected but they don't worry…". This data can also indicate that lack of understanding and awareness may influence level of concern about climate change.

However, there was one teacher who reported that she was neither concerned nor worried about climate change. According to her story, she said that she learnt from her grandparents that they should be satisfied with what God has given to them. She stated:

> I am not at all worried about climate change. As a little girl, my grandparents taught me and my other siblings that we have to be satisfied with whatever God has given to us. They said that God will protect us no matter what, and that understanding has been ingrained in my heart, so, for me: God will look after me and he will protect me from the impacts of climate change. It sounds selfish but I still stick to what my grandparents said (Lavinia, 44, TFG1).

Lavinia's response indicates that her Christian belief and her upbringing had impacted her feelings and attitudes about climate change.

4.7 Motivation to Act

This section presents data on students' and teachers' motivation to act to address climate change. Data are presented from questionnaires and talanoa fakatokolahi.

4.7.1 Students' motivation to act

While 99% of students expressed concern about climate change, students also showed high levels of motivation and willingness to act upon climate change. Five items in the questionnaire eliciting students' motivation to act present a relatively high proportion of

students willing to do something about climate change. Figure 14 presents the percentage and distribution of the students' responses.

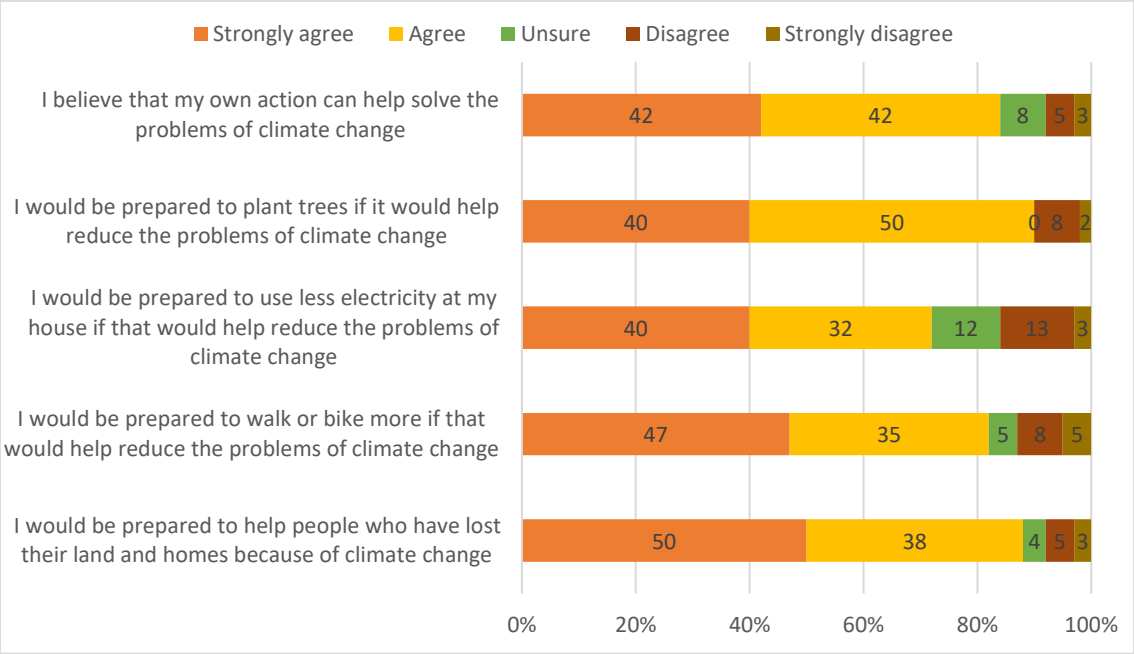


Figure 14 *Percentage and distribution of students' responses about their motivation to act upon climate change*

The students were asked whether their own actions can help solve the problems of climate change, and a majority of the students (84%) either strongly agreed or disagreed with this, while there were 5% who were unsure and 13% who were either disagreed or strongly agreed. This data indicated that while most students felt some agency in their own actions, there was a small number of students who did not believe their actions can help solve the problems of climate change. Out of the five items given, the statement, *I would be prepared to plant trees if it would help reduce the problems of climate change* scored the highest level of agreement. Ninety percent of the students either strongly agreed or agreed about the statement, and only 10% were either strongly disagreed or disagreed. This finding may be attributed to the knowledge that students indicated about how replanting is a way to address climate change.

When asked if they would like to walk and bike to reduce the impacts of climate change, a majority (82%) of the students either strongly agreed or agreed about the statement *I would be prepared to walk or bike more if that would help reduce the problems of climate change*, 12% were unsure, and only 10% were either disagreed or agreed with the

statement. Students were also given the statement, *I would be prepared to use less electricity at my house if that would help reduce the problems of climate change*. Seventy two percent either strongly agreed or agreed, 12% were unsure and 16% were either disagreed or strongly agreed with the statement. Data indicated that this is the statement that received the least agreement. The reason may have been attributed to students' lack of understanding in terms of how using less electricity may help reduce the problems of climate change. The actions that are mentioned in these latter two statements are examples of mitigation measures. The IPCC states that mitigation attempts to deal with the causes of climate change. It achieves this through actions that prevent the increase of atmospheric greenhouse gas concentration by limiting current and future emissions from sources of greenhouse gases and enhancing potential sinks (IPCC, 1996). Therefore, these findings indicate that many students were willing to engage in mitigation actions but that some were less willing, possibly due to other factors.

The last statement relates to climate adaptation, in which students were given the statement, *I would be prepared to help people who have lost their land and homes because of climate change*. A very high proportion (88%) of students either strongly agreed or agreed, 3% was unsure, 8% either disagreed or disagreed and about the statement. Their motivation to help people who have lost their land and homes could be linked closely to their high level of awareness and concern about the impacts of sea level rise in Ha'apai. The cultural concepts of tauhi vaha'a (maintain relationship) and 'ofa (love) within the village community in Tonga could be another reason for their motivation to help. Compared to the first three statements that deal with mitigation strategies, more students appeared to feel motivated to act upon climate change adaptation.

4.7.2 Teachers' motivation to act

To explore teachers' levels of motivation to act against climate change, five statements were given in the questionnaire. The number and distribution of teachers' responses to each statement are illustrated in Figure 15.

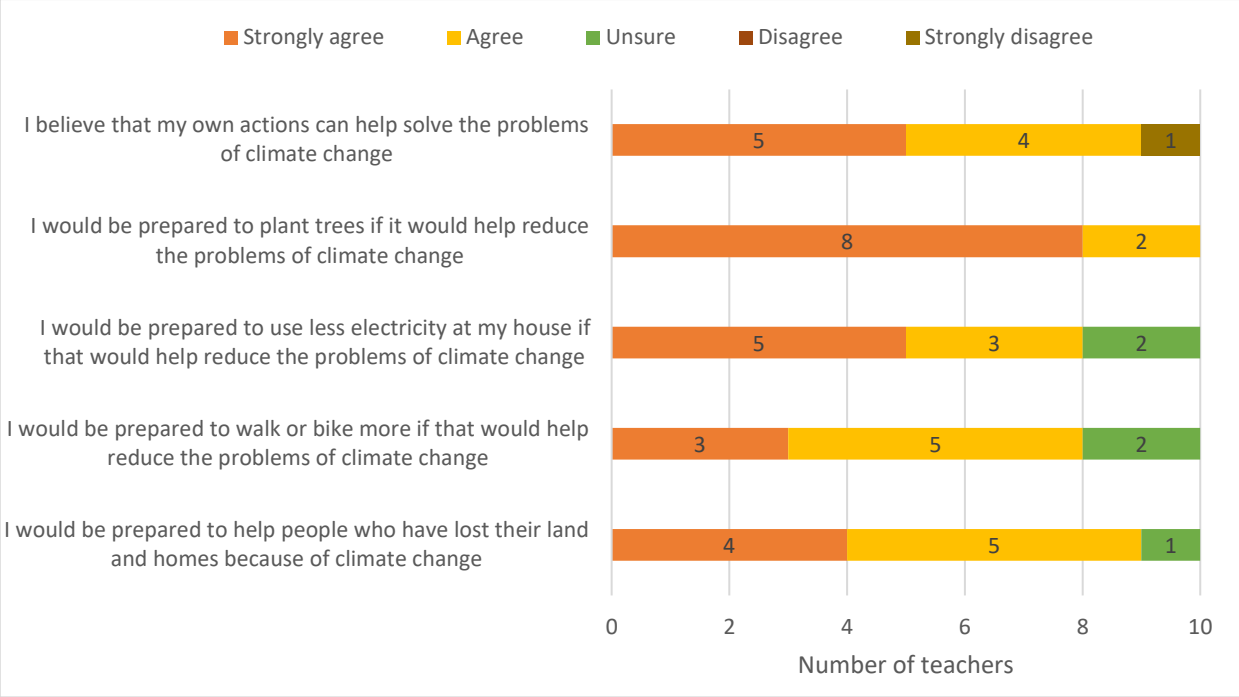


Figure 15 Number of teachers' responses about their motivation to act upon climate change

A high proportion of teachers agreed (5 strongly agreed and 4 agreed) that their own actions can help solve the problems of climate change. However, 1 teacher strongly disagreed. This result shows that despite the strong belief held by the majority of the teachers that their own actions can help solve the problems of climate change, one teacher did not believe that what they did would make a difference. Yet, when asked if they were prepared to plant trees if it would help reduce the problems of climate change, all teachers agreed. This finding is in line with the finding in Section 4.5.9 where teachers thought that planting trees could be the key way to mitigate climate change. In contrast, the next two statements also include mitigation ideas but some teachers appeared to be unsure. They were given the statement, *I would be prepared to use less electricity at my house if that would help reduce the problems of climate change*. Eight teachers either strongly agreed or agreed and 2 were unsure about the statement. Similar results were obtained from the statement, *I would be prepared to walk or bike more if that would help reduce the problems of climate change*. Eight teachers either strongly agreed or agreed with the statement, and two were unsure. This data may also be a reflection of how the level of knowledge and awareness about mitigation measures may influence one's motivation to act upon climate change. On the other hand, the last statement sought teachers' motivation to adapt to climate change. They were given the statement, *I would be prepared to help*

people who have lost their land and homes to climate change. Nine teachers reported being either strongly agreed or agreed with the statement.

To further examine the teachers' level of motivation to act and or to address the issues of climate change, they were asked to explain how likely are they to do something to help reduce the impacts of climate change. A majority of the teachers expressed their agreement to do something about climate change, however, they were not able to name a specific action to take. The teachers who discussed and expressed their concerns about climate change in the talanoa fakatokolahi were also the same people who indicated their willingness and motivation to act upon climate change. For example, Siua (52, TFG2) stated:

> For me personally, I am so concerned about climate change. This is the time, that we should do something to alleviate the negative effects of climate change…we should do something to stop climate change for the sake of our grandchildren and our future generations…I am so concerned about my children. We can't afford to just sit and do nothing…(Siua, 52, TFG2).

As discussed in Section 4.5.7, Siua was concerned about the future of his children and his grandchildren, and this has become the great motivation for him to address the issues of climate change.

Meleseini (48, TFG2) also indicated her keenness to help reduce the impacts of climate change. She expressed how worried she was about climate change first before she named her proposed actions to address the issue. She reported:

> I am so worried about the effects of climate change in Ha'apai. It is already happening, and we need to do something to help Ha'apai. There should be a focus on the solutions of climate change. I think the solutions are significant to be taught to the students. We have to give the students clear and accurate information about climate change. For example, you ask the student to pick up the rubbish, you also educate him or her to understand why he needs to pick the rubbish up (Meleseini, 48, TFG2).

4.8 Desire to learn about climate change

This section presents data about students' and teachers' desire to learn more about climate change. Data in this section are presented from both teachers' and students' questionnaires and talanoa fakatokolahi.

4.8.1 Students' desire to learn about climate change

To explore students' desire and willingness to learn more about climate change, they were given the statement, *I want to learn more about climate change at school*. The 5 point Likert Scale (1 – Strongly Disagree to 5 – Strongly Agree) was used to report the students' responses (See Figure 16). The data indicates that a majority of the students (78%) strongly agreed, and 17% agreed that they wanted to learn more about climate change at school. There was a small proportion of students (3%) who were unsure, and only 2% who disagreed and none of the students strongly disagreed with the statement.

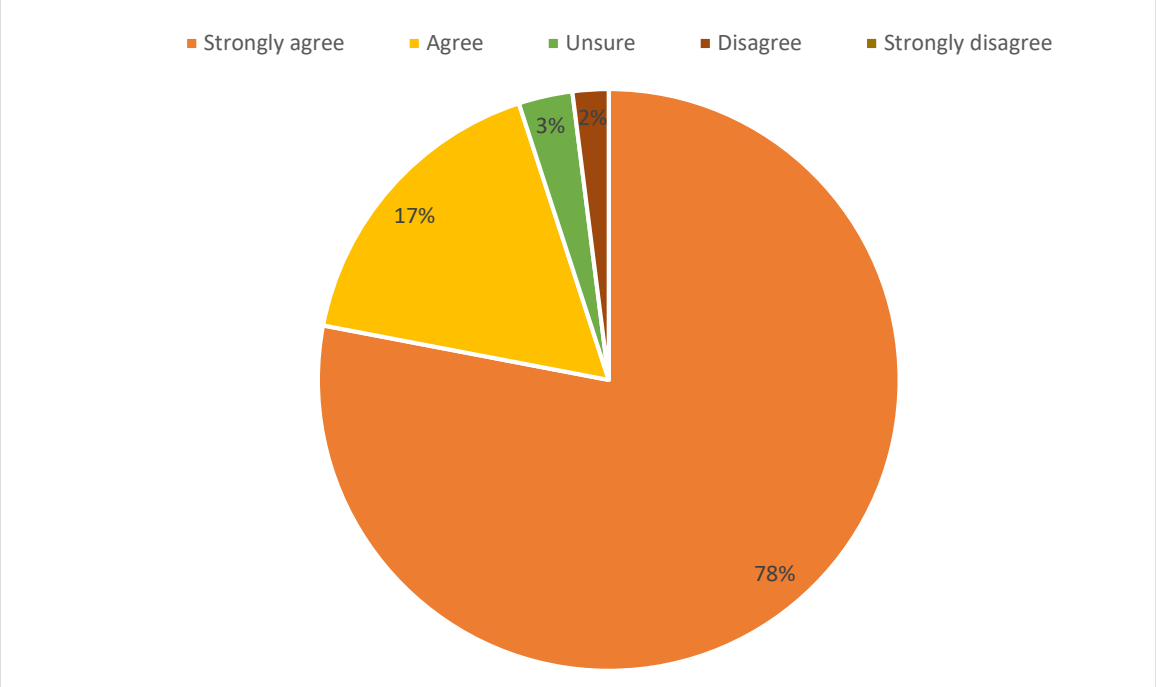


Figure 16 *Percentage and distribution of students' responses what they want to learn more about climate change at school.*

The students were then asked to suggest what they wanted to learn more about climate change. Consequently, seven items in the questionnaire were provided to identify the students' responses, and each item presented an aspect that students may wish to learn. They were asked to state whether they found each item *Very important, Moderately*

important, or *Not important*. The students' responses to each item are illustrated in Figure 17.

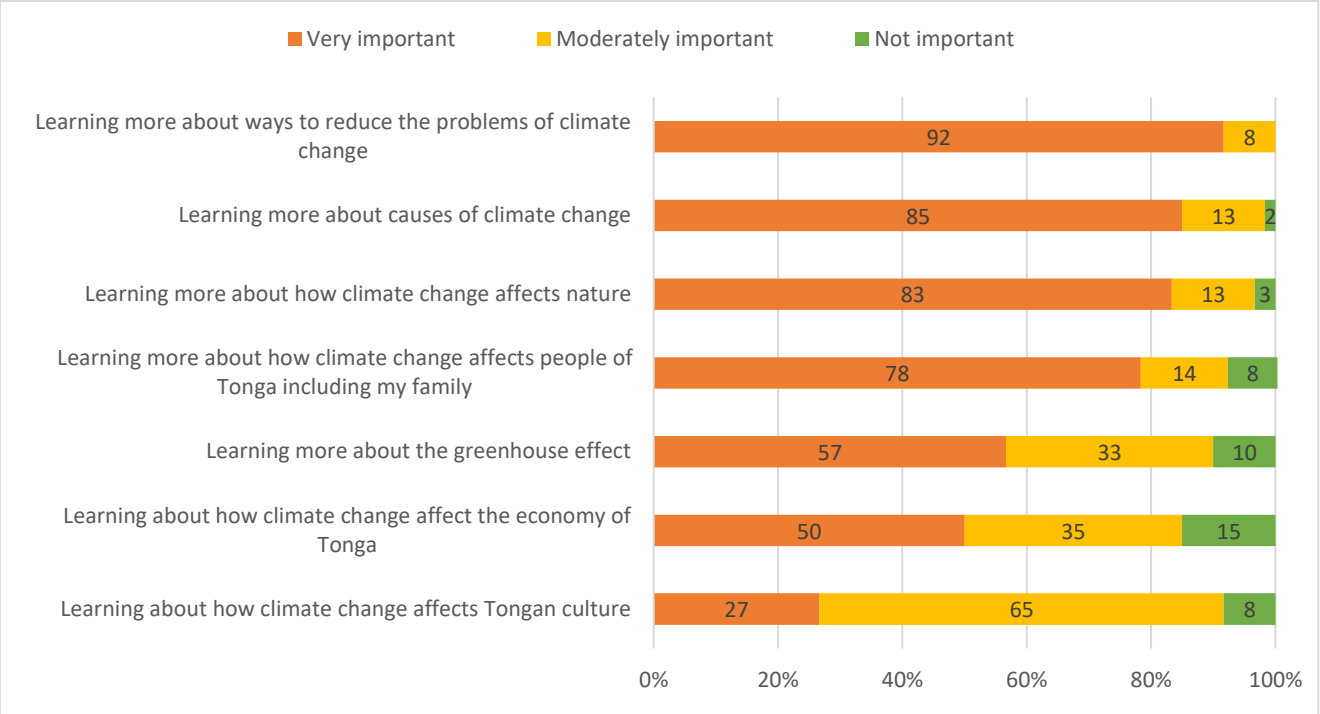


Figure 17 *Percentage and distribution of students' responses about their desire to learn climate change.*

Data indicates that of the seven items presented, students rated learning more about ways to reduce the problems of climate change most highly. A high proportion of the students (92%) considered *Learning more about ways to reduce the problems of climate change* very important and only 8% found it moderately. This data reflects the students' willingness to learn about ways to reduce the problems of climate change. Students also felt it is very important to learn more about causes (85% of students), and impacts of climate change on nature (83%).

When they were asked if they wanted to learn more about how climate change affects people of Tonga including their families, a majority of the students (78%) thought it was very important, 14% thought it was relatively important and 8% stated it was not important.

Data indicated that the percentage of students considered learning more about greenhouse effect very important was less (57% very important and 33% moderately important) . Similarly, when students were given the statement, *Learning about how climate change*

affects the economy of Tonga, only 50% considered it very important, 35% thought it was moderately important and 15% found it unimportant. Students rated learning about how climate change affect Tongan culture lowly. Only 27% thought it was very important, 65% considered it moderately important and 8% regarded it unimportant.

During the talanoa fakatokolahi, further insights into students' desire to learn about climate change were seen. Findings appeared to be aligned with the data presented in the questionnaires, although not all students were able to state what their motivations might be. Students considered learning about ways to reduce climate change the most important. A few students indicated that they take responsibility for their actions, and they wish to learn about ways to help reducing climate change. Saunia (SFG 2) said that, "I wish to learn about solutions. My individual actions contribute to climate change, so I need to learn about what I can do to help". Learning about how to cope with climate change was also highlighted by Aisea and Pulotu, (both from SFG 1) so that they know what to do when there is a cyclone. Not only that but they also felt sorry for the people because they are affected by climate change.

A high proportion of students also thought that learning about causes of climate change is very important. Akosita (SFG 3) highlighted that it is important for her to first learn about causes of climate change and then learn about the solutions to deal with climate change. Learning about impacts was also considered important by a small number of participants.

4.8.2 Teachers' desire to learn about climate change

To gain an understanding about teachers' willingness to learn more about climate change, they were given seven items and they could state whether the statement was very important, moderately important or not important to them. Figure 18 presents the percentage and distribution of the teachers' responses.

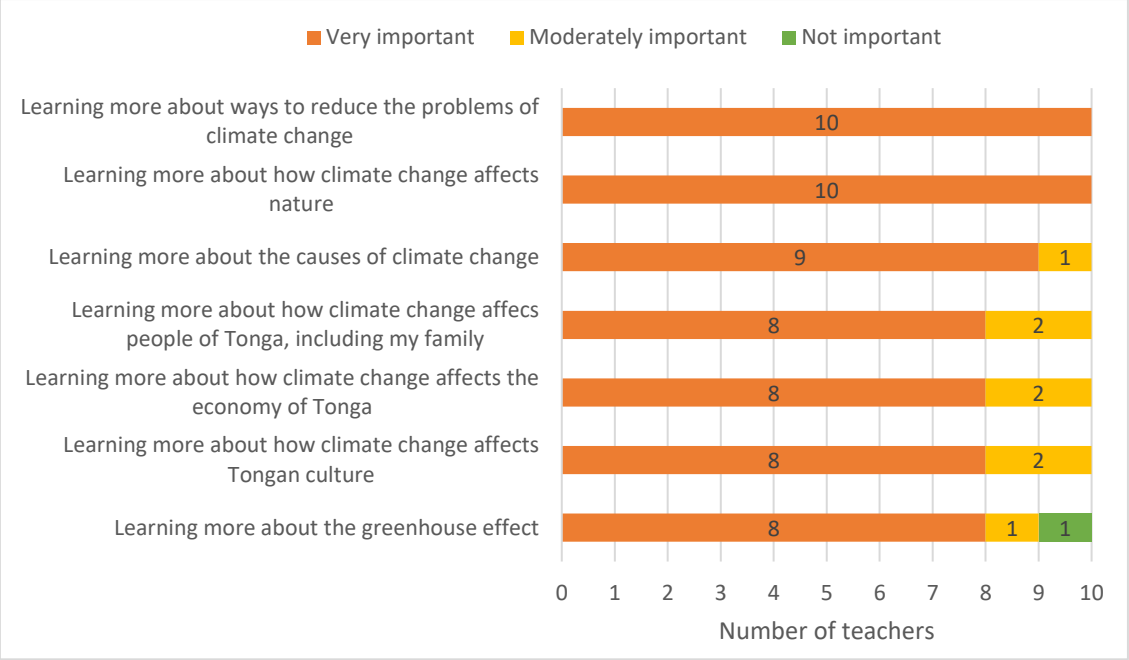


Figure 18 *Numbers of the teachers' responses about their desire to learn about climate change.*

Out of the all the items presented, teachers rated *Learning more about ways to reduce the problems of climate change*" and "*Learning more about how climate change affects nature* the most important. All participants (100%) felt that the two items were very important. A very high proportion (90%) of the teachers also felt that it is very important to learn about the causes of climate change and only one felt that it was moderately important. Similar results were obtained for the next three items, with 80% felt that it is very important to learn more about: how climate change affects the people of Tonga including their families; how climate change affects the economy of Tonga; and how climate change affects the Tongan culture, and only 20% felt they were moderately important. Similarly, 80% of the teachers felt it is very important to learn more about greenhouse effect, 10% rated moderately important, and only one rated it unimportant.

To explore more on teachers' desire to learn more about climate change, they were asked in the talanoa fakatokolahi, *Do you want to learn more about climate change?* All teacher participants stated that they wanted to learn more about climate change. They also reported that the two most important aspects for them to learn about were: the causes of climate change and the solutions to reduce or to stop climate change. Teachers felt that improving their content knowledge would be very beneficial not only to them but to the students as well. A number of participants from both of the teacher's talanoa fakatokolahi highlighted that in order to teach climate change to the students effectively, they required

sufficient knowledge about the issues. When asked how confident they are in teaching climate change, Lavinia (44, TFG1) stated that,

> …From 1-10, I place myself at 3. I do not have substantial knowledge about climate change, so I have to go on Google and search for climate change information. I have to learn more about it otherwise the students will ask questions.

4.9 Chapter summary

This chapter explored students' and teachers' awareness, knowledge and attitudes of climate change, their motivation to act and their willingness to learn more about climate change.

Section 4.3 reported the students' and teachers' perceptions about their connections to the place. The findings indicate that the participants do connect to Ha'apai island in various and significant ways. For instance, participants who were born and raised in Ha'apai were naturally and emotionally attached to the place, whereas the participants who came to live in Ha'apai for work explained how their connection to the place has been built over time on the basis of the safe and peaceful life they can lead there. Data indicated that there were main ways why the participants connected to the place: sea as sustenance of life; recreation; family place; and serenity.

Section 4.4 presented teachers' and students' awareness of climate change issues. Data from the questionnaires and talanoa fakatokolahi indicated a high level of climate change awareness among students and teachers. Ninety nine percent of the students, and all ten teachers who participated in the questionnaire believed that climate change is happening. Ninety percent of the students and 9 teachers out of 10 who participated in the questionnaire agreed that climate change is a threat to the people and the environment of Tonga. Data from talanoa fakatokolahi indicated that climate change manifests in diverse ways: students and teachers are already experiencing its impacts. The three impacts of climate change that were frequently mentioned by students and teachers in the talanoa fakatokolahi were: sea level rise, extreme weather events, and temperature rise. The teachers' awareness of climate change seemed to be developed primarily from their personal observations and experience.

Students' and teachers' knowledge about climate change were explored in Section 4.5. In the questionnaire, the participants were asked to define climate change. Four aspects that were expected to be included in the participants' definitions were: change in climate over time; result of natural process, result of human activity; and examples of climate change. The majority of the students (51/60) and the teachers (9/10) mentioned only one or two of the aspects and focused particularly on discussing the impacts and activities causing climate change. Nine teachers and none of the students mentioned the aspect – 'change in climate over time' in their definitions. This could be influenced by the fact that the term 'climate' is used interchangeably for weather and climate in the Tongan language. Language appeared to be attributed to students' and teachers' lack of understanding about the connection of weather and climate.

Data reported that students (88%) and all the teachers (10/10) agreed that climate change can be attributed to human actions. Data from the questionnaires presented that 82% of the students and all 10 teachers agreed that burning fossil fuels have caused recent climate change, however, the talanoa fakatokolahi reported that students and teachers thought that climate change is attributed mainly to their localised activities, specifically burning rubbish and cutting down trees at their homes. Only a few believed climate change is caused by the industrialised countries, and majority of the participants blamed the local people in Tonga for the cause of climate change. Apart from carbon dioxide, both students and teachers barely mentioned other greenhouse gases such as methane and nitrous oxide to be contributors to climate change. The process of greenhouse gases and their contribution to climate change was clearly misunderstood by the participants. The process of greenhouse effect was conflated with the idea of ozone layer depletion. This demonstrated students' and teachers' lack of knowledge about the science around climate change. Data from the questionnaires and the talanoa fakatokolahi reported that students and teachers had a decent understanding about the environmental impacts of climate change but less on economic, cultural and social impacts. Findings also indicated that students' and teachers' understanding of climate change impacts were influenced by their personal observations and experiences. Rising sea levels and increase in extreme weather events appeared the most discussed impacts during the talanoa fakatokolahi. Talanoa fakatokolahi allowed the participants to express emotions about these impacts posing more direct effects on their lives. Findings for students' and teachers' knowledge about ways to alleviate climate change indicated that they lacked the understanding about

possible mitigation and adaptation measures to address climate change. Building sea walls as an adaptation measure for sea level rise appeared not to be a potential way to deal with climate change for some students and some teachers. This is supported by data from the questionnaires – 58% of the students and 3 teachers out of 10 either strongly disagreed or disagreed with the statement that building sea walls could help reduce the problems of climate change. Refraining from cutting down trees and burning rubbish were the two main ways that the majority suggested as ways to address climate change. Overall, data demonstrated a lack of understanding about ways to mitigate and adapt to the impacts of climate change among the students and teachers.

The students' and teachers' attitudes about climate change were examined in Section 4.6. Data from the questionnaires (Section 4.6.1 and Section 4.6.2) reported that students and teachers have high levels of concern about climate change and they believed their daily actions contribute to climate change. The findings also reported that most of the students and the teachers felt that everyone in Tonga, not just the government, should help stop climate change. Data indicate that both students and teachers are concerned about losing their land to sea level rise and fear losing family and friends due to relocation or migration. Due to their experience of the recent Tropical Cyclone Ian in 2014, students are more concerned about the safety of their family and the people of their island. One teacher highlighted that he's concerned about his children and grandchildren. Poor water quality also appeared as a concern by some of the teachers. Out of the ten teachers who participated, only one teacher seemed not to be concerned about climate change. Her Christianity belief and her grandparents' advice have led her to believe that she will be saved by God, and that everyone should be satisfied with what God has given to them. This highlights the fact that the Christian beliefs can be a factor that can possibly impact people's concern about climate change.

Students' and teachers' motivation to act against climate change was explored in Section 4.7. Data indicated that students and teachers believed their own actions can help solve the problems of climate change. Having observed and experienced the impacts of climate change in several ways, both students and teachers had a high level of motivation to address climate change in Tonga. However, students and teachers showed uncertainty about actions and solutions to mitigate or to adapt to the impacts of climate change. They wanted to help reduce the problems of climate change but do not know what to do.

Section 4.8 explored students' and teachers' desire to learn more about climate change. Data indicated that the two main aspects of climate change that most students and teachers found very important to learn about were: learning about ways to reduce the problems of climate change; and learning about the causes of climate change. The aspect that seemed not to be rated very important by the students was learning about how climate change affects culture, which correlates with the data in Section 4.5.6, where students showed little understanding about how climate change affects cultural matters. However, most of the teachers thought that learning about how climate change affects Tongan culture is very important.

The next chapter presents the findings which indicate the place of climate change in the school curriculum. In the same chapter, the guiding principles for the climate change education intervention are presented. A brief description of the nature of the intervention is also outlined in this chapter.

Chapter 5: Findings – Philosophy of Intervention

5.1 Introduction

Chapter 4 has presented the findings focusing on students' and teacher's perceptions of climate change. In this chapter, Section 5.2 presents data from two of the Government Ministries, namely Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC) and Ministry of Education and Training (MET), regarding their policies towards climate change education. Section 5.3 reports the views of the Phase 1 participants about the place of climate change in the school curriculum. Section 5.4 synthesises the Phase 1 findings with the recommendations from the literature on the effectiveness of using talanoa to teach and learn about climate change in the Tongan classroom. A brief description of a Professional Learning Development session is presented in Section 5.4.1 in which the three ideas of talanoa are introduced. Section 5.4.2 reports the description of the teaching unit which is further clarified in the next chapter.

5.2 Document Analysis

This section reports the findings that were obtained from analysing these documents – Tonga climate change policy, Tonga Education policy, Tonga school curriculum, and Class 10 Science and Geography syllabi.

5.2.1 Climate change Policy

The policy documents of the MEIDECC and MET were analysed in order to explore what they mention about climate change education. The key findings are illustrated in Table 9.

Table 9 What the policy documents note about climate change education

Policy	Department	Climate Change Education inclusion
Tonga Climate Change Policy – A Resilient Tonga by 2035	Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC)	Out of the 20 targets stipulated in the Tonga Climate Change Policy, target 16 indicates that Education for resilience is incorporated into curricula at all levels of primary, secondary and tertiary education.
Tongan Education Policy Framework 2004-2019	Ministry of Education and Training (MET)	Climate change does not feature in the Tongan Education Policy Framework.

Table 9 shows that in the MEIDECC policy (Ministry of Climate Change Meteorology Energy Information Disaster Management Environment Climate Change and Communications, 2016) there is a target in place to address climate change and embed it in the curricula at all levels of primary, secondary and tertiary education. The MEIDECC established the Tongan Joint National Action Plan 1 (JNAP 1) which comprises six priority goals of which goal number 2 relates to education. It states: "Enhanced technical knowledge base, information, education and understanding of climate change adaptation and effective disaster risk management" (Ministry of Environment and Climate Change (MECC) and Ministry of National Emergency and Management Office (NEMO), 2010, p. 6). The JNAP 2 was released in 2018 to provide some updates on what had been achieved from JNAP 1. JNAP 2 indicates that Tonga's education system is slowly moving towards integrating climate change into the national curriculum. It also highlights considerable work needed to train teachers and resource this integration in a systematic way (MEIDECC, 2018). Developing child-centred approaches to climate change education is also recommended by JNAP 2 to be highly beneficial to Tonga as it offers a powerful pathway to advancing climate change knowledge and resilience, not only of children, but also of the entire community (Ministry of Meteorological Energy Information Disaster Management Environment Climate Change and Communications, 2018).

Despite the plan that is put forth by the MEIDECC, it is clearly illustrated by Table 8 that climate change does not feature in the MET policy. This is problematic because the

MEIDECC policy, and the JNAP 1 and JNAP 2 plan to fully integrate climate change education into the school curriculum, yet the Education policy does not mention teaching and learning about climate change. The MET is responsible for implementing climate change education and it is crucial that they work alongside the MEIDECC in order to establish climate change education in the Education policy. If the MET will not support this, then the implementation of climate change education in schools may not have the opportunity to happen.

The Tonga curriculum framework was then analysed to examine the existing place of climate change education in the curriculum (Ministry of Education and Training, 2016). Although the analysis of the curriculum framework indicates no mention of climate change education itself, the inclusion of Education for Sustainable Development (ESD), Education for sustainable livelihoods, and Tongan cultures and values in the five overarching themes could be potential to include climate change as a context for learning. Education for sustainable development (ESD) in the Tongan context embraces the Tongan people's closeness to nature and dependency on the land and the ocean (Fua et al., 2008). ESD is identified in the Tongan curriculum as allied to environmental education:

> Education for Sustainable Development (ESD) is inseparable from environmental education. People's social and economic needs and national development depend on, and affect, the environment. And, since natural resources are limited, and environments are fragile, conservation and management of the environment is a precondition of development that is sustainable (Ministry of Education and Training, 2016).

The above quote indicates that there is a possibility the climate change, which considers the social, economic and environmental impacts of people's actions, can fit under the curriculum's requirement for teaching and learning about ESD. To explore the place of climate change in the Tongan school Class 10 syllabus, the Class 10 Geography syllabus and the Class 10 Science syllabus were analysed to examine the status of climate change. This is discussed in the next section.

5.2.1 Climate change in the school syllabi

The Class 10 Geography syllabus has not been reviewed recently. It appears from the findings that the syllabus that the schools are currently using was written in 1994. As this predates much of the current concern about climate change, it would be reasonable to expect little mention of climate change in this document.

The Class 10 science syllabi was reviewed and published in 2016 by the Tonga Ministry of Education, and as such could be expected to include mention of climate change as a key context for learning for students of Tonga. The Tongan science syllabus for year 10 has 5 strands – The Living World, The Physical World, The material World, Plant Earth and Beyond, and Scientific Skills and Attitudes. Of these 5 strands, only Planet Earth and Beyond appeared to mention anything related to climate change education in Class 10. Table 10 indicates the topics that are taught in Class 10 which are related to climate change.

Table 10 *Class 10 – Strand 4: Planet Earth and Beyond – aspects related to climate change*

Learning Outcome: After this *Strand 10.4 – Planet Earth and Beyond*, students are to explain the composition, structure and features of the Earth's atmosphere, geosphere, hydrosphere and biosphere; factors affecting Tonga's weather and the global climate; and some advice and guidelines to follow before, during and after natural disasters such as cyclones, tsunami and earthquakes.

STRAND 10.4: PLANET EARTH AND BEYOND

What students are to KNOW	What Students are to DO	Skill Level	IA/EA
	Earth System		
1. Definition of the atmosphere, geosphere, hydrosphere and biosphere	i. Define atmosphere, geosphere, hydrosphere and biosphere	1	IA
2. Greenhouse gases and their effects.	i. Name the greenhouse gases and also discuss their effect	1	EA
	Atmosphere		
3. Composition, structure and features of the atmosphere;	i. Describe the composition, structure and features of the atmosphere.	2	EA
4. Factors affecting Tonga's weather and the global climate;	i. Explain the differences between weather and climate.	3	EA
	ii. Identify and describe factors that determine the Earth's climate and Tonga's weather.	2	EA

5. Ozone and how it relates to global warming	i. Describe ozone and its nature (physical and chemical), write its chemical formula,	2	EA
	ii. Describe how ozone is naturally formed, and places of common occurrences,	2	EA
	iii. List the functions of ozone in the atmosphere.	2	EA
	iv. Explain using equations how chlorofluorocarbon, CFC from refrigerators and air conditions can affect a lot of ozone molecules; and use this example to explain one of the causes of 'ozone depletion'	3	EA
	v. Differentiate between effects of ozone depletion and 'green-house effect' on global warming and human lives.	3	EA
6. Origin and nature of some natural disasters;	i. Discuss by revising the origin, nature of natural disasters (year 9) • Cyclone • Tsunami • Drought	3	IA
	ii. Discuss the causes and impacts of floods – hot spots of vulnerable areas for floods	3	IA
	iii. Describe appropriate advice or guidelines to follow before, during and after cyclones, earthquakes and tsunamis.	2	IA
	Hydrosphere		
7. Composition, structure and features of the hydrosphere;	i. Describe the composition, structure and features of the hydrosphere.	2	EA
8. Features and the importance of the water cycle and ocean circulation	i. State the important properties of water and describe its ability to be a universal solvent.	2	IA
	ii. Explain the features and importance of the water cycle	3	IA
	iii. State its six main parts (evaporation, transpiration, condensation, precipitation, runoff and sublimation).	2	IA
	iv. Describe the features of the ocean circulation and its importance of the world.	2	IA
9. Water management and natural disasters	i. Describe the different aspects of the water that are essential for healthy living in the local communities.	2	EA
	ii. Describe effective ways of managing water for human consumption after natural disasters.	2	EA
	Geosphere		
10. Composition, structure and features of the geosphere.	i. Describe the composition, structure and features of the geosphere.	2	EA
	Biosphere		
14. Composition, structure and features of the biosphere.	i. Describe composition, structure and features of the biosphere.	2	EA
	ii. Explain how the terrestrial and marine life influences the composition and production of greenhouse gases.	2	EA

(Adapted from Ministry of Education and Training, 2016, pp. 44-45) Note: IA – Internal Assessment, EA – External Assessment.

The term climate change is not explicitly mentioned in Table 10. However, the elements that are outlined in the syllabus are closely related to climate change and this is discussed

next. In the first sub-section, Earth System, students are required to define the four earth systems: Atmosphere; Geosphere; Geosphere; and Biosphere. Students would be able to learn about each system and their interrelationships with one another. This can also be an effective introduction for climate change where students may be aware about the possible impacts if one of the earth systems may be disrupted or be destroyed, most likely by human beings.

To study about climate change, Greenhouse gases are mentioned specifically under the Earth System but students are only required to name the greenhouse gases and to discuss their effects. The syllabus does not appear to give a specific mention of human-induced greenhouse gases. The greenhouse effect and how it links to the cause of climate change is also missing in the syllabus.

Apparently introducing ozone depletion in sub-topic 5 (Refer to Table 10) can be problematic. Weather and the global climate are included in number 4 and since ozone depletion is the next topic, there is a potential that students can develop some alternative conceptions about the ozone depletion. However, it is interesting to note that in the syllabus, the students are required to differentiate between effects of ozone layer depletion and greenhouse effects on global warming and human lives (Ministry of Education and Training, 2016). Since climate change and global warming are used interchangeably in some contexts, it is very important for the school syllabus to also identify the differences between climate change and global warming.

The next section explores different participant views about the place of climate change in the school curriculum.

5.3 Views about climate change and its place in the curriculum

This section discusses the perceptions of teachers, students and officials from the Ministry of Education and Training (MET) and from the Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate change and Communications (MEIDECC) about the status of climate change in the school curriculum. Data were collected from talanoa fakatokolahi - two teachers' and three students' talanoa fakatokolahi, and talanoa fakataautaha - two officials from the Ministry of Education and one official from the Ministry of Climate Change, and two school Principals. Three themes that arose from the analysis of the data were: Lack of inclusion of climate change

education in the syllabus; a call for effective climate change programmes and climate change resources; and a call for an effective climate change syllabus. These themes are presented in the next sections.

5.3.1 Lack of inclusion of climate change education in the syllabus

Data from the talanoa fakatokolahi reported that both students and teachers believe the issues of climate change are not effectively addressed in the school curriculum. Teachers teaching science asserted that the text books currently used do not contain enough climate change information and that this hindered their ability to teach climate change issues. Lavinia, a female teacher (44 years old) from TFG 1, said:

> I just learnt about climate change from the Class 10 science text book, and for me, the information there is too general. If I teach climate change according to the information in the text book, the students will not learn much about climate change. So I think, the Ministry of Education should do something and include climate change issues in more detail… (Lavinia, 44 TFG 1).

One Geography teacher who participated in the TFG2 also talked about how climate change issues are poorly addressed in the Geography syllabus. He said:

> I teach Geography, and only about 1% of the syllabus says something about climate change, but that is only talking about deforestation and etc, there is nothing much about climate change. The students won't have deep understanding about the issues (Samison, 29, TFG 1).

Teachers who participated in the talanoa fakatokolahi were asked to rate from 1-10 how confident they are in teaching climate change (1 = Not confident all, 1 = Very confident). Nine teachers that participated in the talanoa fakatokolahi were Science and Geography teachers, while one teacher was an Economics teacher. Nine out of the 10 teachers rated their confidence to teach climate change in the range of 1 to 5. These teachers believed that it is impossible to say they are confident to teach the issues because they have very limited knowledge about climate change issues. Asked whether climate change should be taught only in Science and Geography, all ten teachers agreed that climate change should be integrated into every subject including English, Tongan studies, Maths and Agriculture.

They believed climate change should be addressed from various perspectives. For example, Sekope (38, TFG 2) stated:

> I believe that each subject should address climate change from different perspectives. For example, Economics addresses climate change from the economic perspective, the Tongan subject examines climate change and how it may affect Tongan cultural matters, and in Science, they can think of ways to mitigate climate change, for example, think of ways to replace activities that are contributing to carbon emissions (Sekope, 38, TFG 2).

Data also indicated that teachers who participated in talanoa fakatokolahi made a specific recommendation that the syllabus be revisited to ensure that the issues of climate change are integrated across all subjects and all levels. Two teachers suggested that there should be one single subject called Climate Change to enable every student access to climate change information. Not every teacher seemed to agree with this idea, however, the majority of them supported the idea that climate change should be integrated into all subjects taught at school. There were also suggestions for the Tongan Institute of Education (TIOE) to include climate change and its related issues in their syllabus to make sure that student teachers are equipped with substantial knowledge before they became teachers in the classroom. Exploring the TIOE syllabus was beyond the scope of this study.

Students also demonstrated similar responses to those of the teachers. Data from the talanoa fakatokolahi indicated that students were not easily able to respond to questions about climate change as they appeared to lack knowledge on the subject. The students indicated that they had only been able to access climate change information in science and geography classes. The solutions to climate change issues in Tonga appeared to be the aspect that all the student participants wanted to learn, but they highlighted that even in science and in geography, they didn't get to learn about it. Lupe (SFG 2) said, "I need to see more in the syllabus, I need to know how to reduce the impacts of climate change…". The questionnaire data from Phase One indicated that 95 percent of the students believed that the information they were given in school on climate change overall was very limited and too general.

5.3.2 A call for effective climate change programmes and resources

> Students of Ha'apai do not have rich understanding about climate change issues. But when the problems of climate change are directly related to them, immediate action is needed to take place. To date, there has not been any visitations from the Ministry of Education or from the Ministry of Climate Change to educate teachers and students or to raise climate change awareness at schools here in Ha'apai, but we need people who have the knowledge to visit the schools and to run some awareness programs (Principal 1).

The above quote was given by a school principal during one of the talanoa fakataautaha. This participant stressed that students in Ha'apai are already facing the problems of climate change. He called specifically to the Ministry of Education and to the Ministry of Climate Change for some awareness programs to enrich students' knowledge on how to cope with the impacts of climate change. Data from the talanoa fakataautaha showed that the two principals who took part believed that it is significant to implement some awareness programs in Ha'apai. The impacts of climate change such as sea level rise are observed on the island but the students and the people need to understand how to deal with these impacts. One principal said:

> The students and the people on this island are not aware of the seriousness of this problem and to their lives and to the environment. It is very important for everyone to understand the issue because a healthy environment depends on how its citizens comprehend and act upon environmental problems such as climate change (Principal 2).

When the teachers were asked whether a climate change awareness program had been implemented in their school, all ten teachers who participated in the talanoa fakatokolahi gave negative responses. However, one teacher mentioned that she has experienced awareness programs at the previous school she was teaching in, but this school is on a different island. That program involved inter-school essay and drama competitions. Other teachers also believed that such programs should also be conducted in schools in Ha'apai. There was also a suggestion from the teachers that the curriculum should re-introduce traditional ideas such as using banana leaves to wrap the lū (Meat and coconut milk

wrapped in taro leaves). They believed this would help replace the aluminium foil now being used by Tongans to wrap the lū. As one said:

> In the syllabus, it should include some striking ideas…it would be more effective to go back and use old ways of cooking. Some are already aware but we need to use more ways to reinforce the kids. The MET should reintroduce the olden ways like using banana leaves for *lū*, you know some activities like that which may help students to cope with the impacts of climate change (Talita, TFG 2).

These teachers think that reintroducing the banana leaves may help to impact on the students' consumption, where buying aluminium foil contributes to the cause of climate change.

Data from the talanoa fakatokolahi indicated that all the ten teachers who took part in the talanoa fakatokolahi believed that the Ministry of Education should work together with the Ministry of Climate Change to provide some climate change awareness programmes to all schools in Ha'apai. It also appeared from the talanoa fakatokolahi that there is a lack of climate change resources at schools, which also reflected that the Ministry of Education has not provided such resources to help teachers teach climate change. Lavinia (TFG 1) stated, "The Ministry of Education should run climate change awareness programs and also to carry out activities such as waste management programs at schools". Data indicated that teachers who participated in the talanoa fakatokolahi heavily relied on the Ministry of Education and on the Ministry of Climate Change to deliver the resources and the programmes to the schools. This finding correlates with a study that was conducted by the United Nations Education, Scientific and Cultural Organization (UNESCO) on the community understanding of climate change in the islands of Samoa, Fiji, and Vanuatu, where teachers were reported to perceive climate change as an important issue and worth teaching but they were left constrained by a "lack of training on the issue and insufficient resources to make it easy to communicate content on climate change in the local context" (UNESCO, 2014, p. 27).

5.3.3 Suggestions for an effective syllabus

At one of the talanoa fakataautaha, an Official from the Ministry of Education (MET) and Training wanted to highlight that one of their key responsibilities was to ensure that the

students are learning about climate change, and to learn how to cope with the impacts of climate change. She said:

> The role of the Ministry of Education is to ensure that students will make effective contribution when leading the community, and to equip, empower and enable them to live in a normal way where they can adjust to the impacts of climate change…(Susana, MET).

She also added that "…climate change affects our economy, our livelihoods and our cultures. What we value in our society are affected…". Anitelu, also an official from the MET added that climate change is a very important issue, and that Tonga has already faced the impacts of climate change today and it's an everyday hazard. Anitelu named some observed impacts in Tonga such as sea level rise and seasonal instability. He focused heavily on the concept of Tā e langō kei mama'o, (Cutting wooden cradles in time), a Tongan proverb which refers to the importance of being well prepared for any upcoming events. Anitelu stated:

> …'Oku fiema'u ke tau tā e langō kei mama'o – It's good that we do consider this issue now before it's too late, otherwise our children and our grandchildren will blame us in the future because we didn't do anything to help…(Anitelu, Ministry of Education and Training (MET).

Susana wanted to stress that since climate change is relevant to everyday life and also can be considered as an 'everyday hazard', the curriculum therefore needs to make changes in that direction and the curriculum needs to be specific. Susana said: "For us, we need to go further and address climate change in practical ways. And how the future citizens of Tonga face the challenges in climate change and how they may overcome the challenges" (Susana, MET). She highlighted that the Ministry of Education needs to unpack climate change from the lower level upwards. When asked what subjects currently address climate change at schools, Susana mentioned that the climate change issue is addressed in the science and geography syllabus. She added that climate change is also addressed in the Tonga Culture and Society (TCS) and other subjects but in a different perspective. However, she did not provide a clarification on the ways that she thought these other subjects address climate change. Education for Sustainable Development (ESD) was also

mentioned by Susana as one of the themes of the Tonga Curriculum framework. ESD in the Tongan school curriculum considers the social, economic and environmental impacts of people's actions. Hence, Susana suggested that was the reason why climate change could be addressed by other subjects but in different ways, for instance, in English, students could be asked to write an essay about climate change.

This view somewhat contradicts data that were obtained from the teachers' talanoa fakatokolahi. Regardless of what may be in the syllabus, all teachers who took part in the talanoa fakatokolahi said that climate change issues were rarely included in their teaching. According to the teachers who taught geography for Class 10 level, they barely talk about climate change during geography classes. At the time of this study, the Geography curriculum was still under a review process. As mentioned earlier, geography teachers have been using a 1994 syllabus, which mentioned little in connection to climate change and that is likely to have contributed to issues of climate change not being addressed by these teachers. Climate change is included in the science syllabus for Class 9 and Class 10. However, teachers could hardly teach climate change in the classroom because they appeared not to have substantial knowledge about the issues due to lack of learning development programmes and also lack of climate change resources such as up-to-date text books.

It also appeared from the talanoa fakataautaha that the officials from the MET do expect teachers not to fully rely on what is provided in the syllabus but to go out and look for information. For instance, they could invite speakers from the Ministry of Climate Change to come and talk or ask the school principal to download climate change information from the internet. Susana highlights that the teachers do have the responsibility to search for information if the information provided in the syllabus is not efficient. She stated:

> A resourceful teacher has to look for information…The problem is that if they are hungry for information or hungry to learn, then they have the responsibility to look for information rather than expecting it to come…One visitor told me to tell my teachers to go extra mile, and not to focus only on what is given in the curriculum. They need to go beyond. (Susana, MET).

When asked how climate change can be effectively addressed in schools, Susana stated, "We need to focus on the 'Practical Know How'". She stressed that it is significant for both students and teachers to know how to deal with climate change, and teachers and students will both benefit if the lessons are practical. She highlighted that, "Most of them know about climate change from books, but it's good to actually get them to see the problems in person…", Anitelu also from the MET added that it is paramount to include environmental science in the syllabus and to encourage practical activities in schools. He said, "Planting native plants and vegetables are practical activities that should be encouraged at school, activities such as compost and recycling should be established at schools too…" (Anitelu, MET).

Revisiting the syllabus to include the traditional knowledge was recognised by Anitelu as an effective way to teach climate change in schools. He said that, "Traditional knowledge is vital to be integrated in the school curriculum. For example, the traditional farming methods. Today we use fertilizers, but in the past, people knew what crops to grow in each season, so it is important to integrate traditional knowledge in the curriculum". He considered it as an instrumental way for students to deal with climate change.

Lupe, the official from the Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communication (MEIDECC), elaborated on the two main ways to address climate change – mitigation and adaptation and how their department holds responsibility for projects that implement different adaptation strategies. She said that one of the project's components was looking at incorporating climate change into the curriculum. Similar to claims made by Susana from the MET, Lupe said that MEIDECC is working alongside the MET to ensure climate change is integrated into the curriculum. Susana said, "We are working together with MEIDECC and it's ongoing. We have a working community which compiles members from the MEIDECC and NEMO [provide full name here]". This finding indicates that the Ministry of Education and the Ministry of Climate Change are intent on integrating climate change into the school curriculum.

Data from the MET Officials indicated that there are informative resources such as posters and brochures about climate change that were developed by the Curriculum Development Unit and were sent out to schools across Tonga. One official said:

> We developed posters and brochures and gave them out to school last year. The question is: 'Where are they?' Are the teachers using them or are they sitting in the administration? We also developed study guide? But do they use it? (Susana, MET).

The officials also highlighted the fact that many teachers who are teaching climate change have not taught the issues before, which was also a challenge. This is aligned with the data from the teachers' talanoa fakatokolahi when they expressed their lack of confidence to teach the issues because they have not taught it before.

Findings also showed that the MET used to send an official to the outer islands, including Ha'apai, to train the teachers about the issues of climate change. Susana stated that in 2013, a climate change initiative was conducted where students were asked to design a climate change project. She said that it was another way of training the students to take part in finding solutions to address climate change and also to adapt to the impacts of climate change, and this program was piloted in outer islands. The problem as she saw it, is that some of those students had then moved to upper classes, and the teachers who used to run the programmes may have moved to different schools. This data showed that the implementation of such programmes were not ongoing from time to time. Anitelu from MET said:

> The young children or the future of Tonga depend on the educational programmes and kind of projects that is sustainable, projects that do not focus only on today, but they have to also consider the future…Education is for everyone to achieve the Excellence, Equality, Accessible and Relevance

Anitelu seemed to heavily emphasize the importance of running educational projects that are sustainable so that every child, today and in the future, will have the chance to access to an education.

5.3.4 Section summary

While students and teachers argued that there is a lack of inclusion of climate change in the school syllabus, the official from the MET pointed out that the climate change issue is addressed in the science and geography syllabus and a few other subjects including

Tonga Culture and Society. Similarly, both students and teachers indicated that they required effective climate change resources and awareness programmes in schools. However, the official from the MET announced that resources were already distributed out to schools including the schools in Ha'apai. These findings indicate there is a confusion between the two levels – the curriculum maker level and the school level. What also appears to be the gap here is that the climate change programmes that are running in schools especially on outer islands have not been sustainable. As suggested by the teacher participants and the Principals, provision of the climate change awareness programmes should be regular, so that every teacher and every student should equally access the same climate change information.

5.4 Guiding principles for the Intervention

In order to develop an effective curriculum and approach for teaching and learning climate change in Tonga, the key findings from Phase One as well as ideas derived from literature were considered. The key findings from Phase One are highlighted first followed by key ideas from literature. These are then distilled and integrated with the requirements of the Class 10 Science syllabus, and the Tongan school curriculum to establish principles for a climate change education intervention.

5.4.1 Key findings from Phase 1

The key findings from Phase One can be summarised in the following points.

- Teacher and student participants attributed their sense of connecting to the place, Ha'apai island, to the sea as sustenance of life, recreation, family place and serenity.
- Despite the high level of climate change awareness among teachers and students, their knowledge of the processes that lead to its cause were lacking and vague and teachers and students seemed to hold alternative conceptions. Teachers and students mistakenly thought that the hole in the ozone layer is what is causing climate change. They demonstrated very low understanding about the process of greenhouse effects and its contribution to the cause of climate change. It appeared that there is a conflation between the two concepts – the greenhouse effects and the ozone layer depletion.

- The participants were confused about the connection between weather and climate. Climate change was mainly defined by students and teachers as a condition of weather on a daily basis. However, this confusion can also be attributed to the term 'climate' being used interchangeably for weather and climate in the Tongan language.

- Human activities were the key contribution to the cause of climate change. The localised activities such as burning the rubbish and cutting down trees were what was causing climate change and that everyone in Tonga should be blamed. The industrialised countries were also to get the blame but people of Tonga should be blamed first. The participants considered humans and their attitudes to be the key driver for climate change.

- Knowledge about the impacts of climate change on the environment was fairly high among the participants, but low on its economic, cultural and social impacts.

- Climate change is a major concern to the students and teachers of Tonga and they had high motivation to do something to address climate change, but they lacked the understanding about the adaptation and mitigation measures to deal with climate change. Climate change also seemed to have an emotional effect, especially on the students.

- The majority of students and teachers want to learn more about the causes of climate change and ways to reduce or stop climate change. There is also a call to integrate climate change into the school syllabus and across all subject areas.

- There is lack of inclusion of climate change issues in the school syllabus. Practical Know-How is recommended as an effective way to teach climate change in a Tongan classroom. The four pillars of the Tongan society should be integrated in teaching climate change so the teachers and students can start from the basics.

- 'Practical Know How' should be effectively introduced in schools.

5.4.2 Key ideas from literature

These are the main key points from literature that helped to inform the climate change education intervention in this research.

- Climate change education must be framed strategically to promote mitigation and adaptation with an emphasis on the causes and impacts as well as required knowledge, skills, values and attitudes for effective mitigation using appropriate action-oriented pedagogies. Addressing the causes and the consequences of climate change requires content and methodologies that will build capacity in society for mitigation, adaptation, and transformability.

- Climate change education requires teaching and learning methodologies that are participatory, experiential, critical and open-ended. Climate change needs to be taught from an interdisciplinary perspective and it should also be focused on the wider social, political and economic processes that need to be transformed if climate change is to be meaningfully addressed. Education provision is likely to be more meaningful, and participation in learning processes more active, when programmes deliver knowledge and skills which are relevant to local contexts and needs.

- Pacific islands students learn best in a group; and Pacific Islands learners learn better from discussion (Jarvis, 1987). While the cultural emphases on communality and oral traditions are recognized, it is arguable that learning styles are directly related to cultural heritage. On the other hand, cognitive style is a product of socialisation (Jarvis, 1987). Through observation, listening, imitation, participation and some direct instruction, young people obtain the necessary knowledge, skills and values of their cultures, elders from adults and sometimes their peers. Learning is practical and directly related to shared values and beliefs

- Culturally relevant pedagogy informs students to understand that individually and collectively their voices are heard, that they matter, and their presence and contributions are valued. Such accomplishment will enable people's voices to be heard, acknowledged and accepted in the society in which they live. Culturally-inclusive curricula and methods with indigenous perspectives also help to create educational experiences that are more relevant to indigenous learners and to ensure that multiple and diverse intercultural perspectives are embraced in the learning environment.

- An effective curriculum can only be designed and implemented successfully if we understand where the students are in terms of their knowledge and disposition about

the issue. In order to educate the students, it is essential to identify what they already know and understand and how it differs from what they need to know in order to make effective decisions. Climate change knowledge is not a simple body of knowledge in that, depending on whether a student learns about causes, impacts of or responses to climate change, different concepts and skills are required.

- Thaman acknowledges the significance of integrating Tongan values and beliefs into global education initiatives such as education for sustainable development (ESD) at the regional and local level. One of the core values of indigenous education is 'relationship'; this is in connection with relationships among people, and relationship between people and nature. Thaman advocates that this indigenous education empowers knowledge and understanding of how people are related to one another, together with associated responsibilities and obligations (Thaman, 2010).

- Talanoa is suggested as a pedagogy that best explores the knowledge, strengths and merits of using the Tongan language and cultural practices in the teaching and learning of Tongan children (Lātū, 2009). Dilling and Moser (2004) recommend that teaching climate change has to be effective, concrete and doable, otherwise a message of fear will not produce reasonable responses to danger, but instead it will produce denial. Therefore, talanoa provides a platform for the participants to co-construct new solutions or knowledge (Vaioleti, 2013). Talanoa is an oral form of communication which enables people in the Pacific to learn, relate to each other, narrate, tell stories (Morrison et al., 2002; Tavola, 1991), it is an activity used for creating and transferring knowledge (Vaioleti, 2013) and it also allows people to talk from their hearts (Halapua, 2005b).

- The kind of talk within the classroom has a considerable impact on the processes of thinking and learning. Talanoa is suggested as an approach that best explores the knowledge and strengths in the teaching and learning of Tongan children. The Tongan system of supporting thinking, teaching and learning occurs through the verbal expression of talanoa. As the concept of talanoa has no time restrictions, it can lead to problems and conflict between 'slow' and 'fast' thinkers, with some people arriving at a decision more quickly than others. However, this does provide the opportunity for "slow thinkers" to be engaged in the discussions.

- The influence of social and cultural contexts on learning and knowledge construction is underscored in Vygotsky's social constructivist theory (Vygotsky, 1978). Vygotsky furthered the view that children's thinking and meaning-making is socially constructed and emerges out of their social interactions with their environment. Children's learning is facilitated by parents, peers, teachers, and others around them in the community and teachers too are learners in this context (Vygotsky, 1978). Developed by Vygotsky, the concept of social constructivism emphasised collaborative learning environments and social interactions (Barker, 2008). Vygotsky claimed that people create meaning through interactions and learning is a social activity; "human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around them" (Vygotsky, 1978, p. 88).

5.5 The nature of the intervention

The findings in Phase One indicated gaps in the current teaching and learning in climate change in Tonga which could be addressed through an intervention. Based on the key findings of Phase One and some important ideas obtained from the literature, a climate change education intervention was designed to be trialled at a secondary school in Tonga. Further details about the setting of this school are discussed in Chapter 6. One of the important features of the intervention was to marry talanoa as a Tongan cultural learning process and socio-constructivist perspectives on teaching and learning.

The intervention involved one science teacher, Lavinia, and her class. When discussing the possibility of implementing the intervention with her class, Lavinia was enthusiastic but also concerned about the level of her own climate change knowledge. She said:

> …this Professional development is very important for me. I am so keen to teach this topic to the students but my limited knowledge about climate change affects my ability to teach the subject to the students and to deliver this intervention. This professional development we're doing will help improving my knowledge about climate change. I want to know more about the causes and impacts of climate change and also about the solutions…I do not understand

climate change adaptation and mitigation at all… (Lavinia, 20th September 2017).

5.5.1 Co-Construction with the teacher

Talanoa with its dialogic and interactive nature was considered as an appropriate approach because it may help elevating the effectiveness of teaching and communicating climate change in the Tongan classroom. The three ideas of talanoa which were used to conduct the Professional Development (PD) and later used during the classroom teaching were: Talanoa fakatoka, Talanoa felāfoaki, and Talanoa kavekavehoko.

5.5.1.1 Talanoa fakatoka (To set or lay a foundation, to lay out properly, to give or devote (thought or idea) to something)

Talanoa fakatoka was employed in order to gain a better understanding of Lavinia's current perceptions of climate change-related issues. The first part of the talanoa fakatoka involved introductory conversation, where we got to introduce ourselves to each other, and shared some of our stories. Lavinia appeared not to be confident at the start but as we conducted the talanoa fakatoka, I noticed that she slowly started to gain her confidence and started to talk openly about her perceptions of climate change.

When asked to share about her understanding and knowledge about climate change, Lavinia clearly stated that her understanding of the causes, impacts of, and solutions for, climate change was not sufficient. For instance, when she was asked to explain what mitigation and adaptation are, she said that she did not know much about the two terms (Observation, 23rd September 2017). Lavinia also mentioned that the Professional Development would be an opportunity to deepen and to enrich her knowledge about the issues of climate change. Talanoa fakatoka created a platform where Lavinia and I were free to communicate, and it also helped to remove any potential barrier which may emerge to discourage us from working together. Therefore, talanoa fakatoka was an effective tool to explore Lavinia's existing knowledge about climate change which was helpful in guiding the content of the PD. Lavinia appeared to hold the common alternative conception about the ozone layer depletion being the main cause of climate change (Observation, 23rd September 2017). Lavinia had been a participant in a Phase One talanoa fakatokolahi, during which she mentioned that she believed God will save people

from climate change, which may explain her uncertainty about people's need to adapt and mitigate, as she trusted in another source of help.

It was during this talanoa fakatoka that we made an agreement to do a talanoa about a teaching sequence which I had drafted on the basis of findings from Phase 1 and the literature and that as we would explore this, Lavinia would ask questions and we would co-construct the final content of the teaching sequence. The talanoa fakatoka helped me to change the initial plan to teach climate change issues to Lavinia to her suggestion that we should go through the teaching sequence and consider knowledge gaps as they arose.

5.5.1.2 Talanoa felāfoaki (Co-construct ideas and create new knowledge)

Felāfoaki is derived from the Tongan term 'lafo'. Lafo means to throw (a rope, fishing-line, net or disks). Lafo can also refer to a disc-throwing game (Churchward, 1959), a popular indigenous game played by the Tongan population right up to contact with the European settlers. Aki can mean reciprocating or back and forth. When used in talanoa, felāfoaki refers to 'tossing ideas about from one to another' (Churchward, 1959, p. 163). Talanoa felāfoaki is a platform that is used by Tongan people to tease out other people's thoughts, contribute and discuss ideas on a given issue. This talanoa approach is used in times when significant social, economic or cultural matters arise. Because of the importance of the topics discussed, talanoa felāfoaki can contain strategies such as lighthearted exchanges designed to trigger deeper engagement and meaningful exchanges which lead to finding solutions and the achievement of the state of malie. Talanoa felāfoaki embodies co-constructing of ideas and perspectives. It attracts attention and those involved are driven by a common goal of finding solutions, options or meaning for the benefit of the collective.

In Tonga, talanoa felāfoaki is one of the popular programs that is conducted on the national radio station, where a topic or an issue is given, and it is open for people to throw in their ideas, and this is happening live on radio and everyone can hear what has been said. The same form of talanoa is used widely by Tongan community radio programs in New Zealand, Australia and the USA as well. Talanoa felāfoaki helps to enable voices to be heard, including those of disadvantaged individuals and communities. It is empowering, interactive, collaborative, participatory, encouraging, and purposeful (Ofanoa et al., 2015).

As Talanoa felāfoaki created a space for deeper discussion and co-construction to take place, Lavinia and I reviewed and re-constructed the lesson plans in the teaching sequence. The resulting co-construction ensured that the plans considered the findings of Phase One, conceptual ideas about teaching and learning in climate change education from the literature, Lavinia's own teaching experience and knowledge of her students, and that they aligned with the requirements of the syllabus.

While we went through the process of examining the lesson plans, the talanoa felāfoaki was adopted to allow discussion of new ideas which could assist to develop Lavinia's existing understanding. For instance, on Friday 23rd September 2017, I provided an information sheet to Lavinia which provided simple climate change information. We went through the information sheet together, and she was be able to identify some key causes of climate change. She also indicated that she comprehended the process of the greenhouse effect and how it may contribute to the cause of climate change. A video clip which demonstrated the difference between the greenhouse effect and the ozone layer depletion was also played (Makemegenius, 2012). Through the process of felāfoaki, we came to agree that the ozone layer depletion was not the cause of climate change. Felāfoaki was used not only to co-construct ideas, but it was effective in helping to enhance her climate change knowledge.

Lavinia provided suggestions to the lesson plans during the felāfoaki. For instance, in regards to Lesson 3 – Weather and Climate she suggested to rearrange some of the activities and we made the changes accordingly. I thought that the changes she made were based on her understanding of the students' abilities and that was important to me as well. She also made a suggestion on Lesson 2 – Earth system. Initially, the students were going to discuss the 4 systems in class (Observation, 22nd September 2017). Lavinia thought it would be best to get students into their various groups. Each group had to represent one of the Earth systems. Then each group would discuss how they may interrelate with one another (Observation, 22nd September 2017).

5.5.1.3 Talanoa kavekavehoko (Share new knowledge, report actions to climate change)

Talanoa kavekavehoko was when Lavinia shared the new knowledge she created during the PD and she was able to show confidence to teach climate change in the classroom.

From the western perspectives, talanoa kavekavehoko aligns with Barne's idea of presentational talk. Barnes (2008) believed that presentational talk also occurs when the student is speaking to a large or unfamiliar audience. Pierce and Gilles (2008) supports Barnes by saying that presentational talk is used to share new understandings with others. They state that:

> When students reflect on what they have learned, and consider the audience for their presentations, they can view their learning from a new perspective. Sharing with others can invite students to reflect on their learning (Pierce & Gilles, 2008, p. 51)

5.6 Chapter summary

Chapter 5 began with presenting the findings on the place of climate change in the school curriculum. Data was drawn from document analysis, questionnaires, talanoa fakatokolahi and talanoa fakataautaha. It is evident from this research that there is a lack of inclusion of climate change issues in the curriculum. There is a call for climate change related-issues to be integrated into school curriculum and also across all subjects and not to be limited only to Science or Geography.

The second part of this chapter outlined the key findings from Phase One and key ideas from literature that helped to inform the designing of the climate change education internvention. One of the key points that was considered as an important idea was the use of talanoa as an approach for teaching and learning about climate change. The nature of the intervention was introduced in this chapter which involved a teaching and learning unit to be trialled in one of the high schools in Tonga. This was proposed as a result of a gap that was found in the current teaching and learning in climate change in Tonga.

The next chapter presents the implementation of the intervention.

Chapter 6: Implementation of the intervention

6.1 Introduction

The data presented in Chapter 5 describes the underlying principles for the designing of the climate change education intervention. Talanoa was also introduced in Chapter 3 as a research methodology whereas in Chapter 5, it is referred to as an approach for teaching and learning about climate change in Tonga. This chapter outlines the process of planning, designing and implementing the climate change education intervention. This chapter has five sections. Section 6.2 describes the context where the intervention was conducted and the participants who took part in the intervention. Section 6.3 discusses planning the intervention. The pedagogical framework for the intervention is also illustrated in this section. Section 6.4 describes the three aspects of talanoa that were developed to assist students' learning about climate change. Section 6.5 details the process of implementing the intervention lesson by lesson and how the three aspects of talanoa were integrated into the lesson plans.

6.2 Context and participants

The intervention was implemented at a secondary school at Pangai, Lifuka, the main island of the Ha'apai group. Pangai is the administrative centre of the Ha'apai group. There are approximately 350-450 students attending this secondary school per year. The Ha'apai group is comprised of 62 islands. It consists of 5 volcanic islands, and 57 raised limestone islands or sand cays (Steadman, 1998). Of the 62 islands, only 17 are inhabited by approximately 8,000 people living in 30 villages. Almost all the population on Ha'apai are active members of a Christian church. A large source of income comes from the remittances, where family members living overseas send money back home (Tongan Tourism, 2017).

On 11 January 2014, the worst tropical cyclone to hit Tonga in decades slammed into the country's northeast island of Ha'apai, causing widespread devastation (Matangi Tonga Online, 2014). The Category 5 storm, with winds of more than 200 kilometers per hour, affected two-thirds of the population. The storm flattened houses, uprooted trees, destroyed 90% of power lines and severely damaged or destroyed more than half of its 31 primary and secondary schools.

The participants for the climate change education intervention comprised 40 Class 10 students (14-15 years old) and one science teacher. There were two classes in this level, and each class had a different science teacher. Lavinia, a 45 year old female teacher involved in the Professional Development (PD) described in Chapter 5 was the teacher who delivered the climate change lessons. Lavinia and the other science teacher agreed that the two classes should be combined during the period of the intervention so that more students could learn about climate change. With reference to the initial plan, the intervention was intended only for Lavinia's class, but when I was notified about the teachers' decision to combine the two classes, I discussed this with my Chief Supervisor to inform him of the change. The combining of the two classes was approved for the study.

6.3 Process of planning the intervention

As illustrated in Table 11, a total of 12 lessons were implemented in this intervention, which included 3 lessons (Lessons 9-11) where students were asked to organise a climate change expo to be conducted on the last day of the intervention. The duration of each lesson was normally 50 minutes, however, the duration for lessons 1-8 was doubled which means that each lesson went for 1 hour and 40 minutes. Other teachers offered their 50 minutes-period to the intervention as they felt it would be valuable to the students and to the two science teachers. Each lesson was conducted according to the lesson framework shown in Table 11.

On Day 1, the students were allocated into eight groups – Red, Yellow, Purple, Orange, Green, Maroon, Blue and White. Each mixed-gendered group consisted of 5 students. Due to the significant number of students, allocating them into groups seemed to make the teaching and learning more manageable. Figure 19 illustrates the layout of the classroom where the intervention took place. As shown in the picture, each table was named. Once the students entered the classroom, they had to look for their group's colour.

Students had to work in the same group throughout the whole period of the intervention.

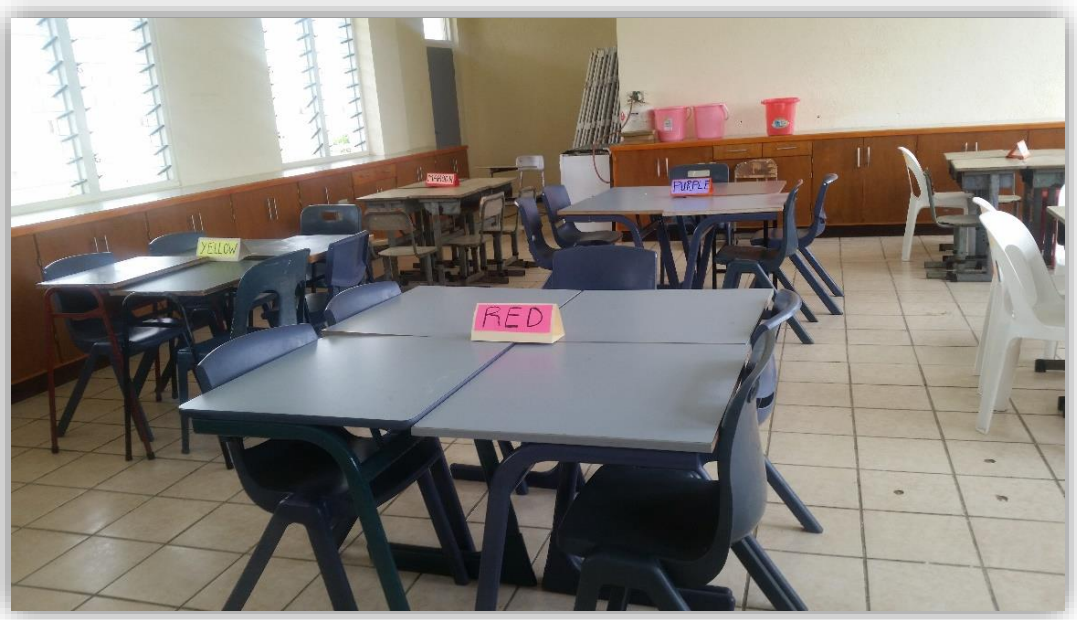


Figure 19 *Groups' seating arrangement*

Prior to the design of the intervention, Lavinia and I agreed that the climate change teaching unit would be based on the Class 10 science syllabus, Strand 4 – Planet Earth and Beyond (Ministry of Education and Training, 2016). Lavinia pointed out that although the intervention was a part of my research, it would be important to inform the students that the content of the intervention is also a part of the syllabus to be included in their external exams. Accordingly, this would make an impact on the students' perspectives about the rationale behind the intervention.

The climate change teaching and learning framework included the following contents: Earth system; climate and weather; Greenhouse effect and causes of climate change; Human activities and Greenhouse gas (GHG's) emissions; Impacts of climate change on human and natural systems; Impacts of climate change – Sea level rise in Ha'apai; and climate change adaptation and mitigation. Table 10 illustrates the three teaching and learning approaches that underpinned the teaching of climate change in this intervention: Talanoa fakatoka, Talanoa felāfoaki and Talanoa kavekavehoko. Talanoa fakatoka provided the framework for Lesson 1 and Lesson 2. Talanoa felāfoaki framed the majority of the lessons in this intervention – Lesson 3 – Lesson 11. Talanoa kavekavehoko guided the last lesson of the intervention. This teaching and learning framework provides the foundation (*Ko e ngaahi pou tuliki*) to assist teaching and learning about climate change

issues in a Tongan classroom *(Ako'i pea mo e ako fekau'aki mo e feliuliuaki 'o e 'ea 'i lokiako).* There was also a lesson plan developed to outline the tasks that were delivered in every lessons, and this lesson plan is attached in Appendix M.

Table 11 Learning about climate change – *Ko e ngaahi poutuliki ki hono talanoa'i e feliuliuaki e 'ea 'i lokiako*

***Ko e gaahi pou tuliki ki hono ako'i pea mo e ako fekau'aki mo e feliuliuaki 'o e 'ea 'i lokiako* - Framework for pedagogy**	***Tefito'i kaveinga 'o e lesoni taautaha* - Contexts**	***Tefito'i taumu'a 'o e lesoni taautaha* - Learning objectives**	***Ngaahi ngaue ke fakahoko* - Activities**
Talanoa Fakatoka • Explore students' and local people's experiences of climate change • Access students' existing knowledge of climate change • Teacher and students establish relational links	**Lesson 1** • Connect with local knowledge and draw on students' experiences	**Students will:** • Understand Tongan perspective of climate change over 40 years • Revisit climate change knowledge (Phase 1) • Communicate existing understanding of climate change – causes, impacts and solutions.	• Guest speaker – local person • Catching the ball – students share their experience about climate change • Mind maps – Each group to brainstorm what they know about the causes, impacts and solutions for climate change
	Lesson 2 • Earth systems – Atmosphere, Biosphere, Geosphere, and Hydrosphere.	**Students will:** • Identify the interrelationships between the four Earth systems • Discuss unsustainable practices that affect the interrelationships of the four Earth systems and may need to be addressed. • Name potential Tongan values which may help to sustain a healthy relationships between them and the Earth systems.	• Nature Walk – explore the interrelationships between different systems of the earth • Ball of String and build connections – identify importance of the connections between the 4 systems of the Earth.
Talanoa felāfoaki • Co-constructing ideas about climate change • Processing of knowledge and ideas of climate change • Addressing students' alternative conceptions of climate change	**Lesson 3** • Weather and Climate	**Students will:** • Differentiate between weather and climate • Describe the local weather and climate using Tongan language and concepts • Apply their understanding and experience of climate and weather	• Weather and climate game – to identify the differences between weather and climate • Graphs and tables interpretation with guiding questions – identify differences between weather and climate • Role play – deepening students' understanding about climate and weather.
	Lesson 4 • **Causes of climate change** - Greenhouse effect	**Students will:** • Describe the key causes of climate change. • Identify the names of greenhouse gases and the concept of greenhouse effect. • Differentiate the concepts of greenhouse effect and the ozone layer depletion	• Watch video clip http://www.youtube.com/watch?v=-RMD88DNaGk with guiding questions to identify the differences between the greenhouse effect and ozone layer depletion • Paper cutting – diagram of greenhouse effect process • Multiple choice and filling gaps questions – to identify the learning outcomes.

	Lesson 5 • **Causes of climate change** – Local and Global focus	**Students will:** • Identify the human activities contributing to climate change • Describe Tongan perspectives about human contributions to the cause of climate change in Tonga • Interpret data and explain the key contributors to climate change.	• Carbon footprint activity – Calculating the students' individual carbon footprint • Graph and image interpretation – data illustrating human activities that contribute to the cause of climate change
	Lesson 6 • **Impacts of climate change** – impacts on the natural system and on humans.	**Students will:** • Identify the impacts of climate change on human and natural systems • Discuss Tongan perspectives about the impacts of climate change on the people and on the environment • Name and classify the groups that are vulnerable to the impacts of climate change at local, regional and global scale	• Shrinking island game – to experience the impact of sea level rise • Consequence wheel – exploring impacts of climate change
	Lesson 7 • **Impacts of climate change** – sea level rise	**Students will:** • Identify the two main causes of sea level rise • Discuss the impacts of sea level rise on the people and the environments of Tonga • Experiment with the melting of glaciers and its contribution to sea level rise	• Experiment – Melting glaciers and sea level rise/identify the two causes of sea level rise. • Picture interpretation – data showing sea level rise at a global, regional and a local scale. – Lifuka Island 1989 – 2009 and Ebeye Island (Marshall Island) 1971 - 2016
	Lesson 8 • **Responses to climate change** - Towards empowerment and action	**Students will:** • Differentiate between adaptation and mitigation actions • Develop feelings of purposefulness and empowerment in the face of climate change • Name potential Tongan approaches to address climate change • Develop actions responding to climate change at a national, regional and global scale	• Resource interpretation – identify differences between adaptation and mitigation
	Lessons 9 – 11 • **Group organisation** Group working skills	**Students will:** • Demonstrate their communication and organizational skills • Prepare a presentation for the Climate Change expo	• Group discussions • Designing posters • Presentation rehearsals
Talanoa kavekavehoko • Communicate new learning • Active decision-making • Empowering others to take action	**Lesson 12** **Talanoa Ola Climate Change Expo**	**Students will:** • Conduct talanoa kavekavehoko to communicate learning and knowledge about climate change • Demonstrate the Tongan concept of 'Ngaue fakataha' to address the climate change issues	• Group presentations – all eight groups established 8 different stations to present their allocated tasks. • *Talanoa kavekavehoko* – Sharing students' new knowledge about climate change and to communicate climate change actions.

6.4 *Talanoa* - teaching and learning approach (T-TLA)

The Talanoa - teaching and learning approach (T-TLA) was developed as an attempt to help students and teachers in Tonga understand climate change as a complex and often

misunderstood environmental phenomenon. T-TLA was also an attempt to help modify students' and teachers' existing knowledge about climate change which appeared to be different from the accepted science. The development of the T-TLA was prompted by a desire to give students in Tonga an opportunity to be empowered and motivated to address the adverse impacts of climate change. The development of T-TLA also addressed research question 3 – How could a climate change education intervention be designed for Tongan secondary education?

The three ideas of T-TLA, that were adopted in the climate change education intervention were: Talanoa fakatoka (To set or lay a foundation, to lay out properly); Talanoa felāfoaki (co-construct ideas); and Talanoa kavekavehoko (Share new knowledge, report actions to climate change). Figure 20 clarifies what was involved in each talanoa session. Talanoa fakatoka intends to access the students' existing knowledge about climate change. Literature indicates that in order to educate students about climate change, it is important to identify what the students already know and understand how it differs from what they need to know in order to make effective decisions (Bostrom, Morgan, Fischhoff, & Read, 1994). If students are asked, "What causes climate change?" – there is a possibility to find out about their level of understanding about the causes of climate change. Talanoa felāfoaki involves the co-constructing of ideas and processing of climate change knowledge. Accordingly, talanoa is shifted to another level where the participants need to discuss ideas a bit deeper, make meanings and co-construct ideas together. For example, questions such as "Why is climate change a problem in Tonga?" or "What will we do to help reduce climate change?" are explored. During this stage of the talanoa, the students will also be able re-work ideas to ensure that some of the existing knowledge may be replaced with new and more accurate knowledge. Talanoa kavekavehoko is about sharing new knowledge and manifests climate change action. Students will not only have to share their new knowledge but they can also share plans for their future in terms of addressing climate change.

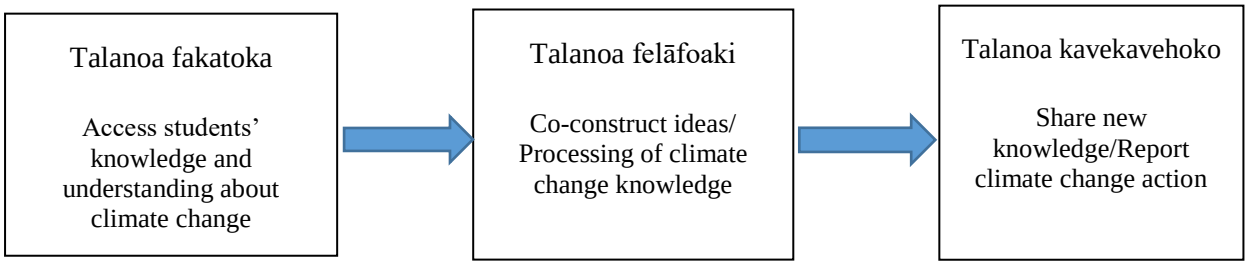


Figure 20 T-TLA for climate change education in Tonga

Based on my experience as a Tongan person who attended primary and secondary schools in Tonga, and as a secondary school teacher in Tonga for eight and a half years, a teacher-centred approach was commonly used across Tongan classrooms. A teacher-centred approach refers to the teaching method where the teacher is actively involved in teaching while the learners are in a passive, receptive mode listening as the teacher teaches. The introduction of talanoa as a teaching and learning approach was not intended to challenge the norm in teaching and learning in a Tongan classroom, but it was adopted so it might enhance the teaching and learning of climate change in Tonga.

6.5 Implementing lessons

This section presents the implementation of lessons 1 – 8, these are the lessons that covered the climate change topics that were to be taught within the intervention. As shown in Table 10, a poutuliki (teaching and learning framework) was designed to guide the implementation of each lesson, and this is discussed in the following sub-sections.

6.5.1 Connect with local knowledge and draw on students' experiences

(Lesson 1) *Talanoa fakatoka*

The first activity of the intervention (as shown in Table 11) involved a guest speaker, who was a 65 years old man from one of the local villages, known as Paula. He spoke about his experiences and his understanding of climate change (Classroom observation, 26.09.2017). Paula highlighted some key changes he could identify today as compared to the last 30-40 years, which included the rise in temperature and sea levels. An increase in the frequency and intensity of cyclones happening these days was one of Paula's key points in his speech. Students had an opportunity to ask questions or make comments at the end of Paula's talk. The purpose of inviting Paula was a desire to give the students an opportunity to hear about climate change from their own local people, so that they can develop a sense of connectedness to the stories they had heard. A talanoa fakatoka approach was adopted so that Paula could explain things straight from his heart and from his own experience. The inviting of Paula resulted from a comment made by Siua (male teacher) in Phase One, who accentuated the importance of starting from the basics. He said, "…it is important that we start from the basics, from the family, from home…by doing that, it will spread out, kids will help indicating attitude and impacts others as well..." (Siua, TFG 1, Phase One). In my view, students may benefit when the stories that they hear focus around their own personal contexts.

The second activity of Day 1 was 'Catching the Ball' and students were asked to form a big circle and whoever the teacher passed the ball to, that person communicated a talanoa fakatoka about his or her experience of and understanding about climate change. The ball was randomly passed around to ensure that students' stories were heard, and those who listened also had a chance to ask questions. The 'Catching the Ball' activity aimed to give students an opportunity to share their own stories, which aimed to build on from Paula's talanoa. After the 'Catching the Ball' activity, students returned to their various groups. A chart and marker pens were distributed to each group. Their task was to design a mind map about climate change and they had to write down their answers under these three categories – Causes, Impacts, and Solutions. The teacher asked the group leaders to allow each member in the group to do a talanoa fakatoka about their own understanding of climate change. This activity was aimed at identifying the students' existing knowledge about the causes, impacts of and solutions for climate change. The teacher and I could also learn some possible alternative conceptions which might be held by the students.

6.5.2 Earth systems – Atmosphere, Biosphere, Geosphere and Hydrosphere (Lesson 2) *Talanoa fakatoka*

The next lesson focused on the Earth systems – atmosphere, hydrosphere, geosphere and biosphere. This is one of the requirements of the Tongan national curriculum, however, students also needed to be aware that the four systems of Earth are interconnected and that each part cannot be operated on its own for anything to work or survive in nature. The students walked around their local area in groups to some specific locations that were allocated to them by the teacher. These locations included an open field, the school backyard and the teachers' residential area. A worksheet was handed to each student to answer the questions during this 'Nature walk'. The questions included: What do you see? What's going on outside these days? What do you see happening in nature: Have you noticed any changes in nature around your home or school? This activity correlates with the literature, that climate change education requires teaching and learning methodologies that are experiential and participatory (Bartels et al., 2012; McNamara, 2013a; UNESCO, 2009). On the theoretical level, experiential learning enabled students to grasp a tangible awareness of climate change through observing their natural surroundings (Pruneau, Gravel, Bourque, & Langis, 2003). The socio-constructivist approach effectively motivated the students to consider the changes in nature around their home or school which may lead to identifying local impacts of climate change that may pose risks on

their lives (Pruneau et al., 2003). The findings from their 'Nature walk' activity were discussed among group members. Each group identified themselves as part of the Earth systems, with two groups to represent each Earth system, for example, the Group Purple and Group Yellow would represent the Atmosphere. When each group knew the Earth system that they represented, then a ball of string was passed around. One group had to throw the ball to another group but a member from the throwing group would hold on to one end of the string. The group that caught the ball would have to explain how they, for instance, geosphere are interconnected with the group that threw them the ball, for example, atmosphere. There was also an opportunity for talanoa fakatoka to take place during this activity. The string then formed up a web which is illustrated in Figure 21.

Figure 21 *A web was woven to indicate the interrelations between the four Earth systems.*

While each group continued on with their talanoa fakatoka, Lavinia the teacher, used a pair of scissors to cut some of the strings. The students then were asked to discuss among themselves what could be the effects if one part of the connection is affected. This activity may help enhancing the students' awareness about the interconnection of the Earth systems including the climate, the weather, the human beings and the environment. Once a part of the Earth system is affected, then the whole system can be affected.

6.5.3 Weather and climate (Lesson 3) *Talanoa felāfoaki*

The inclusion of the topic 'Weather and climate' aimed not only to address students' and teachers' confusion between climate and weather but it was also a part of the curriculum. In the curriculum, the students are required to explain the differences between weather and climate (See Table 9). The findings in Phase One indicated that some student and teacher participants understood climate change as the weather changes on a daily basis, for instance, in the morning it was raining, and it was sunny in the afternoon. Weather and climate are both interpreted in the Tongan language as 'ea', and the English term 'climate change' could lead Tongans to confuse the two terms. To address this confusion, one recommendation from the literature was taken on board to ensure that after this particular class, the students would be able to distinguish between weather and climate, and also be able to grasp a more accurate definition of climate change. The literature recommends that climate change needs to be taught from an interdisciplinary perspective (Gonzalez-Gaudiano & Meira-Cartea, 2010). The literature also emphasized that education will be more meaningful, and participation in learning processes will be more active, if the programmes deliver knowledge and skills relevant to local contexts and needs (Bangay & Blum, 2010). A worksheet that illustrated the weather of Ha'apai, and a table which showed data about the climate of Tonga (See Resource 5 in Appendix N) that was collected between 1982-2012 (Climate -Data.org, 1982-2012) were handed out to the students. In groups, the students were required to study the two datasets. They were asked then to conduct a talanoa felāfoaki to identify the differences between the two datasets.

The last activity for this lesson was a 'role play'. The following scenario below was given to each group and they were asked to role-play the given scenario. That was followed by a set of questions which each group had to answer.

Scenario	Sione and Mele are on their way to school on an April morning. Once they get on the 'Malo e lelei' bus, Sione takes off his jacket. "I'm hot," he says. "I thought it was supposed to be cool today like it was yesterday" says Mele as she takes off her jacket too. "It was cool the day before, but now the temperature is climbing. It's going to be warm."

	"It's hot today because of climate change", says an elderly woman sitting in the row in front of them. She turns to look at Sione and Mele and shakes her head back and forth with gloom. "No it's not" calls the bus driver over his shoulder. Sione and Mele look at each other with confusion. They didn't mean to start an argument. If you were on the bus, how would you respond?
Questions	1. Are the weather and climate the same? How would you respond to the people on the bus? 2. If yesterday was cool and today is warm, could that be due to climate change? Explain your answer.

All groups were required to conduct the talanoa felāfoaki to answer the questions given and be able to identify the differences between weather and climate. These activities intended to address students' confusion about the aspects of weather and climate.

6.5.4 Causes of climate change – Greenhouse effect (Lesson 4) *Talanoa felāfoaki*

Lesson 4 focused on the key factors that contributed to the cause of climate change. Data from Phase One reported that students and teachers had limited understanding about the causes of climate change. When asked if they had heard or knew something about the greenhouse effect, about 100% of the students and 8 out of the 10 teachers demonstrated no understanding about the concept of greenhouse effect. One of the alternative conceptions commonly held among teachers and students was conflating climate change with ozone layer depletion. This lesson was designed to improve the students' understanding so they were able to identify greenhouse gases and their contributions to climate change. A video clip was played and students were required to watch the video and then answer the questions given on a worksheet. The video can be found in the link - https://www.youtube.com/watch?v=-RMD88DNaGk. The questions that were given are shown in the Lesson Plan 4, as attached in the Appendix M. After playing the video clip a couple of times, the students then conducted a talanoa felāfoaki so that they could co-create meanings together and be able to understand the concept of greenhouse effect. The conflation between climate change and ozone layer depletion also had the possibility of being effectively addressed by talanoa felāfoaki. The talanoa felāfoaki gave students an

opportunity to co-construct ideas, which helped the students' current understanding being developed to a level desired by the teacher.

The next activity involved paper cutting. Students developed what they learned from watching the video clip and from the talanoa felāfoaki into a greenhouse effect visual form of art. Students had to cut the following using coloured papers: Earth, greenhouse gases (names), sun, arrow and trees. The talanoa felāfoaki was also carried out during this activity so students could not only co-construct ideas together but could identify how greenhouse gases contribute to the cause of climate change. Figure 22 illustrates a group that conducted the talanoa felāfoaki during the formation of their greenhouse effect picture. As shown in the picture, every member in the group was required to participate and join in the learning process.

Figure 22 *Students designing the process of greenhouse effect using the talanoa felāfoaki*

This particular activity was an approach to address alternative conceptions that had been identified earlier in the intervention about the greenhouse effect and its contribution to climate change. The activity was also intended to address the students' confusion between the process of greenhouse effect and ozone layer depletion. These activities also aimed to enhance their knowledge about the causes of climate change.

The last activity in this lesson involved 'Filling in gaps' , where students had to fill in the gaps in the given sentences with the most appropriate words, and multi-choice questions ,

where they had to circle the letter with the correct answer. These students were asked to do talanoa felāfoaki to come up with the correct answers.

6.5.5 Causes of climate change – human contributions to climate change (Lesson 5) *Talanoa felāfoaki*

Findings of Phase One indicated that the student participants considered their local activities such as cutting down trees and burning rubbish at their various homes as key contributions to climate change. Therefore this lesson was designed to further the students' understandings about some other activities, especially at a global level, that could contribute to climate change. This is aligned to what is suggested by literature (Chang, 2014; National Research Council, 1996; Shepardson, Niyogi, et al., 2011) that an effective curriculum can only be designed and implemented successfully if we understand where the students are in terms of their knowledge and dispositions about an issue. The lesson started with a talanoa felāfoaki so that students would be able to create meanings for the term carbon footprint. The teacher provided the students with copies of the Carbon footprint handout (See Figure 23), and asked students to answer and score themselves in accordance with the questionnaire. Students then compared their total scores to see who had the highest and lowest scores. The teacher announced that students with the score 0-5 were to go to her left side, those with the score 6-14 may go to her right, and students with the score 15-25 were to stand in the middle. The majority of the students were in the middle group, and the group on the right was next and the group with 0-5 scores had the least number. The teacher then facilitated a discussion so students could identify how much their individual carbon footprint had contributed to climate change.

Your carbon footprint

Calculate your carbon footprint

1. **When it is hot, you cool your room by:**
a. Air conditioner (3)
b Fan (2)
c. Natural ventilation (your room keeps cool by itself because it is well designed and insulated) (0)

2. **When you are not using the electrical devices at home (TV, fans and computers):**
a. You usually leave them running (3)
b. Sometimes you turn them off or leave them in stand-by mode (2)
c. Your leave them in stand-by mode (1)
d. You always turn them off and unplug them (0)

3. **Do you have energy saving devices or use solar energy? You:**
a. Do not have any energy saving devices in your house (3)
b. There are some energy saving devices in your house (1)
c. All or most of the devices in your house are energy saving (0)

4. **For getting around, you usually use:**
a. Private car (10)
b. Motorbike (5)
c. bus (1)
d. Bicycle or walking (0)

5. **Your diet consists of:**
a. A lot of meat and not many vegetables (3)
b. Both meat and vegetables and sometimes vegetarian food (1)
d. Mostly vegetarian food (0)

6. **You re-use old stuff or recycle:**
a. Never (3)

Figure 23 *The carbon footprint activity*

(Adapted from Ministry of Education and Training and Live and Learn and Plan in Vietnam, 2012)

Two pie graphs - Global emissions by Gas (Figure 24) and Emissions by country (Figure 25) - were given to the students. Based on Figure 23, the students conducted a talanoa felāfoaki to develop their understanding of the distribution of the global greenhouse gas emissions by gas. This activity could help students learn the names of greenhouse gases

more and talanoa felāfoaki would give each group member a chance to discuss the greenhouse gas that they thought contributed the most to the cause of climate change.

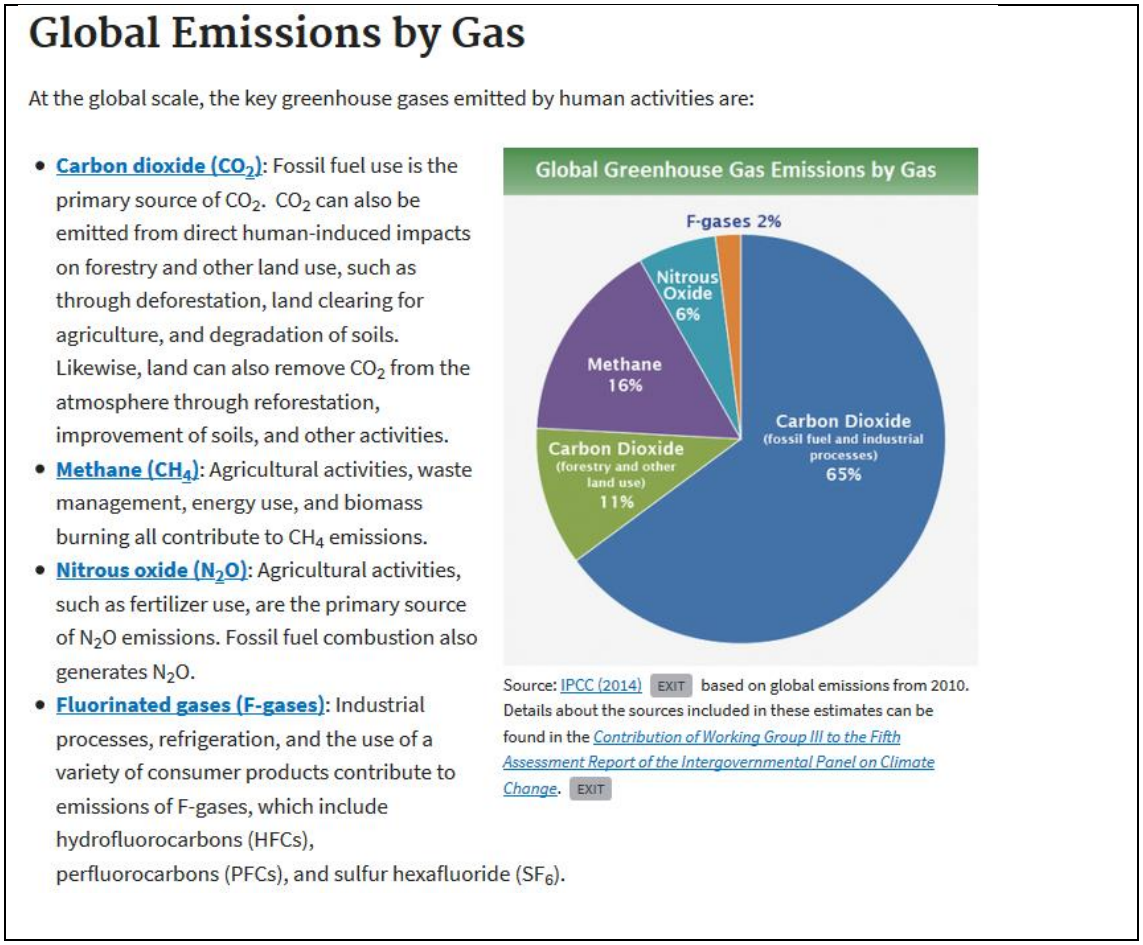


Figure 24 *Global emissions by gas*

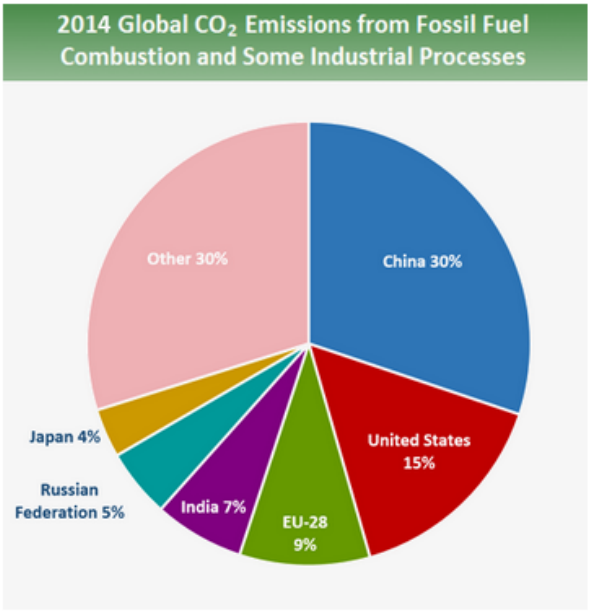
(Source: https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data)

Figure 23 illustrates the global CO_2 emissions from fossil fuel combustion and some industrial processes in 2014. This activity gave students an opportunity to think about climate change from a global level point of view. Instead of limiting their perspective around the localised activities, students should be given an opportunity to examine how other countries may contribute to climate change. The talanoa felāfoaki also took place during this activity so the students could modify some of their existing knowledge and be able to see the bigger picture of how other countries may contribute to the cause of climate change.

Emissions by Country

In 2014, the top carbon dioxide (CO_2) emitters were China, the United States, the European Union, India, the Russian Federation, and Japan. These data include CO_2 emissions from fossil fuel combustion, as well as cement manufacturing and gas flaring. Together, these sources represent a large proportion of total global CO_2 emissions.

Emissions and sinks related to changes in land use are not included in these estimates. However, changes in land use can be important: estimates indicate that net global greenhouse gas emissions from agriculture, forestry, and other land use were over 8 billion metric tons of CO_2 equivalent,[2] or about 24% of total global greenhouse gas emissions.[3] In areas such as the United States and Europe, changes in land use associated with human activities have the net effect of absorbing CO_2, partially offsetting the emissions from deforestation in other regions.



Source: Boden, T.A., Marland, G., and Andres, R.J. (2017). National CO2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751-2014, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, doi 10.3334/CDIAC/00001_V2017.

Figure 25 *Emissions by Country*

(Source: https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data)

6.5.6 Impacts of climate change – Impacts on natural systems and on humans

(Lesson 6) ***Talanoa felāfoaki***

The next lesson focused on the impacts of climate change on human and natural systems, and also sought to identify groups that are vulnerable to the impacts of climate change at national, regional, and global levels. Data from Phase One reported that students had good knowledge about some impacts of climate change on natural systems such as sea level rise, rising temperature and increase in extreme weather events, but they lacked knowledge about the impacts on the social and economic sectors. The lesson started with an activity called 'Shrinking islands' (Secretariat of the Pacific Community and Gesellschaft für Internationale Zusammenarbeit, 2013). The teacher provided the students

with a chart and marking pens and they were asked to draw a map of an island on the chart. On the chart, they had to draw an agricultural area, a manufacturing area, a school, and a settlement area, and each group made up a name for their island. Talanoa felāfoaki provided a platform for these students to co-construct ideas of what their island would be like and what name they would give to their island. Some groups named their islands after some of the islands in Ha'apai that they are originally from. When each group finished their map, the teacher asked them to place it on the floor. The teacher asked everyone to imagine that they had lived on the island for many years, so everyone had to stand on the map. Despite five people in each group, they all managed to stand on the map (though they had to hold on to each other to make sure no one was left out). Figure 26 illustrates students in this group all fitting in the map that they drew.

Figure 26 *Group members all fit on the island they drew on the paper*

The teacher then called out that after 10 years, sea level rise would take a quarter of the island. The students had to tear off about a quarter of their map. They repeated the same process about 2-3 times until some students could no longer find a space on the island to stand on, so they had to step aside. They became refugees. Figure 27 represents a map with more than half of the island taken by sea water, and the fewer people who could fit on the map. The teacher announced that after about 30 years, sea water would cover the whole island, and while everyone showed distress on their faces, the teacher asked them do a Talanoa felāfoaki among themselves about the impacts of sea level rise that they had

just experienced. After about few minutes of talanoa, each group had to share their ideas. This talanoa felāfoaki intended to prompt students to think about how sea level rise impacts different areas of their lives such as their social, cultural and economic lives, and also how it impacts the environment.

Figure 27 *Map representing half of the island taken by sea level rise*

The teacher listed some areas that could possibly be affected by climate change on the board, and then asked the students to talk among their group members about how climate change could impact those areas on the board. The areas included health, agriculture and fisheries, water and marine resources, ecosystems and food production. The teacher walked from group to group to ensure that productive discussions took place. The talanoa felāfoaki was carried out in this part of the lesson so that students were able to co-construct ideas and have productive discussions. The teacher could identify some important impacts that were not mentioned by the students. So she had to facilitate the group discussions to ensure those impacts could be included.

The next activity was a reading exercise. A copy of a case study was distributed among each group and they were required to read it and then answer the questions that followed. Again, the talanoa felāfoaki took place in this activity so that students could co-construct ideas. At the end of the activity, each group had to share their ideas.

The last activity for this lesson was a Consequence Wheel, where students were asked by the teacher to draw how a particular impact of climate change might impact on other sectors such as the society, environment, economy and culture. Figure 28 is an illustration of one group's consequence wheel. After a given time, the teacher advised everyone to choose a group reporter to report on their consequence wheel. In this way, students' understandings about the economic, social, and cultural effects of climate could be elevated and improved.

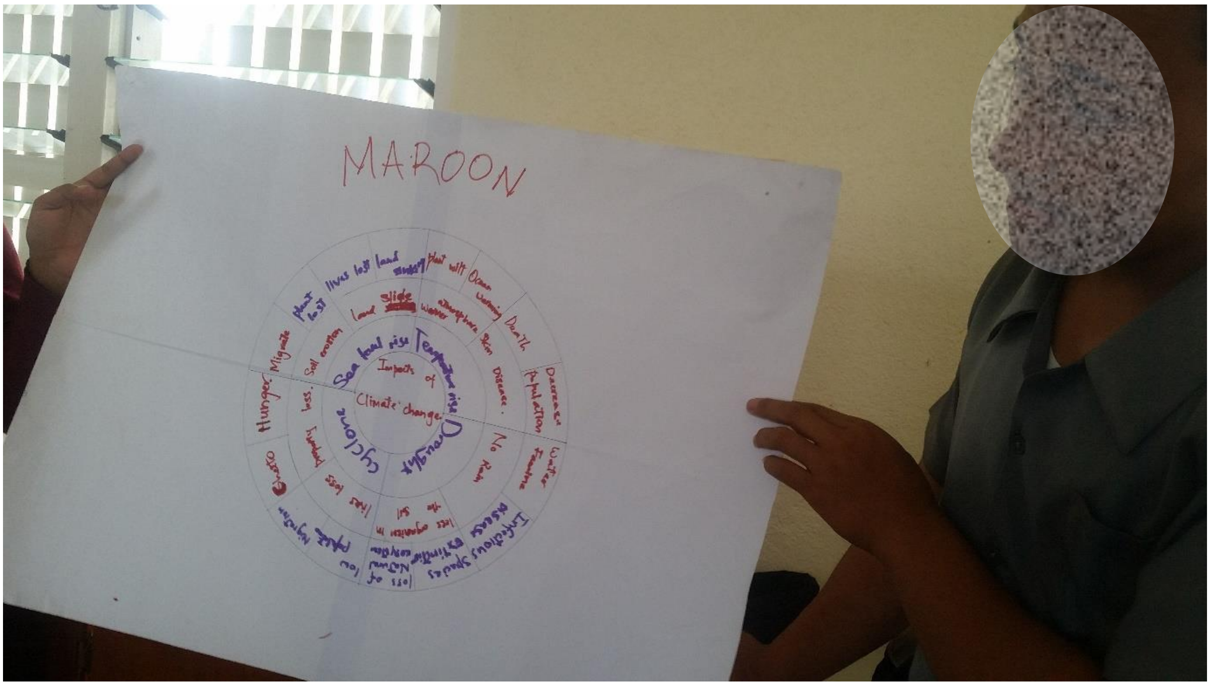


Figure 28 *Consequence wheel to showcase the students' understanding about impacts of climate change*

6.5.7 Impacts of climate change – Sea level rise

(Lesson 7) Talanoa felāfoaki

The next lesson focused mainly on the impacts and causes of sea level rise (SLR). Data from the talanoa fakatokolahi in Phase One reported that both teachers and students believed that sea level rise is an impact of climate change which can be observed in Ha'apai. When asked during the talanoa fakatokolahi to explain the causes of sea level rise, the students demonstrated very limited knowledge about the two major causes of global SLR: the thermal expansion caused by warming of the ocean (since water expands as it warms); and increased melting of land-based ice, such as glaciers and ice sheets (National Oceanic and Atmospheric Administration, 2018). This lesson was designed to

enrich the students' scientific knowledge about the two main causes of SLR. The students conducted a talanoa felāfoaki so that they could reach an understanding of how sea level rise could affect people and the environment at a local, regional and global level.

An experiment was done by each group to demonstrate how melting of land-based ice could cause sea level to rise. Prior to the lesson, the teacher prepared the resources such as – trays, sand, rock, soil, ice cubes, and hot water. Students were given about 20-30 minutes to build their island where the mountain was expected to have some ice-glaciers on top. The hot water represents the warmth of the sun. The teacher then asked each group to slowly put the hot water on the ice cubes, the melting ice-cubes caused the water level on the tray, that was referred to as sea water, to increase in height (See Figure 29). With the help of the talanoa felāfoaki, the students had a chance to talanoa felāfoaki among themselves about the melting glaciers. These students may have not seen glaciers before or even big mountains, but this experiment had a potential to enrich their existing knowledge and give more space to absorb information about how melting mountain glaciers may cause climate change. The second cause of sea level rise discussed by the teacher and the students was thermal expansion. The teacher conducted a talanoa felāfoaki with the students to help their understanding of this thermal expansion.

Figure 29 Experiment on melting glaciers

Pictures of the Lifuka coastal area in 1968 and in 2011 were given out to the students and each group had to do a talanoa felāfoaki to encourage the students to identify the differences between the two images. The 1999 picture illustrates a coastal area with land and some trees growing alongside the coast. The 2016 shows the same area but the land has consumed by sea water, and the trees are being uprooted. Students conducted a talanoa felāfoaki to co-construct ideas about the impacts of sea level rise as illustrated in these images. This activity intended to reinforce the students' feeling of connectedness to their environment. It also gave them an opportunity to relate to the lesson. A debate was planned to be conducted in this class, but it didn't happen due to time restraint.

6.5 8 Responses to climate change: Towards empowerment and action

(Lesson 8) ***Talanoa felāfoaki***

The last planned lesson aimed to heighten students' knowledge about the ways to address climate change, as data from Phase One indicated that students demonstrated limited knowledge about ways to address climate change and also were not aware of the key responses to climate change - adaptation and mitigation. This lesson also intended to elicit students' concerns about the future and to translate those feelings of despair and powerlessness in the face of climate change, that they expressed during the talanoa fakatokolahi in Phase One and also the talanoa fakatoka, into feelings of purposefulness and empowerment. The first activity was called the 'Fighting climate change' game. The teacher gathered all students to stand in a circle, then she named different activities that increase greenhouse gas emissions, and activities that help respond to climate change. For activities that contribute to escalate greenhouse gas emissions, students had to bend their bodies, and for activities that help addressing climate change, students had to stand upright, putting their arms over each others' shoulders. The teacher had to watch them carefully because for those who made an incorrect action would be penalised to sit down. Some of the activities contributing to climate change were: forest fire, deforestation, travelling by plane, travelling by car, travelling by motor bike, burning coal and using an air-conditioner. The activities adapting to climate change were: changing the crops we grow on farmland, using less water on farms and in villages, preparing early when we hear warning of storms and floods, and building sea walls to protect the land from being taken away by sea water. The teacher then wrote the two terms on the board, and asked

the students to classify each action under the right heading. This activity was conducted to deepen students' understanding of the two main ways to deal with climate change.

The teacher provided each group with a task based on the actions to respond to climate change as carried out by individuals, by school, by the community and by the government. The teacher reminded students that each group had to include both mitigation and adaptation actions in their answers. There were only four topics so she selected two groups to work on each topic. The talanoa felāfoaki was adopted by each group to help them discuss and be able to co-construct ideas about ways to mitigate and to adapt to climate change. The teacher also gave out handouts that showed both international efforts and efforts in Tonga in response to climate change. The teacher asked the students to compare these efforts with the efforts that they had suggested in their group work. This activity aimed to enrich the students' understanding with some new solutions that they did not mention in their group discussions.

The students were then required to write a letter to the Governor of Ha'apai island to outline some of the ways that could possibly help to solve the problem of climate change in Ha'apai and in Tonga. This activity gave the students an opportunity to realise that they could voice their concern about the issue of climate change, and that they also have a voice in dealing with climate change. The teachers gave the students some time towards the end of the class to share their ideas or to conduct a talanoa felāfoaki on the proposal that will be included in their letters.

6.5.9 Preparation for the climate change Expo (Lesson 9-11) *Talanoa kavekavehoko*

The teacher and the students then co-constructed the way the climate change Expo would operate. Since the Expo involved members from the community, students were reminded by the teacher about some cultural protocols that they should take note of, especially on the day of the Expo. The teacher-centred approach was then adopted so that students could listen exclusively to the teacher to ensure that they would follow protocols accordingly. One of these cultural protocols concerned the verbal addressing of the people from the community who would turn up on the day. The teacher-centred approach also provided an opportunity for the teacher to explain the talanoa kavekavehoko and its value to the students and for the students to listen carefully in order to conduct a successful expo. Students were advised that talanoa kavekavehoko meant they were going to share their

new knowledge about climate change with a wide audience. Not only that, but they would also have the chance to discuss the actions that would address the problems of climate change. The students decided to do group presentations on the day of the Expo. So the teacher allocated the tasks as follows:

- Green – causes of climate change – explain the process of the Greenhouse effect
- Yellow – Impacts of climate change - Sea Level Rise (SLR), its causes and its impacts.
- Red – Impacts of climate change – Drought and Tropical Cyclone
- Green – Impacts of climate change – Rising temperature
- Maroon – Responses to climate change – Mitigation
- Orange – Responses to climate change – Mitigation
- Blue – Responses to climate change – Adaptation
- White – Responses to climate change - Adaptation

The last two lessons were dedicated to the students' preparation for the Expo. The next chapter reports on the evaluation of the intervention and the climate change Expo.

6.6 Chapter Summary

This chapter detailed the process of designing and implementing an intervention for climate change education in Tonga. The Talanoa - Teaching and Learning Approach (T-TLA) provided a framework which enabled the process of implementing of the lesson to take place. The purpose for designing each lesson varied. For example, one lesson was designed to address an alternative conception that students appeared to currently hold, while another lesson aimed to explore the students' existing understanding about climate change. In that case, each lesson implemented had to adopt the most relevant aspect of the T-TLA so that it could assist the students' learning. Having considered the T-TLA developed to assist the climate change education intervention, the next chapter describes the findings from the implementation experiences as encountered by the participants in the intervention.

Chapter 7: Evaluating the Intervention – the learning outcomes

7.1 Introduction

Chapters 5 and 6 reported on the designing and implementation of the intervention. This chapter presents the evaluation data of the intervention which includes the students' and teachers' perspectives regarding the intervention. These data are drawn from teaching and learning observation records, students' post-intervention questionnaire, students' talanoa fakatokolahi and talanoa fakataautaha with the teacher. It answers the final research question, "What are the learning outcomes for Tongan students and teachers about the issue of climate change in response to the educational intervention?" The nine learning objectives that guided the teaching and learning processes in this intervention are outlined in Table 8. These learning objectives were in turn informed by the key guiding principles that are shown in Section 5.4 – the key findings of Phase One and key recommendations from the literature. This chapter starts with a brief description of the participants in Section 7.2 and then it proceeds to evaluating the intervention as follows.

The evaluation section is organised into three different themes: the students' outcomes and perspectives; the teacher's outcomes; and the community outcomes.

7.2 Participants' backgrounds

There were 40 students who participated in the climate change education intervention. However, only 38 students participated in the questionnaires, as 2 students were absent on the day of its completion. Out of 38 students who participated in the questionnaire, 27 were girls and 11 were boys and they were all between the age group of 14-15 years old. Eight students (5 girls and 3 boys) were randomly selected from both classes so they could participate in a talanoa fakatokolahi. This talanoa fakatokolahi was conducted in order to obtain a more in-depth talanoa kavekavehoko about the students' perspectives of the intervention. A talanoa fakataautaha was conducted with the teacher, Lavinia, to collect an insight into what she thought about the intervention. It also gave her an opportunity to do a talanoa kavekavehoko about her experiences during the Professional Development and during the teaching of the climate change unit.

7.3 The students' outcomes and perspectives

This section is in two parts: the first part is classified into four main categories: Conceptual change; Knowledge and understanding development; Feeling motivated to play a part in their future; and Willingness to become agents of change. The second part of the section presents data on the students' perspectives about the use of a Talanoa teaching and learning approach (T-TLA) during climate change education and the students' perspectives on working in small groups. Data are drawn from the observation records, talanoa fakatokolahi and questionnaire.

7.3.1 Conceptual change

7.3.1.1 Greenhouse effect and ozone depletion

Data from the pre-intervention questionnaire indicated an alternative conception that was commonly held by the students – that the ozone layer depletion contributes to the cause of climate change. Data from the post-intervention questionnaire reported that there was evidence of a conceptual change among the students. As indicated in Figure 30, the students were given the statement, *Damage to the ozone layer is contributing to climate change* in the pre-intervention questionnaire, a majority of the students (78%) either strongly agreed or agreed, 7% were unsure and 15% were either strongly disagreed or disagreed with the statement. This data implies that a high level of students thought that ozone layer depletion contributes to the cause of climate change. Data from the post-intervention questionnaire (See Figure 30) indicated that of the 38 students who participated in the post-intervention questionnaire (who were also involved in the pre-intervention questionnaire), only 24% (n=9) of the students now either strongly agreed or agreed with the statement, and 74% (n=28) of the students indicated their disagreement with the given statement,. Only one of the students was unsure. Although there were some students who still held the alternative conception (one reason may be attributed to being absent on the day the topic was taught), 74% (n=28) of the students disagreed with the statement, indicating that students' alternative conceptions were addressed by the intervention.

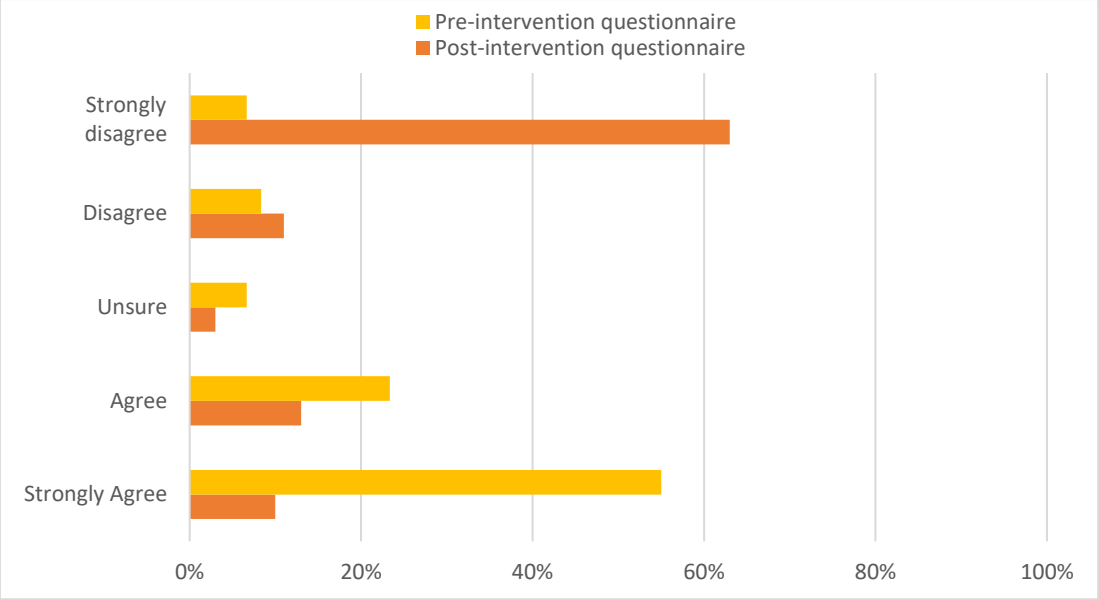


Figure 30 *Percentage and distribution of students' responses to the statement: Damage to the ozone layer is contributing to climate change (Pre-intervention questionnaire, n=60) and (Post-intervention questionnaire, n=38).*

Data from the observation records (29th September 2017) indicated that the 'Paper cut activity' in Lesson 4 (see Appendix M) may have played a part in addressing the students' conceptions about the ozone layer depletion being the cause of climate change. As shown in Figure 31, a diagram of the greenhouse effect was designed during the 'Paper cut'. This activity was implemented primarily to enrich students' understandings about how the process of greenhouse effect (GHE) plays a part in causing climate change, and it also aimed to address students' alternative conceptions – that ozone layer depletion contributes the most to climate change. Each group was asked to present and explain their diagrams to the rest of the class. The observation record indicated that students during their group discussion were surprised to find out about the band of greenhouse gases that surrounded the Earth. From the conversation that took place while designing the GHE, students appeared to be aware only about the ozone layer that surrounds the Earth but not about the band of greenhouse gases.

Figure 31 *The greenhouse effect process designed by one of the groups*

Students were also exposed in this activity to the idea that climate change was a natural process but the enhanced greenhouse gases that are released from human activities have caused a major impact on the climate system. The video clip that was played at the start of the lesson was followed by a talanoa felāfoaki. There were some guiding questions given to the students, and based on those given questions, talanoa felāfoaki was conducted while they watched the video clip. Data from observation records (29th September 2017) suggested that this activity appeared to help to enhance the students' conceptions about the causes of climate change. So when they were asked to do the paper cutting activity to design the GHE process, they showed confidence and willingness to design their diagram. Playing the video clip alongside talanoa felāfoaki appeared to be effective in addressing students' initial conceptions about the role of ozone layer depletion in climate change.

Data from the post-intervention questionnaire also reported that the students' understandings about the contributions of greenhouse gases to the cause of climate change were improved. Data that is illustrated in Table 12 shows the number of students with the scientifically accurate answer. In the pre-intervention questionnaire (See Table 7), the proportion of students with the right answers was very low, which indicated that students'

did not have a good understanding of greenhouse gases and their contributions to the cause of climate change prior to the intervention.

Table 12 Multiple choice questions and percentage of students' of students with the correct answer.

Questions	Answer options	Correct answer	Percentage of students with the correct answer
There is more carbon dioxide (CO2) in the atmosphere now than in the past hundred years. What is the most likely cause of the current increase in carbon dioxide?	a) The sun is releasing more heat energy b) There is an increase in volcanic activity. c) Humans are generating more air pollution d) The Earth's orbit around the Sun is changing.	c. Humans are generating more air pollution	87
Scientists believe that global temperatures are rising primarily because of:	a) an increase in the use of toxic chemicals such as pesticides sprays. b) increase in the amount of carbon dioxide (CO_2) from burning fossil fuels c) a hole in the ozone layer allowing heat to enter the earth's atmosphere. d) excess heat given off from energy generation in power stations.	Increase in the amount of carbon dioxide (CO_2) from burning fossil fuels.	89
Certain gases in the atmosphere - water vapour, carbon dioxide and methane - can influence Earth's temperature and climate. They are called:	a) ozone gases b) solar gases c) greenhouse gases d) atmosphere gases	Greenhouse gases.	100

7.3.1.2 Students' confusion about weather and climate addressed

One of the learning objectives that is outlined in Table 10 (Section 5.2.1) concerns the students being able to define and contrast weather and climate and to identify the concept of climate change. A lesson and its learning objectives (Lesson 3, Appendix M) was designed in order to address the students' confusion between weather and climate that was found in the pre-intervention questionnaire and talanoa fakatokolahi data in Phase One. This confusion was manifested by the questionnaire data when they were asked to define the term 'climate change' – and students appeared to think that climate change referred to the constant change in daily weather. This confusion appeared to have been addressed when the students attempted the activity – Weather and climate change data (See Resource 5 Appendix N). Data from the questionnaire confirmed that students attained conceptual change to the extent that by the end of the intervention, students were able to include more aspects in their definition of climate change. Table 13 illustrates that in the pre-intervention questionnaire, none of the students mentioned three or four of the aspects in their definitions, but in the post-intervention questionnaire, almost half of the students (15/38) were able to mention all four aspects and 8 students mentioned three aspects.

Table 13 *The Frequencies of student responses in comparing their definitions to the IPCC's definitions of climate change*

List of aspects	Change in climate over time, Result of natural process, Result of human activity, Impact(s)				
Scoring Rubric	Students mention four from the list above:	Students mention any three of the list above:	Students mention any two from the list above:	Students mention any one from the list above:	Students mention none from the list above:
Number of respondents N=60 (Pre-intervention questionnaire)	0	0	11	40	9
Number of respondents No=38 (Post-intervention questionnaire)	15	8	10	5	0

An example of a student response in the post-test was given by Student 9, who defined climate change as: "... the long term change in climate pattern that have occurred in long period of time caused by natural factor and human activity (burning fossil fuels). For

example, more rain during dry season (Nov-April)" (Student 9, Post-intervention questionnaire). In comparison to the definition that is provided by the IPCC (2001, p. 984), Student 9 included all 4 aspects in her definition. Data from the post-intervention questionnaire indicated that students' confusion between climate and weather appeared to be addressed and they developed a more scientific accepted understanding about the definition of climate change in response to the intervention.

7.3.2 Knowledge and understanding development

This section reports data on the development in students' knowledge and understanding – this includes students' knowledge development about the cause of climate change and about the impacts of climate change. Data are drawn from the pre-intervention questionnaires, talanoa fakatokolahi and observation records.

7.3.2.1 Knowledge development about the cause of climate change

> This intervention helped me to learn about the cause of climate change. At first, I thought climate change is caused by the ozone layer depletion, however, the intervention helped me to understand that it is the high concentration of greenhouse gases in the atmosphere that contributes the most to the cause of climate change, and not the ozone layer depletion, (Ane, SFG Phase 2).

The above quote was given by Ane, a female student who participated in the talanoa fakatokolahi. Her quote foregrounds the students' understanding that has been developed in responses to the intervention – she developed an understanding which is scientifically accepted, the high concentration of the greenhouse gases is the cause of climate change. Lisa, also a female student, highlighted in the talanoa fakatokolahi that "I thought climate change is caused by the hole in the ozone layer, but this study helped to realise that it is caused by greenhouse gases". These two quotes indicated that the students' knowledge and understanding about the main cause of climate change developed in response to the intervention.

Data from the observation records also highlighted that the students demonstrated development in their knowledge about the causes of climate change. The observation record (26.09.2017) showed that the students brainstormed their existing understandings

about the causes of climate change. This activity took place on the first day of the intervention and it intended to explore what the students already know about the causes, impacts and solutions for climate change. As shown in Figure 32, this group of students stated that climate change is caused by burning plastic and rubbish, cutting trees (deforestation), littering and water pollution. At the end of the intervention, the students were given the same chart they had at the beginning and they were asked to write down what they now understood about the causes, impacts and solution for climate change. As indicated by the texts in red colour (see Figure 33), the students from this group demonstrated a more sophisticated knowledge about the causes of climate change. They did not write down littering or pollution as they did earlier on. Instead, they wrote down energy wastage, high concentration of greenhouse gases (CO_2, CH_4, N_2O) in the atmosphere, inefficient use of energy, and exploitation and use of fossil fuels. This data reported that in response to the climate change intervention, the students developed knowledge and understanding that are scientifically accepted.

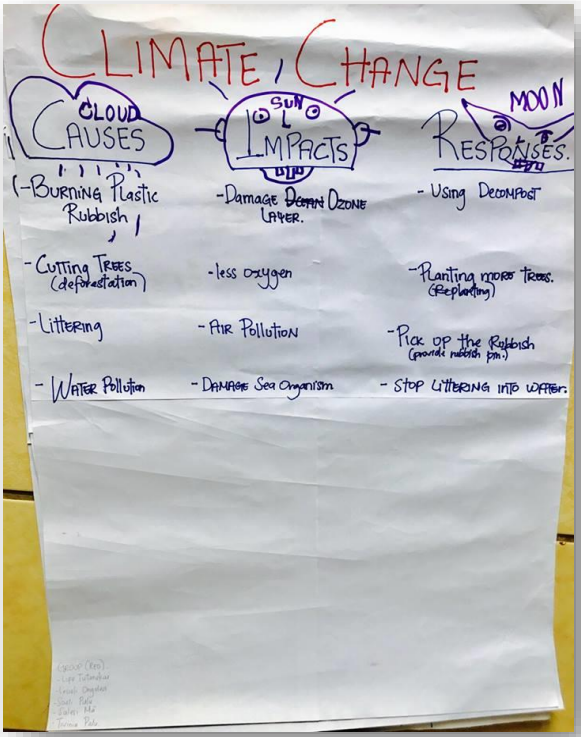


Figure 32 Students' understanding of causes, impacts and responses to climate change before the intervention

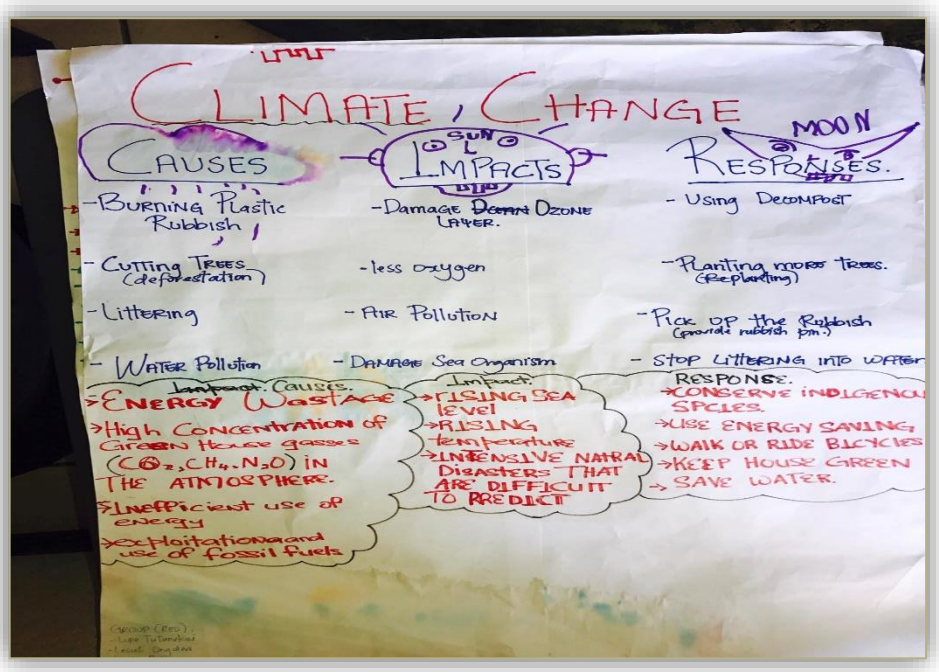


Figure 33 *Students' understanding of causes, impacts and responses to climate change after the intervention*

7.3.2.2 Knowledge development about the impacts of climate change

Data from the pre-intervention questionnaire reported that students had developed some understanding about the different impacts of climate change from the intervention. While the students did indicate good understanding that climate change could cause more cyclones and droughts, cause sea level to rise, and cause people to migrate and have harm to their health, they had more limited understanding of impacts on coral reefs, finances, water supply and food production. After the invention there was a noticeable increase in expressed understanding, as Figure 34 indicates a high proportion of students who either strongly agreed or agreed about many impacts. For instance, all students either strongly agreed or agreed that climate change would make cyclones and drought worse. Eighty five percent of the students either strongly agreed or agreed that climate change could cause money problems to families in Tonga. This data represents a successful outcome in regards to the students improved understanding about the impacts of climate change on the economy. High proportions of students (90%) did not agree that climate change would not affect the food production such as taro, banana and yams, or water supply (97%).

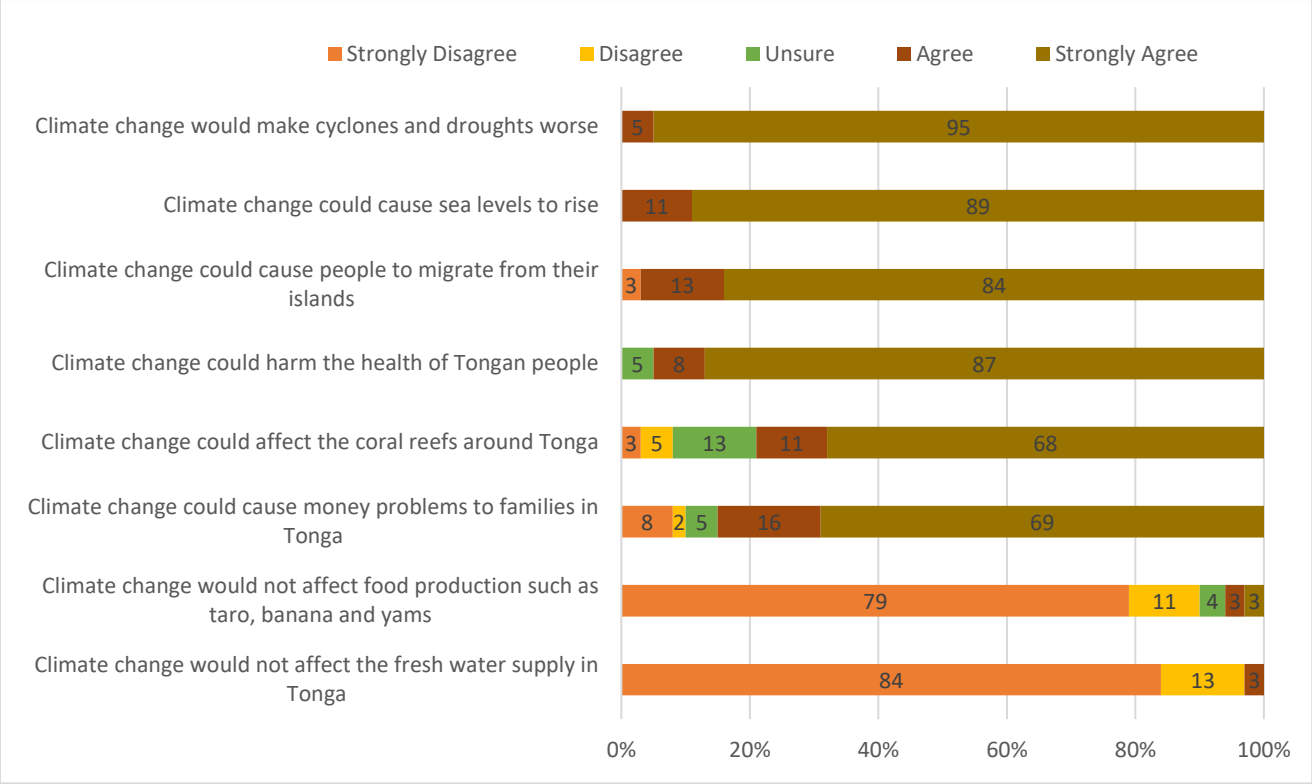


Figure 34 Percentage and distribution of students' responses about the impacts of climate change

Ane highlighted during the post intervention talanoa fakatokolahi that she had learnt more about the impacts of climate change. She said:

> Before the intervention, I only knew about two impacts of climate change, the rising sea levels and rising temperature. After the intervention, my knowledge was broadened, I know now that extreme weather events such as cyclone and drought will happen more frequently and more intense as a result of climate change (Ane, female student, SFG Phase 2).

During the post intervention talanoa fakatokolahi, the 'Shrinking island' and the 'Consequence wheel' activities were stressed by the participants to be effective in expanding their knowledge about the various impacts of climate change. Lisa, a female student mentioned that:

> The consequence wheel was so effective. It helped us to realise how one impact of climate change may cause more problems in many ways. For example, my group started with 4 impacts of climate

> change, but when we plot them on the wheel map, then more impacts are added into the wheel. For example, we started with the rising temperature. We found out that rising temperature causes ice-melting and this may cause sea level rise (Lisa, SFG Phase 2)

Data from the observation records (03.10.2017) reported that the consequence wheel activity was effective in enhancing students' understanding about climate change. They were able to examine how climate change could affect different sectors such as the economy, the culture, the society and the environment. During the talanoa kavekavehoko where each group presented their consequence wheel, students were so excited about the new things they have learnt during that lesson. Figure 35 illustrates the Maroon group's consequence wheel, which indicates how they built on their knowledge from the four given impacts namely: drought; sea level rise; cyclone; and temperature rise.

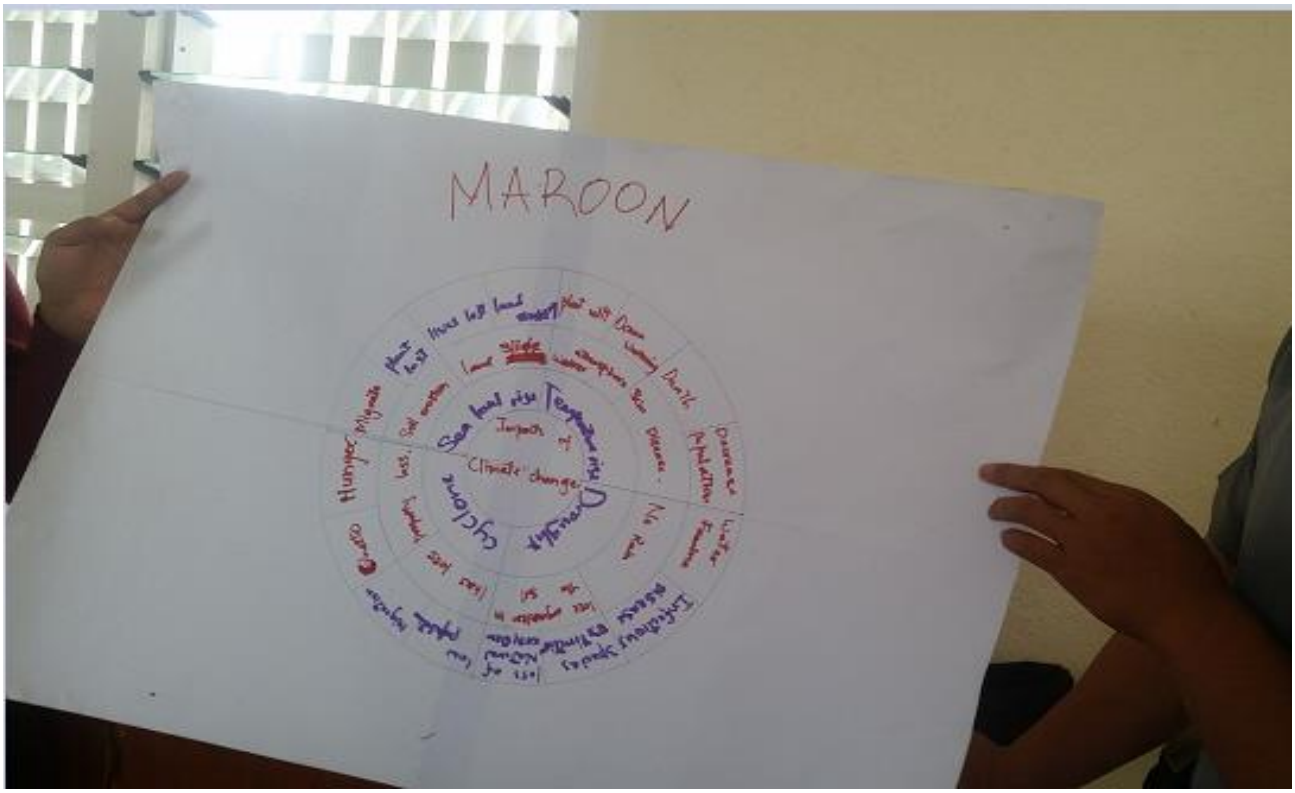


Figure 35 *Consequence wheel map*

The shrinking island activity also helped students to think more in depth about the problems that they currently encounter in their own island. In groups, students were asked

to draw an island on a piece of paper to live on. Initially, everyone in the group could stand on the island. The island was affected either by sea level rise or by storm, so a piece of the paper got torn off to represent what could be lost by these impacts. It came to a time that some groups only had a small portion of the island remaining and for some groups, their islands were completely disappeared. Data from the observation records (26.09.2017) reported that some students were frustrated when they lost a part of their island, which also meant to them that there was a loss of amenities – homes, businesses and infrastructures. During the post intervention talanoa fakatokolahi, some of the students mentioned that they weren't happy because their houses are gone, some were sad that the agriculture that they heavily relied on for food and for economic reasons were all gone. Saane, a female student stated that, "The Shrinking island activity boosts our understanding about the impacts of climate change. The land is being consumed by sea water and we know that it may impact us, our society, our agriculture and our economy…" (Saane, SFG Phase 2).

As shown in Figure 32 and Figure 33 (Section 7.3.2.1), initially, these students thought the impacts of climate change were damage to the ozone layer, less oxygen, air pollution and damage to sea organisms. This response indicated not only the students' limited understanding but it also showed the alternative conceptions they had regarding damage to the ozone layer as an impact of climate change. After the intervention, these students' understandings of the impacts of climate change appeared to be extended – they added their new understanding to their list and these can be shown in the red-coloured texts in Figure 35. They added to their list new ideas such as rising sea level, rising temperature and intensive (initially referred to intense) natural disaster are difficult to protect from. This data indicated that these students developed a more advanced knowledge about the impacts of climate change (Observation record 26.09.2017).

7.3.2.3 Knowledge about ways to address climate change expanded

Similar to the previous two sections, students were asked on the first day of the intervention to do a talanoa fakatoka about their understanding of solutions to address the negative impacts of climate change. As shown in Figure 32, these students' understanding about the solutions were using decompose (which was later discovered through class discussion that they meant compost), planting more trees, and stop littering into water. As a result of the teaching and learning intervention, these students

demonstrated a more advanced understanding about the ways to address climate change. These new additions are illustrated in the red-coloured texts in Figure 35, the consequence wheel – they listed more sophisticated solutions such as use energy saving, walk or ride bicycles, and save water. These responses align very well with the students' responses in the talanoa fakatokolahi. For instance, Lisa, a female student mentioned in the post-intervention talanoa fakatokolahi "I used to come by van to school, but I am trying now to walk to school, and I also try to help at home to stop cutting trees etc." Lisa's quotation showed that she learned from this intervention that using the van less will help to stop climate change, so she decided to start walking to school.

During the post-intervention talanoa fakatokolahi, the students acknowledged some new understandings that they gained during the intervention, and that helped them to think of effective ways to deal with climate change. For example, Ane, a female student, highlighted that learning about the two types of solutions to deal with climate change – mitigation and adaptation - had strengthened her ability and her willingness to help address climate change. She realised that she had a role in dealing with climate change. She mentioned:

> I remembered one of the classes, we were asked to list the solutions to solve the impacts of climate change. We got to learn about two ways to help reducing climate change – the mitigation and adaptation. Knowing about these solutions is extremely helpful. The impacts of climate change are already observed in Ha'apai, and these activities motivated us to do something about the problem. We should do something to mitigate and to adapt to climate change (Ane, female student, SFG Phase 2).

Some students expressed their disappointment and frustration after finding out that human activities are believed to be causing climate change. Tupou, a male student said that "I thought climate change is just a natural process, but I have learnt from this intervention that it is the human's fault, and I feel so frustrated and disappointed because climate change is human caused…". Noulisi, also a male student, acknowledged he had been accountable for causing climate change. Attending the intervention, however, assisted him with a sense of willingness to modify his actions as a way to help reducing climate change. He said:

> I know now that climate change is caused by human beings. I used to cut down the trees and burn the rubbish at home. This study helps me to understand and to realise that my actions were completely not helpful at all, and I need to change that… (Noulisi, male student, SFG Phase 2).

One of the students commented on the effectiveness of sea level rise experiment (See Lesson 7 in Appendix M), as it not only enriched his understanding about the causes of sea level rise, but it also helped to empower him to take actions. He said:

> The experiment we did on sea level rise helped me to realise that cutting down trees contributes to the cause of climate change. In my island, sea water already consumed part of the land. It's good to know, so I can ask the people in my island not to cut down trees (Tupou, male student, SFG Phase 2).

Tupou's quote indicated that the level of understanding that he currently held will be utilized to inform the people in his island to mitigate climate change by not cutting down trees.

Data from the questionnaire also presented a high level of willingness and motivation to act upon climate change. As shown in Figure 36, 92% of the students expressed their concern about climate change but 82% of the students strongly disagreed that it was too late to address it. This indicates that these students are worried but they have hope that climate change can be stopped. The majority of the students (68%) agreed that their daily actions could contribute to climate change. When asked if it is the Tongan government's responsibility to stop climate change, the majority of the students (79%) of the students either strongly disagreed or disagreed with the statement. A high proportion of the students (87%) agreed that everyone in Tonga, not just the government, should help stop climate change. This shows that these students believe that everyone in Tonga including themselves hold responsibility to stop climate change. Compared to the pre-intervention questionnaire data, this shows a change as in that data there were a higher number of students who agreed that it is the Tongan government's responsibility to stop climate change.

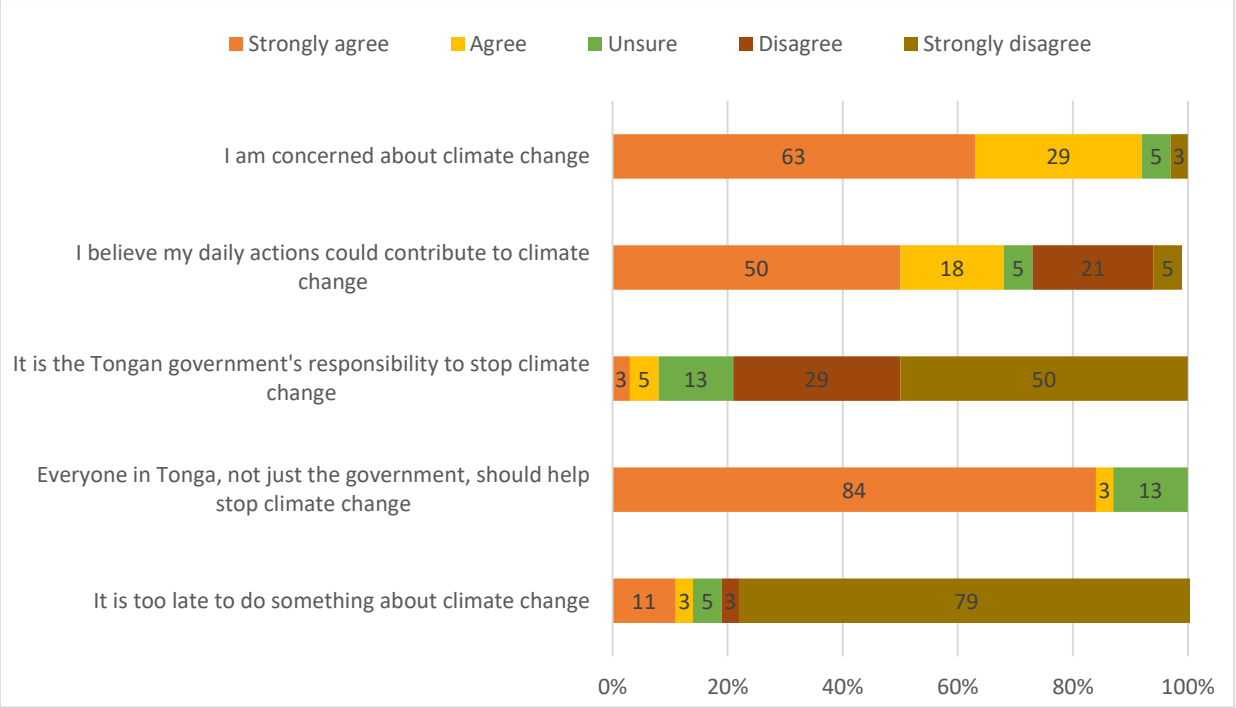


Figure 36 *Percentage and distribution of students' responses about their attitudes towards climate change.*

Data presented in Figure 37 report that a higher proportion of the students who participated in the post-intervention questionnaire are motivated to do something about climate change. A majority of the students (84%) believed that their own actions can help solve the problems of climate change. Ninety four percent of the students were prepared to plant trees if it would help reduce the problems of climate change. When they were asked if they are prepared to use less electricity at their houses if that would help reduce the problems of climate change, 89% of the student either strongly agreed or agreed with the statement. All the students (100%) who took part in the questionnaire either strongly agreed or agreed to walk or bike more if that would help reduce the problems of climate change. A high proportion of the students (93%) mentioned that they would be prepared to help people who have lost their land and homes because of climate change. This data indicated that the majority of the students who took part in post-intervention questionnaire felt positive about their ability to help in order to reduce the impacts of climate change. Compared to the data in the pre-intervention questionnaire, the proportion of students who indicated that they were willing to do something about climate change was higher in the post-intervention questionnaire.

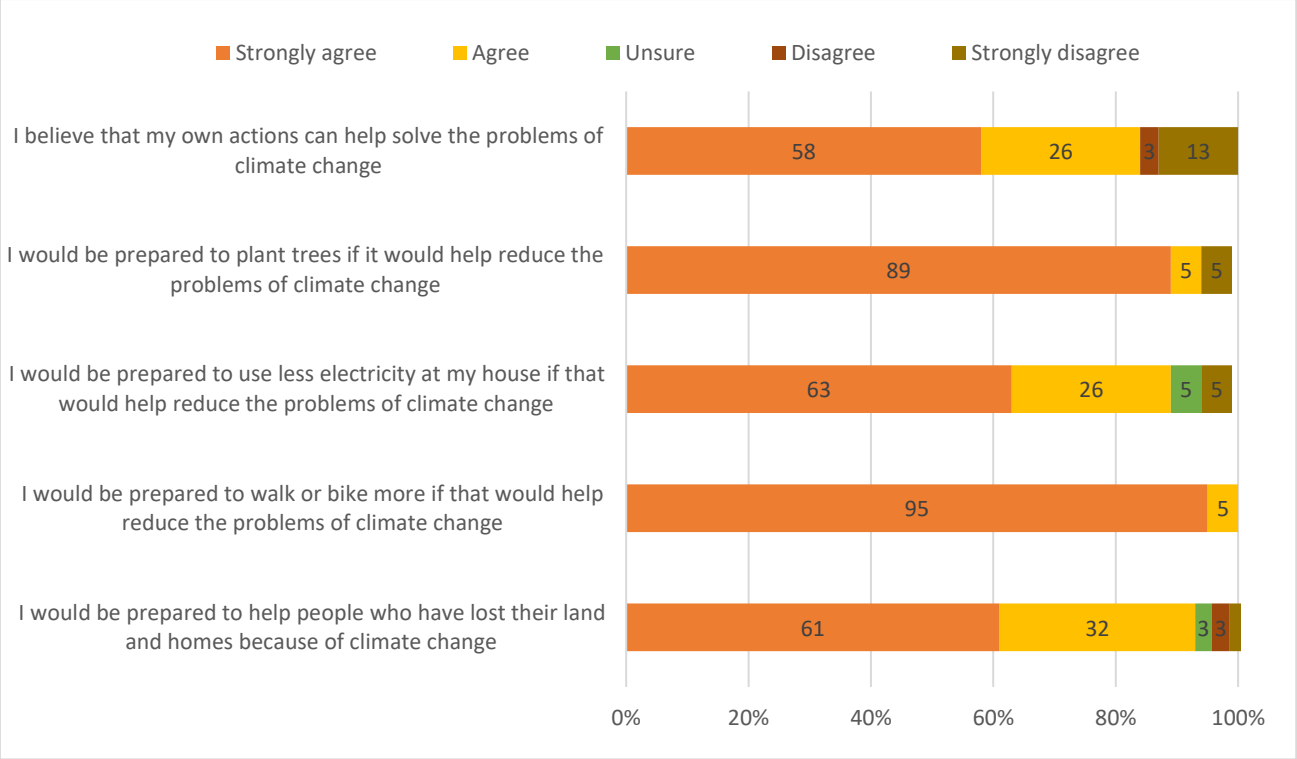


Figure 37 *Percentage and distribution of students' responses about their motivation to act upon climate change*

Data from the observation records (05.10.2017) also manifested the students' high level of motivation to act upon climate change. Students demonstrated a sense of eagerness and empowerment to help address climate change when the terms 'mitigation' and 'adaptation', were introduced to them by the teacher. Students appeared to differentiate the two terms easily when they were advised by the teacher that mitigation deals with causes of climate change and adaptation is concerned with the impacts of climate change. This explanation seemed to work effectively on the students' decisions to address climate change. The groups who worked on the actions that were considered to be 'mitigation' were totally engaged. None of the students seemed to be off task as they all seemed keen to participate in the discussion. It was the same thing that happened to the groups that worked on 'adaptation'. They showed their willingness to help by actively participating in their various group discussions. Each group had to present their findings at the end of the class, and surprisingly, a majority of them reported that they have made a commitment to play the role of climate change active agents. In order for their family members, and for their friends to be aware of climate change, students thought that they have the responsibility to first display the actions at home, at school, and in their various villages.

On the very last day of the intervention, the students and the teacher conducted a climate change expo and this was held at the school. Each group were given three days to prepare for the expo. Within this period of preparation time, the students were highly engaged and worked hard. Each group was given a task, either to talk about the causes of climate change, the impacts or the solutions. The 8 groups were allocated into 8 different stations at the hall, and the teacher advised them that they could do any decoration for their individual stations. One group who worked on climate change mitigation (see Figure 38) designed posters to suggest various ways to reduce carbon emissions. As shown on the blue chart, a picture of a man riding on a horse was drawn by the group members to indicate that people should use horses for transportation instead of using motor vehicles.

Figure 38 *Posters showing ways to mitigate climate change*

One group was given the task to display the ways of how to adapt to the impact of sea level rise and rising temperature. As showed in Figure 39 these students used a large piece of tapa (ngatu) as the screen background. The tapa is a representation of the students' identity and their voices – it represents a Tongan situation. This group did a talanoa kavekavehoko on how to adapt to the impacts of rising sea levels and rising temperature – the use of the tapa emphasised the fact that Tonga has experienced these impacts of climate change.

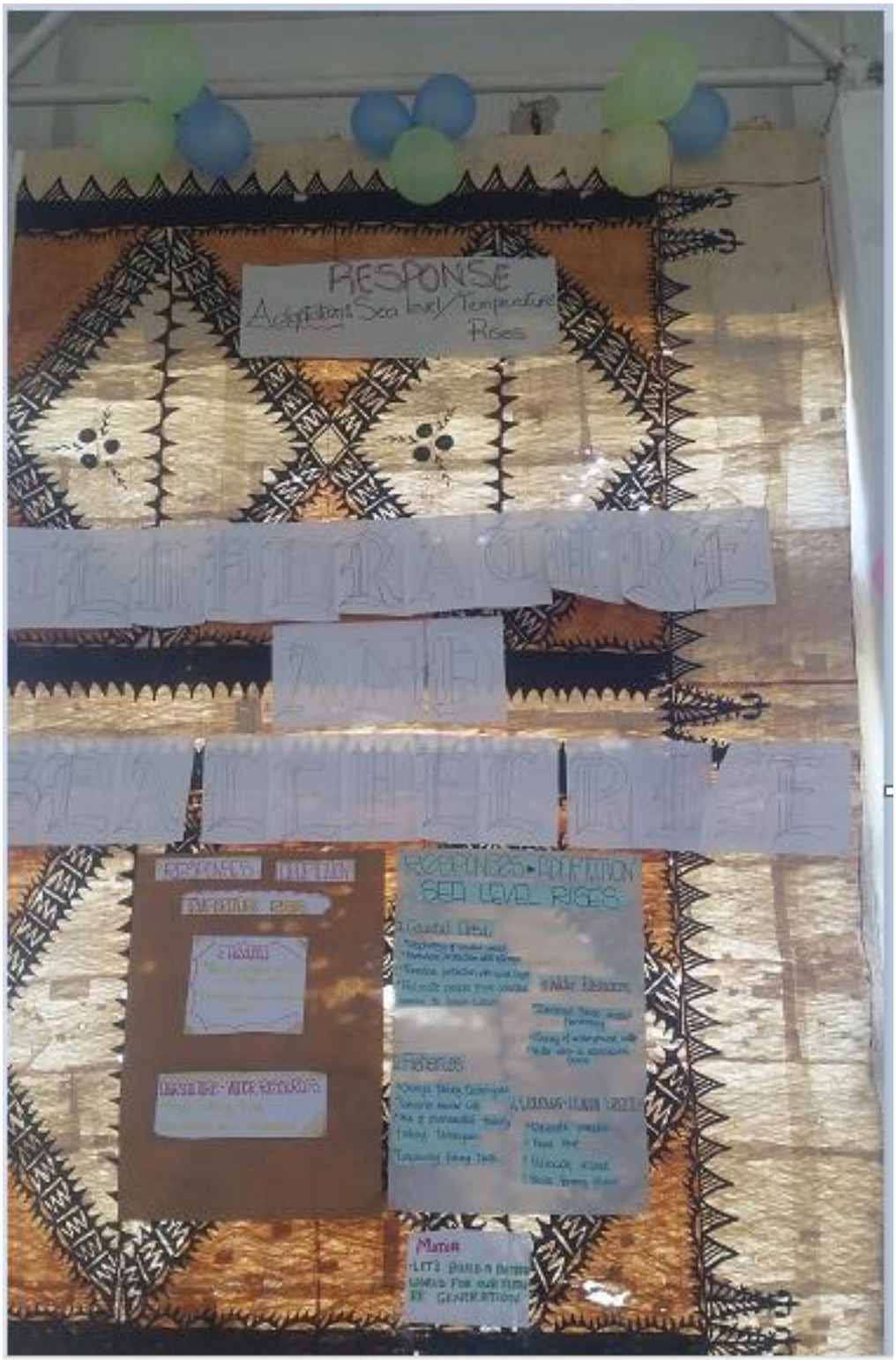


Figure 39 Presentation on adaptation to tropical cyclones

To respond to the impacts of drought, a problem that has also affected Tonga, these students did their talanoa kavekavehoko on ways to adapt to this problem. As shown in Figure 40, one student was holding a piece of paper saying ‘Stop Now’. When asked what

they needed to stop, they suggested that people need to stop using the water unwisely given the reason that when there is a drought, a lack of water will be the main problem in their island. There are two students also holding the containers with dried grasses which appeared to indicate the negative impacts of drought on the environment.

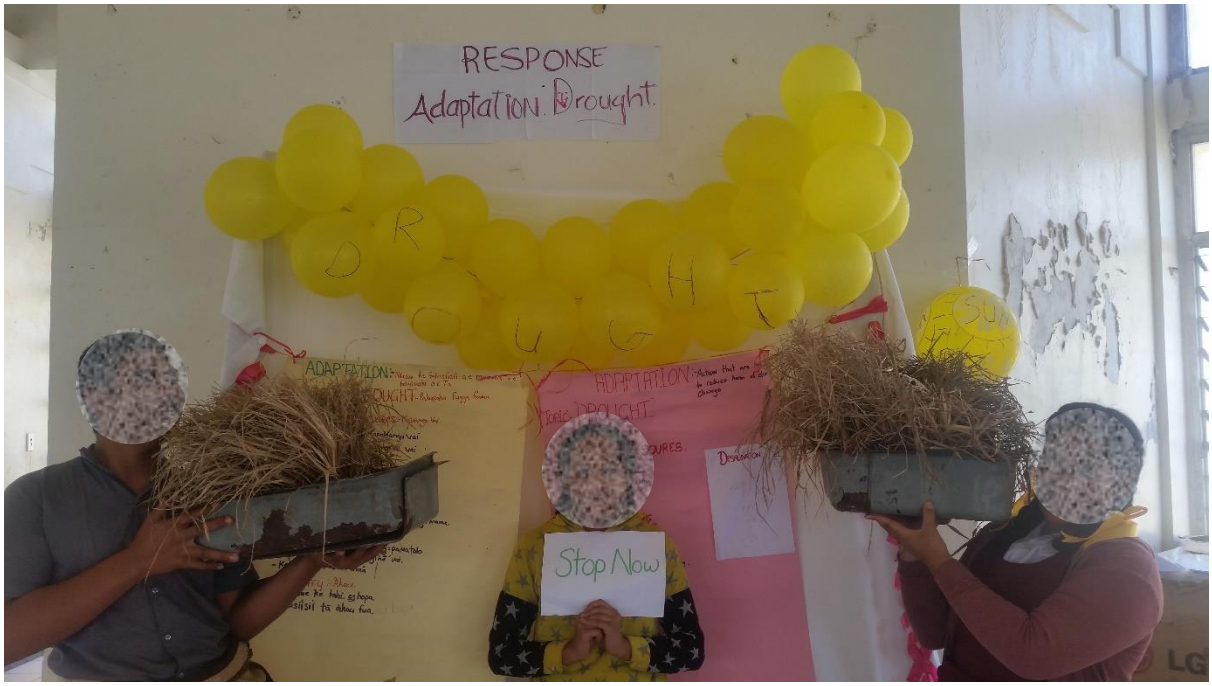


Figure 40 *Presentation on how to adapt to the impacts of drought*

On the day of the Expo, all the students who participated in the intervention performed an action song in front of their parents, school teachers and student visitors and students from their own school. Based on my own observations on that day, I noticed that the students felt so motivated and so confident to present their work to this wide audience. They had the courage to stand in front of their friends and everyone to showcase their willingness to participate in raising climate change awareness outside their comfort zone. They conducted the talanoa kavekavehoko effectively to ensure their voices were heard and the message of climate change was communicated to the audience well. Students displayed values of caring, love and respect to their environment and to the people of Ha'apai by motivating and empowering them to start working together as locals to address the impacts of climate change in their island. This highlighted the effectiveness of using talanoa kavekavehoko as a tool to communicate the issues of climate change and to empower others to take climate change action.

One student mentioned in the post-intervention talanoa fakatokolahi that the Expo had helped them to realise that they had ability to do their best and it also enhanced their team work skills. She said, "Last Friday was an exciting day for us, group members worked cooperatively in their various stations to decorate their stations according the tasks they were given. The spirit of teamwork was wonderful" (Saane, female student SFG Phase Two).

7.3.3 *Ta takaua ka ta ikuna* - Willingness to become Agents of Change

> Impacts of climate change such as sea level rise and rising temperature are caused by human activities and we all contribute to these problems. We need to work together to solve these problems. Together we change the world, and we have to be the change (Ane, female student, SFG Phase Two).

The above quote indicated that this student (Ane) believed that they should become the change. She also mentioned in the post-intervention talanoa fakatokolahi that she will be able to help reduce the impacts of climate change by using vehicles less and to grow more plants. Lisa also mentioned that she used to go to school by their family van, but the intervention had encouraged her to start walking to school. She stated that she would also try not to cut down trees as a way to influence her family members to do the same. One student also mentioned that she learnt about important information such as how to save electrical power at home. She highlighted that she will try to unplug her phone charger when it's not in use. She also emphasized the idea that it is significant to do what they thought is right to do.

It was highlighted during the talanoa fakatokolahi that the 3-4 weeks of intervention have helped the students accomplished some skills. Ane said, "…if we students can possibly make some changes as a result of these three to four weeks of studying about climate change, I think we can possibly go out to the public and conduct the similar programs so that people may be aware of it… (Ane, a female student, SFG Phase 2). Ane also highlighted that it is really important for her to make changes both at school and at home. Students were asked if they would have the opportunity to talk about climate change to the young people of Ha'apai then, what their key messages would be. Taniela, a male student, stated that, "I will focus on the future, what you're doing today is your investment

for the future, for your children and your grandchildren. We should do something worthwhile for the future generation". This quote stressed the fact that this student does consider the future generations. He is alerted about the risks that we may pose on their lives. Noulisi, a male student, added that he will run a workshop in his village and he will talk about mitigation and adaptation. Lisa contributed to the conversation with a very powerful message "Walk the talk" (Lisa, female student, SFG Phase Two). Ane echoed the importance of raising public awareness about climate change. She said, "Yes I will be happy to do that. I will talk about the causes, the impacts of climate change and the solutions to reduce or to stop climate change, so that the young people will know about it. (SFG Phase Two)" Students appeared to be empowered to start making a change and to influence others as well so that they can do something to help solving the climate change problems.

The students' willingness to act upon climate change could also be witnessed when they gathered together as students to perform a song. As seen in Figure 41, they performed the song in front of everyone which really demonstrated their confidence and willingness to empower others that they could do something about climate change. The song that they performed was called 'Do it now' (www11be, 2012, November 30), and they wanted to communicate a key message to the listeners that climate change had affected their lives in so many ways.

Figure 41 *Students performing a song about climate change*

Data from the observation records (13.10.2017) reported that students, teachers and parents were so engaged during the performance, their attentions focused on these

students. The audiences' complete attention reflected their willingness to listen the message that they wanted to communicate.

7.3.4 Students' views on using talanoa as an approach to learn about climate change

Talanoa was a concept developed to help the students and teachers in Tonga learning about climate change. The 3 ideas of the talanoa that was conducted during the climate change educational intervention were: Talanoa fakatoka; talanoa felāfoaki; and Talanoa kavekavehoko. This section presents the students' views on the effectiveness of using the three ideas of talanoa in the intervention. During the post-intervention talanoa fakatokolahi, the students were asked to comment on the three different stages of the talanoa that they did in class and based on their responses, I classified them under the 3 ideas of talanoa fakatoka, talanoa felāfoaki and talanoa kavekavehoko. Data are drawn mainly from the talanoa fakatokolahi, however, data from the questionnaire and the observations are also included to support the talanoa fakatokolahi data.

Students who participated in the post-intervention talanoa fakatokolahi thought that the talanoa fakatoka was a powerful tool and it was more like an ice breaker to them. Students who were shy and seemed to be hesitant to speak in front of their group members developed a sense of belonging and started to communicate with their peers. Talanoa fakatoka built relationship among students – it brought students closer to one another. Saane (a female student) stated that, " …talanoa helps bringing us together and to work more closer with one another…" (SFG, Phase Two). Saane also believed that talanoa offered them an opportunity to share what they have already known about climate change with their group members. She said, "…students could share what they knew already, and to share things that might come up in their minds…". Some students also thought that Talanoa fakatoka brought feelings of joy and happiness to them. Kaki (a female student) said that "…talanoa brings feeling of joy and happiness…".

Taniela (a male student) stated that "Talanoa enables students to share what they know, and of course, there are some aspects of climate change that I do not know about. And talanoa helped me to learn about those aspects from others, and this learning took place through talanoa". Taniela highlighted that talanoa fakatoka is potentially a stepping stone to the next idea of talanoa, which is the talanoa felāfoaki

Students believed that talanoa felāfoaki paved the way for the group members to build on each other's ideas and it enhanced their abilities to produce a good outcome. Kaki (a female participant) stated, "I bring my knowledge along, and the other group members bring their knowledge and understanding, and then we co-constructed these ideas to produce a good quality piece of work for our group". Students also found talanoa felāfoaki an effective way to enhance 'listening' during the group discussion. Saane emphasized the effectiveness of talanoa by saying, "…talanoa gives us an opportunity to broaden and to extend our knowledge because we could listen to each other's ideas and it helped a lot*…"*. Saane also discussed how talanoa felāfoaki could become an important approach to speed up the discussion and their class activities. It appeared that students often reached a point of consensus when they did the talanoa felāfoaki and the outcome as well was positive. She said, "Talanoa helped to speed up our work and we also ended up with a productive work".

Students' were asked to make comments on using talanoa kavekavehoko as a way to share new knowledge, or to voice their concerns and their motivation to deal with climate change. A majority of the student participants stated that when they were asked to present or report their work to the whole class, it helped them to build their confidence to be able to stand in front and to share their knowledge with everyone else. Talanoa kavekavehoko is labelled here as a way to share their climate change knowledge with others. Talanoa kavekavehoko also featured students' motivation and willingness to act upon climate change. Tupou (a male participant) shared his experience by saying: "Talanoa helped to strengthen my motivation and willingness to do something about climate change". Saane highlighted that talanoa kavekavehoko also helped to improve learning. She said:

> …when we are asked to go up to the front to report our group work, we kind of have an extra courage to really stand up and talk about our work. I do believe that this new strategy is so crucial and it helps us a lot. If these strategies will be adapted, our learning will be very much improved (Saane, SFG, Phase 2).

Talanoa kavekavehoko was also reported by Kaki, a female student to be an exciting time for them as students and it was very encouraging too. She said, "Talanoa encourages us to report back the work that we managed to produce through co-

construction and team work. That makes us happy". Talanoa kavekavehoko therefore developed feelings of joy and happiness among the students.

7.3.2.1 Talanoa kavekavehoko – The climate change Expo

During the post-intervention talanoa fakatokolahi, students were asked make comments about their feelings on the day of the Expo, and to give feedback on whether they found talanoa kavekavehoko effective in that context. Many of them seemed to become emotional as they started to share their experiences. Noulisi (a male participant) explained how the talanoa kavekavehoko at the Expo impacted him in a positive way. He said, "Talanoa helped us to work alongside each other. On the day of the Expo, the students had the courage to stand in front of everyone and talk. It gave us an opportunity to share the work we did and what we learnt". One student thought that the Expo provided a venue for them to feel encouraged and to consider them a powerful agent to share their knowledge with others and to help raising the awareness about climate change. Ane, a female participant said:

> One of the things that motivated me the most in this Expo was that I know that it's my job and it's my responsibility to stand up in front of my friends and my classmates, and one way that we can do to reduce the impacts of climate change is to explain it to everyone, we have to explain the story of climate change to everyone – its causes and impacts and what we have to do to stop climate change. It's my job and I feel so encouraged to speak in front of everyone, to do something to help stop or reduce climate change (Ane, SFG Phase 2)

The above quote accentuated the effectiveness of talanoa kavekavehoko to the students. Talanoa kavekavehoko is being depicted here as an approach to deal with climate change. It is a vehicle for disseminating the information about climate change. It also helped to equip students with a sense of accountability and responsibility. Data from the observation record reported that the students were so active and they did not hesitate to stand in front of their parents, teachers and students to share the climate change information. Figure 42 shows one speaker who used talanoa kavekavehoko to share the new knowledge she gained about the causes of climate change. Data from observations records also indicated that this particular presentation made an impact on some teachers' conceptions of the causes of climate change. One teacher came to share the knowledge

that she got from this presentation. This teacher was not aware at all about the band of greenhouse gases in the atmosphere. She was completely empowered by the student's presentation.

Figure 42 *Student doing a talanoa kavekavehoko to explain the greenhouse gases and their contribution to climate change*

Talanoa kavekavehoko helped students to step out of their comfort zone. Lisa said that:

> I am not confident in talking in front of many audiences, but the Expo helped me to overcome that feeling. I was extremely scared because that was the first time for me to stand in front of many people. When I started to talk, I felt so encouraged to speak confidently and to pass my message to the listeners (Lisa, female student, SFG Phase 2).

7.3.2.2 Ngaue fakataha – Working together (in small groups)

Data from the post-intervention talanoa fakatokolahi and observation records reported that working in small groups was an effective approach in climate change education. Although talanoa is literally referred to as informal conversation, in this context, talanoa

was utilized as a platform for various things to take place such as exploring students' dispositions, students to co-construct ideas, and students to share new knowledge about ways to deal with climate change. Saane stated that, "I really admire the different strategies that we used during the intervention, for example the group work. Group work gave us an opportunity to work a bit closer with one another". One student also said that working in small groups encouraged his group members to feel more responsible so everyone in the group had to have a say in whatever they did. Data from the observation records also indicated that students seemed to enjoy walking into class knowing that they are going to sit together with their group members. I realised during the group activities that students built their confidence, which helped in shaping the kind of talanoa that is happening in various groups. When I walked around the groups, I could hear the students conducting very productive talk. Working with small numbers appeared to boost the level of conversation and learning of the students.

7.3.2.3 The resources – Were they effective?

Data from the post-intervention talanoa fakataautaha reported that Lavinia thought the resources were so helpful in enhancing students' learning about climate change. Lavinia emphasised her point on the effectiveness of using the resources such the video clips. She thought that the video clip helped a lot in addressing students' alternative conceptions about the ozone layer. She said, "The students also had misconceptions, they thought that the ozone layer depletion is the key cause of climate change. They can understand now that climate change is caused by greenhouse gases" (Lavinia, teacher). When asked what resources she would use if she was running a professional development for the teachers at her school, she said:

> Based on the experience I had when I conducted this intervention, I will use the video clip that we used in class. I will also use the graphs and tables because they do indicate the rising temperature really well and they also identify the differences between the climate and weather. These resources are so powerful in communicating the climate change information to the students, and the students were able to learn in a very effective way. (Lavinia, teacher)

Data from the observation records (03.10.2017) showed that students appeared to be strongly engaged in drawing the map of their island on the chart provided (See Lesson 6

in Appendix M). For example, when they were told by the teacher that the sea level rise took about half of the island, the students had to rip half of their map, the students were so interested. They were also given a chart to draw a consequence wheel. Students seemed to have gained broader knowledge about the impacts of climate change when they were involved with these resources. Table 13 indicates the students' engagement and participation for the lesson on the 3rd September, 2017. Table 13 presents a high rate of engagement and participation among students to the given activities mainly because of the resources they were provided were eye-catching and thought provoking for the students (Observation records, 03.10.2017). I rated these students' engagement and participant during the lesson. From 1 to 7, where 1 is no engagement and no participation, and 7 is high engagement and high participation. Students who showed no engagement and no participation scored 1-2, those who are scored 3-5 are the students that are engaged and participated but are also can be distracted and they were off task. They tended to talk among themselves sometime. Students who have a high engagement and participation are those that are focused on the tasks given, and they appeared to collaborate with their group members, these students scored 6-7.

Table 13 Rating of students' engagement and participation for activities in Lesson 6 (03.10.2017)

Activity	**What are students doing?**	**What is the teacher doing?**	**Student engagement**	**Students participation**
			1 -7	1 - 7
Shrinking island	- Draw a map of an island - follow the instructions that are given by the teacher.	- Provide guidance to the map drawing - Read out the scenarios to the students – eg: After 15 years 1/3 of the island is taken by sea level rise.	7	7
Talanoa	- Share talanoa about impacts of CC	- Facilitate points in the talanoa	6	6
Consequence wheel/ Impact wheel	- Students work in group to identify impacts that are common in Tonga such as increasing extreme weather events such as cyclone, sea level rise, and temperature rise.	- Facilitate information	6	6

7.4 Teacher's outcomes

This section presents findings on the teacher's outcomes in response to the professional development and the education intervention. The section is divided into two parts. The first part reports data on the teacher's views about the professional development. Two themes emerged from this data namely: Promoting content knowledge; and Promoting preparedness to teach about climate change. Data is drawn mainly from observation records, and talanoa fakataautaha. The second part of this section presents data on the teacher's outcomes in response to teaching climate change to her students. The three themes that emerged from this data are: Impact of climate change education on teacher's pedagogical knowledge; integrating talanoa in the teaching and learning of climate change; and the teacher's transformation.

7.4.1 Professional Development (PD) – Promoting teacher's content knowledge

A talanoa kavekavehoko was conducted prior to the commencement of the actual PD to explore Lavinia's existing understanding about the key aspects of climate change including the cause, impacts and solutions. This included recognising the teacher may have similar alternative conceptions to the students, for instance, the ozone layer was conceptualised by Lavinia to be the main cause of climate change. The observation record indicated that Lavinia stated that the PD would help strengthen her understanding about climate change. She also directly expressed that she had limited understanding about the causes and impacts of climate change (20th September 2017). Lavinia indicated a willingness to learn about the process of greenhouse effect. When she was asked if she knew about the responses that are classified under adaptation and mitigation, she said she did understand about the two terms. However, she could identify some basic responses to climate change such as 'refrain from cutting down trees'. Talanoa fakatoka worked effectively in this context. Lavinia was being honest with identifying her existing understanding about climate change, which was helpful to me in terms of providing the appropriate and necessary plans for the PD programme. The video clip which was planned to play during the classroom teaching was introduced during the PD so the teacher could first be able to identify greenhouse gases and also be able to differentiate ozone layer depletion and greenhouse effect before she could teach the concepts in the classroom. The

PD which attended specifically to common areas of confusion in climate change science was successful in helping Lavinia improve her understanding of climate change and the greenhouse effect.

It was important for me to see that Lavinia's alternative conceptions would be addressed so that she could be able to address the students' alternative conceptions in the classroom. Data from the observation records reported that Lavinia demonstrated a much improved understanding about the processes that cause climate change. Her explanation of the greenhouse effect, with the help of the video clip reflected the knowledge that she gained about the topic. Data from the post-intervention talanoa fakataautaha showed that Lavinia was impressed with the knowledge that she had developed as a result of the PD. She said, "During the Professional Development…I read the resources that you gave me and we did the talanoa, that helped me to understand more about climate change, I got to learn more about the causes of climate change".

7.4.2 Building confidence to teach climate change

The PD appeared to have played a significant role in building Lavinia's confidence to teach climate change. The lesson plans were co-constructed between Lavinia and me during the PD through talanoa felāfoaki. Each lesson plan was evaluated, and according to the observation record, Lavinia contributed a lot in making changes to the lesson plans. For example, Lavinia suggested to make a change on Lesson Plan 3 (see Appendix M). She suggested that we could move Task 4 and discuss it after the Task. She thought that it is important that students would be able to distinguish climate change from global warming at the beginning of the lesson. In that case, the role play that was allocated in Task 3 was used to conclude the lesson. Lavinia stated during the post-intervention talanoa fakataautaha that, "The fact is that the PD helped building my confidence to teach the issues of climate change. If I did not attend any PD but went straight and taught it, I would not be able to have the confidence". The standard of the resources provided during the PD were also powerful in building her confidence to teach in the classroom. She said that, "…the resources you provided helped a lot, it wouldn't be the same if I were the one who look for the resources". Professional Development for Lavinia was a way of equipping her with the knowledge so that she could gain confidence to work alongside the students confidently. She said that:

> When the students are doing activities, they are of course working in their various groups and I could be able to facilitate the discussion and be more cautious of what the students are learning. I get to communicate with them more. The PD that you conducted has helped filling up my cup, and I felt so confident and ready to teach the unit in the classroom (Lavinia, teacher).

When asked in the post-intervention talanoa fakataautaha about the potential factors that may have hindered her ability and confidence to teach climate change, Lavinia said, "…Lack of climate change knowledge would be the main key factor that might hinder my ability and confidence to teach climate change".

7.4.3 Teacher's pedagogical knowledge benefits from teaching climate change

Pedagogical knowledge as adopted in this research refers to knowledge about teaching, an understanding of how particular topics, problems, or issues are organized, presented, and adapted to the diverse interests and abilities of learners and the ways of representing and formulating the subject that makes it comprehensible to others (Shulman, 1987). Data from post-intervention talanoa fakataautaha indicated that Lavinia increased her pedagogical strategies as a result of teaching climate change during the intervention. She said:

> I was a bit confused, first, the lesson plans are so new to me, it looks totally different to what I normally do in class. I could see that there were almost two activities in every lesson, and I thought it's a bit too much in compared to the students' abilities…However, during the teaching, I noticed that the students enjoyed learning, they loved the activities, they were coping well with the transitions of activities. That is when I realised that I'm kind of fall short of much needed teaching strategies…(Lavinia, teacher).

The above quote was given by Lavinia during the post-intervention talanoa fakataautaha, which indicates her feelings about the lessons when she first saw them. At first, she expressed her lack of confidence to teach these lessons thinking that conducting two activities in one lesson would not be effective as students may not be able to adapt to the

new approach. Her perspectives started to change when she realised that students enjoyed the activities they were given, and they seemed to enjoy learning.

Lavinia also commented that the ongoing feedback that I provided after every lesson to be very powerful and effective. After every lesson, Lavinia and I did a talanoa, we went through the lesson and talked how the lesson went and whether the objectives were achieved or not. Based on that talanoa, Lavinia was able to realise what worked and what could be improved. The same approach applied after every lesson, and it appeared to have a positive impact on the students' learning and on the teacher's pedagogical knowledge. For example, in one of the classes, the students were required to do a group task. While most students were engaged, I realised three students were talking and totally off track but perhaps they were not seen by Lavinia. I brought this up during our talanoa at the end of the class and Lavinia appreciated that. At our talanoa fakataautaha, Lavinia said:

> …Normally, I just ignore students who are talking and are disengaged during my class. I only pay my attention on the students who seem to put their attention on me during my teaching. But you know when you talked to me one day about that group of students who were talking and disengaged, I started to be more alert and had to make sure everyone is on track. That teaches be a lot because I do not always notice that in my teaching… (Lavinia, teacher).

7.4.3.1 Effectiveness of using group work

One of the approaches that Lavinia thought to be powerful was group work. Lavinia mentioned in the talanoa fakataautaha that she was so happy to see the students engaged in every lesson. She realised that students participated more in discussion when they are in their various groups. Lavinia also admired the group leaders' abilities to take the lead and she referred them as 'good leaders'. During the talanoa fakataautaha, Lavinia said:

> …the students are so engaged, they are so active and I am so happy to see them that way. They participated a lot when they worked in their various groups, and that is the part that I enjoyed the most is when I see them fully committed in their various groups. The group leaders are good leaders, they help to motivate the group members and they

> kind of motivated each other, and they learnt a lot from it (Lavinia, teacher)

Students appeared to work more effectively when they worked in groups. Lavinia said, "I believe the students were familiar with each other, so when a task was given to their various groups, they seemed to know what they were doing. They worked within the time frame, they worked faster and effectively. If you can see, when they got their confidence, they communicated with each other very well".

7.4.3.2 The activities

Lavinia had positive feedbacks about the valuable of the activities that were conducted during the delivery of the lessons. Data from the observation records also indicated that students felt so positive about the activities that allowed them to work out the meanings on their own, and they also appreciated the time when they were asked to present their work in front of everyone.

> I thought drama can only be used for English classes, but this intervention has taught me a significant lesson that drama can also be conducted in a science classroom as well. (Lavinia, teacher)

Table 14 illustrates the observation records that were obtained during Lesson 4 (29.09.2017). There were four different activities conducted in this lesson, and it indicates a high rate of students' engagement and participation in each activities.

Table 14 *Rating of students' engagement and participation for activities in Lesson 4 (29.09.2017)*

Activity	What are students doing?	What is the teacher doing?	Students engagement	Students participation
			1 -7	**1 - 7**
Playing video clip: GHG's & ozone layer depletion.	- Carefully study the video and answer the questions given which are based on the video they are watching.	- Play the video clip and clarify on some key ideas of the video	7	6

Talanoa *b*ased on the video	- *Talanoa* took place among the students and their answers were written down	- Ensure students are on tasks	6	6
Paper cutting	- Paper cutting and then use them to design diagram of the greenhouse effect	- Distribute resources and guide the students what they are expected to do.	7	7
Report	- Group leaders explained their diagrams and the process of greenhouse effect to the whole class	- Facilitate the group presentation and ensure there is a time to ask questions or make comments	6	6

Data in Table 14 aligns with data from talanoa fakataautaha. Lavinia highlighted the importance of conducting effective activities in the teaching process. She referred these activities as 'student-based' activities. She said,

> I am very happy about the activities that we did during the lessons. I can see and prove it to myself now that student-based activities are very effective and powerful. I can now see that it is important to leave it for the students to find the answers on their own. In my teaching, if the students do not know the answer, I tell them. This intervention helped me to realise that I should leave students to work out the meaning themselves. And I could prove it that students needed to be given the opportunity and the space to do so, and that is an important lesson that learnt from teaching this unit (Lavinia, teacher)

When asked whether the activities given in class helped to promote students' learning and understanding about climate change, Lavinia responded positively by saying yes. She started by highlighting the outcome of the day of the expo when the students confidently communicate their knowledge to a wide range of audience. She also identified some lessons where she noticed the shift and improvement in the students' understanding of climate change. Addressing of some key alternative conceptions that was commonly held among the students was also another outcome of executing the activities. She said,

> First thing is regarding the fact that students are now be able to label different greenhouse gases. Before the intervention, they referred to these gases as kasa kona they do know now that these gases are called

> ‘greenhouse gases’. Well, the students and I are both learning, we have learnt new things…(Lavinia, teacher).

Lavinia also highlighted that the Science Head of Department continuously reminded them to be more practical in their teaching and to avoid spending too much time on the blackboard. She believed that the intervention helped her to realise the effectiveness of using practical work both in teaching and learning. She stressed how the students had so much passion to learn about climate change because of the quality of activities they were given, and that also impacted her pedagogical knowledge. She said,

> The practical work that was conducted in the activities were so interesting for students, so they were so keen to learn more about climate change and they showed passion to be involved in climate change education. That is exactly what Talia (Head of Department for Science) had been emphasising us teacher to employ in our teaching. We were asked to be more practical and spend less time on using the blackboard because the students will learn more when the lesson is more practical. I did not bother too much about this kind of thing, but now, I know, I have to change my teaching approach and get to use practical work more often (Lavinia, teacher).

7.4.4 The effectiveness of using ‘talanoa’ in teaching and learning about climate change

This section presents data on the teacher’s perspectives about using talanoa as a teaching and learning approach for climate change education. Data is drawn from the post-intervention talanoa fakataautaha and observation records. The two sub-themes that emerged from the main theme were: successful leaning; provide a platform for students’ voices to be heard.

7.4.4.1 Successful learning – cater for level of thinkers

Data from the post-intervention talanoa fakataautaha indicated that talanoa was not commonly used when teaching science. Introducing talanoa made a huge impact on Lavinia’s perspectives about teaching in a science classroom. She said:

> Talanoa approach was remarkable. Students are hardly ever given the opportunity to conduct a talanoa in small groups. It was effective...I mean if those lessons were based on blackboard teaching, I think, only the students who are above average that may understand the lessons. Talanoa gave every student an opportunity to participate in the discussion, and they learn together as a group. That is when I realised that students learn from each other well through talanoa (Lavinia, teacher).

7.4.4.2 Provide a platform for students' voices to be heard

Talanoa also played a significant part in allowing students' voices to be heard. Lavinia expressed her total surprise when finding out that her students were capable of presenting their ideas verbally. During the post-intervention talanoa fakataautaha, she said:

> …this was the first time for me to literally hear the students expressing their views and perceptions, and their ideas verbally. They are so involved in their discussions. I am surprised that they could also have the ability to stand and share their new knowledge with everyone. The climate change unit did not really go for a long time, it's only few weeks, but seeing students getting so heavily involved and valuing the talanoa approach is very impressive…(Lavinia, teacher)

7.4.5 What has been transformed?

Prior to the implementation of the climate change unit, Lavinia believed that climate change was a problem that would have planned by God so there is nothing that people could do to help reduce the consequences of climate change. During the post-intervention talanoa fakataautaha, she pointed out that she remembered what she said during the talanoa fakatokolahi in the Phase One. She thought that climate change is God's plan so people do not have to do anything, God will save them. She started to get emotional when she said:

> …I still remember very well when I said that climate change is God's plan and that we will be saved by God. The truth is that, there is a

> change in the way how I think and the way how I believe about climate change. Climate change is human-caused, it is caused by human's carelessness and unwise decisions, and I understand now that we should consider this problem seriously and we should worry about it. We have to do something about it…(Lavinia, teacher)

Lavinia demonstrated a shift not only in her understanding about climate change but also in her attitude – she is worried about the issue and expresses that there is a need to do something about climate change. She is now in a position where she realises that climate change is caused by humans thus it is the people's responsibility to do something to reduce or to stop the problems. Data in Phase One had indicated that Lavinia's perspectives about climate change were heavily influenced by her religious beliefs and by what she was advised by the elders that their religious beliefs in God can always save them from obstacles.

Data from the post-intervention talanoa fakataautaha also reported that Lavinia's improved knowledge had an impact on her willingness to teach climate change and her views about the importance of delivering this issue to the students at a young age. She said:

> I wish that I'd be given another chance to run the whole unit again because I can say that I am more confident now to teach climate change. There is a great improvement on my content and pedagogical knowledge about climate change. I am more familiar with the lesson plans. I can realise now the few things that I could have done better during my teaching. Well I am more confident now and so do my students, they seem to have better knowledge about climate change... (Lavinia, teacher)

As mentioned in section 7.4.3, Lavinia was a bit confused in the beginning, she thought that it would not be possible to communicate the climate change information effectively to the students. She thought that she did not have the ability to teach the subject well. Her lack of confidence about the subject could be the reason she felt that way. At the end of the intervention, she cheerfully shared her stories during the post-intervention talanoa

fakataautaha – she had gained her confidence and she hoped she will be given another chance to do the climate change teaching again.

Lavinia also believed that teaching climate change to the students at a young age will shape the way they respond to the issue and will also equip the young people to pass on the climate change information to their family and the people around them. She thought that students will be able transform what they have learnt in the classroom into practice. She said:

> I believe that getting students to learn about climate change at young age will have a huge impact on them over their lifetime. For example, they may start disseminating the climate change information among their family members. Not only that but when they hang out with the people in their various village communities, then they can put their knowledge into practice… (Lavinia, teacher).

7.5 Community outcomes

This section presents the data about the outcomes of the implemented climate change education on the community. The community in this section refers to the audiences that were specifically invited by the teacher and the students to the day of the Expo, and that includes the parents, students and teachers from the school that was involved in the Phase One of data collection, and the students and teachers within the school where the intervention was implemented. Data is drawn from the observation record. The two sub-themes that emerged from this data are: Community appreciation; and Community motivation to act.

7.5.1 Community appreciation

The Expo provided a venue for the students who were involved in the climate change education intervention to show-case their new knowledge and ways to help address the problems of climate change. Data from the observation record indicated that during the groups' presentation, the community were fully engaged in listening and paid attention to each group report. This was clearly shown by the time when a presenter was speaking, the hall was in silence, and only the speaker's voice could be heard. Everyone's attention was on the speaker, and that indicated how appreciative the community was for the

students' efforts. There were eight different stations which represented the eight different student groups. My observations also showed that the audience focused on the whole presentation – from the first group up to the very last group.

My observations also indicated that some members of the community asked questions to the students and one of these questions was related to the ways of how to adapt to the impacts of climate change. The students who answered the question made a great attempt in answering the question, and the facial expressions and gestures from everyone the audience indicated that they were impressed by the way this student attended to the question. This student later participated in the talanoa fakatokolahi and she shared her feelings she had when a question was asked of her during the Expo, she said "…I was scared…but then I started to have the courage…When Pila asked the question, I was happy and satisfied as I knew that I answered his question" (Lisa, student). The willingness to know more about the students' presentation demonstrated a sense of appreciation from the community – it showed that they were so keen to know more about climate change.

I also received very positive feedback from the community – from the students, the teachers and some of the parents who turned up to the Expo. One of the teachers shared how her understanding of climate change has been improved by hearing the students' presentation. She also seemed to have held the common alternative conceptions about the ozone layer depletion and that she learnt about the layer of greenhouse gases in the atmosphere. Teachers also commented on students' confidence to present in front of a wide range of audiences.

7.5.2 Community motivation to act

The level of participation at the Expo from the community demonstrated their keenness to know more about the issue, but they also showed great motivation to do something about climate change. The groups who presented on the adaptation and mitigation of climate change were the ones who received the most queries and questions from the community. Not only that, but the observation records also indicate that the community showed a special interest in the solutions to climate change.

The Expo attracted a large number of people which included students and teachers within the same school, students and teachers from other schools, and parents, and this is clearly portrayed in Figures 43 and 44..

Figure 43 *Community's engagement during the students' talanoa kavekavehoko*

Figure 44 *Community's engagement during the students' talanoa kavekavehoko*

7.6 Chapter summary

Chapter 7 has presented the outcomes of the climate change education intervention for the students, the teacher and also the community. After the climate change education intervention, students' knowledge and understanding about the climate change were elevated, and the alternative conceptions that they held about the ozone layer were also addressed. Their level of awareness and concern about climate change were also increased

as a result of the intervention, and they were more willing to help to do something about climate change. The use of talanoa for teaching and learning about climate change had a huge impact on enhancing students' interactions in class. It strengthened students' relationships and provided more opportunities for discussing, and co-constructing ideas. The teacher who delivered the intervention encountered a number of improvements not only in her climate change knowledge, but also in her teaching skills. The Professional development was also recommended by the teacher as an effective way to prepare someone who is planning to teach climate change. Based on the data from an informal observation that took place during the day of the climate change expo, parents, students and teachers who attended the expo were inspired by the presentations that they saw on the day. Some of them indicated their willingness to help addressing climate change. The next chapter presents the discussion of the findings, and conclusions and recommendations of this study.

Chapter 8: Discussion, Conclusions, and Recommendations

8.1 Introduction

This research was conducted in two main phases. Phase One explored the teachers' and students' perceptions of climate change in Tonga and its place in their school curriculum. It also examined the existing status of climate change-related issues in the secondary school curriculum in Tonga. Data collected in Phase One and recommendations from literature informed a climate change education intervention which was designed, implemented and evaluated in Phase Two. This chapter revisits the research questions and discusses the key findings and the contribution of this research to knowledge. Section 8.2 discusses the key research findings, Section 8.3 draws conclusions of the research. Section 8.4 examines the research implications while the limitations are presented in Section 8.5. The last section of this chapter, Section 8.6 discusses the recommendations for further research.

8.2 Discussion of key findings

This section discusses the key findings of this research and addresses the four research questions that guided this research:

1. What are secondary school students' and teachers' perceptions of climate change in Tonga?

2. What is the existing status of climate change-related issues in the secondary school curriculum in Tonga?

3. How can a climate change education intervention be designed for Tongan secondary education?

4. What are the learning outcomes for Tongan students and teachers about the issue of climate change in response to the education intervention?

The next sub-sections discuss the key findings for each research question mentioned above.

8.2.1 Students' and teachers' perceptions of climate change

This subsection addresses research question 1 – What are secondary school students' and teachers' perceptions of climate change and education for it in Tongan settings? The subsection starts with a discussion of the students' and teachers' awareness, and proceeds on to discussing their understanding and perspectives of the climate change issues which includes; the processes that lead to the causes of climate change, the impacts and the solutions to help reduce or to stop climate change. Students' and teachers' awareness, knowledge and attitude about the issues of climate change and their motivation to act upon it are also included in this discussion. The final part discusses the students' and teachers' desires to learn more about climate change.

8.2.1.1 Climate change is happening

It is clear that Tonga is experiencing the impacts of climate change. This study is about the students' and teachers' perceptions of what is happening. Students and teachers believed that climate change is happening in Tonga and it is an issue. There was a high level of climate change awareness indicated among students and teachers in this study, and that had developed from their personal experience and observations of the obvious manifestations of climate change. Students and teachers indicated that they are living with climate change - rising sea levels, rising temperatures and increase in the frequencies and intensity of extreme weather events such as cyclones, were the impacts that they reported having experienced.

This is mirrored in other countries, for instance, a study that was conducted by Harker-Schuch and Bugge-Henriksen (2013) on the opinions of high school students in Austria and Denmark about climate change reported that the majority of students in these countries and schools believe that climate change is a threat and it is happening now. According to Mimura, Nurse, McLean, Agard, et al. (2007), and Nunn and Mimura (2006), the elements of climate change that threaten the lives of the Pacific peoples were the ones identified by the students and teachers.

Teachers' and students' awareness of climate change could also be due to their strong connection with the environment. Teachers and students indicated that they are naturally and emotionally attached to the land and sea. One of the teacher participants who was born and raised on the study island explained her experience in losing her sense of

connection to the beautiful sandy beaches she used to enjoy walking and playing on during her childhood. The sandy beach no longer existed as the whole area was flooded with sea water. This is aligned with what is advocated by the Global Humanitarian Forum (2010), that one of the reasons why Indigenous people have a particular interest in climate change is because of their physical and spiritual relationship with the land, water and associated ecosystems.

8.2.1.2 Climate change is affecting the people and the environment of Tonga

Students believed that Cyclone Ian, a powerful cyclone that affected their island in January 2014, was associated with climate change. One student described the cyclone as 'powerful and scary' while another student thought that that would be the last day of the world. One student was emotional when she recalled her memories of what she saw on the day – a family took refuge in an empty water tank because their house was completely blown down by the cyclone.

Students attributed the rising sea levels that they observed in their local areas to climate change. Students witnessed family and friends who have moved further inland due to rising sea levels. These stories clearly indicated that students were emotionally and mentally affected by what they have encountered so far as a result of climate change. Although students have experienced some of the direct impacts of climate change and they reported being aware of the connection between these and climate change, students showed little knowledge of other indirect impacts of climate change such as the impact of climate change on the economy and food production in Tonga.

Teachers, on the other hand, demonstrated a more sophisticated knowledge about the impacts of climate change compared to the students. The impact of drought was barely discussed by the students, however, teachers indicated knowledge and awareness about the impacts of drought on the food supply and also on the economy particularly on the families' income. They indicated that people of the island were also complaining about the impacts of climate change on fishing. Fishing was a main source of income for many families, but the impacts of the rising temperatures affected the productivity of the fish, and that has brought about financial pressure on people. Rising temperatures and drought were also thought to have affected the growth of pandanus leaves which are used for weaving, and as a result, people and their financial and cultural aspects would also be

affected as well. Women not only financially depended on weaving to sell their products, but were weaving mats to fulfil their family, church, and community's cultural obligations.

Findings from this research accentuate the impacts of climate change, both direct and indirect, and these impacts also feature in other countries – the loss of traditional life styles and cultures (Keener et al., 2012), the psychological effects of stress and mental effects from extreme weather events (Keener et al., 2012; Swim et al., 2009), and droughts that threaten traditional food sources and rising temperatures will likely threaten subsistence fisheries in island communities (Maclellan, 2009).

A range of literature reports the detrimental impacts of climate change to both people and the environment of the Pacific, including Tonga, which are similar to the impacts that were identified by the students and the teachers in this research. For instance, during the COP25 that was held in Madrid, Spain from 2 – 13 December, 2019, The Prime Minister of Tonga, Hon Pohiva Tu'i'onetoa advised the world leaders of the effects of climate change and how they continue to pose risks to the lives of people and the environment (SPREP, 2019). Hon Tu'ionetoa specifically mentioned the impacts of sea level rising since Tonga continues to experience record rates of coastal erosion. He also voiced his concern about the increasing intensity of tropical cyclones and that they are now up to a rate that Tonga lacks the capacity to respond to and to recover from.

8.2.1.3 Understanding the causes of climate change

Burning rubbish and cutting down trees were declared by students and teachers in Tonga as key activities leading to the cause of climate change. Although burning fossil fuels, especially in the developed and industrialised countries, was identified by both students and teachers as an activity contributing to climate change, they did not seem to put the blame only on those countries, and they thought that the people and the Government of Tonga also contribute to the causes of climate change. This indicates that students and teachers do feel accountable to causing climate change. While the UNFCCC (2014a) acknowledges climate change is caused by human activities such as burning coal and deforestation, students and teachers in Tonga also acknowledge their contribution to climate change from their own local scale.

Although students associated these localised activities, as well as heavy industrial activities in developed countries, to be the key causes of climate change, they indicated a

lack of understanding about some key scientific concepts that lead to the causes of climate change. For instance, apart from carbon dioxide, they could not identify other greenhouse gases such as methane and nitrous oxide. They referred to these greenhouse gases as 'kasa kona' or toxic gases. Other activities which are identified by literature to have contributed to climate change were not mentioned by either students or teachers. Denman et al. (2007) observed carbon dioxide emissions from cement manufacture, and methane and nitrous oxide emissions from waste disposal and landfills, agriculture, biomass burning and raising cattle as key activities contributing to climate change, however, these were absent in the students' and teachers' discussions. The students' and teachers' limited understanding may also be attributed to their lack of experiences of industrial activities. There is not one industry in Tonga that produces carbon at the rate they are produced at the industrialised countries.

According to Lambert et al. (2012), the greenhouse effect is one of the key concepts in understanding climate change. Similarly, greenhouse effect and its contribution to climate change was clearly misunderstood by the students in this study. The process of the greenhouse effect was confused with the concept of ozone layer depletion. This correlates with some studies that were conducted on students' understanding of climate change science which illustrated that students have difficulty distinguishing between the ozone layer depletion and the greenhouse effect in contributing to climate change (Boon, 2009). Literature reports that this confusion between the greenhouse effect and ozone layer depletion is an alternative conception that is commonly held by students (Koulaidis & Christidou, 1999; Myers et al., 2004). Findings on the students' alternative conceptions in Tonga are also likened to a study conducted in Norway which found that 70% of the students were confused between greenhouse effect and the ozone layer, with almost one-third of students agreeing with the statement that the climate change is caused by the ozone layer depletion (Hansen, 2010).

Similar to the students' responses, teachers agreed that climate change is caused by human activities but they did not demonstrate understanding of the science concepts underlying climate change. This supports previous studies indicating that although teachers are well-informed and aware about climate change, they still appeared to misunderstand the science around climate change and the process of greenhouse effect (Dawson, 2012; Dove, 1996; Summers et al., 2000). In addition, all the teacher

participants also believe that damage to the ozone layer is contributing to climate change. This finding shows that teachers were unable to differentiate the greenhouse effect from ozone depletion. This is consistent with an array of previous studies which report that school teachers believe the hole in the ozone links to the cause of climate change (Groves & Pugh, 1999; Papadimitriou, 2004).

The findings of this study indicated that students and teachers were less focussed about climate change being also attributable to natural causes, as their focus was mainly on human causes.

8.2.1.4 Understanding the responses to climate change

Mitigation and adaptation are the two main responses to the impacts posed by climate change (IPCC, 2018). Mitigation refers to the human intervention to reduce the sources of greenhouse gases (IPCC, 2014a), and adaptation refers to the process of adjustment to actual or expected climate change and its effects (IPCC, 2014c). Findings from the questionnaires indicated that students and teachers who participated in the study had more understanding about the mitigation approaches than the adaptation processes. For instance, 84% of the students either strongly agreed or disagreed that biking or walking instead of using cars could reduce climate change. Only 58% of them either strongly agreed or agreed that building sea walls could help reduce the problems of climate change. Building sea walls is an adaptation measure to reduce the impacts of climate change (McCarthy et al., 2001). Findings from the talanoa fakatokolahi showed that students and teachers believed that climate change could be alleviated if people stop cutting down trees, and burning rubbish. They did not mention how the household energy use contributes to climate change and this is corresponded with a claim made by Kilinc et al. (2008) that students are often unaware that household energy use can contribute to greenhouse gases emissions and climate change.

Findings from this study also indicate the significance of fatongia (responsibility/duty) in addressing climate change in Tonga. Students and teachers believed climate change is in the hands of both the Government and the people of Tonga. They highlighted that the Government, the Ministry of Education, schools, the local communities and individuals must play a role in addressing climate change. For instance, the Government of Tonga were expected to reinforce laws and to establish new laws which will help inform the

people of Tonga about the importance and values of looking after the environment. In addition, teachers felt the Ministry of Education needs to review the current state of the curriculum in order to incorporate key aspects of climate change. Parents at home could also help by reminding their children of the importance of caring for their environment. Findings showed that education should be provided to inform the local people in Tonga about climate change. This is aligned with the Tongan Prime Minister's speech at the COP25 in Madrid, Spain. He highlighted that fatongia is crucial when addressing climate change. He pointed out that the civil society, academia and the private sectors must continue to be dedicated in their roles in ensuring genuine accountability and to be key drivers in searching for solutions to address the adverse effects of climate change (SPREP, 2019). A study which was conducted in Austria and Denmark also reported that a majority of students in these countries agree that climate change is happening and that it is the responsibility of both individuals and governments to address it (Harker-Schuch & Bugge-Henriksen, 2013).

8.2.1.5Teachers' and students' attitude and motivation to act

Students and teachers expressed a high level of concern about climate change. Based on what they have experienced and observed, they were concerned about the future of the generations to come. They were concerned about losing their land to sea level rise and feared losing family and friends due to relocation or migration. One of the teachers, however, expressed a different view from the rest. She indicated that her Christian belief influences her attitude about climate change. She insisted that God would save her from climate change and that she was not concerned or worried about it. This finding is complemented by Walshe et al. (2018) as they recognized that local spiritual beliefs on small island developing states may influence people's perceptions of climate change. Havea (2015) identified a similar finding that people in Tonga believe climate change occurred as God's punishment on humans; her participants also believed that they will be saved by God. This shows that personal experience, cultural and social context, worldviews and values are also factors that can shape people's perceptions when responding to the impacts of climate change (Dessai et al., 2004; McLeman & Smit, 2006; Mercer et al., 2014).

Notwithstanding these spiritual beliefs, teachers and students demonstrated a high level of motivation to act upon climate change. They believed that their actions can help

mitigate the impacts of climate change. Despite their willingness to act upon climate change, they showed uncertainty about actions and solutions to mitigate or to adapt to the impacts of climate change. It is crucial that teachers who are the key stakeholders in educating young people (Miler et al., 2012) understand the key science underlying climate change (Lambert et al., 2012). Their role is to promote understanding of climate change and that the consequences of personal actions is also an important part of the solution (Dawson & Carson, 2013). Miler et al. (2012) emphasize that exploring teachers' knowledge about climate change is an effective way of examining their level of readiness to teach climate change, and it is evident from this study that teachers in Tonga may require some learning development so that they can advance their knowledge about climate change and be able to teach climate change effectively in classrooms. Some studies indicate the importance of running climate change-focused professional development which may help to enhance teachers' knowledge about climate change (Chang, 2014; Dawson & Carson, 2013; Liu et al., 2015; Walshe et al., 2018).

8.2.1.6 Desire to learn more about climate change

In relation to what students and teachers desire to learn about climate change, findings indicate that they were willing to learn more about the causes of climate change and the science underlying it. They also want to learn about ways to respond and to address the impacts of climate change. This is accorded with a study that was conducted in Samoa, Fiji and Vanuatu where teachers advocated the importance of the climate change issue and the worth of teaching it. They believed that their limited understanding about the issue, lack of training, and lack of resources restricted their ability to communicate or to teach climate change effectively to their students (Walshe et al., 2018).

8.2.2 Existing status of climate change related-issues in the school curriculum

This subsection addresses the findings for research question 2 - 'What is the existing status of climate change education in the secondary school curriculum in Tonga?' Data were derived from document analysis (Tongan school curriculum, Class 10 Science and Geography Syllabi), talanoa fakatokolahi (students and teachers) and talanoa fakataautaha (Officials from MET and MEIDECC), and questionnaires.

8.2.2.1 Place of climate change education in the school curriculum

This study finds that the term climate change is not featured in either the curriculum document or the education policy document (Tonga Ministry of Education, 2004). However, the guiding principles, aims and overarching themes in the curriculum document can be directly or indirectly relate to climate change education. One of the aims of the secondary education curriculum is to enable boys and girls in Tonga to participate in sustainable development by utilising and adapting new technologies and knowledge in ways that serve their own social and economic needs, and those of their community, as well as the needs of the environment (Ministry of Education and Training, 2016). Similarly, education for sustainable development (ESD) is one of the overarching themes of the curriculum (Ministry of Education and Training, 2016). Learning that is relevant, meaningful and useful is one of the guiding principles of the school curriculum. In this guiding principle, learning is advised to be related to real life and lifelike contexts. In a context where climate change is seen by students and teachers as a major issue in Tonga, climate change can be a part of the students' real life. The same guiding principle states that the school curriculum offers '…programs that help learners build resilience to assist them in adapting to the growing complexity of changing families, communities and cultures and prepares them for future roles and responsibilities' (Ministry of Education and Training, 2016, p. 7). Although there is no mention of changing climate or environment, there is a possibility for climate change related-issues to be addressed in the classroom based on what is outlined in the curriculum. In relation to the Pacific context, the mainstreaming of climate change within the education policy frameworks in the Pacific has been in slow progress (Hartmann et al., 2010). There have not been effective plans to improve education sector capacities to integrate climate change in relevant programs in the Pacific (Hartmann et al., 2010)

These findings are similar to a study that was conducted by Eames (2017). His study indicated that the New Zealand curriculum does not explicitly address climate change as an issue. He found that the phrase climate change does not appear at all in the achievement objectives of the learning areas in the New Zealand curriculum (Ministry of Education, 2007). However, like in the Tongan curriculum, he stated that a number of the achievement objectives in the New Zealand curriculum could directly or indirectly contribute to climate change education (Eames, 2017).

While climate change is not mentioned in either the education policy or education curriculum, the Tongan Climate Policy that was produced by MEIDECC highlights that there is a target in place to address climate change and incorporate it into curricula at all levels of primary, secondary and tertiary education. In addition, the Tongan Joint National Action Plan (JNAP) 1 and 2 plan to fully integrate climate change education into the curriculum. One of the priority goals in JNAP 1 is to enhance the technical knowledge base, information, education and understanding of climate change adaptation and effective disaster risk management. The JNAP 2 was established to present some key updates on what have been achieved from JNAP 1 and one of the updates that is presented in the JNAP 2 is that the Tonga's education system is slowly moving towards integrating climate change in the national curriculum (Ministry of Meteorological Energy Information Disaster Management Environment Climate Change and Communications, 2018). In the talanoa fakataautaha, the officials from the MET and the MEIDECC indicated that the two departments are working alongside each other to ensure climate change is integrated into the curriculum. This study indicates that the process of integrating climate change into curriculum is progressing at a slow pace. It appears from the findings that there's a need for the MET and MEIDECC to work together closely if climate change is to be fully integrated into the curriculum in a timely manner.

The Tongan Class 10 science syllabus that was a focus of this study was recently reviewed in 2016 and there is an indication of climate change related-issues being included in the syllabus (Ministry of Education and Training, 2016). However, the basic elements of climate change - causes, effects and solutions - are not illustrated distinctly. In the talanoa fakatokolahi that were conducted with both students and teachers, it was clear that the aspects of climate change may require attention in the classroom as student participants could not clearly describe the scientific concepts that lead to the cause of climate change. Both students and teachers who participated in the study believed that the ozone layer depletion was one of the key causes of climate change. This confusion could be attributed to various reasons but one may be the fact that the two concepts – ozone depletion and greenhouse effect - are both mentioned under the sub-topic 'Atmosphere' in the Class 10 science syllabus. For example, the syllabus states, "Differentiate between effects of ozone depletion and 'green-house effect' on global warming and human lives" (Ministry of Education and Training, 2016, p. 44). As shown in Table 8 (Section 5.2.1), the greenhouse gases and their effects are mentioned in the syllabus but there is no mention of human-

induced greenhouse gases, and how the process of greenhouse effect links to the cause of climate change is also not shown clearly in the syllabus. It is reported that human activities such as clear-felling forests and certain farming methods have accumulated the quantities of greenhouse gases in the atmosphere (UNFCCC, 2014a). Merging the greenhouse effect and ozone depletion could possibly be the reason students and teachers were confused about the two concepts and leading them to believe that ozone depletion is a key cause of climate change.

Findings in this study are similar to a study which was conducted by Walshe et al. (2018). They investigated climate change perceptions of teachers in Samoa, Fiji and Vanuatu. Similar to what was suggested by teachers in Tonga, teachers in Samoa, Fiji and Vanuatu regarded climate change as an important issue to address in the classroom, however, their ability to teach the subject effectively in the classroom was hindered by insufficient knowledge and inadequate resources. Teachers in Fiji echoed that the curriculum did not adequately include climate change. Teachers in Vanuatu agreed that the curriculum was lacking in terms of its coverage of climate change and this was a major barrier to teaching climate change. Another study which examined secondary and pre-service teachers' knowledge, conceptual understanding and sources of information about climate change in Australia found that that there is a need to develop courses to improve the knowledge of student teachers about climate change. The same study also showed that there are gaps in relevant school curriculum topics such as science and geography (Boon, 2010).

8.2.3 Designing a climate change education intervention

This subsection presents discussion on how the climate change education intervention was designed. It addresses research question 3 – How can a climate change education intervention be designed for a Tongan secondary school? Discussion about the design and development of the climate change education intervention are presented in four parts as follows.

8.2.3.1 Acknowledging students' and teachers' climate change perceptions

Educational strategies are best designed when they are based on learners' levels of knowledge and preconceptions (Fortner, 2001). Findings from Phase One of this study indicate that both students and teachers expressed a desire for learning about climate change, particularly the processes that lead to the causes of climate change and solutions

to help address the impacts of climate change. Findings also show that students and teachers in Tonga held alternative conceptions about climate change. For instance, they thought ozone depletion was the main cause of climate change. Gowda et al. (1997) echo that the significant alternative conceptions that students display in the context of climate change suggest the need for better climate change education that is focused on these major conceptions. Findings also indicate that students and teachers are willing to do something to reduce or stop the impacts of climate change. These findings were significant in helping me to shape the nature of the climate change education intervention that I intended to design. This aligns with what Anderson (2012) claimed, that it is pertinent to explore people's skills, attitudes and behaviour in order to determine what works for formal climate change education (CCE) content. Chang (2014) agrees by saying that it is important to understand students' and teachers' prior knowledge and attitudes before embarking on any programs to improve their readiness for CCE.

This study regards students as future citizens of society and government leaders, and it is in their power to mitigate the consequences of climate change (Dawson & Carson, 2013). This study also indicates limited inclusion of climate change related-issues in the Class 10 science syllabus, therefore the climate change educational intervention in this study needed to include a climate change teaching unit designed to incorporate the key aspects of climate change such as causes, impacts and solutions. Tjernström and Tietenberg (2008) highlight the importance of considering climate change science as a key factor accounting for an individuals' motivation to be concerned about climate change. Therefore, this study observed climate change science as a significant element of climate change education. In order to design and implement an effective curriculum for climate change education, it is vital to find out the students' existing understanding and disposition of climate change issues in order to shape their interpretation of the issue and the world (Carey, 1985; Chang, 2014; Driver, 1985; Osborne & Freyberg, 1985; Posner et al., 1982). Climate change education must be framed strategically with an emphasis on the causes and impacts as well as required knowledge, skills, values and attitudes for effective mitigation and adaptation using appropriate action-oriented pedagogies (UNESCO & UNEP, 2011).

8.2.3.2 Talanoa – Teaching and Learning Approach (T-TLA) for Climate Change Education

The development of talanoa as a learning and teaching approach in this study is in line with the recommendations of both Pacific scholars and some western perspectives. Thompson et al. (2009) suggest that Pacific learners' engagement in classroom discussion and with the classroom curriculum can be enhanced by adopting appropriate teaching methodology, and cultural contextualisation and customisation. For instance, Pacific students have the potential to learn best in a group and from discussion (Jarvis, 1987). When students participate in activities and talk, they create meaning together and can find out ways of going about things that are important to their social environment, to their families and to the other groups they belong to (Vygotsky, 1962). The use of talanoa aligns with the process of scaffolding – this is when students could build their understanding of causes and effects of climate change but also about how scientists support their claims (Holthuis et al., 2012).

Talanoa is an oral form of communication which enables people in the Pacific to learn and relate to each other through narration and storytelling (Morrison et al., 2002; Tavola, 1991), thus talanoa is used for creating and transferring knowledge (Vaioleti, 2013). Therefore, talanoa can be a potential vehicle for students to co-construct ideas about climate change. Findings from Phase One indicate that students and teachers experienced impacts of climate change and executing talanoa as a learning and teaching approach in the classroom could give the students in Tonga the confidence to co-construct ideas about climate change as well as give them a possible way to discuss some solutions to address the impacts of climate change.

The three elements of talanoa - talanoa fakatoka, talanoa felāfoaki, and talanoa kavekavehoko were developed in this study in order to make the learning about climate change more effective and at the same time empower the young people in Tonga with knowledge and skills to act upon climate change. Talanoa fakatoka aimed to explore students' existing knowledge and attitudes about climate. It could help students express their feelings about climate change. This is in line with Otsuka (2006) and Tavola (1991) who believed that talanoa is a way to obtain information and to find out people's feelings about things. This would help the teacher to decide what she or he may need to address in the classroom. Talanoa fakatoka is also intended to build positive relationships among

group members so they could work harmoniously within groups. The teaching aspect of the intervention lasted for 3 weeks. It was important that the students enjoyed working in their particular group during the 3 weeks.

The second element was talanoa felāfoaki; it was developed so that students could have a space to co-construct new solutions or knowledge (Vaioleti, 2013) about climate change. Talanoa felāfoaki aligns with the concept of social constructivism where students' thinking and meaning-making were socially constructed (Vygotsky, 1978). Talanoa felāfoaki also provides a platform for students to scaffold. Scaffolding introduces students into new perspectives and new ways of thinking about reconceptualising (Holthuis et al., 2012) climate change issues. The intervention regarded Lavinia (teacher) as the facilitator, however, the theory of social constructivism also regarded Lavinia as a learner too (Vygotsky, 1978). Talanoa felāfoaki as a social constructivist approach is consequential in climate change education because it emphasised collaborative learning and social interactions. Vygotsky (1978) highlights that learning is a social activity and through interactions, learners can create meaning and children can grow into the intellectual life of those around them. Talanoa is also identified by the UNFCCC (2019) as an inclusive and participatory process.

Mercer (2000) and Alexander (2006) argue that children learn through conversation which explores their thinking and understanding. In the classroom, the conversation needs to be scaffolded and children need to interact in ways that improve the process of learning. Talanoa and its dialogic and interactive nature could allow the students to scaffold from where they are in terms of their climate change knowledge to where the scientific knowledge is.

The third element was talanoa kavekavehoko; this was the part of the learning where students shared their new knowledge with others and voiced their concerns about the impacts they had already experienced and those that may happen in the future. Talanoa kavekavehoko gave them an opportunity to discuss the possible action plans to deal with climate change in Tonga. During the talanoa kavekavehoko that students expressed how they feel empowered and motivated to address climate change not only in their own local context, but also in Tonga. This is correlated with the UNFCCC (2019) which stated that talanoa had the potential to generate greater confidence, courage, and enhanced ambition to address climate change.

8.2.3.3 Teacher Professional Learning Development

One of the key teaching strategies that can be utilised by a teacher preparing to teach about climate change is to first educate himself or herself on the subject – teachers may need to seek out professional development on climate change (Johnson, 2013). Findings of this research indicate that the teachers who participated in this study appeared to have limited understanding about climate change, especially the scientific process that lead to the cause of climate change. These teachers also held alternative conceptions about the processes that cause climate change. These findings are mirrored in a study that was conducted in the United States. The study reported that teachers from across the United States had limited understanding about the science, and they also held several alternative conceptions about the science of climate change in general (Matkins & Bell, 2007). The same study indicated that a professional development workshop was held to help these teachers obtain a better understanding about climate change. At the end of the Professional Development Workshop, the teachers indicated that their understandings about climate change were improved (Matkins & Bell, 2007). Hestness et al. (2014) argue that in order to successfully prepare the students to make scientifically informed decisions related to climate change, teachers must be able to obtain the right scientific knowledge about the topic. The majority of the teachers in this study suggested that they needed professional development so that they could obtain better climate change knowledge in order to teach climate change effectively in the classroom.

Consequently, a professional learning development programme was designed for the purpose of equipping Lavinia (teacher) with new information about climate change and to ensure she was confident enough to teach climate change issues to the students. Miler et al. (2012) argued that if teachers are key stakeholders in educating young people about climate change, then it is important that they are ready to deliver the climate change education curriculum. Professional development workshops can be effective in addressing alternative conceptions, deepening understanding, stressing the topic's cross-curricular nature, and improving teachers' confidence and preparedness to teach climate change (Hestness et al., 2014).

8.2.3.4 Multi-disciplinary approach

It is evident from this research that the teachers believed that climate change should be taught from a wide range of disciplines and. The traditional thinking on climate change

education (CCE) in formal educational settings is limited to teaching atmospheric composition and processes from a natural science perspective and climate science has traditionally been taught in geography and earth science (Punter et al., 2011). In contrast, many believe that climate change should be addressed in all subject areas (Punter et al., 2011). Likewise, teachers who participated in the study suggested including climate change related-issues in all subjects. An official from the MET in Tonga also mentioned that the curriculum writers are working on integrating climate change into different subject areas. This study found that teachers felt that climate change education is broader than climate science – it is cross curricular. Mitigating as well as adapting to climate change is going to take far more than knowledge of the natural sciences (UNESCO & UNEP, 2011). It is crucial that climate change education is relevant to students and youth, therefore, curricula with a purely scientific focus may not adequately convey to students how temperature changes can have huge impacts on their lives (Monroe et al., 2013). There are important questions that should be considered when designing a climate change education program for children, some of which are "Who is most vulnerable to climate change impacts, and what is our responsibility to them?" or "How can coastal cities better prepare for rising sea levels?" (Monroe et al., 2013, p. 5). Data from document analysis report that both science and geography syllabi do not seem to espouse the key aspects that are questioned by Monroe et al. (2013) – for instance, the syllabus does not feature any discussion about who is most vulnerable to climate change impacts and who would be responsible for them.

The designing of the climate change education intervention aimed to incorporate multi-disciplinary approaches. Although it was initially intended to be taught in a science classroom the data from Phase One and the recommendations from literature helped to reshape the design of the intervention so that it drew in other subjects. Examples of this include a graph and table interpretation from geography, a scenario in English where students read about climate change and answered questions that followed, as well as drama performances. Teaching climate change in a multi-disciplinary manner and employing activities as mentioned above, could enhance the students' understanding of climate change and how they can prepare for rising sea levels and other impacts.

8.2.4 Students' and teacher's learning outcomes in response to the climate change educational intervention

This subsection presents discussion on the learning outcomes of the students and Lavinia (teacher) as well as addressing research question 4 – 'What are the learning outcomes for Tongan students and teachers about the issue of climate change in response to the educational intervention?' Members of the community, including parents, teachers and students who were invited to attend the climate change Expo on the final day, also provided feedback which was regarded as the community outcomes. These data were recorded as an informal observation record. Discussion about the learning outcomes is presented in four parts as follows.

8.2.4.1 Efficacy of the climate change education intervention

Data from the post-intervention questionnaire, talanoa fakatokolahi with the students and talanoa fakataautaha with the teacher indicated that the climate change education intervention led to learning outcomes.

8.2.4.1.1 Addressing alternative conceptions

During the post-intervention talanoa fakatokolahi, students reported how the intervention helped to address their alternative conceptions regarding ozone depletion as a cause of climate change. One student pointed out that the 'Paper cut activity' (see Lesson 4 in Appendix M) helped modify their conceptions of the causes of climate change. Data from the post talanoa kavekavehoko and post-intervention questionnaire reported that most students no longer related ozone depletion to climate change. Their understanding of greenhouse gases and their contribution to climate change had developed and they appeared to have addressed the alternative conceptions that they held in the Phase One of the study. Studies that were conducted by Monroe et al. (2017) in the United States, and Niebert and Gropengiesser (2013) in Germany indicate that involvement in climate change-related programmes such as workshops and learning activities have successful impacts on those who are participating. The participants would increase their concern about climate change and improve their understanding of how humans affect climate (Monroe et al., 2017). Climate change learning activities such as experiments can change students' perceptions by directly addressing alternative conceptions (Niebert & Gropengiesser, 2013). Students would be able to understand the role of atmospheric

carbon dioxide in trapping heat (Monroe et al., 2017; Niebert & Gropengiesser, 2013). This is aligned with the experiment that the students did to identify the causes of sea level rise during the intervention. A majority of these students were not familiar with melting glaciers so an experiment was conducted to help building a better understanding about how melting glaciers may contribute to sea level rise (Sub-section 6.5.7). During the post-talanoa fakatokolahi or talanoa kavekavehoko with the students, they stated that the experiment helped to improve their understanding about climate change.

8.2.4.1.2 Enhance climate change knowledge and understanding

Students thought that the climate change education intervention helped them to improve their knowledge about climate change science. One of the new understandings that they appeared to acquire was that climate change was a natural process but it has been fuelled largely by enhanced greenhouse gases resulting from human activities. Students should be aware that the Earth's climate has always changed due to natural processes with the Sun, such as the water and energy cycle (Secretariat of the Pacific Regional Environment Programme, 2014), but the rise in greenhouse gas emissions as a result of human activities has rapidly warmed the Earth leading to rapid climate change (Denman et al., 2007; IPCC, 2007c; Secretariat of the Pacific Regional Environment Programme, 2014). Prior to the intervention, students connected the causes of climate change at their local scale. They thought climate change was caused by the localised activities such as cutting down trees and burning rubbish. At the end of the intervention, students were reported to have acquired a more sophisticated understanding about the causes of climate change such as high concentration of greenhouse gases in the atmosphere, energy wastage, inefficient use of energy, and exploration and use of fossil fuel. Denman et al. (2007) indicate that the observed increases in atmospheric greenhouse gas concentration are directly associated with human activities such as energy production from coal and natural gas, waste disposal in landfills and industrial activities.

Students' understandings about the impacts of climate change were also strengthened in response to the climate change education intervention. According to the findings in Phase One, students indicate a limited understanding about the impacts of climate on the economy, on the food supply and on culture. One outcome of the intervention is that the students were able to identify how climate change may pose problems to the financial matters of their families and of the country. They also demonstrated good understanding

about how climate change could affect food production in Tonga. In the Pacific context, Keener et al. (2012) stress the importance to understand how climate change poses serious impacts on the cultures and traditional life-styles of the Pacific island communities.

The intervention effectively equipped students with new understandings about how to deal with climate change. Students believed that learning about the concepts of adaptation and mitigation had helped shape their understanding about how to address climate change in Tonga. They demonstrated an ability to think further and more broadly – instead of focussing only on the localised activities such as avoiding cutting trees and refraining from burning rubbish, students were able to think of ways to mitigate climate change by using energy saving, saving water, and walking or riding bicycles. Dawson (2012) and Uzzell (1999) echo that students, particularly in the Pacific, are going to school with pre-formed opinions and conceptions which may not be accurate and they also highlight that these students are the key audience for environmental messages as they are regarded as the future leaders. This study finds that learning about climate change in the classroom can help develop students' understanding about climate change.

8.2.4.1.3 Elevating students' empowerment and motivation to act

Students expressed high concern about the impacts of climate change that is affecting their lives and the natural environment. The intervention appeared to help give them hope that climate change can be stopped. Students expressed that as the climate change education intervention improved their understanding about climate change, they were willing to do something about climate change. They indicated high motivation to become agents of change in their schools and in their community. One student said that she learnt from the intervention that walking or biking to school would be her contribution to fight against climate change. She stated that she will make it a commitment to walk to school, and she will encourage her friends and family to do the same. Another student indicated that he would help informing the people in his village not to cut down trees. A majority of the students who participated in the post-intervention questionnaire indicated they are prepared to use less electricity at the houses.

Lavinia, the teacher who delivered the climate change education intervention in the classroom, reported benefitting herself from the intervention. Prior to the intervention, she thought her religious beliefs would help protect her from any harm of climate change,

therefore, she was not concerned about climate change or willing to do anything about it. During the post-intervention talanoa kavekavehoko, Lavinia said:

> …I still remember very well when I said that climate change is God's plan and that we will be saved by God. The truth is, there is a change in the way how I think and the way how I believe about climate change… (Lavinia, teacher)

Her involvement in the teaching process changed her perceptions of climate change issues – she now believed climate change is a problem, she worries about it and she is now motivated to do something about it.

In regards to the community outcomes, the climate change education intervention also had a positive impact on motivating the people who attended the climate change Expo to start working together to address climate change impacts. Findings from the observation record indicate that the groups that received the most questions from the audience were the groups who presented on adaptation and mitigation. Students' abilities to tackle some of the critical questions from the audience were admired by many in the audience, and for them, that showed the students' confidence and their willingness to take part in addressing climate change.

Findings of this study correlate with what is advocated in some literature that climate change education helps in equipping individuals with the values, knowledge, and skills to make choices and decisions to address the impacts of climate change (Fernandez et al., 2014; Mochizuki & Bryan, 2015; UNESCO, 2014). In addition, levels of knowledge and awareness can influence people's perceptions about climate change, attitudes towards adaptive capacity and future responses to climate change (Barnett & Campbell, 2010).

8.2.4.2 Talanoa – A teaching and learning approach (T-TLA) for climate change education

The use of talanoa as an approach to teach and learn about climate change in Tonga has made an impact both on the students and on the teacher who delivered the intervention. Talanoa fakatoka was successful in breaking down the barriers within the group members and helped them rebuild confidence so they could be able to communicate freely and

openly. Talanoa fakatoka strengthens the relationships between students as well as between students and teachers. Talanoa fakatoka was an effective way to explore the students' and teachers' existing understanding about climate change. Students and teachers were open to express what they knew or felt about the issue through talanoa fakatoka. For instance, during the Professional Development (PD) with Lavinia, our talanoa fakatoka helped me to identify the areas that she required some assistance or further learning development on. One student mentioned that talanoa brings them joy and happiness while another student thought that talanoa helps them together as a group and it enhances their spirit of togetherness.

Talanoa felāfoaki was employed in this study to allow the process of co-construction and scaffolding enhancing learning about climate change. Students believed that talanoa felāfoaki provided a platform for them to build their knowledge together and to reconceptualise climate change. Conducting talanoa felāfoaki appeared to help the students' interpretation and critical skills. Talanoa felāfoaki was effective in allowing students to show-case what they already knew about climate change, and then it also helped them shaping or enhancing their understanding about climate change. One student believed that talanoa felāfoaki was effective in allowing them to appreciate and acknowledge other people's ideas and also helped them embrace the importance of listening to others.

Talanoa kavekavehoko played a part in empowering students to voice their concerns about the issues of climate change and their willingness to help fight against the detrimental impacts of climate change. Findings from post-intervention talanoa kavekavehoko indicate that it provides an opportunity for the students to show-case what they have co-constructed during the talanoa felāfoaki. Students appeared to gain confidence when they conducted the talanoa kavekavehoko. One of the students stated:

> One of the things that motivated me the most in this expo was that I know that it's my job and it's my responsibility to stand up in front of my friends and my classmates, and one way that we can do to reduce the impacts of climate change is to explain it to everyone. (Ane, SFG Phase Two)

The Expo was conducted using talanoa kavekavehoko and its impact on the audience could be seen on how they responded by asking questions and providing feedback after the expo.

Lavinia thought that talanoa approach could cater for all level of thinkers. Lavinia stated that that was the first time for her to use talanoa and group work in her teaching and she was so impressed that students could actually discuss and learn as a group. That was the first time for her to hear her students debating or expressing their views and perceptions.

Using talanoa as a teaching and learning approach in this context can align to what Thaman (2010) stresses to integrate Tongan values and beliefs into global education initiatives. Values such as ‘ofa (compassion), faka’apa’apa (respect), feveitokai’aki (reciprocity) and tauhivaha’a (nurturing inter-personal relations) are crucial to be instilled in young people, and they could learn these values through listening and participation (Fua et al., 2008; Morrison et al., 2002; Thaman, 2010). Hence, talanoa was an appropriate tool to instil these values into the young people in Tonga.

Working in small groups was also recommended by both students and teachers to be effective in learning about climate change. Working in groups helped build their confidence, and students appeared to work closer when they were in small groups for talanoa. The benefits of working in groups for Pacific island students is also highlighted by Jarvis (1987), who noted that Pacific island learners learn best in a group and from discussions or talanoa.

8.2.4.3 Effectiveness of using multi-disciplinary approach

Teaching climate change from a wide range of disciplines appeared to be a powerful approach. Students and the teacher, Lavinia, commented on the effectiveness of the activities that were conducted during the intervention.

The introduction of drama in the intervention to teach climate change appeared to benefit the students as well as the teacher. Not only did the students enjoy role playing the subject matter, but they learnt about climate change effectively in that way. According to the students and the observation reports, the drama helped them to identify the differences between climate change and global warming.

One of the activities which appeared to be effective in enhancing students' understanding about causes of climate change was the Paper cutting activity. The paper cutting activity was art work where students were asked to design a diagram of the greenhouse effect using paper. Students commented on the effectiveness of this activity as they were able to identify how enhanced greenhouse gases contribute to climate change.

8.2.4.4 Effectiveness of including personal relevance in climate change education

Findings from the observation records, as well as the post-intervention talanoa fakakulupu with students, and the post-intervention talanoa fakataautaha with Lavinia, illustrated that climate change education can be effective when it is connected to the individual students' interests, aspirations and life experiences. As evidenced by findings in Phase One, students who participated in the study have experienced climate change. They witness rising sea levels in their local villages and they also agreed that Cyclone Ian that hit their island in 2014 was also an impact of climate change. The students' perceptions verify that they live with climate change and it becomes a part of their lives. On the very first day of the intervention, Tevita, a local man (65 years of age) was invited to about his views of climate change. During the post-intervention talanoa fakakulupu, students expressed that they found Tevita's talk relevant and meaningful to them.

The Shrinking island activity required each group to give a name to the island that they designed. Apparently, the islands were named by the students for their own local village or one of the outer islands. At the end of the activity, when almost their whole islands were taken by sea water, I could see the frustration in their eyes. At the time, the teacher asked what they would do if their island drowns. The students responded with different solutions, such as migrating to another island.

These findings echo what Bangay and Blum (2010) indicate that education is likely to be more meaningful, and participation in learning processes more active, when programmes deliver knowledge and skills which are relevant to local contexts and needs. This is further emphasised by Anderson (2012) who notes that local relevant, issues-based climate change education has a potential to improve students' learning.

8.3 Conclusion

In this research, students and teachers considered climate change as a major problem facing the people and the environment of Tonga. They had a profound concern about the impacts of climate change and a desire to do something to reduce or to stop climate change in Tonga. However, it is evident from this study, that although students and teachers are concerned about climate change and are inclined to play a part in addressing the issue, their knowledge about climate change was limited, particularly on the processes that lead to the cause of climate change, and on the adaptation and mitigation strategies to alleviate climate change risks. These could be the key factors that hindered their capabilities to act upon climate change. The alternative conception regarding ozone layer depletion contributing significantly to the cause of climate change was strongly held among students and teachers. They seemed to conflate the process of greenhouse effect and ozone depletion. It is clear from this research that students desired to learn more about climate change at school, and teachers in particular requested a professional development program to help deepen their understanding about climate change related-issues, and more climate change teaching resources.

This research also reported that climate change is not sufficiently addressed in the school curriculum. Teachers who were teaching science and geography appeared to be dissatisfied with the coverage of climate change related-issues in the science and geography syllabi. Some of these teachers were also teaching other subjects such as agricultural science and economics, and similarly, they felt that climate change is not effectively addressed in those subjects either. Students and teachers who took part in this study made a call for more inclusion of climate change-related issues in the school curriculum. Climate change is neither mentioned in the education policy nor in the Tongan school curriculum, however, the Tongan Climate Policy produced by MEIDECC illustrates that there is a target in place to incorporate climate change in to the curricular at all levels of primary, secondary and tertiary education. Although the officials from MET and MEIDECC stated that the two Government departments are working alongside each other to integrate climate change related-issues into the curriculum, it is evident from this research that this process is progressing at a slow pace. It is clear from this research, that the MET and MEIDECC could work in cooperation with each other to include climate change in the curriculum in a timely manner.

The climate change education intervention which was designed and later implemented in this study included a climate change teaching and learning module. The key findings in the Phase One of data collection, and key ideas derived from literature informed the designing of the teaching and learning module. In particular the design needed to address content knowledge, including any known alternative conceptions, and incorporate teaching and learning methodologies that are participatory, critical and open-ended. A culturally appropriate approach known as talanoa was used to acknowledge the knowledge, strengths and merits of using Tongan language and cultural practices in the teaching and learning of Tongan children.

The Class 10 students who took part in this intervention, as well as the teacher who delivered the teaching process, found the intervention effective. Students, in particular, showed knowledge development. Their understanding of the causes of climate change, the impacts and the responses to climate change were advanced and more sophisticated. Their alternative conceptions about the process of the greenhouse effect and ozone layer depletion were addressed as the result of the intervention. This study recognizes the important role that is played by climate change education in equipping the students and teachers in Tonga with sufficient and sophisticated knowledge about the cause and impacts of climate change. Climate change education can empower students and teachers with skills, values, and understanding to address the impacts of climate change.

The use of talanoa in this research to teach and learn about climate change in Tonga had a positive impact both on the students and the teacher. Talanoa was instrumental in eliciting student interaction and meaning-making. Talanoa provided an intellectual space for students to explore what they knew and what they didn't know about climate change. Talanoa also helped students to explore broadly how impacts of climate change may affect themselves, their families, society, and systems. Importantly, talanoa was successful in engendering interest and developing sufficient climate change knowledge for students to be able to develop action plans to mitigate and to adapt to climate change. Talanoa is a culturally relevant approach because it it helps instilling cultural values and knowledge to make teaching and learning relevant and meaningful. Talanoa helped to enhance the vā or relationship among students and between the students and the teacher.

Talanoa was effective in data collection as it gave an opportunity for my participants to share their ideas openly, be able to talk from their hearts, and also provided them a tool

for co-construction of ideas. There were two forms of talanoa that took place during the data collection – talanoa fakataautaha (one-on-one talanoa), and talanoa fakatokolahi (group discussions). Talatalanoa and tālanga were used to guide the talanoa fakataautaha and talanoa fakakulupu.

8.4 Recommendations

This research presents several recommendations for the students, teachers and the Ministry of Education and Training in Tonga, as well as other education sectors and all relevant stakeholders.

1. Students in Tonga need to be well prepared to be able to withstand the risks that are posed by climate change on their lives and on the environment. Students need to be provided with education so they could be equipped with knowledge and skills for mitigation and adaptation measures. Climate change education would be more effective if the education providers identify the students' and teachers' current perceptions of the issue, and then design the education programs to address and build on these perceptions.

2. Professional development should be made available to teachers who are planning to teach climate change need Talanoa is recommended as an approach to enhance teacher knowledge and skills in addressing climate change. Climate change teaching and learning resources should be distributed evenly among schools in Tonga.

3. The MEIDECC's Joint Action National Plan is clear about climate change education, but this is not flowing through to the MET's policy and curriculum, so there is a need for a coherent and more consistent collaboration between the MEIDECC and MET for a more effective and successful integration of climate change education in the school curriculum.

2. The Class 10 Science syllabus in Tonga (and possibly at other levels and subjects) should be reviewed for emphasis on causes and impacts of climate change, and solutions to dealing with climate change. Placing the two processes - ozone layer depletion and greenhouse effect together in one category, as shown on the science syllabus (Ministry of Education and Training, 2016, p. 44) can be

problematic as it may cause confusion between the two processes. Greenhouse gases and their effects could be placed as a starting point for the discussion of the scientific processes that contribute to human-induced climate change.

4. Teaching and learning approaches which are interactive and culturally responsive such as talanoa should be used in climate change education to empower the students with skills, values, and knowledge to analyse types of impacts that climate change will have on local systems and future societies, and to discuss their roles in reducing greenhouse gas emissions and what they could do in their own lives to bring about societal change. Talanoa would help improve students' abilities to adapt to, and to mitigate, climate change. It could also help to improve students' relationship in the classroom and may give students the confidence to talk from their hearts.

8.5 Limitations of the study

This study also encountered some limitations which are outlined below:

- This study focused on Class 10 students and teachers from two schools in Ha'apai. Therefore, these participants cannot accurately represent all the Class 10 students and teachers in Tonga. Extending the number of participants to include other schools and schools from different island groups in Tonga would have provided a more detailed apprehension of students' and teachers' perceptions of climate change in Tonga.
- The intervention was designed and implemented to align with the requirements of the Class 10 science syllabus. Teaching was done according to the timetable provided by the school and planning of the lessons would have to be within the timeframe of each period. This was problematic for some of the key activities were not able to be conducted because of the time limit. For instance, the field trip was not undertaken although it was a crucial part of this intervention.
- This study was aligned mainly with Science and Geography subjects so that findings are most relevant to teachers of these subjects. Including other subjects could possibly give a clearer representation of the place of climate change in the secondary school curriculum.

8.6 Suggestions for further study

This study has contributed to the understanding of students' and teachers' perceptions of climate change in Tonga, and the potential for climate change education using talanoa as a method to teach and learn about climate change in Tonga. This section presents some suggestions for further research.

- A study should explore the current and/or future plans of the Ministry of Education and Training (MET) in Tonga to ensure that school facilities, as well as students and teachers, are well adapted to and able to cope with the projected impacts of climate change such as tropical cyclone, drought, rising sea levels, and rising temperature. Findings in this study indicate that students and teachers believe climate change is happening. The officials from the MET and MEIDECC emphasized the importance of integrating climate change-related issues into the school curriculum. Mitigation strategies such as reducing the use of electrical appliances at school were rarely mentioned by the participants. It would be of value to know what plans are in place to deal with school facilities in times of climate change-related events such as tropical cyclones. A study of this nature may also be able to explore how these plans may influence the way students and teachers perceive climate change.
- A study to explore the existing status of climate change-related issues in the curriculum of the Tongan Institute of Education (TIOE) in Tonga (which educates preservice teachers) would be beneficial. This study indicates that teachers are key stakeholders in channelling climate change information to the students, hence, it is crucial to find out how the preservice teachers are being prepared at the TIOE to deliver climate change education in their future classrooms.
- Further study to explore the efficacy of using talanoa in teaching and learning about climate change in other Pacific countries, including New Zealand and Australia which have large numbers of Tongan-origin students, is also suggested. Findings from these studies would be important in determining the effectiveness of using talanoa in different contexts.

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List of talanoa fakataautaha and talanoa fakatokolahi, and quotes

Quotes that are used in this thesis are presented in this section as well as the dates in which the talanoa fakataautaha (one-on-one talanoa) or the talanoa fakatokolahi (group talanoa) were happening.

Quote	Date	Talanoa fakataautaha or talanoa fakatokolahi
I like it here because there are heaps of seafood in Ha'apai, and my family in Vava'u always ask for seafood (Samisoni, TFG1).	13.04.2017	Talanoa fakatokolahi
"I grew up in Ha'apai, and I like to live here…I like going to the beach, Ha'apai has got the most beautiful beaches in Tonga" (Salome, TFG1)	13.04.2017	Talanoa fakatokolahi
"…I like hanging around with the people, they are a bit more conservative, and they have good attitudes" (Sekope, TFG2).	20.04.2017	Talanoa fakatokolahi
I love this place because I was born and raised here in Ha'apai, and I am familiar with the lifestyle of this island, we got families here. What I don't like is that there's not enough higher level of education here, so when we finish from secondary school, we have to go to Tongatapu to attend higher institutions (Saunia, SFG 2)	20.04.2017	Talanoa fakatokolahi
"It's peaceful in Ha'apai, and there is not much obligations. I would prefer a peaceful place like Ha'apai for my kids to live, there's no distractions from night clubs and such places…" (Siua, TFG 1)	13.04.2017	Talanoa fakatokolahi
When I grew up, there was a foreshore in front of the coastal area in Pangai, and I used to go swimming there. Today the foreshore is no longer there, and numbers of coastal plants have decreased as well, I think it is because of climate change (Akosita, SFG 3).	18.04.2017	Talanoa fakatokolahi
Yes, when there's a long period of drought, the crops are not growing well. Crops can't survive because there is not enough	11.04.2017	Talanoa fakatokolahi

water, the products are very poor quality. Climate change causes drought, therefore, there is not enough rain (Lupe, SFG 2).		
When Ian struck, no one was prepared for it. *Ne mole 'emau 'amanaki* (All hope was gone). My neighbour's house was completely destroyed, and the whole family just stood there, so we helped taking them to another house (Nau, SFG 2)	11.04.2017	Talanoa fakatokolahi
"My parents worked as church ministers in Mo'unga'one island and my father said in the past, the sea water was a bit distant from the land. Today, the sea water has reached the land already…" (Peni, SFG 1).	11.04.2017	Talanoa fakatokolahi
Trees act as carbon sinks, so when we cut down trees, we disturb the carbon sink cycle. When trees are removed, the smoke travels up in the air, and that's how climate change tended to happen (Siua, 52, TFG1).	13.04.2017	Talanoa fakatokolahi
I do blame the industrialised countries because they are the ones that contribute the most to climate change. They are selfish, they do not consider small island countries like Tonga (Lavinia, 44, TFG1)	13.04.2017	Talanoa fakatokolahi
I believe that when humans started to shift from the traditional ways of doing things to incorporate ideas of technology and development, that is when problems related to climate change started to emerge. Striving for economic standard and a convenient lifestyle is powerful these days, and it seems to control our daily lives. For example, yesterday, we used banana leaves for wrapping lu (taro leaves, coconut milk with meat), but today, we are shifting to using aluminium foil (Siua, 52, TFG1)	13.04.2017	Talanoa fakatokolahi
…I do blame the government of Tonga. They trade a lot, and import vehicles and other goods that are not good for the environment of Tonga. Even though it is the industrialised countries that contribute the most to climate change, but we in Tonga, also contribute but in different ways (Siua, 52, TFG1).	13.04.2017	Talanoa fakatokolahi
…Yes, the problem of ozone depletion, that the sun is getting hotter and cause ice melting at the two poles…Yes we know that the ozone depletion is the main cause of climate change (Sione, SFG 3).	20.04.2017	Talanoa fakatokolahi
Greenhouse gases are released from burning fossil fuels and burning plastics. These gases are making holes in the ozone layer, and causing ozone layer depletion. The greenhouse that	13.04.2017	Talanoa fakatokolahi

protects us from the sun has holes in it, and that is why the Earth's temperature is dramatically rising these days (Meleseini, 48 TFG2).		
Climate change will bring more intense and frequent natural disasters, like Cyclone Ian. We have experienced quite a number of earthquakes recently. I think these are the impacts of climate change (Salome, 28, TFG1).	13.04.2017	Talanoa fakatokolahi
When I was at Primary school, I learnt that burning releases gases, and these gases contribute to thinning the ozone layer, and then the ice on both Poles melt. This melting ice is deposited in low lying areas causing sea level to rise (Akosita, SFG 3)	18.04.2017	Talanoa fakatokolahi
…in 2014, during Cyclone Ian, our neighbour's house was destroyed by the cyclone, it saddened me because they got nowhere to hide, so they all ran and hid inside an empty water tank (Nau, SFG 2).	13.04.2017	Talanoa fakatokolahi
"'Kuo 'osi 'asi e nunu'a 'o e feliuliuaki 'o e 'ea" - The detrimental impacts of climate change are already observed (Sekope, 38, TFG2)	13.04.2017	Talanoa fakatokolahi
I went to Uoleva island, and I could observe very clearly the impact of sea level rise. The water has come inland and taken much of the land, and the roots of the trees are quite exposed, I could see them (Tilila, 31, TFG2).	13.04.2017	Talanoa fakatokolahi
Koe to'ukai 'oku 'ikai pau, 'oku feliuliuaki. 'Oku 'ohofia e mahaki e to'ukai, pea 'oku 'ilonga lelei ia 'i Ha'apai ni. The seasonal produce are unpredictable, its changes regularly. Pests and diseases attack the seasonal food, and these are clearly the case here in Ha'apai (Sekope, 38, TFG2).	13.04.2017	Talanoa fakatokolahi
Economically, the Fa'a (a gardener, a planter or a farmer) of Ha'apai can no longer export their crops, they said the weather condition is unsuitable for the crops and they can't grow well. One man said to me that he used to export his crop products to overseas, that was his main source of income, but he does not do that anymore. He lost thousands of dollars, it is also a loss for his family's income. Not only it affects him personally, but it affects his family and the whole community, because the community could also get food from my garden (Sekope, 38, TFG2).	13.04.2017	Talanoa fakatokolahi

I believe that students should pick the rubbish up and the Government can help stopping people from cutting down trees. And us students, we should stop littering and stop burning rubbish (Akosita, SFG 3).	18.04.2017	Talanoa fakatokolahi
The Government should design a law to stop burning the rubbish that everyone should make it a priority. It is our 'fatongia', our responsibility to stop cutting down trees. By doing that, others will see what you're doing, then they will do the same. We should be more responsible (Sione, SFG 3).	20.04.2017	Talanoa fakatokolahi
Disposition and knowledge…teach the child so s/he knows the factors that cause climate change…and students to value his/her environment and the sense of love…make responsibility and compassion for the environment her/his natural disposition… you may be 1% contribute to the cause of climate change, but if you are a teacher, your job is to instil values and skills into the child's mind, teach them not to litter… (Siua, 52, TFG1).	13.04.2017	Talanoa fakatokolahi
…the Ministry of Education should introduce the traditional ideas of doing things, such as cooking, in the curriculum. For instance, instead of using aluminium foil for wrapping lū (traditional food made of taro leaves, meat and coconut cream), students should be taught and encouraged to use banana leaves, the olden days style should be re-introduced… (Tilila, 31, TFG2).	13.04.2017	Talanoa fakatokolahi
There should be workshops in the village community to educate the local people and build their climate change awareness. Some teachers including myself need to be trained. When I did your questionnaire, that was the first time for me to look up for any information about climate change…Lavnia TFG1)	13.04.2017	Talanoa fakatokolahi
Parents should re-introduce the Four Pillars to be the foundation of every Tongan families: Faka'apa'apa (respect), Anga fakatokilalo/loto tō (humility), Tauhi vaha'a (reciprocation), Mamahi'i me'a (patriotism) (Siua, 52, TFG1)	13.04.2017	Talanoa fakatokolahi
In my village, one family used to live near the sea, they have now moved and live further inland as their house is now flooded with sea water. It concerns me because we have lost a neighbour, and our connection with this family is distanced because their house is a bit further away (Pulotu, SFG 2).	20.04.2017	Talanoa fakatokolahi

…it worries me because tropical cyclones are now increasing in frequency and intensity. What worries me the most is that, here in Ha'apai, there is not enough strong houses to protect the people. There is no safety hub for families whose houses were affected by the cyclone (Nau, SFG2)	11.04.2017	Talanoa fakatokolahi
The environment suffers from Cyclone Ian. The trees were gone, and everything was gone. The environment was completely destroyed (Pauline, 47, TFG2).	20.04.2017	Talanoa fakatokolahi
I am not at all worried about climate change. As a little girl, my grandparents taught me and my other siblings that we have to be satisfied with whatever God has given to us. They said that God will protect us no matter what, and that understanding has been ingrained in my heart, so, for me: God will look after me and he will protect me from the impacts of climate change. It sounds selfish but I still stick to what my grandparents said (Lavinia, 44, TFG1).	13.04.2017	Talanoa fakatokolahi
For me personally, I am so concerned about climate change. This is the time, that we should do something to alleviate the negative effects of climate change…we should do something to stop climate change for the sake of our grandchildren and our future generations…I am so concerned about my children. We can't afford to just sit and do nothing…(Siua, 52, TFG1).	13.04.2017	Talanoa fakatokolahi
I am so worried about the effects of climate change in Ha'apai. It is already happening, and we need to do something to help Ha'apai. There should be a focus on the solutions of climate change. I think the solutions are significant to be taught to the students. We have to give the students clear and accurate information about climate change. For example, you ask the student to pick up the rubbish, you also educate him or her to understand why he needs to pick the rubbish up (Meleseini, 48, TFG2).	20.04.2017	Talanoa fakatokolahi
…From 1-10, I place myself at 3. I do not have substantial knowledge about climate change, so I have to go on Google and search for climate change information. I have to learn more about it otherwise the students will ask questions (Lavinia, TFG1)	13.04.2017	Talanoa fakatokolahi
I just learnt about climate change from the Class 10 science text book, and for me, the information there is too general. If I teach climate change according to the information in the text book, the students will not learn much about climate change. So I think, the	13.04.2017	Talanoa fakatokolahi

Ministry of Education should do something and include climate change issues in more detail… (Lavinia, 44 TFG 1).		
I teach Geography, and only about 1% of the syllabus says something about climate change, but that is only talking about deforestation and etc, there is nothing much about climate change. The students won't have deep understanding about the issues (Samison, 29, TFG 1).	13.04.2017	Talanoa fakatokolahi
I believe that each subject should address climate change from different perspectives. For example, Economics addresses climate change from the economic perspective, the Tongan subject examines climate change and how it may affect Tongan cultural matters, and in Science, they can think of ways to mitigate climate change, for example, think of ways to replace activities that are contributing to carbon emissions (Sekope, 38, TFG 2).	20.04.2017	Talanoa fakatokolahi
Students of Ha'apai do not have rich understanding about climate change issues. But when the problems of climate change are directly related to them, immediate action is needed to take place. To date, there has not been any visitations from the Ministry of Education or from the Ministry of Climate Change to educate teachers and students or to raise climate change awareness at schools here in Ha'apai, but we need people who have the knowledge to visit the schools and to run some awareness programs (Principal 1).	21.04.2017	Talanoa fakataautaha
The students and the people on this island are not aware of the seriousness of this problem and to their lives and to the environment. It is very important for everyone to understand the issue because a healthy environment depends on how its citizens comprehend and act upon environmental problems such as climate change (Principal 2).	21.04.2017	Talanoa fakataautaha
In the syllabus, it should include some striking ideas…it would be more effective to go back and use old ways of cooking. Some are already aware but we need to use more ways to reinforce the kids. The MET should reintroduce the olden ways like using banana leaves for lu, you know some activities like that which may help students to cope with the impacts of climate change (Talita, TFG 2).	20.04.2017	Talanoa fakatokolahi
The role of the Ministry of Education is to ensure that students will make effective contribution when leading the community, and to equip, empower and enable them to live in a normal way	04.04.2017	Talanoa fakataautaha

where they can adjust to the impacts of climate change…(Susana, MET).		
…'Oku fiema'u ke tau ta e langa kei mama'o – It's good that we do consider this issue now before it's too late, otherwise our children and our grandchildren will blame us in the future because we didn't do anything to help…(Anitelu, MET).	04.04.2017	Talanoa fakataautaha
A resourceful teacher has to look for information…The problem is that if they are hungry for information or hungry to learn, then they have the responsibility to look for information rather than expecting it to come…One visitor told me to tell my teachers to go extra mile, and not to focus only on what is given in the curriculum. They need to go beyond. (Susana, MET).	04.04.2017	Talanoa fakataautaha
We developed posters and brochures and gave them out to school last year. The question is: 'Where are they?' Are the teachers using them or are they sitting in the administration? We also developed study guide? But do they use it? (Susana, MET).	04.04.2017	Talanoa fakataautaha
…this Professional development is very important for me. I am so keen to teach this topic to the students but my limited knowledge about climate change affects my ability to teach the subject to the students and to deliver this intervention. This professional development we're doing will help improving my knowledge about climate change. I want to know more about the causes and impacts of climate change and also about the solutions…I do not understand climate change adaptation and mitigation at all… (Lavinia, 20th September 2017).	16.10.2017	Talanoa fakataautaha
This intervention helped me to learn about the cause of climate change. At first, I thought climate change is caused by the ozone layer depletion, however, the intervention helped me to understand that it is the high concentration of greenhouse gases in the atmosphere that contributes the most to the cause of climate change, and not the ozone layer depletion, (Ane, SFG Phase Two).	16.10.2017	Talanoa fakatokolahi
Before the intervention, I only knew about two impacts of climate change, the rising sea levels and rising temperature. After the intervention, my knowledge was broadened, I know now that extreme weather events such as cyclone and drought will happen more frequently and more intense as a result of climate change (Ane, female student, SFG Phase Two).	16.10.2017	Talanoa fakatokolahi

The consequence wheel was so effective. It helped us to realise how one impact of climate change may cause more problems in many ways. For example, my group started with 4 impacts of climate change, but when we plot them on the wheel map, then more impacts are added into the wheel. For example, we started with the rising temperature. We found out that rising temperature causes ice-melting and this may cause sea level rise (Lisa, SFG Phase Two)	16.10.2017	Talanoa fakatokolahi
I remembered one of the classes, we were asked to list the solutions to solve the impacts of climate change. We got to learn about two ways to help reducing climate change – the mitigation and adaptation. Knowing about these solutions is extremely helpful. The impacts of climate change are already observed in Ha'apai, and these activities motivated us to do something about the problem. We should do something to mitigate and to adapt to climate change (Ane, female student, SFG Phase Two).	16.10.2017	Talanoa fakatokolahi
I know now that climate change is caused by human beings. I used to cut down the trees and burn the rubbish at home. This study helps me to understand and to realise that my actions were completely not helpful at all, and I need to change that… (Noulisi, male student, SFG Phase Two).	16.10.2017	Talanoa fakatokolahi
The experiment we did on sea level rise helped me to realise that cutting down trees contributes to the cause of climate change. In my island, sea water already consumed part of the land. It's good to know, so I can ask the people in my island not to cut down trees (Tupou, male student, SFG Phase Two).	16.10.2017	Talanoa fakatokolahi
Impacts of climate change such as sea level rise and rising temperature are caused by human activities and we all contribute to these problems. We need to work together to solve these problems. Together we change the world, and we have to be the change (Ane, female student, SFG Phase Two).	16.10.2017	Talanoa fakatokolahi
"Talanoa encourages us to report back the work that we managed to produce through co-construction and team work. That makes us happy" (Kaki, SFG Phase Two)	16.10.2017	Talanoa fakatokolahi
…when we are asked to go up to the front to report our group work, we kind of have an extra courage to really stand up and talk about our work. I do believe that this new strategy is so crucial and it helps us a lot. If these strategies will be adapted, our learning will be very much improved (Saane, SFG, Phase Two)	16.10.2017	Talanoa fakatokolahi

One of the things that motivated me the most in this Expo was that I know that it's my job and it's my responsibility to stand up in front of my friends and my classmates, and one way that we can do to reduce the impacts of climate change is to explain it to everyone, we have to explain the story of climate change to everyone – its causes and impacts and what we have to do to stop climate change. It's my job and I feel so encouraged to speak in front of everyone, to do something to help stop or reduce climate change (Ane, SFG Phase Two)	16.10.2017	Talanoa fakatokolahi
I am not confident in talking in front of many audiences, but the Expo helped me to overcome that feeling. I was extremely scared because that was the first time for me to stand in front of many people. When I started to talk, I felt so encouraged to speak confidently and to pass my message to the listeners (Lisa, SFG Phase Two).	16.10.2017	Talanoa fakatokolahi
Based on the experience I had when I conducted this intervention, I will use the video clip that we used in class. I will also use the graphs and tables because they do indicate the rising temperature really well and they also identify the differences between the climate and weather. These resources are so powerful in communicating the climate change information to the students, and the students were able to learn in a very effective way. (Lavinia, teacher, Phase Two)	16.10.2017	Talanoa fakataautaha
When the students are doing activities, they are of course working in their various groups and I could be able to facilitate the discussion and be more cautious of what the students are learning. I get to communicate with them more. The PD that you conducted has helped filling up my cup, and I felt so confident and ready to teach the unit in the classroom (Lavinia, teacher).	16.10.2017	Talanoa fakataautaha
I was a bit confused, first, the lesson plans are so new to me, it looks totally different to what I normally do in class. I could see that there were almost two activities in every lesson, and I thought it's a bit too much in compared to the students' abilities…However, during the teaching, I noticed that the students enjoyed learning, they loved the activities, they were coping well with the transitions of activities. That is when I realised that I'm kind of fall short of much needed teaching strategies…(Lavinia, teacher).	16.10.2017	Talanoa fakataautaha
…Normally, I just ignore students who are talking and are disengaged during my class. I only pay my attention on the students who seem to put their attention on me during my teaching. But you know when you talked to me one day about	16.10.2017	Talanoa fakataautaha

that group of students who were talking and disengaged, I started to be more alert and had to make sure everyone is on track. That teaches be a lot because I do not always notice that in my teaching… (Lavinia, teacher).		
…the students are so engaged, they are so active and I am so happy to see them that way. They participated a lot when they worked in their various groups, and that is the part that I enjoyed the most is when I see them fully committed in their various groups. The group leaders are good leaders, they help to motivate the group members and they kind of motivated each other, and they learnt a lot from it (Lavinia, teacher)	16.10.2017	Talanoa fakataautaha
I thought drama can only be used for English classes, but this intervention has taught me a significant lesson that drama can also be conducted in a science classroom as well. (Lavinia, teacher)	16.10.2017	Talanoa fakataautaha
I am very happy about the activities that we did during the lessons. I can see and prove it to myself now that student-based activities are very effective and powerful. I can now see that it is important to leave it for the students to find the answers on their own. In my teaching, if the students do not know the answer, I tell them. This intervention helped me to realise that I should leave students to work out the meaning themselves. And I could prove it that students needed to be given the opportunity and the space to do so, and that is an important lesson that learnt from teaching this unit (Lavinia, teacher)	16.10.2017	Talanoa fakataautaha
First thing is regarding the fact that students are now be able to label different greenhouse gases. Before the intervention, they referred to these gases as kasa kona they do know now that these gases are called 'greenhouse gases'. Well, the students and I are both learning, we have learnt new things…(Lavinia, teacher).	16.10.2017	Talanoa fakataautaha
The practical work that was conducted in the activities were so interesting for students, so they were so keen to learn more about climate change and they showed passion to be involved in climate change education. That is exactly what Talia (Head of Department for Science) had been emphasising us teacher to employ in our teaching. We were asked to be more practical and spend less time on using the blackboard because the students will learn more when the lesson is more practical. I did not bother too much about this kind of thing, but now, I know, I have to change my teaching approach and get to use practical work more often (Lavinia, teacher).	16.10.2017	Talanoa fakataautaha

Talanoa approach was remarkable. Students are hardly ever given the opportunity to conduct a talanoa in small groups. It was effective...I mean if those lessons were based on blackboard teaching, I think, only the students who are above average that may understand the lessons. Talanoa gave every student an opportunity to participate in the discussion, and they learn together as a group. That is when I realised that students learn from each other well through talanoa (Lavinia, teacher).	16.10.2017	Talanoa fakataautaha
…this was the first time for me to literally hear the students expressing their views and perceptions, and their ideas verbally. They are so involved in their discussions. I am surprised that they could also have the ability to stand and share their new knowledge with everyone. The climate change unit did not really go for a long time, it's only few weeks, but seeing students getting so heavily involved and valuing the talanoa approach is very impressive…(Lavinia, teacher)	16.10.2017	Talanoa fakataautaha
…I still remember very well when I said that climate change is God's plan and that we will be saved by God. The truth is that, there is a change in the way how I think and the way how I believe about climate change. Climate change is human-caused, it is caused by human's carelessness and unwise decisions, and I understand now that we should consider this problem seriously and we should worry about it. We have to do something about it…(Lavinia, teacher)	16.10.2017	Talanoa fakataautaha
I wish that I'd be given another chance to run the whole unit again because I can say that I am more confident now to teach climate change. There is a great improvement on my content and pedagogical knowledge about climate change. I am more familiar with the lesson plans. I can realise now the few things that I could have done better during my teaching. Well I am more confident now and so do my students, they seem to have better knowledge about climate change... (Lavinia, teacher)	16.10.2017	Talanoa fakataautaha
I believe that getting students to learn about climate change at young age will have a huge impact on them over their lifetime. For example, they may start disseminating the climate change information among their family members. Not only that but when they hang out with the people in their various village communities, then they can put their knowledge into practice… (Lavinia, teacher).	16.10.2017	Talanoa fakataautaha

Appendices

Appendix A: Ethical Approval

Dean's Office
Faculty of Education
Te Kura Toi Tangata
The University of Waikato
Private Bag 3105
Hamilton, New Zealand

Phone +64 7 838 4500
www.waikato.ac.nz

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

MEMORANDUM

To: **Elisapesi Hepi Havea,**

cc: Dr Chris Eames

From: **Dr Carl Mika**
Chairperson, Research Ethics Committee

Date: 27 July 2016

Subject: **Supervised Postgraduate Research – Application for Ethical Approval**

Thank you for submitting the revisions to your application for ethical approval for the research project:

Climate change education in Tongan secondary schools

I am pleased to advise that your application has received approval.

Please note that researchers are asked to consult with the Faculty's Research Ethics Committee in the first instance if any further changes to the approved research design are proposed.

The Committee wishes you all the best with your research.

Carl Mika

Dr Carl Mika
Chairperson
Research Ethics Committee

Appendix B: Research Permit from the Government of Tonga

Prime Minister's Office
Nuku'alofa

Ref No.: ORG 1/8 v15

5 September, 2016

Mrs. 'Elisapesi Havea,
PHD Student,
University of Waikato
Hamilton,
New Zealand.

Dear Mrs. Havea,

RE: Research Permit for Mrs. 'Elisapesi Havea, University of Waikato

I am pleased to inform you that the Tongan Prime Minister's Office has approved your application to conduct a postgraduate research in the Kingdom of Tonga entitled *'Climate Change Education in Tongan Secondary Schools'* which will commence in September, 2016 'til June, 2017.

Your proposal has complied with all the requirements under the Government Research Policy as stipulated under His Majesty's Cabinet Decision No. 410 of 12 May, 2011.

We wish you the very best and every success in your endeavour and should you require further assistance, please do not hesitate to contact our office.

Sincerely,

Fono-ki-moana Hola
for **Chief Secretary & Secretary to Cabinet**

GPO Box 62, Nuku'alofa, TONGA. Cable Address: GOVSEC NUKU'ALOFA. Telephone 24-644 Telex: 66269 PRIMO TS. Fax: 23-888

Appendix C: Letter to the Prime Minister Office

TEMS Research Centre
University of Waikato
Hamilton
New Zealand

The Prime Minister of Tonga,
The Prime Minister Office,
Government of Tonga.

11.08.2016

Dear Sir,

I am writing this letter to inform you of my willingness to submit two copies of my thesis, free of charge to the Government of Tonga.

I have my submitted my application with applicable documentation for your permission to conduct my research in Tonga. The title of my research is 'Climate change education in Tongan secondary schools'

Should you require any information regarding my research, please do not hesitate to contact me: ehh2@students.waikato.ac.nz or 00 64 212 663 422.

Thank you for your time and looking forward to hearing from you soon.

Respectfully,

Elisapesi Havea.

Elisapesi Hepi Havea.

Appendix D: Questionnaire for Pilot test

Students' Questionnaire

Dear Participant,

I am conducting a study entitled "Climate change education in Tongan secondary schools" for my doctorate degree in Education. I would like to know what you think about this issue. I therefore kindly request your voluntary participation in completing this survey. All responses will be treated as confidential, so do NOT put your name on this survey paper. All responses will be reported only as aggregated figures so no individual responses can be identified in my thesis or published articles. Please answer all questions as honestly as possible.

Section A

1. What is your gender?

Female ☐ Male ☐

2. What is your age? _____ (In years)

3. Have you ever taken a subject at school where climate change issues were discussed? (Please tick one)

Yes ☐ No ☐

4. Have you ever attended any climate change awareness programme at school or at your village? (Please tick one)

Yes ☐ No ☐

5. Have you ever volunteered to do any activity that you thought might tackle climate change? (Please tick one)

Yes ☐ No ☐

Section B

Awareness and Attitude about climate change

Please indicate your agreement or disagreement with the following statements by circling the appropriate response

		Strongly disagree	Disagree	Unsure	Agree	Strongly Agree
6	I believe climate change is happening	1	2	3	4	5
7	I am concerned about climate change	1	2	3	4	5
8	I believe my daily actions could contribute to climate change	1	2	3	4	5
9	Climate change is a problem for Tonga, including the Ha'apai islands	1	2	3	4	5
10	I feel a moral duty to do something about climate change	1	2	3	4	5
11	It is the Tongan government's responsibility to stop climate change	1	2	3	4	5
12	Everyone in Tonga, not just the government, should help stop climate change	1	2	3	4	5
13	Europe, Asia and America are causing most climate change, so they should take responsibility for it	1	2	3	4	5
14	It is already too late to do anything about climate change	1	2	3	4	5
15	I always pay attention to climate change news on television, radio and in the newspaper	1	2	3	4	5
16	I want to help prevent climate change in Tonga	1	2	3	4	5

Section C

17. Please explain what you think climate change is

_____

_____

_____
_____
_____
_____

For the following, please circle the letter beside the answer that best fits your understanding of the question:

18. Over the past several decades, the Earth has warmed faster than any other time period. What best explains this increase?
a. The sun is releasing more heat energy.
b. There's an increase in volcanic activity.
c. Humans are generating more air pollution.
d. The Earth's orbit around the Sun is changing.

19. There is a strong evidence that there is more carbon dioxide (CO_2) in the atmosphere now than in the past hundred years. What is most likely the cause of the current increase in carbon dioxide?
a. There's more toxic chemicals in the oceans
b. Plants are releasing more carbon dioxide
c. Humans are using more fossil fuels
d. Volcanoes are producing more ash than gases

20. Scientists believe that global temperatures are rising primarily because of:
a. an increase in the use of toxic chemicals such as pesticides sprays
b. increase in the amount of carbon dioxide (CO_2) from burning fossil fuels.
c. a hole in the ozone layer allowing heat to enter the earth's atmosphere.
d. excess heat given off from energy generation in power stations.

21. Certain gases in the atmosphere: water vapour, carbon dioxide, methane and nitrous oxide help maintain the Earth's temperatures and climate are called _____.
a. ozone gases
b. solar gases
c. greenhouse gases
d. atmosphere gases

22. Data collected by scientists show that the average global temperature is rising and will continue to rise in the future. What actions could people in your village community take to reduce the negative impacts of climate change?

a. Banning chemicals that break down ozone in the earth's ozone layer

b. Prevent litter and pollution from entering oceans

c. Plant more trees or reduce the number of trees being cut down

d. Buy fruit and vegetables from overseas

Section D

Knowledge of the causes of climate change

Indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

		Strongly disagree	Disagree	Unsure	Agree	Strongly Agree
23	Human action is not responsible for causing climate change	1	2	3	4	5
24	Burning fossil fuels is contributing to climate change	1	2	3	4	5
25	Deforestation is contributing to climate change	1	2	3	4	5
26	Damage to the ozone layer is contributing to climate change	1	2	3	4	5
27	Putting waste in a landfill is contributing to climate change	1	2	3	4	5

Section E

Knowledge of the impacts of climate change

Indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

	Aspects of impacts	Strongly disagree	Disagree	Unsure	Agree	Strongly Agree
28	Climate change would not cause increasing extreme weather events	1	2	3	4	5
29	Climate change could cause sea levels to rise	1	2	3	4	5

30	Climate change could cause people to migrate from their islands	1	2	3	4	5
31	Climate change would not affect food production such as agriculture	1	2	3	4	5
32	Climate change could cause financial problems to families in Tonga	1	2	3	4	5
33	Climate change would not affect the fresh water supply in Tonga	1	2	3	4	5
34	Climate change could affect the coral reefs around Tonga	1	2	3	4	5
35	Climate change could harm the health of Tongan people	1	2	3	4	5

Section F

Knowledge of methods of mitigation and adaptation to climate change

Indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

		Strongly disagree	Disagree	Unsure	Agree	Strongly Agree
36	Biking or walking instead of using cars could reduce the impacts of climate change	1	2	3	4	5
37	People can help stop climate change by using solar energy rather than diesel generators	1	2	3	4	5
38	People can help reduce impacts of climate change by growing more of their own food?	1	2	3	4	5
39	Planting mangroves along the coast can help reduce climate change	1	2	3	4	5
40	Building sea walls can help reduce impacts of climate change	1	2	3	4	5

Section G Intention to act

Indicate your agreement or disagreement with the following statements by circling the appropriate number.

		Strongly disagree	Disagree	Unsure	Agree	Strongly Agree
41	I believe that my own actions can help solve the problems of climate change	1	2	3	4	5
42	I would be prepared to plant trees if it would help reduce the impacts of climate change	1	2	3	4	5
43	I would be prepared to use less electricity at my house if that would help reduce the impacts of climate change	1	2	3	4	5
44	I would be prepared to walk or bike more if that would help reduce the impacts of climate change	1	2	3	4	6
45	I would be prepared to help climate change refugees	1	2	3	4	5

Section H

This section explores the existing status of climate change related issues in the secondary school curriculum in Tonga.

Indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

		Strongly disagree	Disagree	Undecided	Agree	Strongly Agree
46	Climate change awareness campaigns are well established at my school	1	2	3	4	5
47	I have learnt about issues of climate change in Science	1	2	3	4	5
48	I have learnt about issues of climate change in Geography	1	2	3	4	5
49	I want to learn more about climate change at school	1	2	3	4	5

54. If you believe you need to learn more about climate change, please rate how important are the below aspects to you in your willingness to know more about climate change?

		Not important	Moderately important	Very important
50	The causes of climate change	1	2	3

51	The greenhouse effect	1	2	3
52	The impacts of climate change on the environment	1	2	3
53	The impacts of climate change on the people of Tonga, including my family	1	2	3
54	The impacts of Tonga on the economy of Tonga	1	2	3
4555	The impacts of climate change on the Tongan culture	1	2	3
4556	Ways to reduce the impacts of climate change	1	2	3
57	Other: Please state any other aspects that you wish to learn about climate change			

Appendix E: Questionnaire for students (Phase One)

Dear Participant,

I am conducting a study entitled "Climate change education in Tongan secondary schools" for my doctorate degree in Education. I would like to know what you think about this issue. I therefore kindly request your voluntary participation in completing this survey. All responses will be treated as confidential, so do NOT put your name on this survey paper. All responses will be reported only as aggregated figures so no individual responses can be identified in my thesis or published articles. Please answer all questions as honestly as possible.

Section A

1. What is your gender?

Female ☐ Male ☐

2. What is your age? _____ (In years)

3. Have you ever taken a subject at school where climate change issues were discussed? (Please tick one)

Yes ☐ No ☐

4. Have you ever attended any climate change awareness programme at school or at your village? (Please tick one)

Yes ☐ No ☐

5. Have you ever volunteered to do any activity that you thought might tackle climate change? (Please tick one)

Yes ☐ No ☐

Section B

Awareness and Attitude about climate change

Please indicate your agreement or disagreement with the following statements by circling the appropriate response

		Strongly disagree	Disagree	Unsure	Agree	Strongly Agree
6	I believe climate change is happening	1	2	3	4	5
7	I am concerned about climate change	1	2	3	4	5
8	I believe my daily actions could contribute to climate change	1	2	3	4	5
9	Climate change is a problem for Tonga, including the Ha'apai islands	1	2	3	4	5
10	I feel a moral duty to do something about climate change	1	2	3	4	5
11	It is the Tongan government's responsibility to stop climate change	1	2	3	4	5
12	Everyone in Tonga, not just the government, should help stop climate change	1	2	3	4	5
13	Europe, Asia and America are causing most climate change, so they should take responsibility for it	1	2	3	4	5
14	It is already too late to do anything about climate change	1	2	3	4	5
15	I always pay attention to climate change news on television, radio and in the newspaper	1	2	3	4	5
16	I want to help prevent climate change in Tonga	1	2	3	4	5

Section C

17. Please explain what you think climate change is

_____

_____

_____

_____

_____

_____

_____

_____

For the following, please circle the letter beside the answer that best fits your understanding of the question:

18. Over the past several decades, the Earth has warmed faster than any other time period. What best explains this increase?

a. The sun is releasing more heat energy.

b. There's an increase in volcanic activity.

c. Humans are generating more air pollution.

d. The Earth's orbit around the Sun is changing.

19. There is a strong evidence that there is more carbon dioxide (CO2) in the atmosphere now than in the past hundred years. What is most likely cause of the current increase in carbon dioxide?

a. There's more toxic chemicals in the oceans

b. Plants are releasing more carbon dioxide

c. Humans are using more fossil fuels

d. Volcanoes are producing more ash than gases

20. Scientists believe that global temperatures are rising primarily because of:

a. an increase in the use of toxic chemicals such as pesticides sprays

b. increase in the amount of carbon dioxide (CO2) from burning fossil fuels.

c. a hole in the ozone layer allowing heat to enter the earth's atmosphere.

d. excess heat given off from energy generation in power stations.

21. Certain gases in the atmosphere: water vapour, carbon dioxide, methane and nitrous oxide help maintain the Earth's temperatures and climate are called _____.

a. ozone gases

b. solar gases

c. greenhouse gases

d. atmosphere gases

22. Data collected by scientists show that the average global temperature is rising and will continue to rise in the future. What actions could people in your village community take to reduce the negative impacts of climate change?

a. Banning chemicals that break down ozone in the earth's ozone layer

b. Prevent litter and pollution from entering oceans

c. Plant more trees or reduce the number of trees being cut down

d. Buy fruit and vegetables from overseas

Section D

Knowledge of the causes of climate change

Indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

		Strongly disagree	Disagree	Unsure	Agree	Strongly Agree
23	Human action is not responsible for causing climate change	1	2	3	4	5
24	Burning fossil fuels is contributing to climate change	1	2	3	4	5
25	Cutting down trees is contributing to climate change	1	2	3	4	5
26	Damage to the ozone layer is contributing to climate change	1	2	3	4	5

27	Putting waste in a landfill is contributing to climate change	1	2	3	4	5

Section E

Knowledge of the impacts of climate change

Indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

	Aspects of impacts	Strongly disagree	Disagree	Unsure	Agree	Strongly Agree
28	Climate change would not make cyclones and droughts worse	1	2	3	4	5
29	Climate change could cause sea levels to rise	1	2	3	4	5
30	Climate change could cause people to migrate from their islands	1	2	3	4	5
31	Climate change would not affect food production such as agriculture	1	2	3	4	5
32	Climate change could cause financial problems to families in Tonga	1	2	3	4	5
33	Climate change would not affect the fresh water supply in Tonga	1	2	3	4	5
34	Climate change could affect the coral reefs around Tonga					
35	Climate change could harm the health of Tongan people	1	2	3	4	5

Section F

Knowledge of methods of mitigation and adaptation to climate change

Indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

		Strongly disagree	Disagree	Unsure	Agree	Strongly Agree
36	Biking or walking instead of using cars could reduce the impacts of climate change	1	2	3	4	5
37	People can help stop climate change by using solar energy rather than diesel generators	1	2	3	4	5
38	People can help reduce impacts of climate change by growing more of their own food?	1	2	3	4	5
39	Planting mangroves along the coast can help reduce climate change	1	2	3	4	5
40	Building sea walls can help reduce impacts of climate change	1	2	3	4	5

Section G Intention to act

Indicate your agreement or disagreement with the following statements by circling the appropriate number.

		Strongly disagree	Disagree	Unsure	Agree	Strongly Agree
41	I believe that my own actions can help solve the problems of climate change	1	2	3	4	5
42	I would be prepared to plant trees if it would help reduce the impacts of climate change	1	2	3	4	5
43	I would be prepared to use less electricity at my house if that would help reduce the impacts of climate change	1	2	3	4	5
44	I would be prepared to walk or bike more if that would help reduce the impacts of climate change	1	2	3	4	6
45	I would be prepared to help climate change refugees	1	2	3	4	5

Section H

This section explores the existing status of climate change related issues in the secondary school curriculum in Tonga.

Indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

		Strongly disagree	Disagree	Undecided	Agree	Strongly Agree
46	Climate change awareness campaigns are well established at my school	1	2	3	4	5
47	I have learnt about issues of climate change in Science	1	2	3	4	5
48	I have learnt about issues of climate change in Geography	1	2	3	4	5
49	I want to learn more about climate change at school	1	2	3	4	5

54. If you believe you need to learn more about climate change, please rate how important are the below aspects to you in your willingness to know more about climate change?

		Not important	Moderately important	Very important
50	The causes of climate change	1	2	3
51	The greenhouse effect	1	2	3
52	The impacts of climate change on the environment	1	2	3
53	The impacts of climate change on the people of Tonga, including my family	1	2	3
54	The impacts of Tonga on the economy of Tonga	1	2	3
4555	The impacts of climate change on the Tongan culture	1	2	3
4556	Ways to reduce the impacts of climate change	1	2	3
57	Other: Please state any other aspects that you wish to learn about climate change			

Appendix F: Teachers questionnaire

Dear Participant,

My name is Elisapesi Havea, I am studying for my doctoral degree at the University of Waikato in New Zealand. I am carrying out research on climate change education in Tongan secondary schools. The positions that educators take are a significant factor in climate change education. For that reason, I would like your help, by volunteering to complete this survey. It should take only a few minutes. You don't need to put your name on this survey paper. The responses will be reported only as grouped results and no name will be identified in my thesis or published articles.

Section A

1. What is your agenda? (Please tick the appropriate box)

Female ☐ Male ☐

2. What is your age? _____ (In years)

3. Do you have any role(s) in the community (For example: Faifekau; akonaki; Malanga; matapule)? (Please tick the appropriate box)

Yes ☐ No ☐

4. If you have answered Yes in Question 3, please state the role(s) on the spaces provided below.

_____

_____

_____

5. What is your highest formal education qualification? (Please tick the appropriate box.

High school certificate ☐ Tertiary Certificate ☐

Diploma ☐ Bachelor ☐

Masters ☐ Doctorate ☐

6. Do you include climate change and/or the problems it causes in your teaching? (Please tick the appropriate box)

Yes ☐ No ☐

7. Have you ever volunteered to do any activity that you thought might stop climate change or the problems it causes? (Please tick one)

Yes ☐ No ☐

Section B: Please indicate your level of agreement or disagreement with the following statements by circling the appropriate number in the boxes below.

		Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
8	I believe climate change is happening	1	2	3	4	5
9	I am concerned about climate change	1	2	3	4	5
10	I believe my daily actions could contribute to climate change	1	2	3	4	5
11	Climate change is a problem for Tonga, including the Ha'apai islands	1	2	3	4	5
12	It is the Tongan government's responsibility to stop climate change	1	2	3	4	5
13	Everyone in Tonga, not just the government, should help stop climate change	1	2	3	4	5

14	Europe, Asia and America are causing most climate change, so they should take responsibility for it	1	2	3	4	5
15	It is already too late to do something about climate change	1	2	3	4	5
16	I always pay attention to climate change news on television, radio and in the newspaper	1	2	3	4	5
17	I want to help prevent climate change in Tonga	1	2	3	4	5

Section C

18. Please share your understanding of what climate change is.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Section D: Please indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

		Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
19	Human action is responsible for causing climate change	1	2	3	4	5
20	Burning fossil fuels is contributing to climate change	1	2	3	4	5

21	Cutting down trees is contributing to climate change	1	2	3	4	5
22	Damage to the ozone layer is contributing to climate change	1	2	3	4	5

Section E: Please indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

		Strongly Disagree	Disagree	Unsure	Agree	Strongly Disagree
23	Climate change would make cyclones and droughts worse	1	2	3	4	5
24	Climate change could impact on local language and other cultural matters	1	2	3	4	5
25	Climate change could cause people to migrate from their islands	1	2	3	4	5
26	Climate change would not affect food production such agriculture	1	2	3	4	5
27	Climate change could cause financial problems to families in Tonga	1	2	3	4	5
28	Climate change would not affect the fresh water supply in Tonga	1	2	3	4	5
29	Climate change could affect the coral reefs around Tonga	1	2	3	4	5
30	Climate change could harm the health of Tongan people	1	2	3	4	5

Section F: Please indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

		Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
31	Biking or walking instead of using cars could reduce climate change	1	2	3	4	5
32	Using solar energy rather than diesel generators could reduce climate change	1	2	3	4	5

33	People growing more of their own food could reduce climate change	1	2	3	4	5
34	Planting mangroves along the coast could reduce the problems of climate change	1	2	3	4	5
35	Building sea walls could help reduce the problems of climate change	1	2	3	4	5

Section G: Please indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below.

		Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
36	I believe that my own actions can help solve the problems of climate change	1	2	3	4	5
37	I would be prepared to plant trees if it would help reduce the problems of climate change	1	2	3	4	5
38	I would be prepared to use less electricity at my house if that would help reduce the problems of climate change	1	2	3	4	5
39	I would be prepared to walk or bike more if that would help reduce the problems of climate change	1	2	3	4	5
40	I would be prepared to help people who have lost their land and homes because of climate change	1	2	3	4	5

Section H: Please indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below.

		Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
41	Activities to learn about climate change happen often at my school	1	2	3	4	5
42	Climate change is sufficiently covered in the Science curriculum at my school	1	2	3	4	5
43	Climate change is sufficiently covered in the Geography curriculum at my school	1	2	3	4	5

44	Climate change is sufficiently covered in other subjects at school	1	2	3	4	5

Section I: If you believe you need to learn more about climate change, please rate the aspects below on how important they are for you to learn about by circling the appropriate number in the boxes.

		Not Important	Moderately Important	Very Important
45	Learning more about the causes of climate change	1	2	3
46	Learning more about the greenhouse effect	1	2	3
47	Learning more about how climate change affects nature	1	2	3
48	Learning more about how climate change affects people of Tonga, including my family	1	2	3
49	Learning more about how climate change affect the economy of Tonga	1	2	3
50	Learning more about how climate change affects Tongan culture	1	2	3
51	Learning more about ways to reduce the problems of climate change	1	2	3
52	Other: Please state any other things that you wish to learn about climate change			

Section J:

53. Please state any other aspects that you wish to comment on about climate change

_____
_____
_____
_____
_____
_____
_____

Thank you for assisting me with this survey.

Appendix G: Students' Questionnaire (Phase Two)

Dear Participant,

My name is Elisapesi Havea, I am studying for my doctoral degree at the University of Waikato in New Zealand. I am carrying out research on climate change education in Tongan secondary schools. I would like your help, by volunteering to complete this survey. It should take only a few minutes. You do not need to put your name on this survey paper. The responses will be reported only as grouped results and no name will be identified in my thesis or published articles. Please answer all questions as honestly as possible.

Section A

1. What is your gender? (Please tick the appropriate box)

Female ☐ Male ☐

2. Have you ever been to any programme to learn about climate change at your village? (Please tick one)

Yes ☐ No ☐

3. Have you ever volunteered to do any activity that you thought might stop climate change or the problems it causes? (Please tick one)

Yes ☐ No ☐

Section B: Please indicate your level of agreement or disagreement with the following statements by circling the appropriate number in the boxes below.

		Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
4	I believe climate change is happening	1	2	3	4	5
5	I am concerned about climate change	1	2	3	4	5
6	I believe my daily actions could contribute to climate change	1	2	3	4	5
7	Climate change is a problem for Tonga, including the Ha'apai islands	1	2	3	4	5
8	It is the Tongan government's responsibility to stop climate change	1	2	3	4	5
9	Everyone in Tonga, not just the government, should help stop climate change	1	2	3	4	5
10	Europe, Asia and America are causing most climate change, so they should take responsibility for it	1	2	3	4	5
11	It is already too late to do something about climate change	1	2	3	4	5
12	I always pay attention to climate change news on television, radio and in the newspaper	1	2	3	4	5
13	I want to help prevent climate change in Tonga	1	2	3	4	5

Section C

14. Please explain what you think climate change is

_____

_____

_____

_____

_____

For the following questions, please circle the letter beside the answer that best fits your understanding:

15. Over the past few decades, the Earth has warmed faster than at any other time period. What best explains this increase?

a. The sun is releasing more heat energy.

b. There is an increase in volcanic activity.

c. Humans are generating more air pollution.

d. The Earth's orbit around the Sun is changing.

16. There is more carbon dioxide (CO_2) in the atmosphere now than in the past hundred years. What is the most likely cause of the current increase in carbon dioxide?

a. It is coming from the oceans.

b. Plants are releasing more carbon dioxide.

c. Humans are using more fossil fuels.

d. Volcanoes are producing more gases.

17. Scientists believe that global temperatures are rising primarily because of:

a. an increase in the use of toxic chemicals such as pesticides sprays.

b. increase in the amount of carbon dioxide (CO_2) from burning fossil fuels.

c. a hole in the ozone layer allowing heat to enter the earth's atmosphere.

d. excess heat given off from energy generation in power stations.

18. Certain gases in the atmosphere: water vapour, carbon dioxide, methane and nitrous oxide can influence the Earth's temperature and climate. They are called _____.

a. ozone gases.

b. solar gases.

c. greenhouse gases.

d. atmosphere gases.

Section D: Please indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

		Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
19	Human action is responsible for causing climate change	1	2	3	4	5
20	Burning fossil fuels is contributing to climate change	1	2	3	4	5
21	Cutting down trees is contributing to climate change	1	2	3	4	5
22	Damage to the ozone layer is contributing to climate change	1	2	3	4	5

Section E: Please indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

		Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
23	Climate change would make cyclones and droughts worse	1	2	3	4	5
24	Climate change could cause sea levels to rise	1	2	3	4	5
25	Climate change could cause people to migrate from their islands	1	2	3	4	5
26	Climate change would not affect food production such as taro, banana and yams	1	2	3	4	5
27	Climate change could cause money problems to families in Tonga	1	2	3	4	5
28	Climate change would not affect the fresh water supply in Tonga	1	2	3	4	5
29	Climate change could affect the coral reefs around Tonga	1	2	3	4	5

30	Climate change could harm the health of Tongan people	1	2	3	4	5

Section F: Please indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below

		Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
31	Biking or walking instead of using cars could reduce climate change	1	2	3	4	5
32	Using solar energy rather than oil generators could reduce climate change	1	2	3	4	5
33	People growing more of their own food could reduce climate change	1	2	3	4	5
34	Planting mangroves along the coast could reduce the problems of climate change	1	2	3	4	5
35	Building sea walls could help reduce the problems of climate change	1	2	3	4	5

Section G: Please indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below.

		Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
36	I believe that my own actions can help solve the problems of climate change	1	2	3	4	5
37	I would be prepared to plant trees if it would help reduce the problems of climate change	1	2	3	4	5
38	I would be prepared to use less electricity at my house if that would help reduce the problems of climate change	1	2	3	4	5
39	I would be prepared to walk or bike more if that would help reduce the problems of climate change	1	2	3	4	5
40	I would be prepared to help people who have lost their land and homes because of climate change	1	2	3	4	5

Section H: Please indicate your agreement or disagreement with the following statements by circling the appropriate number in the boxes below.

		Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
41	Activities to learn about climate change happen often at my school	1	2	3	4	5
42	I have learnt about climate change in Science	1	2	3	4	5
43	I have learnt about climate change in Geography	1	2	3	4	5
44	I have learnt about climate change in other subjects at school	1	2	3	4	5
45	I want to learn more about climate change at school	1	2	3	4	5

Section I: If you believe you need to learn more about climate change, please rate the aspects below on how important they are for you to learn about by circling the appropriate number in the boxes.

		Not Important	Moderately Important	Very Important
46	Learning more about the causes of climate change	1	2	3
47	Learning more about the greenhouse effect	1	2	3
48	Learning more about how climate change affects nature	1	2	3
49	Learning more about how climate change affects people of Tonga, including my family	1	2	3
50	Learning more about how climate change affect the economy of Tonga	1	2	3
51	Learning more about how climate change affects Tongan culture	1	2	3
52	Learning more about ways to reduce the problems of climate change	1	2	3
53	Other: Please state any other things that you wish to learn about climate change			

Thank you for assisting me with this survey.

Appendix H: Students Information letter

Date:

Dear Student,

I would like to invite you to participate in a research study. I am interested in your views about climate change. The study is part of my doctorate degree under the supervision of Dr Chris Eames and Dr Timote Vaioleti.

I hope to involve 30 Form 4 students in your school. I hope that findings from this study could help me inform education that can assist students to learn about and deal with the problems of climate change, which are already affecting Tonga.

To help me in this study, I would like you to complete a questionnaire about your views of climate change and your learning about this at school. Your participation is voluntary and, if you participate, you have the right to refuse to answer any question. You will not be asked to put your name on the questionnaire so your responses will be anonymous. I expect the questionnaire will take about 20-30 minutes to complete and with your teacher's permission will be done in class time. After this questionnaire, I may ask you to take part in small group discussion with some of your classmates to talk more about these issues. This discussion may take 45-60 minutes and may be held outside of class time such as in the lunch break or after school. Again your participation is voluntary and, if you do participate, you have the right to refuse to answer any question. I will record the discussion with your permission. Once you participated in the group discussion, then there is no opportunity to withdraw the data.

Data from your questionnaire or discussion collected during the study may be used in writing of my doctorate thesis, reports, publications or in presentations. I will not use your names, the name of your school or the names of other participants in any publications or presentations.

I will be handling the data (information) gathered from you and it will be kept secure at all times. Your own data will not me shown to any teacher or the principal in your school, and participation in the study will not impact in any way on your studies. Your data will be destroyed five years after I receive my Doctorate final grade.

I would appreciate your agreement to be involved in my study. If you agree, can you also discuss this with your parents and if they also agree that you can participate, please can you both sign the attached consent form. If you need any more details about the project, or issues arise for your during the project, please contact me, Elisapesi Havea, ehh2@students.waikato.ac.nz or 751 2185. If I am unable to resolve your concerns, you may contact my research supervisor, Dr Chris Eames, c.eames@waikato.ac.nz or 00 64 7 838 4357.

Yours sincerely

Elisapesi Hepi Havea.

Appendix I: Students and parents consent form

Title of study: Climate change education in Tonga's secondary schools

Researcher: 'Elisapesi Hepi Havea

Institution: University of Waikato, New Zealand.

I ask that you read this form and ask any questions that you may have before participating in this study. Your participation is voluntary.

Description of the study procedures

- If you agree to participate in this study, you/your child will be invited to do the following things:
  - participate in completing a questionnaire
  - may be asked to participate in a group discussion *talanoa* after completing the questionnaire.
- The discussion group *talanoa* will be audio-recorded with the permission of all participants.
- Once you participated in the group discussion, then there is no opportunity to withdraw the data.
- You will be advised through telephones or emails when you might be able to access the outcomes of the study. For instance, you can access via the University of Waikato Research Commons website or a hard copy of my thesis will be available at the library, University of Waikato.
- A summary of the research will be sent to Tonga's Ministry of Education and Ministry of Environment and Climate Change, and to the Principal of your school.

Confidentiality

- You/your child's identity in this study is confidential. I will not be collecting or retaining any information about your child's identity.
- The records of this study will be kept strictly confidential. They may be used in my thesis and other publication and presentations.

Right to refuse or withdraw

- You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research.
- The data collected from talanoa fakakulupu cannot be withdrawn unless a collective process has been agreed by the participants.
- If you have any further questions about the study, at any time, feel free to contact me, email: ehh2@students.waikato.ac.nz or 751 2185. If I will not be able to

resolve your issue, you may contact my Researcher Supervisor, email: c.eames@waikato.ac.nz or by phone: 00 64 7 838 4357.

Consent

I agree to participate in this study.

Student's name:

_____

Student's signature:_____ Date:

_____

I agree to my child participating in this study

Parent/Guardian Name:

_____

Parent/Guardian signature: _____ Date:

_____

Appendix J: Teachers Information letter

Date:

Dear Teacher

I would like to invite you to participate in a research study. I am interested in your views about climate change. The study is part of my doctorate degree under the supervision of Dr Chris Eames and Dr Timote Vaioleti.

I hope to involve 5 teachers in your school. I hope that findings from this study could help me inform education that can assist students to learn about and deal with the problems of climate change, which are already affecting Tonga.

To help me in this study, I would like you to complete a questionnaire about your views of climate change and your teaching (may/may not) it at school. Your participation is voluntary and, if you do participate, you have the right to refuse to answer any question. You will not be asked to put your name on the questionnaire so your responses will be anonymous. I expect the questionnaire will take about 20-30 minutes to complete and with your teacher's permission will be done in class time. After this questionnaire, I will ask you to take part in small group discussion with some of the teachers to talk more about these issues. This discussion may take 45-60 minutes and may be held outside of class time such as in the lunch break or after school. Again your participation is voluntary and, if you do participate, you have the right to refuse to answer any question. I will record the discussion with your permission. Once you participated in the group discussion, then there is no opportunity to withdraw the data.

Data from you questionnaire and discussion collected during the study may be used in writing of my doctorate thesis, reports, publications or in presentations. I will not use your names, the name of your school or the names of other participants in any publications or presentations.

I will be handling the data (information) gathered from you and it will be securely kept at all times. Your own data will not me shown to any teacher or the principal in your school, and participation in the study will not impact in any way on your studies. Your data will be destroyed five years after I receive my Doctorate final grade.

I would appreciate your agreement to be involved in my study. If you agree, can you sign the attached consent form. If you need any more details about the project, or issues arise for your during the project, please contact me, Elisapesi Havea, ehh2@students.waikato.ac.nz or 751 2185. If I am unable to resolve your concerns, you may contact my research supervisor, Dr Chris Eames, c.eames@waikato.ac.nz or 00 64 7 838 4357.

Yours sincerely

Elisapesi Hepi Havea.

Appendix K: Teachers consent form

Title of study: Climate change education in Tonga's secondary schools

Researcher: 'Elisapesi Hepi Havea
Institution: University of Waikato, New Zealand.

I ask that you read this form and ask any questions that you may have before participating in this study. Your participation is voluntary.

Description of the study procedures

- If you agree to participate in this study, you will be invited to do the following things:
  - participate in completing a questionnaire
  - participate in a group discussion *talanoa* after the completing the questionnaire.
- The discussion group *talanoa* will be audio-recorded with the permission of all participants.
- Once you participated in the group discussion, then there is no opportunity to withdraw the data.
- You will be advised through telephones or emails when you might be able to access the outcomes of the study. For instance, you can access via the University of Waikato Research Commons website or a hard copy of my thesis will be available at the library, University of Waikato.
- A summary of the research will be sent to Tonga's Ministry of Education and Ministry of Environment and Climate Change, and to the Principal of your school.

Confidentiality

- The records of this study will be kept strictly confidential. Your data may be used in my thesis and other publication and presentations.

Right to refuse or withdraw

- You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research.
- The data collected from talanoa fakakulupu cannot be withdrawn unless a collective process has been agreed by the participants.
- If you have any further questions about the study, at any time, feel free to contact me, email: ehh2@students.waikato.ac.nz or 751 2185. If I will not be able to resolve your issue, you may contact my Researcher Supervisor, email: c.eames@waikato.ac.nz or by phone: 00 64 7 838 4357.

Consent

I agree to participate in this study.

Teacher's name: _____

Teacher's signature:_____ Date: _____

Appendix L: Observation Record

OBSERVATION RECORDS DAY 1 – DAY 8

DAY ONE

Teacher: Date:

Duration: Time:

Topic(s):

1. **Learning outcomes:** *Did the teacher express clearly the learning outcome*

2. **Introduction to lesson:** provides introduction/motivation; explains activity and how it assesses students' prior knowledge (Engage in 5E's model). *Describe how the teacher starts the lesson and fill in the amount of time (duration) the teacher introduces the lesson.*

Activities

Activity	What are students doing?	What is the teacher doing?	Student engagement 1 -7	Students participating 1 - 7
Guest speaker				
"Catch the Ball & Talk"				
Group work – Mind Map				
Group presentation				

Students:
1. Did the students appear to challenge their current views?

2. Did the students appear to reflect on others' comments and ideas?

3. *Did the students seek information to complete the assigned work or did they seek clarification of conceptual understanding?*

Teacher role:

1. Was the teacher the source of information or did she play the role of a facilitator?

2. Did the teacher appear enthusiastic in her work?

3. Did the teacher appear to prompt the students to think?

4. Did the teacher appear to prompt the students to review their values?

5. Did the teacher appear to prompt the students to take action?

Reflections

1. Overall, what happened during the classroom observation?

2. What didn't happen (e.g. students didn't grasp the idea of the lesson)?

3. Alternative ways teacher might have handled the lesson/question/situation:

4. Characterize students and their attitudes toward the subject matter and the teacher:

6. Surprises/concerns, especially related to the intervention goals (e.g. students do not conduct talanoa as require).

Appendix M: Lesson plans

Episode 1: Introduction to climate change

Lesson 1 - Familiarising with climate change

Sharing stories	• Invite a local to share his or her experience of climate change • Students to listen carefully and ask questions • Students and teacher to share their experiences of climate change
Sharing objects	• Share some stories about a certain object they think that contribute to climate change
"Fofola e fala kae alea 'ae kainga" Rolling out the mat for the kin to talk.	

Lesson 2 – Earth system

Learning objectives	By the end of this lesson, student will be able to: • Identify processes in Earth systems • Describe connections between Earth systems
Task 1	• Give each student a copy of Resource 1. • Explain that they are going outside on a short nature walk. As they walk, some questions students should think about as they walk and observe could include: what do you see? What's going on outside these days/today? What do you see happening in nature? Have you noticed any changes in nature around your home or school? • Walk for about 5-10 minutes and ask students to record a minimum of 5 observations.
Task 2	• Gather students back together in the classroom. Conduct a class discussion based on their observations. • Introduce the four main components of Earth systems: Geosphere (land); Hydrosphere (water); Atmosphere (air); and Biosphere (life) (Resource 2). (Note: Each of the spheres (e.g., the biosphere) is a *component* of the Earth system. *Sphere* and *component* (of the Earth system) are used synonymously. Each sphere or component is made up of *elements* (e.g. a bird is an element of the biosphere; a pond is an element of the hydrosphere). • Ask students to write which system category each observations falls into. They can write this in the left column next to each observation on the Resource 1. • Or divide students into 4 groups and each group to represent each of the spheres. Get them to work out who they are, their characteristics etc.
Task 3	• Now they have categorized their observations, ask them to get into groups of four. Each group will choose one of their observations to consider more detail and describe the interactions between the systems. Hand out Resource 3 to the students. Each group will write the observation and circle the picture of the system it belongs to. • Draw arrows showing the connections between parts based on that observation. Students should write notes along the arrows to explain that connection. They should make as many connections as they can. • Depending on the time, ask a few groups to present their observations and connections to the class. (Another option would be to have students to post their paper around the room and do a quick gallery walk so students can see what other groups produced. • *Students to role play their own sphere and to identify how they interact with the other spheres.*
Task 4	• Ask the students: From what they saw, heard, what overall message can they see? • What are some conclusions they can make? What is this showing us? • Guide students to understand that all of Earth's systems are connected in some way. Each part cannot be on its own for anything to work or survive in nature.
Task 5	• Beat the clock! Show students a picture and ask them to write down as many connections between components as they can in 30 seconds (Resource 4)

Lesson 3 - Weather and climate

Learning objectives	By the end of this lesson, the students will be able to: 1. Distinguish weather from climate. 2. Explain the concept of 'climate change' and distinguish it from global warming.
Task 1	**Weather and climate game** The teacher introduces the following rule: • When the teacher says "light rain" students clap two index fingers together and say 'ti tach, ti tach" (imitating the sound of light rain); • When the teacher says "strong wind", students raise their hands, waving to the left and right, saying "ao, ao" (imitating the sound of blowing wind); • When the teacher says "heavy rain", students stay in their place, stamping their feet, saying "lop bop, lop bop" (imitating the sounds of heavy rain drops); • When the teacher says "thunder", students tap the table with their fists, saying "ung ung, ung ung" (imitating the sounds of thunder); • When the teacher says "lighting", student open their palms, stretching their arms to the front, saying "doang doang" (imitating the sounds of lightning); • The teacher can change the order of the questions to see if students are able to quickly react or not. Prompt the students to explain that such events are known as 'weather'
Task 2	• Ask students about the day's weather • Prompt them to describe aspects such as temperature, cloud cover, precipitation, and wind. • Ask the following questions: - Is today's weather normal? Is it what you would expect? • Tell the students that in this activity they will explore the differences between weather and climate: ***Weather*** is the current state of the atmosphere at a specific time and place. It includes factors such as temperature, rainfall, wind, humidity and other phenomena such as hurricanes and thunderstorms. ***Climate*** is the usual average of weather conditions based on a long period of time (typically 30 years) of averaged weather data for a location. • Climate is what you expect. Weather is what actually happens. • Give each student a copy of Resource 5. Ask the students to identify the differences between the two data. This will enhance the differences between weather and climate.
Task 3	• In groups of 4, students study the given scenario. Based on the scenario, they have to discuss the answer to the questions that follow. Scenario: Sione and Mele are on their way to school on an April morning. Once they get on the city bus, Sione takes of his jacket.

	"I'm hot," he says "I thought it was supposed to be cool today like it was yesterday," says Mele as she takes off her jacket too. "it was cool the day before, but now the temperature is climbing. It's going to be wam." "it's hot today because of global warming," says an elderly woman sitting in the row in front of them. She turns to look at Sione and Mele and shakes her head back and forth with gloom. "No it's not," says a man across the aisle angrily. "It's just the weather, not the climate." "Climate and weather are the same," says a woman in a business suit who is on her way to work. "No it's not," calls the bus driver over his shoulder. Sione and Mele look at each other with confusion. They didn't mean to start an argument. If you were on the bus with the bus, how would you respond? Questions: 1. If yesterday was cool and today is warm, could that be due to global warming? 2. Are weather and climate the same or different? How would you respond to the people on the bus? 3. How would you figure out what weather is normal for that time of year and that location? 4. Can you think of a way that we can use weather data to figure out how climate is changing?
Task 4	• Teacher asks students on their understanding of climate change and teacher to write down students' ideas on the board, summarizing the key points leading to an explanation of concepts related to climate change and distinguish climate change from global warming. • Climate change generally refers to the long-term changes in climate patterns that have occurred over a long period of time. The climate can become warmer or colder. • **Climate change** may be caused by natural factors or human activities (e.g. burning fossil fuels and agriculture activities) that change in the Atmosphere's composition. The term 'climate change' generally now refers to the climatic changes that are direct result of human activities. Teacher can use Resource 6 as source of information. **Global warming** is the rising average temperature of the Earth. It is caused due to an increase in the emission of greenhouse gases such as carbon dioxide, carbon monoxide and gases of sulphur. The emissions from industries, burning of solid waste, the burning of fossil fuels and vehicles are also the sources that emit large quantities of green house gases all over the world. All this is considered a cause of Global Warming.
Task 5	

Episode 2: Causes of climate change

Lesson 4 – Greenhouse effect and causes of climate change

Learning objectives	At the end of this lesson, the students would be able to: 1. Explain the process of greenhouse effects; 2. Identify the main greenhouse gases and describe the causes of climate change. 3. Identify the differences between greenhouse effect and ozone layer
Resources	Video clip**:** **https://www.youtube.com/watch?v=-RMD88DNaGk**
Tasks 1	• Ask two students to volunteer in the activity • Bring them at the front and let one participant sit on a chair with a big label Earth. • Give a blanket/cloths to the standing participant and ask him/her to cover his/her friend who is sitting on the chair. Each blanket is given a name of a greenhouse gas: eg: Carbon dioxide, methane, or nitrous oxide. • Add on the blanket to the sitting participant one by one up to 4-5 blankets. • Then ask him/her how he/she is feeling • Note: Do a *talanoa* session with the whole class and highlight to them that as the blankets are added and added the participant will feel warmer and warmer. The blanket acted as layer of greenhouse gas layer and the participant as the earth. • Prompt them to identify that more that whatever difficulty the participant is feeling, more difficulty is being faced by the earth.
Task 2	• Get students in a group of 5. Give each group these questions: - Name three greenhouse gases - What is greenhouse effect? - Are greenhouse gases good or bad? Why? - What causes global warming? - What does ozone layer do? - What is the main cause of the hole on the ozone layer? - The hole on the ozone layer will have two effects, they are: _____ and _____. - Identify the differences between greenhouse effect and ozone layer. • Show video clip: **https://www.youtube.com/watch?v=-RMD88DNaGk** • Play the video clip 2-3 times so that the students can work out their answers
Task 3	• Conduct a *talanoa* session where each group will share their answers with the class. • Students should be able explain the differences between greenhouse effect and ozone layer, and what they believe to be the main cause of climate change.
Task 4	• Based on these questions: let each group do the paper cutting of the following: Earth, name of Greenhouse gases, sun, arrow (drawing in papers), and trees which are required to show the Greenhouse effect (teacher to provide coloured papers or coloured pens for this task. • Ask each group to arrange the pictures in correct order to represent greenhouse effect. Pictures should be attached on a given chart. • Ask each group to explain briefly about their picture arrangement.

Task 5	Class activities: Question One: Choose the most suitable word for the following sentences: a. The greenhouse effect is the ability to keep the temperature of the Earth at the safe level, due to _____ absorbing heat from the Earth's surface and from external sources like the sun, and trapping it in the atmosphere. (Answer: Greenhouse gases) b. Since the Industrial revolution, _____ have significantly enhanced the greenhouse effect. (Answer: human activities or humans) Question Two: Choose the most appropriate answer for the following questions: 1. Where does the greenhouse effect take place? a. In the forest. b. In the soil. c. In the mountains. **d. In the atmosphere.** 2. of the following greenhouse gases, which one contributes the most to the cause of climate change. a. Ozone b. Carbon dioxide c. Nitrous oxide d. Methane

Lesson 5 – Human activities and GHG emissions

Learning objectives	By the end of this end of this lesson, the students would be able to: 1. Describe the main greenhouse gases and greenhouse gas emission from human activities 2. Identify the global greenhouse gas emission and to discuss countries that contribute the most to climate change.
Task 1	• Students to work in pair. They share stories about what activities they believe that cause climate change. • Let some students share their stories with rest of the class. • Write down their answers on the board.
Task 2	• Divide students in groups of 5. • Distribute a copy of Resource 7 to each group. • Based on the images, each group discusses the 'culprit' that has contributed to the emission of greenhouse gases and how each activity has impacted the environment and climate. • Each group presents the team findings.
Task 3	• Divide students into four groups. • Distribute a copy of Resource 10 to each group. • The teacher invites students to conduct a *talanoa* based on the images. Give them questions as prompts. Eg: Which activity creates more greenhouse gases and which one creates less? Which country emits more greenhouse gases? Do you think Tonga contribute much to global greenhouse gas emission? Why? • A class discussion will take place to listen to every group's stories
Task 4	• Students to work in the same group, and each group to compose a poem on the theme "Human activities cause climate change" (It can be in Tongan or in English) • Each group to sing this poem using a tune of a Tongan song (teacher will help)
Task 5	• Groups to sing their songs.

Episode 3: Impacts of climate change

Lesson 6 – Impacts of climate change on human and natural system

Learning objectives	By the end of this end of this lesson, the students would be able to: 1. Describe the climate change impacts on human and natural systems; 2. Identify groups that are vulnerable to the impact of climate change at national, regional, and global scale.
Task 1	Shrinking island • Divide students in groups of 5 and each group to follow instructions on how to do the shrinking island activity.
Task 2	• In the same group, students respond to this question – what impacts may climate change have on our lives. • Each group discusses this question based on one of these areas; health, agriculture and fisheries, water and marine resources, ecosystem, food production • Each group presents the team findings of their discussion.
Task 3	• Case studies: Climate change impacts • Divide students in groups of 4 and each group to work on one case study. • Case studies will be based on people experiencing climate change in different places e.g. Kiribati, Vietnam, Tonga. • The teacher asks the groups to read the case study carefully, discuss together and answer the following question - What happened to the people in the case studies? - What problems did they face? - Have you seen this happen to people you know in your community or any other areas? - To cope with climate change, what are their capabilities and strengths • Each group to present their work in front of the class
Task 4	• Class discussion based the group report, this will help students to know the extent of how climate change is affecting many people globally as well as the whole natural system.
Task 5	• Sequence Wheel – Students complete a sequence wheel about impacts of climate change on the society, environment, economy, and culture.

Lesson 7 – Impacts of climate change sea level rise on Ha'apai island

Learning objectives	By the end of this end of this lesson, the students would be able to: 1. Identify the main causes of sea level rise; 2. Discuss the impacts of sea level rise on the people and the environment of Ha'apai.
Task 1	• Students to share stories about their experience of sea level rise in Ha'apai.
Task 2	• Experiment on causes of sea level rise: Hydrothermal expansion and Melting ice and glaciers
Task 3	• Divide students in groups of 4 and give each group a copy of the Lifuka coastal area between 1968 and 2011 • Each group to study the image and answer the questions such as: - What are the differences between the two images - Why do people and the environment in the 2011 image would be more vulnerable to climate change? • Each group to report back their work in a form of class discussion. • Students to work in four groups: Identify the impacts of sea level rise on the society, culture, environment and economy of Ha'apai.
Task 4	• Each group to report their work on a chart. Share their work with rest of the class.
Task 5	• Debate: Students to work in the same group and each group to choose 4 members to join in a debate. Two groups to go for and two groups to go against the topic. Topic: *Sea level rise is a threat to Ha'apai, the only solution is for the people to leave the island"* • **FIELD TRIP will be discussed in more details.**

Episode 4 – Response to climate change

Lesson 8 – Climate change adaptation and mitigation

Learning objectives	By the end of this end of this lesson, the students would be able to: 1. Identify activities responding to climate change 2. Distinguish between climate change adaptation and mitigation 3. Develop actions responding to climate change.
Task 1	• Ask students to share some of the local activities that being conducted to reduce the impacts of climate change in Ha'apai.
Task2	• Group work: Each group will be given one or two impact(s) of climate change and students will have come up with solutions to solve those problems. • When each group has reported their work, then the teacher write down the words: adaptation and mitigation on the board. Discuss the two terms with the students then allow them to classify the actions they have come up with under the headings: Adaptation and mitigation (class discussion)
Task 3	• International efforts and efforts in Tonga in response to climate change. • Do case studies based on Tonga Joint National Action Plan (JNAP) • Students to discuss what are the actions have been done in Tonga to reduce impacts of climate change. • Allow students to think of what other options that can be done and write them down on the board.
Task 4	• Get students into four working groups. Each group to work on one of the following topics: - Actions to respond to climate change carried out by individuals. - Actions to respond to climate change carried out by school - Actions to respond to climate change carried out in the community - Actions to respond to climate change carried out by the government
Task 5	• The teacher encourages students to share their action plans with others, through which they can specify step-by-step plans with specific times. **TASKS FOR THE EXPO WILL BE CLARIFIED**

Lessons 9 – 11: Preparation for climate change expo

For Lessons 9 - 11, students worked on preparation for the climate change expo. Each group was given a theme for their presentation and students had the responsibilities to plan how to conduct their presentation on the day of the expo. Details are provided in the table below.

Groups	Presentation theme
Red	Causes of climate change
Yellow	Impacts of climate change – Sea level rise
Purple	Impacts of climate change – Tropical cyclone
Orange	Impacts of climate change – Drought
Green	Impacts of climate change – Rising temperatures
Maroon	Responses to climate change - Mitigation
Blue	Responses to climate change – Adaptation
White	Responses to climate change - Adaptation

Lesson 12: Climate Change Expo

Climate change Expo – Friday 13th October 2017

- At the school hall, 8 stations were set up by each group decorated their own station according to the theme of their presentation
- Students who took part in the intervention performed an action song titled ‘Let’s do it’
- Audience consisted of teachers, students and parents
- Each group conducted a talanoa kavekavehoko to share their new knowledge, voice their concerns, and suggest actions to address climate change
- Audience were given a time to ask questions and students were expected to answer the questions. The teacher may be able to help if required.
- End of the day – cleaning up of each station.

Appendix N: Resources

Resource 1: Nature walk

Name: _____ Date: _____

We are going on a nature walk!

Your Task:

Record at least 5 observations

Remember:

- Quiet please!
- Be respectful of nature and other students

As we walk, think about…

- What do you see?
- What's happening in nature?
- Have you noticed any changes?
- Even something simple is important!

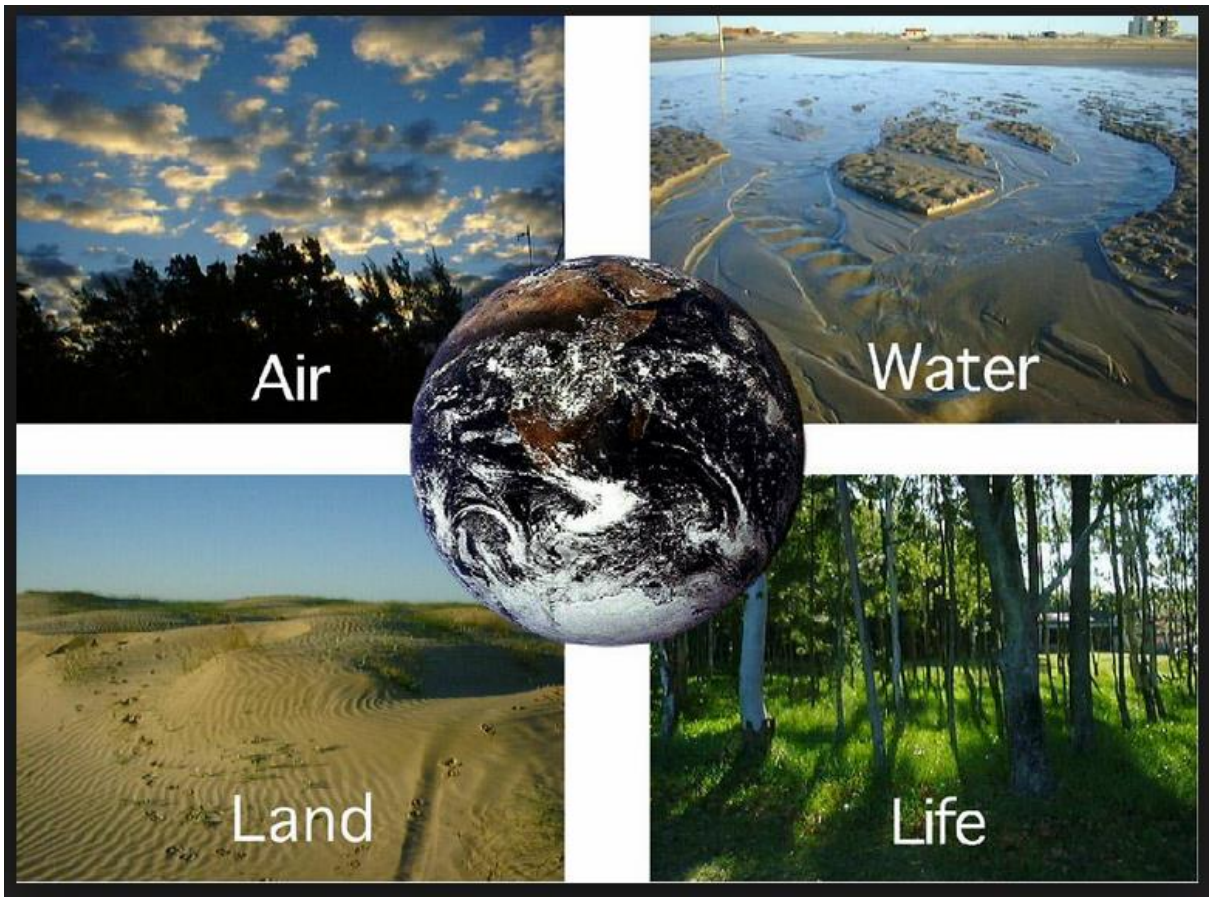
Nature Walk Observation – Make at least 5

	Observation
	1.
	2.
	3.
	4.
	5.

Resource 2: Earth systems

The earth is a system consisting of four major interacting components:

- **The atmosphere (air)**
- **The biosphere (life)**
- **The geosphere (land)**
- **The hydrosphere (water)**



Resource 3

Observation:

_____

1. Circle which system the observation belongs with.

2. Draw arrows to make connections between that system and the othe systems. Make as many as you can.

3. Along each arrow, write details about what that interaction is.

Resource 4: Beat the clock

Picture 1:

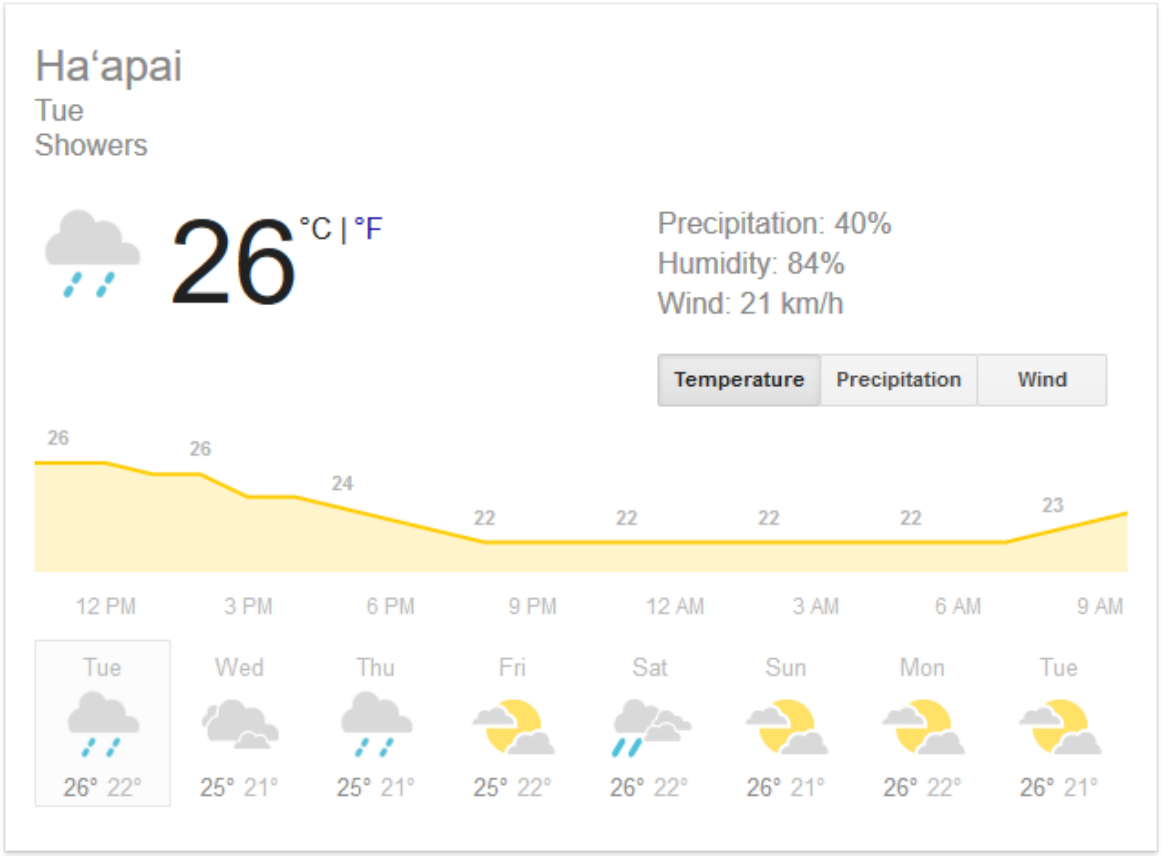
Picture 2:

Picture 3:

Picture 4:

Resource 5: Weather and climate data.

Weather Data for Ha'apai, Tonga



https://www.google.co.nz/search?dcr=0&q=ha%27apai+tonga+weather+forecast&oq=haapai+weather&gs_l=psy-ab.1.1.0i10k1j0i22i30k1l2j0i22i10i30k1.23307.25253.0.27263.14.12.0.0.0.0.421.2533.2-6j2j1.9.0....0...1.1.64.psy-ab..5.9.2530...0j0i10i67k1.MsrTf0hP1nc (Accessed 12th September, 2017)

Tonga climate table

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	23.9	24.5	24.5	24.2	23.7	22.6	21.8	21.9	22.3	22.7	23.4	23.9
Min. Temperature (°C)	18.3	18.7	19.4	19.2	19.1	18.6	18.2	18.1	18.2	18.2	18.7	18.7
Max. Temperature (°C)	29.6	30.4	29.7	29.2	28.3	26.7	25.5	25.7	26.5	27.3	28.1	29.2
Avg. Temperature (°F)	75.0	76.1	76.1	75.6	74.7	72.7	71.2	71.4	72.1	72.9	74.1	75.0
Min. Temperature (°F)	64.9	65.7	66.9	66.6	66.4	65.5	64.8	64.6	64.8	64.8	65.7	65.7
Max. Temperature (°F)	85.3	86.7	85.5	84.6	82.9	80.1	77.9	78.3	79.7	81.1	82.6	84.6
Precipitation / Rainfall (mm)	9	31	119	165	191	195	261	323	364	316	72	8

There is a difference of 356 mm of precipitation between the driest and wettest months. The average temperatures vary during the year by 2.7 °C.

https://en.climate-data.org/location/25515/ (Accessed 12.09.2017)

Resource 6: Climate change

CLIMATE CHANGE

NOAA National Weather Service — OCTOBER 2007

What is Climate Change?

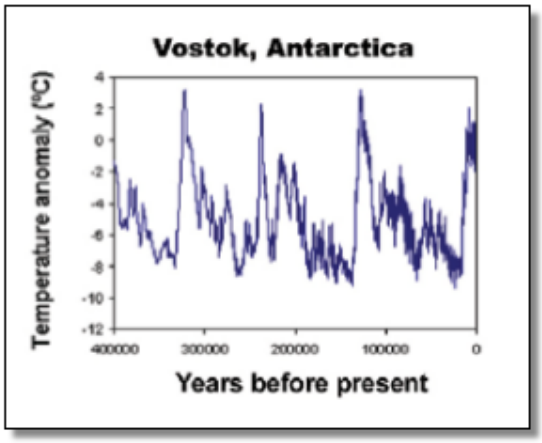
Climate change is a long-term shift in the statistics of the weather (including its averages). For example, it could show up as a change in climate normals (expected average values for temperature and precipitation) for a given place and time of year, from one decade to the next.

We know that the global climate is currently changing. The last decade of the 20th Century and the beginning of the 21st have been the warmest period in the entire global instrumental temperature record, starting in the mid-19th century.

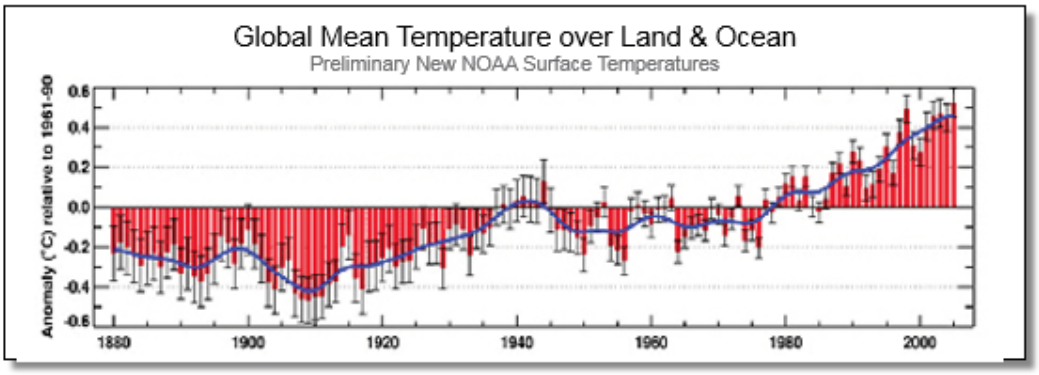
Why is the Climate Changing?

Natural variability

Climate change is a normal part of the Earth's natural variability, which is related to interactions among the atmosphere, ocean, and land, as well as changes in the amount of solar radiation reaching the earth. The geologic record includes significant evidence for large-scale climate changes in Earth's past. An example of this variability is shown in the plot below of temperature data for the last 420,000 years, derived from an Antarctic ice core.



Temperature changes in Antarctica determined from the deuterium proxy measured in the Vostok ice core record. (Reference: Petit, J.R., et al. 1999. Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica. Nature 399: 429-436.) Available at http://www.ncdc.noaa.gov/paleo/abrupt/story2.html



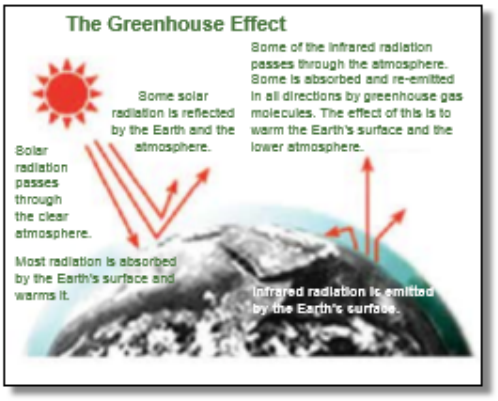
Line plot of global mean land-ocean temperature index, 1880 to present. Individual years are plotted and the blue line is the five-year mean. (Data and plot available from NCDC at http://www.ncdc.noaa.gov/oa/climate/research/anomalies/anomalies.html).

CLIMATE CHANGE

Human-induced change

Greenhouse Gases

Certain naturally occurring gases, such as carbon dioxide (CO_2) and water vapor (H_2O), trap heat in the atmosphere causing a greenhouse effect. Burning of fossil fuels, like oil, coal, and natural gas is adding CO_2 to the atmosphere. The current level is the highest in the past 650,000 years. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change concludes, "that most of the observed increase in the globally averaged temperature since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."



What is being done to Study the Effects of Climate Change

There are numerous potential effects of climate change. Extensive research is being done around the world – a good deal within NOAA – to determine the extent to which climate change is occurring, how much of it is being caused by anthropogenic (man-made) forces, and its potential impacts. In some of these areas, there is not a consensus among scientists and in fact, there are often conflicting points-of-view and studies. However, with further research, no doubt many questions regarding impacts will be resolved in the future. Potential impacts most studied by researchers include the effects on sea level, drought, local weather, and hurricanes.

Most of our current knowledge of global change comes from General Circulation Models (GCMs). At present, GCMs have the ability to provide us with a mean annual temperature for the planet that is reliable. Regional and local temperature and precipitation information from GCMs is, at present, unreliable. Much of the global change research effort is focused on improving these models.

Where Can I Find More Information?

U.S. Climate Change Science Program:
http://www.climatescience.gov/

NOAA National Climatic Data Center site on Global Warming:
http://www.ncdc.noaa.gov/oa/climate/globalwarming.html

NASA GISS recent research website:
http://www.giss.nasa.gov/research/

Global Change Master Directory:
http://gcmd.gsfc.nasa.gov/Resources/pointers/glob_warm.html

Intergovernmental Panel on Climate Change (IPCC) Website:
http://www.ipcc.ch/

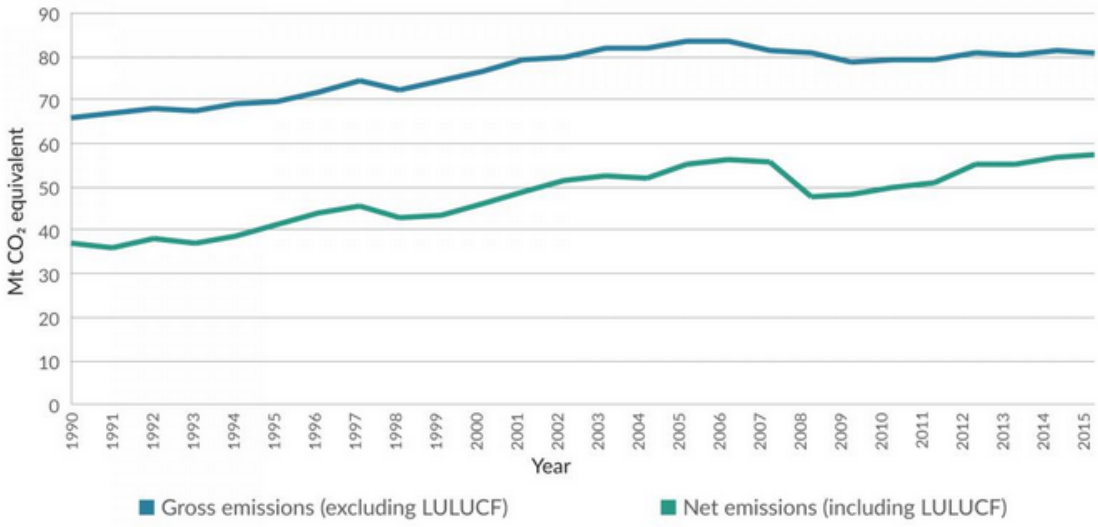
Resource 7

New Zealand greenhouse gas emissions

2014 to 2015

- New Zealand's gross greenhouse gas emissions in 2015 were 80.2 million tonnes of carbon dioxide equivalent (Mt CO_2-e). This comprises emissions from the Energy (including transport), Agriculture, Industrial Processes and Product Use (IPPU), and Waste sectors.
- Gross emissions in 2015 were 0.1 per cent lower than emissions in 2014.
- The Agriculture and Energy sectors were the two largest contributors to New Zealand's gross emissions, at 47.9 per cent and 40.5 per cent respectively in 2015.
- New Zealand's net emissions under the UNFCCC were 56.4 Mt CO2-e in 2015. Net emissions consist of gross emissions combined with emissions and removals from the Land Use, Land-Use Change and Forestry (LULUCF) sector.

Figure 1: New Zealand's gross and net emissions (under the UNFCCC) from 1990 to 2015.



1990 to 2015

- New Zealand's gross emissions have increased 24.1 per cent from the year 1990.
- The key drivers of the increase in gross emissions are:
  - carbon dioxide emissions from road transport
  - carbon dioxide emissions from chemical industry and food processing
  - methane emissions from livestock digestive systems
  - nitrous oxide emissions from fertiliser used on agricultural soils
  - fluorinated gases released from industrial, and household refrigeration and air-conditioning systems.
- Net emissions have increased by 63.6 per cent since 1990. This is due to the increase in gross emissions and the higher harvesting rates in planted forests in 2015 compared with 1990.

(Source: http://www.mfe.govt.nz/climate-change/reporting-greenhouse-gas-emissions/nzs-greenhouse-gas-inventory)

Tonga greenhouse gas emissions

2.3.1 GREENHOUSE GAS EMISSIONS BY SOURCE, 2000

As for greenhouse gas emissions in 2000 by source, the Land Use Change and Forestry Sector was the main source of emission in Tonga accounting for 58% of the national totals. This was followed by the Energy Sector which accounted for 40% of the emissions. The Agriculture and Waste Sectors provided the remaining 2% of the total greenhouse gas emissions. (Figure 2.2).

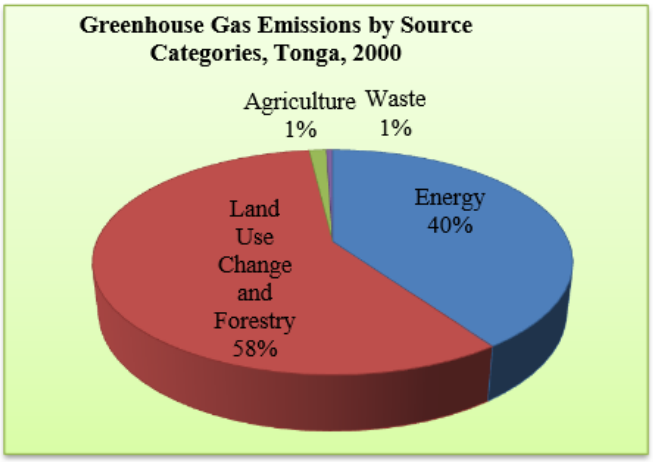
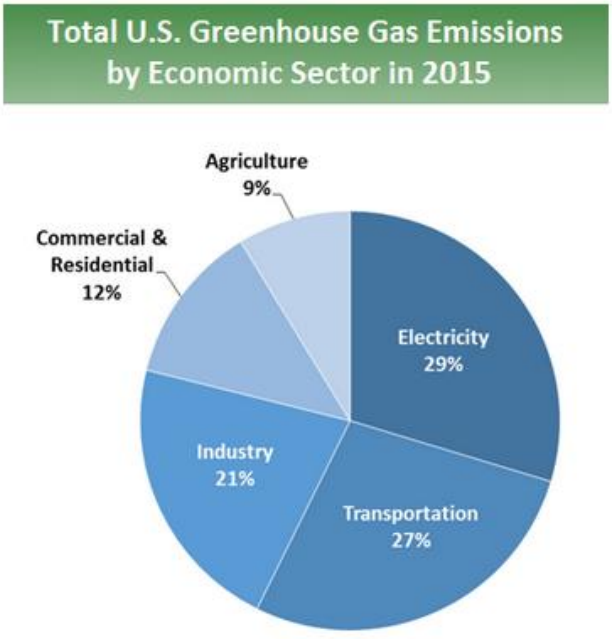


Figure 2.2: Greenhouse Gas emissions by source categories,Tonga, 2000.

(Source: http://adaptation-undp.org/sites/default/files/downloads/tongas_ii_nc_2012.pdf)

USA greenhouse gas emissions



Total Emissions in 2015 = 6,587 Million Metric Tons of CO_2 equivalent

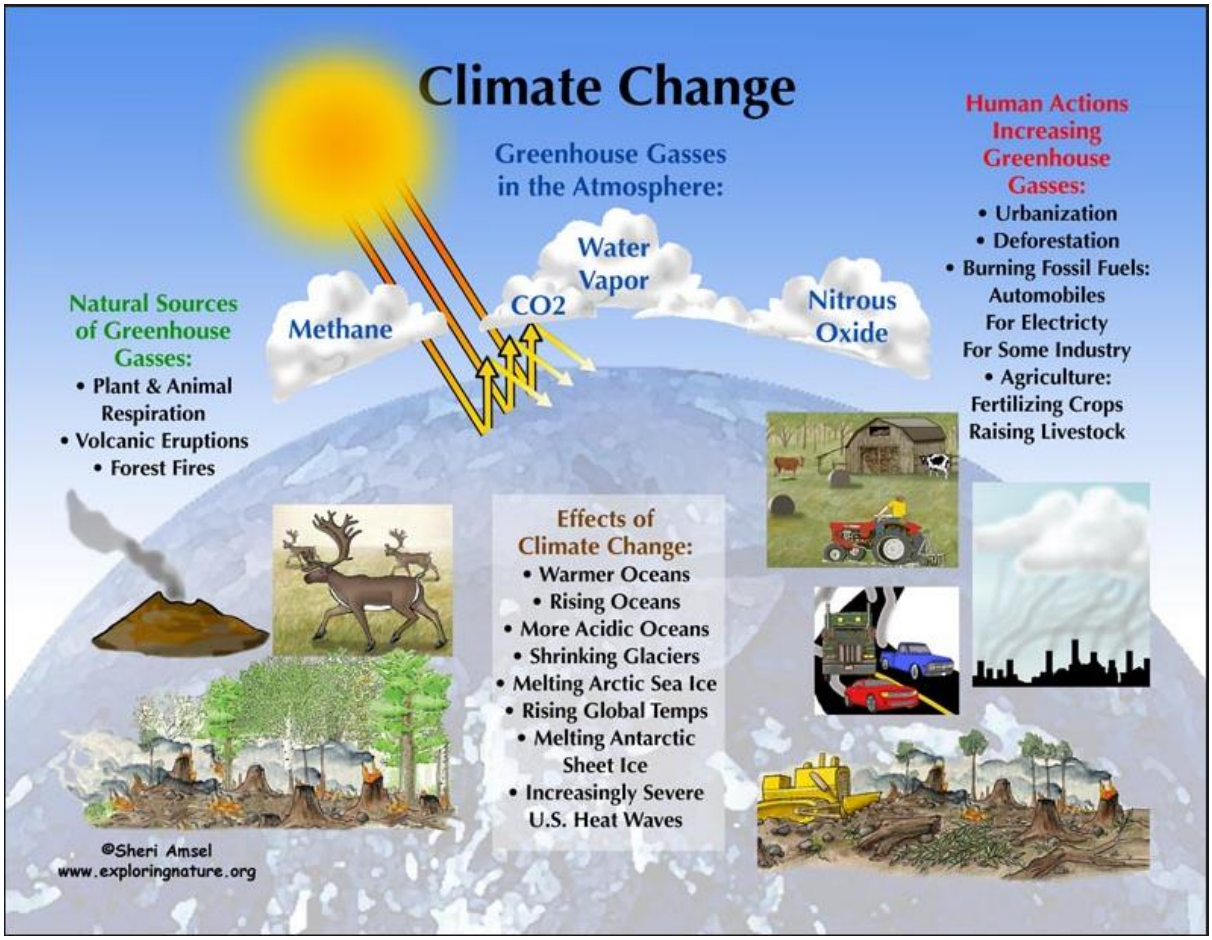
- Electricity production (29 percent of 2015 greenhouse gas emissions) – Electricity production generates the largest share of greenhouse gas emissions. Approximately 67 percent of our electricity comes from burning fossil fuels, mostly coal and natural gas.[2]

- Transportation (27 percent of 2015 greenhouse gas emissions) – Greenhouse gas emissions from transportation primarily come from burning fossil fuel for our cars, trucks, ships, trains, and planes. Over 90 percent of the fuel used for transportation is petroleum based, which includes gasoline and diesel.[3]
- Industry (21 percent of 2015 greenhouse gas emissions) – Greenhouse gas emissions from industry primarily come from burning fossil fuels for energy, as well as greenhouse gas emissions from certain chemical reactions necessary to produce goods from raw materials.
- Commercial and Residential (12 percent of 2015 greenhouse gas emissions) – Greenhouse gas emissions from businesses and homes arise primarily from fossil fuels burned for heat, the use of certain products that contain greenhouse gases, and the handling of waste.

- Agriculture (9 percent of 2015 greenhouse gas emissions) – Greenhouse gas emissions from agriculture come from livestock such as cows, agricultural soils, and rice production.
- Land Use and Forestry (offset of 11.8 percent of 2015 greenhouse gas emissions) – Land areas can act as a sink (absorbing CO_2 from the atmosphere) or a source of greenhouse gas emissions. In the United States, since 1990, managed forests and other lands have absorbed more CO_2 from the atmosphere than they emit.

(Source: https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions)

Resource 8: Human activities and the environment



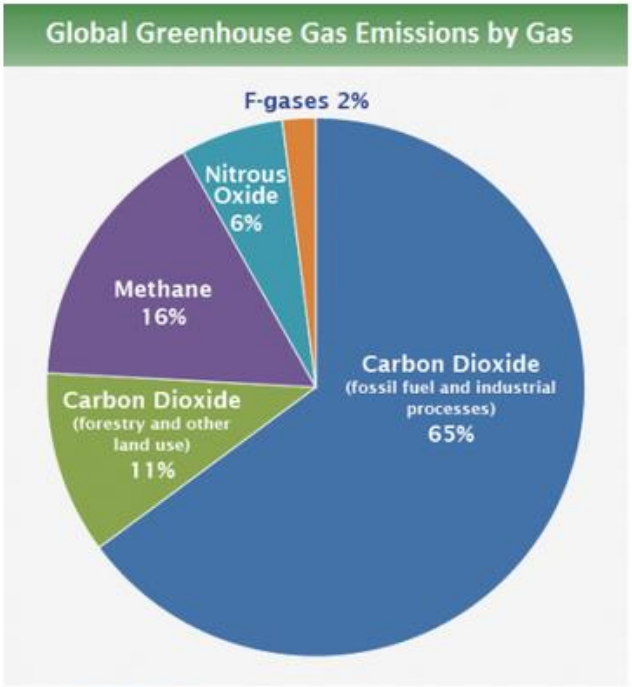
(Source: https://www.google.co.nz/search?q=human+activities+causes+climate+change&dcr=0&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiwtp7vup_WAhUCVLwKHTWsABEQ_AUICigB&biw=1920&bih=947#imgrc=kc3Byy9bqwDVXM:)

Resource 9 – Global emissions by gas and Emissions by country

Global Emissions by Gas

At the global scale, the key greenhouse gases emitted by human activities are:

- **Carbon dioxide (CO_2)**: Fossil fuel use is the primary source of CO_2. CO_2 can also be emitted from direct human-induced impacts on forestry and other land use, such as through deforestation, land clearing for agriculture, and degradation of soils. Likewise, land can also remove CO_2 from the atmosphere through reforestation, improvement of soils, and other activities.
- **Methane (CH_4)**: Agricultural activities, waste management, energy use, and biomass burning all contribute to CH_4 emissions.
- **Nitrous oxide (N_2O)**: Agricultural activities, such as fertilizer use, are the primary source of N_2O emissions. Fossil fuel combustion also generates N_2O.
- **Fluorinated gases (F-gases)**: Industrial processes, refrigeration, and the use of a variety of consumer products contribute to emissions of F-gases, which include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).



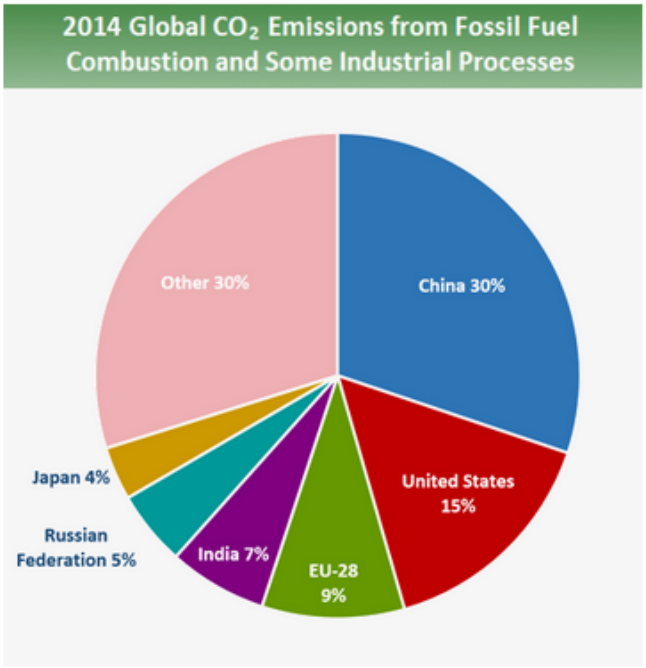
Source: IPCC (2014) EXIT based on global emissions from 2010. Details about the sources included in these estimates can be found in the *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. EXIT

(Source: https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data)

Emissions by Country

In 2014, the top carbon dioxide (CO_2) emitters were China, the United States, the European Union, India, the Russian Federation, and Japan. These data include CO_2 emissions from fossil fuel combustion, as well as cement manufacturing and gas flaring. Together, these sources represent a large proportion of total global CO_2 emissions.

Emissions and sinks related to changes in land use are not included in these estimates. However, changes in land use can be important: estimates indicate that net global greenhouse gas emissions from agriculture, forestry, and other land use were over 8 billion metric tons of CO_2 equivalent,[2] or about 24% of total global greenhouse gas emissions.[3] In areas such as the United States and Europe, changes in land use associated with human activities have the net effect of absorbing CO_2, partially offsetting the emissions from deforestation in other regions.



Source: Boden, T.A., Marland, G., and Andres, R.J. (2017). National CO2 Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751-2014, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, doi 10.3334/CDIAC/00001_V2017.

(Source: https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data)