Extending the knowledge system and food value of kumala *(Ipomoea batatas or sweetpotato)* in Vanuatu as a response to climate change.

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Kumala intercropped with corn, island cabbage (Hibiscus manihot) and cocoyam (Xanthosoma sagittifolium L.*) at Lorevulko, Santo, Vanuatu. Source: Author*

Abstract

Loss of traditional knowledge in food production is a major problem occurring in many countries due to modernization and globalization. Additionally, further compelled by the impacts of climate change, this can have a devastating effect on the livelihood of people. As a result, farmers are therefore compelled to revive the use of traditional knowledge in food production especially its blended use with contemporary knowledge in adapting to and mitigating climate change impacts. The aim of this study is to identify the contribution of traditional knowledge of kumala (*Ipomoea batatas*) production in sustaining the livelihoods of people in Vanuatu. The target population of this study was kumala farmers in two villages: Lorevulko and Sara 1 in East Santo, Vanuatu where qualitative data using semi-structured interviews was obtained. A literature review was also undertaken on kumala production in other countries where kumala is commonly grown.

The younger generations should be educated on traditional knowledge and skills, and efforts should be made to document traditional knowledge. Traditional knowledge is being used in the pre-production activities of kumala such as planting calendar, site selection, land clearing and soil preparation. Both knowledge systems are used in the production of kumala for example in kumala cultivar selection, division of labour, planting, crop maintenance, preparation and management of kumala during droughts and cyclones. In addition, both traditional and contemporary knowledge are used in post-production of kumala in different storage methods such as field, bag, basket, and food bed. Overall, the findings in this study confirm compelling evidence that traditional knowledge contributes towards the sustainable livelihood of the people in Lorevulko and Sara 1. It shows that there is an assimilation of knowledge systems and they create a cultural output that is unique to location and time, and provides a good example of cultural dynamics which never stand still and which respond to environmental and other pressures.

Findings from this research will contribute immensely in improving food security at the household and national level in Vanuatu, and generate sustainable income for farmers and livelihoods for farmers. Researchers can also use the findings of this study as a basis to undertake further studies on traditional knowledge of kumala in Vanuatu. Moreover, the results will be useful for informing and influencing government policy and farming practices.

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1 Introduction

Traditional knowledge plays an important role in people's lives in both traditional and contemporary societies. Traditional knowledge and traditional crops have sustained the livelihood of people in many countries and continents including India, Tanzania, Zimbabwe, Australia and the Pacific (Immanuel, 2017; Malekani, Chailla, & Wamunza, 2014; Portal, 2017; Shava, O'Donoghue, Krasny, & Zazu, 2009). Studies have shown that traditional values and knowledge were also used to sustain the livelihood of Pacific peoples including Māori of New Zealand and Aniwans of Vanuatu (McFarlane, 2007; Wilson, 2013). Recent evidence suggests that traditional knowledge be used in combination with contemporary knowledge to address the issue of food security imposed by climate change (Green, Billy, & Tapim, 2010; King, Skipper, & Tawhai, 2008; Lefale, 2010). This is because previous climate change studies had generally ignored the invaluable contribution of traditional knowledge until the last decade which has highlighted its importance for local communities to adapt and manage disaster risks (McNamara & Prasad, 2014).

Despite its role in sustaining people's livelihood, globalization, new technologies and effects of modernization are having a serious effect on traditional knowledge contributing to its loss (Pelling & Uitto, 2001; Regenvanu, 2010). Furthermore, there is little information or literature on Pacific knowledge as little work has been published and also because oral transmission is the preferred mode of dissemination. Therefore information institutions, and libraries have been tasked to document, manage and disseminate agricultural traditional knowledge in order to achieve sustainable food security (Abioye, Zaid, & Egberongbe, 2011; Chisita, 2011; Stevens, 2008) however more work is needed by libraries and information institutions in achieving these tasks (Abioye et al., 2011; Chisita, 2011). The major objective of this study was to collate traditional knowledge of kumala or sweetpotato (*Ipomoea batatas*) systems in Vanuatu. Vanuatu (see Figure 1) is a South Pacific nation of 82 islands. This study provides an exciting opportunity to advance the understanding of traditional knowledge of kumala and its contribution in sustaining livelihoods in Vanuatu and the wider Pacific communities. It is also an opportunity to compare and contrast the use of traditional and contemporary knowledge in order to better equip the people in responding to events caused by climate change such as droughts and tropical cyclones.

Research question:

How does traditional knowledge of kumala contribute towards sustainable livelihoods in Vanuatu?

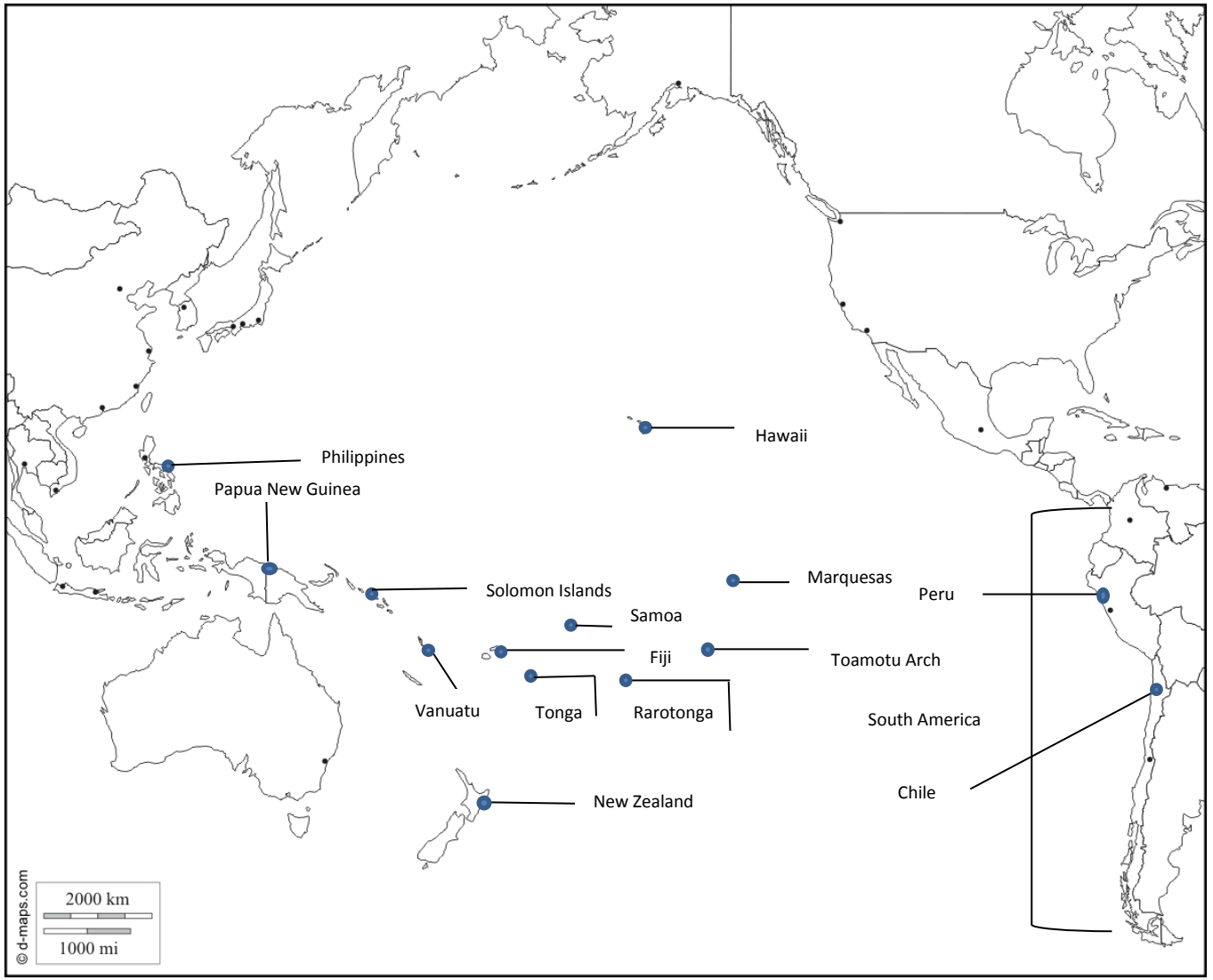


Figure 1: Map of some locations mentioned in this Thesis. Source: d.maps.com

1.1 Background

Kumala (*Ipomoea batatas*) or sweetpotato belongs to the *Convolvulaceae* family and originated from Andean region of South America, (Estrada de la Cerda, 2015) and is now cultivated in many countries around the world. Based on production figures for vegetables, sweetpotato is ranked 7th in the world (Laurie, 2010). The annual production of sweetpotato worldwide is 106.6 Mt[1] with China leading the production in 2010 with 81.7 Mt followed by Africa with 14.2 Mt (Essilfie, Dapaah, Ofosu-Anim, Blay, & Norman, 2016). According to the global monetary value of agricultural commodities, sweetpotato or kumala is ranked 13th in production value and in developing countries, and is ranked fifth among the most valuable foods for nutrition (Tortoe, Obodai, Amoa-Awua, Oduro-Yeboah, & Vowotor, 2008).

The kumala has good agronomic characteristics such as a short growth cycle (three to five months); high yield potential on marginal land; high tolerance to biotic and abiotic stresses, and relatively low maintenance (Mukhopadhyay, Chattopadhyay, Chakraborty, & Bhattacharya, 2011). It also contains more vitamins, minerals, dietary fibre and protein than other carbohydrate foods (Chattopadhyay, Chakraborty, Kumar, Nanda, & Sen, 2006; Lebot, 2009) for example it contains high carbohydrate, carotenoids, phenolics and Vitamins C and E (Lebot, 2010). These values relate to the tubers which are consumed however the immature leaves are also eaten as vegetables in Asia, sub-Saharan region for instance in Ghana and also some Pacific countries (Oduro, Ellis, & Owusu, 2008).

In Vanuatu, kumala is the third most important root crop after taro (*Colocasia esculenta* Schott) and yam (*Dioscorea alata* L.) (Champagne et al., 2010; Lebot, 2013). Traditionally, yam is the most important root crop, however, its cultivation requires rich soil and gardens are traditionally established on fallowed sites. There is now a reduction in fallow periods due to population pressure on the land and pressure from agriculture policies, smallholder farmers and funding organisations for cash crops (cocoa, coffee, coconut) and/or permanent establishment of cattle pasture (Melteras, 2007; Siméoni & Lebot, 2012). Reduction in the fallow period leads to deterioration in soil fertility which impacts on the health of the soil and eventually quality and quantity of produce yield. This may also compel farmers to use synthetic fertilizers. However both taro and yam have a long growth cycle (9 months) and are prone to droughts, and tropical cyclones. This has led to kumala gaining popularity over other root crops because it can produce high yields in marginal soils, has a short growth cycle (3-5 months), and is relatively drought tolerant (Champagne et al., 2010; Lebot, 2013).

[1] Mt = Mega Tonnes = 1 Million metric tonnes

One of the Vanuatu government strategies to address food security is the adoption of crop diversification using varieties which are drought tolerant and can perform well on marginal lands (Vanuatu Government, 2014). Even though the total area and annual production of kumala in Vanuatu are not reported, kumala is cultivated on all the islands of Vanuatu (Mael, 2013). Only the number of households that planted kumala is reported however, for example 32,799 households throughout Vanuatu cultivate kumala with Shefa province having the highest households (7,481) followed by Sanma province with 6,475 (Vanuatu National Statistics Office, 2017). Kumala is predominantly grown for home consumption and also the domestic market. It is a staple food that is eaten boiled, baked or fried. Kumala is also used in cultural ceremonies and for animal feed (Champagne et al., 2010). The immature leaves of kumala are not eaten in Vanuatu, however, the locals often consume the immature leaves of water spinach (*Ipomoea aquatica*), a related plant (Bailey, 1992).

The majority of the farmers in Vanuatu plant kumala using traditional knowledge. Kumala is planted year-round and is harvested three to five months after planting depending on the cultivar characteristics (Lebot, 2009; Pankomera, 2015). Farmers select sites for kumala gardens and clear the land using traditional knowledge. They also use traditional knowledge to prepare the soil, plant the kumala cuttings and maintain the crops. Farmers also use some techniques to prepare and manage the crops during droughts and cyclones. In addition, traditional knowledge is used to store kumala such as field storage or in-ground storage and piece-meal harvesting, including preservation methods such as platform storage, baking and many other methods (Parkinson, 1984).

Kumala contributes to sustained livelihoods in Asia and Africa and is also considered a famine relief crop in many countries. According to Lebot (2009) millions of Chinese were saved from starvation by kumala in the early 1960s due to famine and then the same for the Japanese when rice crops were damaged by typhoons. In KwanZulu- Natal, South Africa, kumala also played an important role in food security during droughts (Motsa, Modi, & Mabhaudhi, 2015b). These examples show kumala as a valuable food that has helped prevent the deaths of many people. Furthermore, it is because of its drought tolerance, fast regeneration of vines and their short growth cycle that makes it a valuable food security crop. Kumala continues to be promoted as a food security crop in the climate change events such as droughts and tropical cyclones (FAO, 2008; Vanuatu Government, 2014). This is due to its good agronomic characteristics such as yielding in marginal soils, tolerance to drought and short growth cycle

(Pankomera, 2015). In addition, kumala is promoted because of its good nutritional content which is high in carbohydrate, carotenoids, phenolics, and Vitamins C and E (Lebot, 2010). Despite wide usage of traditional knowledge in production of kumala in Vanuatu, it is eroding in contemporary society due to changes such as globalization, new technologies and effects of modernization (Janif et al., 2016; Regenvanu, 2010). Therefore the use of traditional knowledge in sustaining food security in adapting and mitigating climate change events will be compromised if traditional knowledge is not documented and preserved for future generations. The main objective of this study is to evaluate the contribution of traditional knowledge of kumala in sustaining livelihoods in Vanuatu.

1.2 Research objectives

- To identify the use of traditional knowledge in production of kumala in Vanuatu
- To identify the application of traditional knowledge of kumala to food security and/or sustainable livelihoods, and
- To give examples of how traditional knowledge contributes to Vanuatu horticulture.

1.3 Surveys

Surveys were conducted on the East Santo (Island), in two villages; Lorevulko and Sara 1. A Survey questionnaire was developed in English and translated into Bislama[2] the local language. A random selection of 17 farmers was made from a list provided by the Vanuatu Department of Agriculture and Rural Department (DARD). Permission was sought from the chief in each village for research work to be undertaken. Meeting times were set during the first consultation in each village. Questionnaires were administered individually by interviewers with the 17 farmers. Topics covered in the survey questionnaire include traditional cultivation of kumala, kumala cultivars, and practices of kumala production during climate change events, extending traditional knowledge and its contribution to sustainable livelihood.

1.4 Chapter overview

The overall structure of the study takes the form of six chapters including this introductory chapter followed by the methodology, literature review, results, discussion and conclusion.

[2] Bislama is a creole language and one of two official languages in Vanuatu

1.4.1 Chapters

Chapter one consists of the introduction, which gives an overview of the topic. Included also is the background, which provides some context to the topic. Both the research question and the research objectives are included in this chapter.

Chapter two covers the methodology used in this study. The mixed methodology draws from ethnobotanical, survey and applied scientific methods.

The third chapter begins by laying out the theoretical dimensions of the research, and examines previous knowledge on the definition and characteristics of traditional knowledge, traditional cultivation of kumala, preparation and management of kumala during droughts and cyclones, storage methods and traditional knowledge of kumala and its contribution to sustainable livelihood. This information is summarised, critiqued and synthesized.

The fourth chapter presents the findings of the research, focussing on the key themes; pre-production, production and post- production of kumala. The first part of this section looks at extending traditional knowledge. This is followed by pre- production of kumala which includes planting calendar, site selection, land clearing and soil preparation. Further findings aligned to production of kumala are also presented and examples of these activities include kumala cultivars, planting, crop maintenance, preparation and management of kumala during droughts and cyclones, harvesting and post-harvest. The final findings are presented on the contribution of traditional knowledge to sustainable livelihood.

Chapter five is the discussion drawn from all the information presented in the earlier chapters. This discussion aims to highlight the use of traditional knowledge in kumala production and its contribution in sustaining the livelihoods of the people in two villages on East Santo, Vanuatu. It also discussed the implication of the findings to future research into this area.

Finally, chapter six is the conclusion, which gives a brief summary and critique of the findings. This is followed by a full list of references, personal communications related to the study and the appendices.

1.5 Definitions

1.5.1 Ethnobotany

Ethnobotany is the scientific study of traditional knowledge and customs of people concerning plants, their medicinal uses, food uses and other uses important to humanity. While it is the scientific study of dynamic relationships among people, biota and environments (Society of Ethnobiology, n.d), it also embraces traditional knowledge systems (Society of Ethnobiology, n.d).

1.5.2 Food security

Food security is a contemporary issue, especially in the Pacific where the combination of climate change, urbanisation, land utilisation issues, food insecurity and other issues are compounding issues for local indigenous communities. Many developing and developed nations in the world today are experiencing shortfalls of food resources and there is a lot of pressure on agricultural producers globally to continue to put food on the table. The following definition of food security is applied in this thesis.

> "*People are considered food secure when they have availability and adequate access at all times to sufficient, safe, nutritious food to maintain a healthy and active life. Food security analysts look at the combination of the following three main elements:"* (World Food Programme, 2018, para 1).
>
> 1. *Food availability*
>
> *"Food must be available in sufficient quantities and on a consistent basis. It considers stock and production in a given area and the capacity to bring in food from elsewhere through trade or aid" (World Food Programme, 2018, para 2).*
>
> 2. *Food access*
>
> *"People must be able to regularly acquire adequate quantities of food, through purchase, home production, barter systems, gifts, borrowing, or food aid/donors" (World Food Programme, 2018, para 3).*
>
> 3. *Food utilization*
>
> *"Consumed food must have a positive nutritional impact on people. It entails cooking, storage and hygiene practices, individual health, water and sanitations, feeding and sharing practices within the household" (World Food Programme, 2018, para 4).*

1.5.3 Climate change

"Climate change is a term used by scientists, politicians and experts to describe changes in the Earth's climate due to human activities (anthropogenic climate change) or natural processes that are already occurring or predicted to occur. These include increasing air and sea- surface temperatures, changing rainfall patterns, sea-level rise, ocean acidification, and changes in frequency and intensity of extreme events such as droughts, floods and tropical cyclones. Anthropogenic climate change is expected to happen much more rapidly than natural changes in the climate, posing an enormous challenge to both natural and human systems" (SPREP as cited in Anon, 2013, p. 38).

1.5.4 Kumala/sweetpotato

For the purposes of this report and to respect the indigenous basis of the information presented, the vernacular term 'kumala' will be used throughout and refers wholly to sweetpotato (*Ipomoea batatas*).

2 Materials and Methods

2.1 Introduction

This chapter describes the methodologies and materials used in this research. Using the appropriate methodologies is important because researchers are accountable for the procedures in which information or data are collected, the way in which it is analysed, and interpreted, ensuring that unbiased results are produced and can be repeated (Krippendorff, 2004). Different research strategies can be used and the three basic ones are surveys, experiments, and case study. In this study, a survey was used. This method was used in order to achieve the objectives of the thesis, which is to evaluate the traditional knowledge and its contribution to sustainable livelihood in Vanuatu.

2.2 Literature review

Key literature on traditional knowledge of kumala was used in this study. In addition various types of literature such as historical (archival) data or ' documents of the past' (Adams & Schvaneveldt, 1991) from primary (e.g. diaries) and secondary (e.g. collated statistics of newspaper articles) sources have also been drawn from to provide further insight into Ni-Vanuatu, Pacific, Māori traditional knowledge and the food value of kumala or sweetpotato (Estrada de la Cerda, 2015; Roskruge, 2007).

A practical approach and application of ethnobotany has been applied in the data collection for this thesis. The nature of working within a cultural group based in their traditional knowledge and seeking in part to restore and revive that knowledge in an academic context is a daunting objective in itself (Estrada de la Cerda, 2015; Roskruge, 2007).

2.3 Pacific Islands

The main focus of this thesis is on traditional knowledge systems in Vanuatu, however a wider context was also used to access other knowledge systems used in kumala production with the aim of answering the research question. Knowledge systems used in farming from the Pacific Islands including New Zealand (Estrada de la Cerda, 2015) were sought drawing from the existing literature on the research topic.

2.3.1 Research framework

When undertaking research in the Pacific and involving Pacific communities, it is crucial that Pasifika frameworks, cultural protocols and principles are embedded in the research process and respected or observed. Research on traditional knowledge must also be conducted according to required regulations, especially since this is an ethnobotany study. Unlike other Pacific countries, Vanuatu does not have an established research framework. There are a number of Pasifika Frameworks that are widely used

mainly by researchers of Tongan, Samoan, and Fijian ethnicity, for example, the Talanoa Methodology (Vaioleti, 2016), Kakala Framework (Thaman, 1993), Vanua Framework (Nabobo-Baba, 2007), Fa'afaletu Framework (Tamasese, Peteru, Waldegrave, & Bush, 2005) and Kaupapa Māori Methodology (Roskruge, 2007). These frameworks are also described as Pan-Pasifika frameworks and have been used by many Pacific researchers in New Zealand and elsewhere. This is because there are commonalities in values and beliefs systems upheld by Pacific nations.

Some of the common themes or aspects reflected in the Pasifika Frameworks include the following:

- they uphold Pasifika values and beliefs,
- they recognize participants as equal partners in the research process,
- reciprocity is a core requirement which involves the sharing of the findings with participants
- establishment of long term relationships between the researcher and the participants in their community.

This study effectively utilised the Talanoa methodology and as stated by Vaioleti (2016) " talanoa can be referred to as a conversation, a talk, an exchange of ideas or thinking, whether formal or informal". Meo-Sewabu (2015) further posited that " talanoa is an effective tool for collecting and analysing data within oral traditions such as that of Fiji and many other Pacific Indigenous cultures" (p.54).This study examined traditional knowledge used in the cultivation of kumala and talanoa was employed to collect data from the participants. Using Talanoa makes it easy to establish trust and form good relationships with the participants and this is critical in ensuring the credibility of information shared.

In addition, principles and protocols intended to guide those doing research with Pasifika communities have also been developed (Otago University, 2011; Pacific Research and Policy Centre, 2016). Research protocols considered important when doing research in the Pacific islands were also considered in how this project was planned and implemented. For instance this study was conducted according to five key research principles which are, "respect for relationships, respect for knowledge holders, reciprocity, holism, and using research to do good" (Pacific Research and Policy Centre, 2016, p. 12). In addition, the five guiding principles stipulated in the *Vanuatu Cultural Research Policy* were also observed. These include the following: *kastom*[3] typifies and communicates the information, practices and connections of the general population of Vanuatu and incorporates and recognizes the different cultures of Vanuatu. Individuals, families, lineages and communities own *kastom*, thus the preservation and development of

[3] Indigenous knowledge and practice and the ways it is expressed and manifested (Vanuatu Cultural Centre, n.d)

kastom and history is important to the people of Vanuatu (Vanuatu Cultural Centre, n.d). It also stated that research on *kastom* must respect the desires and needs of the people whom owns the *kastom*, research results include the researcher's view and research must be approached in a collaborative way (Vanuatu Cultural Centre, n.d).

These are the process that any foreign national has to follow in order to carry out research in Vanuatu. The researchers must obtain a permit from the Vanuatu National Cultural Council for them to undertake research in Vanuatu (Pacific Research and Policy Centre, 2016). Additionally, researchers must sign a research agreement at the Vanuatu Cultural Centre when they arrive in Vanuatu (Pacific Research and Policy Centre, 2016). However, for this study, an agreement was not necessary because the research was done by a ni-Vanuatu[4]. Field work was conducted only after consultation was completed with the director of the Vanuatu Culture Centre.

Overall, the use of Pasifika Framework, Pacific Research Protocols and Guidelines, and the guiding principles stipulated in the *Vanuatu Cultural Research Policy* were instrumental in ensuring the successful completion of this study. This was in part owing to the common belief systems and values shared by different Pacific nations. A good knowledge of the above three aspects by researchers is crucial for success when doing research in the Pacific. Success in this context goes beyond the binding and submission of the thesis, but encompasses the relationships formed, policy advocacy by the researcher at national level, and the tenacity to explore opportunities to put to practice the findings and hence contribute to the greater good of society.

2.3.2 Ethics approval

An ethics application was submitted to Massey University Ethics Committee before any interaction took place between the researcher and the research participants. This research was considered by the University as Low Risk and approved accordingly. (Refer to Appendix 1 for the approved Human Ethics letter).

2.4 Ethnobotanical framework

This is classified as ethnobotanical research because it is based on traditional knowledge, practices and values relative to people and plants. The information gained will contribute to the advancement of knowledge in the field of applied science. The term 'Applied Botany' Villamar (1997) (as cited in De Albuquerque & Hanazaki, 2010) was used in early days; however, today the term ethnobotany is commonly used (Estrada de la Cerda, 2015). Many interpretations are given in the ethnobotany

[4] Ethnic people of Vanuatu

discipline but a simple definition used is: the scientific study of traditional knowledge and customs of people concerning plants, their medicinal uses, food uses and other uses important to humanity. While it is the scientific study of dynamic relationships among people, biota and environments (Society of Ethnobiology, n.d) it also embraces traditional knowledge systems (Society of Ethnobiology, n.d).

According to Berlin (1992) ethnobiological research is not carried out in isolation, it is a collaborative research which combines the insights, skills, and biases of both the biologist and anthropologist (Roskruge, 2007). Utilitarian versus intellectual arguments in ethnobiology form part of the dichotomy in anthropological theory (*ibid, p.11*) and can be identified as cultural particularism and relativism versus cross-cultural generalisation and comparison; essentially a focus on one culture in contrast to a generic approach. Berlin (1992) claims that:

> *Human beings everywhere are constrained in essentially the same ways- by nature's basic plan in their conceptual recognition of the biological diversity of their natural environment. In contrast, social organisation, rituals, religious beliefs... are constructed by human society.* (p. 8).

Researchers in the discipline of ethnobotany identify their role as targeting at least one of three ideals (Given & Harris, 1994): first, rescue missions – aligned to a culture near extinction and this includes the systematic recording of ethnobotanical knowledge, secondly, industry investigations – the relationship between plants and commerce, and thirdly, cultural enhancement – aligning science and culture where possible.

By their very nature, ethnobiology and ethnobotany must be participatory at the very least as they involve both ecology and living cultures. This science is a combination of studies around people, plants and land; each is unique in its own way (Estrada de la Cerda, 2015; Roskruge, 2007).

A conceptual approach to ethnoecology was presented by Toledo (1992) and further refined in 2000 (Toledo, 2002). It was based on three components as a framework for working with indigenous people and knowledge. These are: *Kosmos*, the people's worldview, perceptions and beliefs; *corpus*, primarily 'local' or indigenous knowledge, and *Praxis*, the practical implementation of the corpus of knowledge (Toledo, 1992). It also includes the relationships between people and land. An example of how this is viewed was demonstrated in Roskruge (2007), in his thesis reworked this triad to fit with Māori (and arguably Pacific) interpretations in that the indigenous elements is incorporated into the model where *kosmos* is applied as *Te Ao Māori* (the Māori worldview)*, corpus* is the traditional knowledge (*Mātauranga Māori*) and *praxis* is *tikanga Māori* or the cultural norms or practises.

2.5 Applied Scientific Theory

"Western science" is based on investigation, originality, discussion and accessibility and is the dominant science approach worldwide. Scientific knowledge is considered as proven knowledge, derived from rigorous observation and experiment, and based on what people can see, hear, and touch (Chalmers, 1999). Likewise, indigenous or traditional knowledge is also based on the same principles and processes and hence the reason why indigenous cultures argue about it being 'applied science' (Estrada de la Cerda, 2015).

According to Burns (2000), positivism is the belief that Western science knowledge is the only valid form of knowledge and this is a widely held view. Hypotheses are used widely to prove scientific theories as right or wrong and they form the basis of research. Boundaries of Western science must be maintained within research, this can be repeated and therefore the right methodology must be used to satisfy all these parameters. The methodology used is always aligned to the hypothesis. In Western science, the researcher is favoured first followed by other participants or groups, quantitative methodology is often used, and the results must undergo treatment differences or the use of statistics to be quantified (Estrada de la Cerda, 2015; Roskruge, 2007).

Estrada de la Cerda (2015) stated that the application of western science methodologies in isolation of indigenous conceptual approaches in disciplines aligned to ethnobotany or similar studies would be inappropriate, especially if the projects are focussed on obtaining indigenous knowledge. He further reported that some values exist however for the credibility which can be drawn from the boundaries, repeatability, and quantification of western science and for the values that these research factors may bring. For instance with the information quality, results obtained from surveys of public responses and those from indigenous informants can be quantified in the same way (Estrada de la Cerda, 2015). Therefore, in order to meet the specific study an inclusive approach is needed (Roskruge, 2007) that recognises both western and indigenous methods.

2.6 Survey methodology

A survey is defined as a collection of information from well-defined populations to compare, explain or describe the knowledge, behaviour, preferences, feelings, values of individuals, households, organizations and society (Blair, 2014; Fink, 2013). Surveys can be conducted using a self-administered questionnaire, through telephone or a face-to-face interview (Fink, 2013).

The survey has become an accepted qualitative method in certain research disciplines including ethnobotany. Adams and Schvaneveldt (1991) compared a survey as very similar to descriptive studies

and it is used for hypothesis testing and explanation. They further stated that surveys which have large samples and generalized profiles or in all individual cases, statistics are emphasised and not the individual. A survey allows the researcher to undertake a study from which generalised conclusions can be drawn and discussed (*ibid*.). In social science research the survey is the main tool for data collection and it is crucial that the purpose, problem, and objective is well defined (Adams & Schvaneveldt, 1991).

Interviewing is an effective method of collecting information in a survey research. This allows accurate and complete communication of information between the respondent and the researcher (Cannell & Kahn, 1968 as cited in Berge, 2009). Fink (2013) stated its importance in achieving reliable and valid data, especially for instance if the participants have literacy problems.

The interview structure is important and must be considered by the researcher (Berg, 2009). Either a structured, semi-structured, or unstructured interviews can be used (Whiting, 2008). In addition, open-ended questions are used when the researcher is seeking deeper information while closed ended questions can be used when a researcher wants nominal or ordinal answers from participants (Robbins, 2009). Robbins (2009) further clarified that predetermined questions are used in semi-structure interviews.

2.6.1 Survey data collection

A mix of sources was utilised in the data collection process for this thesis. Ethnobotanical surveys were conducted on two villages on East Santo, Vanuatu: Lorevulko and Sara 1 in December 2017 and considerable organisation was needed prior to the interviews. Prior to this the Root Crops Officer from the Vanuatu Department of Agriculture identified farmers to participate in this survey. This is important in securing the confidence of the participants (Parkinson, 1984). In this study, the villagers had very good rapport with the officer hence they were supportive of being involved. The population of East Santo within the different age category is as follows: 15-29 years, 1,129; 30-49 years, 1,010; and 588 for 50 years and over (Vanuatu National Statistics Office, 2017). Furthermore a basic random sampling strategy was used for this study. From a total of 50 farmers in each village, 10 farmers were selected in Lorevulko and 7 farmers in Sara resulting in a total of 17 farmers (Chipungu, Ambali, Kalenga Saka, Mahungu, & Mkumbira, 2010).

As per village protocol, a formal request was made to each of the village chiefs for the research to be undertaken in their community. This also recognised the gender roles during the research activity. Verbal informed consent was sought from the participants before individual interviews were conducted, especially the use and sharing of data (McNamara & Prasad, 2014). The formal interviews were

conducted in the local language (*Bislama*) using a semi-structured questionnaire (see Appendix 3) and open- ended questions (Bradacs, 2008; Robbins, 2009). In addition, as part of the interview, field visits were also conducted (McNamara & Prasad, 2014). Data collected from each interview was sorted into themes (Maroyi, 2011).

Traditional knowledge of kumala was documented using information collected from individual interviews which consists of open ended questions (See Appendices 3 & 4), on kumala varieties, cultivation techniques, storage techniques, livelihood sustenance and other aspects (Chipungu et al., 2010; Chiwona-Karltun et al., 1998; Lebot, Malapa, & Sardos, 2015). Individual interviews were used because it allows farmers to express themselves more freely and this is especially important in ethnobotanical research (Munyua & Stilwell, 2013) and also enables researchers to gather reliable and direct data which avoids third party influences (Phillips & Gentry, 1993). Furthermore, open ended questions were used because it allows farmers to speak freely especially about what they wanted to say and how they wished to say it (Huntington, 1998; Shava et al., 2009).

2.6.2 Study area

This study was conducted on Espiritu Santo which is the largest island in the archipelago of Vanuatu (formerly New Hebrides) and is located at 166^0- 167^0E and 15^0 – 16^0S (See Figures 1 & 2) (Maitland et al., 1996). Espiritu Santo, together with Malo and Aore islands forms Sanma Province. According to the 2016 mini-census the total population of Sanma province is 54,184 (Vanuatu National Statistics Office, 2017). This region has a tropical climate, which consists of a dry season (June – October) and a wet season (November – May). Temperatures during the wet season range from 24-30^0C and during dry season they are between 22-28^0C. In addition, the average humidity is 82.2%, and during the wet season average monthly rainfall is 300-350mm while it is 200-300mm during the dry season (Maitland et al., 1996). Luganville is the main town on Santo.

Culture and customs plays a large part in the lives of almost all indigenous people of Santo. The chiefly system continues to have a strong influence in most areas of community life. The primary income generating activity for every household in East Santo is copra production. The soil is very rich with farmers growing a diverse number of agricultural produce. Most households are engaged in farming activities. The most common food sources are root crops including taro, yam, manioc/cassava and kumala (Bodonyi, 2017).

Two villages (Lorevulko and Sara 1) on Santo (See Figure 2) were selected for the survey because of the following reasons:

1. Language

   The same dialect is spoken across the two villages. However the oral questionnaire was translated from English to Bislama (the national language).

2. Logistics

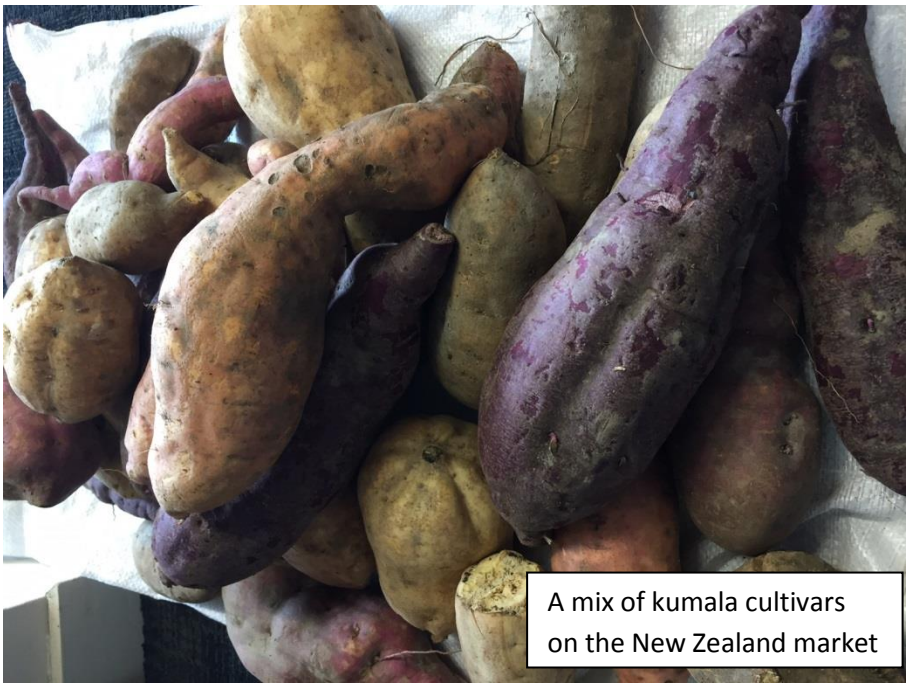
   Both villages were located along the main road which runs from Luganville to Matantas and it is easy to access them. It also required less than 2 hours travelling from Luganville to both villages.

3. Gender roles in Agriculture

   Both men and women are active players in agriculture. Yet there are division of labour by gender. Men tend to carry out heavy work while women do light work. Matrilineality is still practised on Santo (Allen as cited in Thomas, 2013).

4. Clearly defined production systems

   The people are engaged in many agricultural activities for example cultivation of root crops, raising of animals (pigs, chickens, and cattle), copra production and others. They are dependent on all these activities for their sustenance and livelihoods.



A mix of kumala cultivars on the New Zealand market

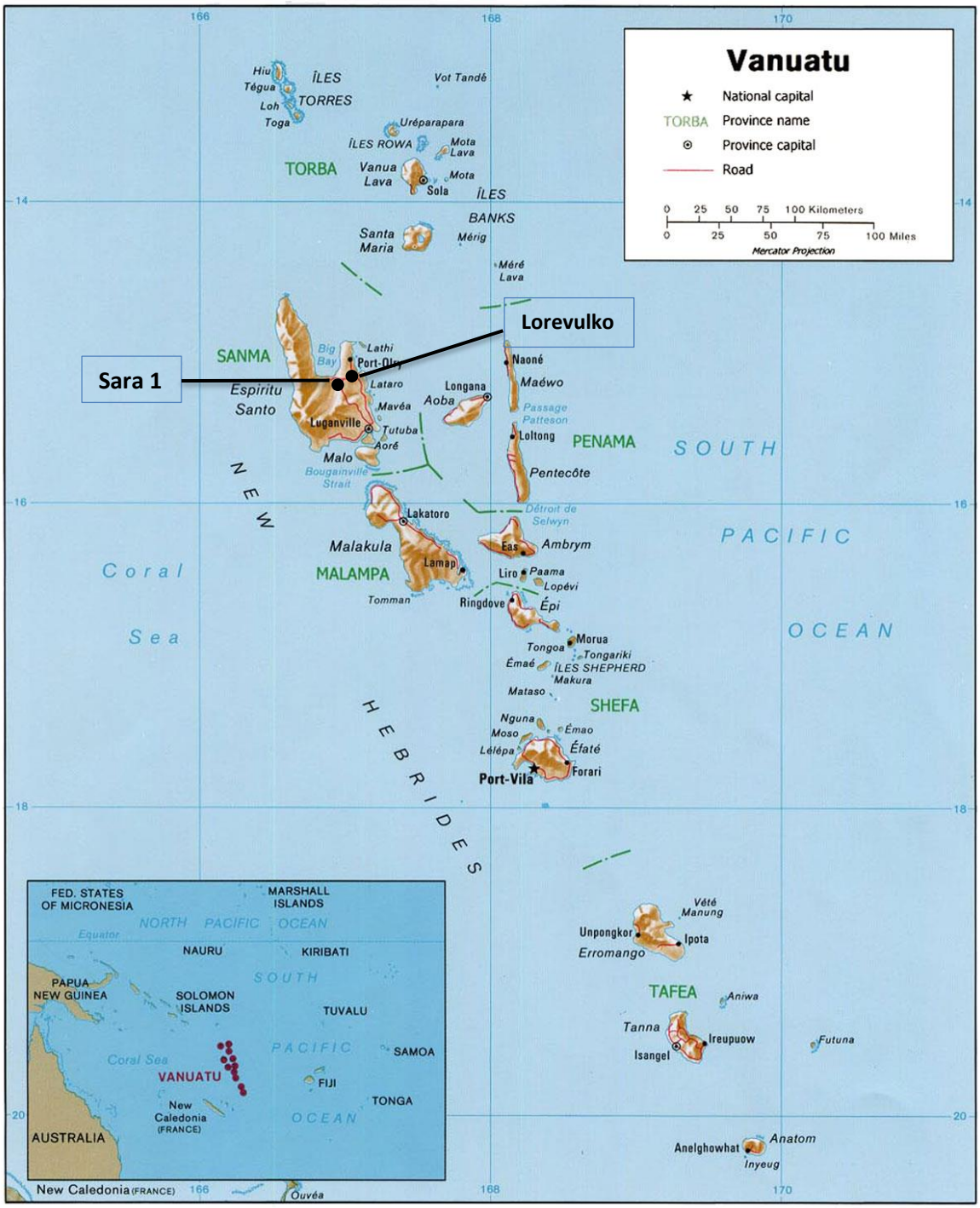


Figure 2: Map of Vanuatu including Santo with the location of study sites[5]

[5] Available at http://members.optusnet.com.au/pla32/photogallery/vanuatu_big.jpg Accessed on 20th March 2018

2.7 Summary

A mixed methodology was used in this study which draws from ethnobotanical, survey and applied scientific methods. Firstly the cultural context was acknowledged and applied across the whole of the research exercise. This involved a review of how Pacific cultures have been included in previous academic research, especially with an ethnobotanical focus and incorporating elements such as *Talanoa* and language as appropriate.

Secondly, both the literature review and survey were used to identify the contribution of traditional knowledge of kumala to the sustainable livelihood of people in Vanuatu. Key literature on traditional knowledge of kumala from both primary and secondary sources was consulted from a global, Pacific and Vanuatu context. Moreover the literature was diverse and included printed materials, digital images and personal communications were also used.

Thirdly, ethnobotanical surveys were conducted at Lorevulko and Sara 1 villages in Santo using semi-structured questionnaires. The questionnaire consisted of different themes on production of kumala. In addition, before the questionnaire was used it was translated to the local *Bislama* language. Interviewers administered the questionnaires to the participants individually.

These methods were important specifically to align previous work on this topic firstly to Vanuatu and secondly to science. For instance exploring the literature on the contribution of traditional knowledge of kumala in different cultures proves useful in supporting and comparing the practices used by Vanuatu farmers. Moreover, the methods used also were aligned to science, and as such they must be done according to the requirements of science, e.g. the data collection procedures, production of unbiased results and repeatability of the results.

3 Literature review

3.1 Introduction

Recent attention has focused on the use and value of traditional knowledge by indigenous communities and its contribution in sustaining people's livelihood in response to climate change in particular. The agronomic characteristics and nutritional value of kumala make it an excellent crop for developing countries. Given these ideal attributes of kumala it has been suggested that the use of traditional knowledge of the crop (kumala) in its cultivation can assist immensely in sustaining people's livelihood through the following: by providing food; improving income;, ensuring continuous supply of planting material; animal feed; and its use in cultural ceremonies (Kapinga et al., 2005; Malekani et al., 2014; Millar, Kendie, Apusigah, & Haverkort, 2006).

There is however, little information or literature on Pacific knowledge associated with kumala production that is available due to traditional knowledge being primarily transferred orally, through narratives, practical skills, songs, and other means (Malekani et al., 2014; Prasad, 2013; Roberts et al., 2004). In addition, only certain people can keep some traditional knowledge in these societies and there are often restrictions in accessing this knowledge (Forsyth, 2011; Recht, 2009; Whimp & Busse, 2000). Failure to comply with these restrictions can result in the knowledge being ineffective and insignificant for example, in Papua New Guinea "The more people who know something, the less significant it is assumed to be." (Whimp & Busse, 2000,p.19). Similarly in Wusi village, West Santo[6], a traditional song used to cure a taro disease will be ineffective if shared widely with others. Therefore exploring the contributions of traditional knowledge and its blended use with contemporary knowledge will enhance our understanding in adapting to climate change events. This review identifies the use of traditional knowledge on production of kumala based on Vanuatu agriculture systems and the contribution of traditional knowledge in sustaining the livelihood of people in two villages of Lorevulko and Sara 1 on East Santo.

3.2 Traditional knowledge

3.2.1 Definition, characteristics and uses of traditional knowledge

Different definitions and terms are used to define traditional knowledge. Traditional knowledge is variously defined as a knowledge that a specific society holds and has developed over a long period of time through experimentations with natural phenomena in their environment and through observations

[6] Buha Laban, Chief , Wusi, Santo, Vanuatu, as told to P Setak in 2014

(Malekani et al., 2014; Naess, 2013; Warren, 1991) for instance, the traditional knowledge of Māori , Pacific islanders and many more (Estrada de la Cerda, 2015). There are also different terms used, which refer to traditional knowledge such as indigenous knowledge, local knowledge, and local people's knowledge (Munyua & Stilwell, 2013; Nakashima & Roué, 2002; Sillitoe, 1998).

Traditional knowledge has certain characteristics which makes it different from the introduced "western" knowledge. According to Naess (2013) , traditional knowledge is unique and its origin and use are connected to the sociocultural context of each society. It is generally passed from generation to generation orally through practical skills, stories and songs (Prasad, 2013). Each society has its own method of preferred transfer (N. Roskruge, personal communication, 6 February 2018). Traditional knowledge is also practical, simple, dynamic, and provides answers to people's needs (Averweg & Greyling, 2010) and it links indigenous people to their place over many generations. In this thesis, the author uses the term traditional knowledge to encompass all forms of local and indigenous knowledge.

Traditional knowledge was widely used in many societies and is instrumental in sustaining people's lives. It was used in the cultivation of crops and also in crop storage which enabled their use for food, planting materials, for sale and feed for animals (Malekani et al., 2014). Many decisions and practices in a society are based entirely on traditional knowledge (Warren, 1991). Examples include agriculture, preparation of food, health, education and management of natural resources. Traditional knowledge was also used to solve problems encountered by the communities (Woytek, 1998). It is also dynamic, resilient and it promotes sustainable forms of agriculture (Millar et al., 2006; Roeling, 2007). Despite the introduction and wider use of western knowledge, there were and remains a high usage of traditional knowledge in the Pacific, including Vanuatu (Malekani et al., 2014; Meo-Sewabu, 2015).

3.3 Vanuatu

3.3.1 Geographical aspects, culture and population

Vanuatu is an archipelago (see Fig. 2 Pg 14) made up of 82 islands which extends from 13^0 to 22^0 S over 900 km^2 (Lebot et al., 2015). According to Bedford (2007), the *Lapita* people settled on these islands over 3,200 years ago. As migrations occurred, people resettled on these different islands and these groups had different cultures and were also different physically (Spriggs, 1997). There was strong indication of cultural diversity in Vanuatu, for example, over 100 vernacular languages are spoken in Vanuatu (Crowley, 2000). Crowley further stated that Vanuatu "is the world's most diverse nation regarding the number of actively spoken indigenous languages compared to the number of its population" (Bradacs et al., 2011, p.434). Ni- Vanuatu is used to refer to the indigenous people. The total

population is around 250,000 with 80% of the population practicing subsistence agriculture as their source of livelihood (Vanuatu Government, 2014; Vanuatu National Statistics Office, 2017).

3.3.2 Agriculture and climate change

The agriculture systems also utilize completely organic farming practices (Vanuatu Government, 2014). Coconut (*Cocos nucifera L*) is the most economical plant, it is mono-cropped in plantations and is also used in combination with cattle (Bradacs, Heilmann, & Weckerle, 2011). According to the Vanuatu Government (2014), other crops of economic importance are cocoa (*Theobroma cacao*) and kava (*Piper methysticum*), which is a stimulant drug that is widely grown and is consumed around the Pacific (Lebot & Lévesque, 1989; Singh, 1992).

Many staple root crops are cultivated in Vanuatu including traditional and introduced ones. Two traditional crops are taro (*Colocasia esculenta* L. Schott) and yam (*Dioscorea alata* L) and these dominate throughout the country (Lebot et al., 2015). This explains their uttermost importance within the different communities. In small plots of land, giant taro (*Alocasia macrorhiza* L.) and minor species of yams (*D. bulbifera* L; *D. esculenta*) are also intercropped (Lebot et al., 2015). Europeans introduced exotic species of root crops to Vanuatu and this includes cocoyam (*Xanthosoma sagittifolium* L.), guinea yam (D. *cayenesis-rotundata*), and kumala (*Ipomoea batatas*) which were quickly adopted by the people (Lebot et al., 2015; Walter & Lebot, 2007).

Agriculture production systems are being threatened by the devastating impacts of climate change events. Like other South Pacific islands, Vanuatu is very vulnerable to climate change events such as tropical cyclones and droughts (Lebot et al., 2015). Tropical cyclones normally form over warm Sea Surface Temperatures (SST) for instance in the Western Pacific Warm Pool (WPWP) and the warm water surfaces provide energy for cyclones (McGregor & Dawson, 2016). Moreover, tropical cyclones continue to pose a serious threat in Vanuatu for example the category 5 Tropical Cyclone (TC) Pam on 13th March 2015, with wind speeds of 270-300 km/h were experienced including storm surges and heavy rains (Lebot & Siméoni, 2015). A total of 26 islands and about 207,000 people were affected by TC Pam and it also greatly affected food security including infrastructure (Lebot & Siméoni, 2015). According to McNamara and Prasad (2014), future cyclone projections shows that less cyclones will occur but their intense activity will increase and more damage will be observed, especially with an increase in wind speed. Impacts caused by cyclones include damage to crops such as kumala, taro, cassava, banana, kava and pawpaw (McNamara & Prasad, 2014).

Another climate change event that impacts on the economy is drought which also occurs regularly in Vanuatu. Drought is defined as a period without a significant amount of rainfall (Mishra & Singh, 2010). This happens when there is a reduction in soil available water and there is continuous loss of water by evaporation and transpiration (Jaleel et al., 2009; Wilhite, 2000). McNamara and Prasad (2014) reported on three cases of droughts in Vanuatu which include the droughts of 1994/1995, 2005/2006 and 2008. They reported that these droughts were induced by the El Niño climate pattern[7]. As a result, many food crops such as taro, banana, cassava, bele (*Hibiscus manihot)*, and kumala, were affected during these droughts (McNamara & Prasad, 2014).

3.4 General information about kumala

3.4.1 Kumala dissemination in the Pacific

Kumala originates from the Andean region of South America and was dispersed across the Pacific (Estrada de la Cerda, 2015). A number of theories exist about the dissemination of kumala in the Pacific. The first theory states that after the Spanish discovered America, they carried the kumala in their ships to Spain (Estrada de la Cerda, 2015). The crop was then introduced to the Philippines from Spain as revealed by Gibson (as cited in Estrada de la Cerda,2015). From there, it spread to other countries in Southeast Asia and continued across countries in Polynesia and Melanesia by Portuguese and Spanish sailors (Dixon, 1932; Lawler, 2010). However, this theory was has been rejected by some academics especially the claim that kumala was introduced to the Pacific from Southeast Asia (Clarke, 2009). The reason for this rejection is that genetic studies have shown a clear relation between kumala samples from South America and those from South Pacific (Estrada de la Cerda, 2015).

The second theory states that the Polynesian voyagers acquired kumala from South America. According to Green (as cited in Montenegro, Avis, & Weaver,2008), this theory is most accepted in Polynesian contemporary studies. Green further stated that the Polynesian voyagers introduced the crop from South America before the 13th century. Te Rangi Hiroa (1938) suggested that they (Polynesian voyagers) must have travelled from Marquesas to South America. Furthermore, the works of Green and Leach (as cited in Montenegro, Avis, & Weaver, 2008), showed evidence that kumala was introduced in the Pacific by the Polynesian voyagers, not the South Americans as the crop is similar to their yam. In addition, new

[7] an irregularly occurring and complex series of climatic changes affecting the equatorial Pacific region and beyond every few years, characterized by the appearance of unusually warm, nutrient-poor water off northern Peru and Ecuador, typically in late December. The effects of El Niño include reversal of wind patterns across the Pacific, drought in Australasia, and unseasonal heavy rain in South America.

DNA analysis on kumala shows that the Polynesians voyagers discovered America before the Europeans, it was then that they took kumala back to Polynesia (Nelson, 2013).

The Polynesian voyagers took the kumala shoots and returned home with them and it is from here that kumala was disseminated (Estrada de la Cerda, 2015). Whistler (2009), stated that from Central Polynesia, kumala spread rapidly to other places in Polynesia including Micronesia and New Guinea. This helps explain why similar generic names of kumala are used in Pacific countries and the name of kumala where it was taken in South America. It is believed that the Polynesians landed in "northern Peru, a region where, according to Te Rangi Hiroa (1938), the sweetpotato was called *kumar* in the native Quechuan dialect" (Estrada de la Cerda, 2015 p.50). Examples of these names used in the Pacific includes the following: in Tahiti it is known as *umara, uma'a* while in Tonga it is called *kumala*, in Samoa it is known as *umala* (Roskruge, 2014). It is called *kumara* in Rarotonga, Tuamotu, Mangareva, Kiribati, Easter Island and New Zealand. In Hawaii it is known as *uala, uwala* (Roskruge, 2014). In Fiji, the Solomon Islands and Vanuatu it is called *kumala*.

3.4.2 Agronomic characteristics and nutritional value of kumala

Kumala has good agronomic characteristics and nutritional value compared with other traditional crops cultivated in Vanuatu. The agronomic characteristics of kumala include the following:

- Firstly, its tolerance to adverse abiotic and biotic stresses (Mukhopadhyay et al., 2011). For instance kumala is considered drought tolerant (Lebot, 2010). It was reported that the prolific root system of kumala makes it able to withstand drought (Leighton, 2007; Mukhopadhyay et al., 2011).
- According to Jaleel et al. (2009), different kumala cultivars respond differently to water stress and this leads to reduction in yields of some cultivars. For example cultivars that have small leaves, short stem length and small canopies are capable of producing higher yields compared to those with broad leaves and long stems (Wilson, Pole, Smit, & Taufatofua, 1989).
- The short growth cycle of kumala makes it a popular root crop because it can be harvested three to five months after planting (Lebot, 2010).
- Unlike other root crops however, kumala can grow well in both fertile and unfertile soils with evidence showing good yields in marginal lands (Pankomera, 2015).
- Kumala require limited inputs for cultivation and once the plants are established they do not need a lot of maintenance (Lebot et al., 2015).

- Kumala can also be cultivated in both dry and wet conditions and fastest plant growth is observed during the wet conditions, however, high yields are produced in dry and cool conditions (McGregor, Taylor, Bourke, & Lebot, 2016).

Kumala is recognised for its nutritive food value because it contains important nutrients needed by the human body. Carbohydrates and minerals especially calcium, potassium, magnesium and zinc (Lebot, 2010; Pankomera, 2015). The crop contains dietary fibre and vitamins including C,B1,B2, A and E (Pankomera, 2015). It also contains phytochemicals such as carotenoids and phenolic acids (Lebot, 2010; Woolfe, 1992). The orange flesh varieties are rich in vitamin A (Ndolo et al., 2001), and are preferred for cultivation due to their potential in addressing malnutrition in many countries in Africa (Pankomera, 2015). The International Potato Centre in Peru (CIP) has done a lot of work on the orange-flesh sweetpotato (OFSP) with high demand of OFSP from Asia, Haiti and Africa (CIP, 2018). Their findings in Uganda have shown an increase in vitamin A in children and women with the introduction of OFSP in households (Hotz et al., 2012).

3.5 Knowledge of kumala in the Pacific

3.5.1 Cropping systems of kumala

Traditionally, kumala was cultivated in intercropping systems in many countries. Intercropping is defined as the cultivation of two crops on the same land. It is a traditional practice that is widely used in many countries for instance in West Africa (Peter & Runge-Metzger, 1994). Farmers determine the crops that can be intercropped with kumala and this differs within countries. For example, in Uganda most farmers planted beans with kumala while a few intercropped kumala with maize, cassava or cereals (Abidin, 2004; Bashaasha, Mwanga, Ocitti p'Obwoya, & Ewell, 1995). Maize, vegetables, cucurbits, peas and common beans are planted with kumala in Papua New Guinea (Kirchhof, 2009). In Vanuatu, kumala is intercropped with bananas, cassava and cocoyam (*Xanthosoma sagittifolium*) (Lebot & Siméoni, 2015). In addition, there are different times for intercropping of kumala and different food crops. In Papua New Guinea this usually occurs in the first year after fallowing (Kirchhof, 2009). However, in Vanuatu, kumala is cultivated after the main crops (yam and taro) are harvested which is during the second and third years of cultivation (Lebot & Siméoni, 2015). Intercropping of these crops occurs as a form of crop rotation.

Mono-cropping of kumala was also used in many traditional societies. Mono-cropping is defined as the cultivation of one crop on the same land. Kumala is mono-cropped in many countries and some examples includes the following: Uganda (Abidin, 2004; Bashaasha et al., 1995), Papua New Guinea

(Kirchhof, 2009), and New Zealand (Burtenshaw, 2010). In addition, when using the mono-cropping system, there is no competition between kumala and other crops, therefore can result in good root development of kumala (Kirchhof, 2009). Moreover due to the kumala ability to yield well on marginal land, it is often mono-cropped in both fertile and unfertile soils. For example, Māori used new land to plant kumala then later continuous cultivation occurred for 3-5 years (Best, 1930; Roskruge, 2007). Similarly, kumala is also planted in infertile or shallow soils in Papua New Guinea (Kirchhof, 2009).

3.5.2 Soil preparation

Traditional knowledge has been widely used in soil tillage for kumala especially the mounding method. Abidin (2004) defined mounds as, "conical heaps of soil of variable size spaced roughly 60-100cm apart" (p.21). This refers to the type of mounds used in northeast of Uganda which might be different in other countries. The cultivation of kumala on mounds is a dominant tillage method that is practised by farmers in many countries for example southern Nigeria (Agbede & Adekiya, 2009), India (Ravindran & Mohankumar, 1985), Uganda (Bashaasha et al., 1995), Papua New Guinea (Kirchhof, 2009), and New Zealand (Burtenshaw, 2010). It is important that tillage is done before kumala vines are planted because tillage facilitates good uptake of nutrients (Agbede & Adekiya, 2009). Growers in Vanuatu use traditional tools made from wood to prepare kumala mounds and these tools were used for digging the soil, planting and also for harvesting the crops. For instance in New Zealand, Māori used the ko (highland spade) for digging the soil and the hoto (blade like spade), puka (shape of spade), akeake, kanuka and wooden spade in the cultivation of kumala (Best, 1930, 1976; Roskruge, 2012). Different sizes of mounds were also prepared for kumala for example small, medium and large (Bashaasha et al., 1995; Kirchhof, 2009), to achieve good root development and removal of excess soil moisture (Kirchhof, 2009).

In developing countries, growers also apply traditional knowledge aligned to soil fertility especially in the use of soil amendments. This is evident in the preparation of mounds where organic fertilizers were either placed in the mounds or are mixed with the soil. As stated by Kapal, Taraken, and Sirabis (2010), people in the highlands of Papua New Guinea added "30kg of biomass, cut from the surrounding area" (p.144) inside a mound[8]. Similarly in Uganda, manure, leaves, and other material are mixed with the soil before planting kumala vines (Bashaasha et al., 1995). In New Zealand, Māori mixed gravels and sands with soil to keep the soil warm and porous for optimum kumala production (Best, 1976; Roskruge, 2007). In addition, Māori used compost and wood ashes as fertilizers for their kumala crops (Bishop, 1924; Hargreaves, 1963).

[8] These are much larger than the mounds used in Vanuatu

3.5.3 Planting of kumala

Traditional knowledge was commonly used in determining the optimum planting time for kumala especially the use of traditional calendars. A traditional calendar is an almanac based on different phases of the moon (Mondragón, 2004; Roberts, Weko, & Clarke, 2006). Horley (2011), also refers to it as the lunar calendar. Traditional calendars are specific to locations and are given their own names for example Māori called it *maramataka*, in Easter Island it is known as *mamari* and on Torres islands it is called the *Torres calendar* (Horley, 2011; Mondragón, 2004; Roberts et al., 2006). Both the *Torres calendar* and *maramataka* have twelve months and thirteen months respectively (Mondragón, 2004; Roberts et al., 2006). Māori planted their kumala "on the moon nights of *O-Tāne and O-Rongo* (usually shown as the 26th and 27th nights in the *maramataka*)" (Roskruge, 2014, p.19), (See Appendix 5).

Kumala is also planted using the modern calendar in contemporary society. In many tropical countries, kumala is cultivated year round, yet there are peak seasons for planting and harvesting. In Uganda, farmers plant kumala between February to October and the rainy seasons indicate their ideal planting time (Abidin, 2004; Bashaasha et al., 1995). In addition, prior to the implementation of gardening activities, Māori used the *maramataka* (Māori calendar for fishing & planting) which indicated the best times for planting, harvesting and other related activities (Roskruge, 2007).

Many cultures also use traditional knowledge in the preparation and collection of kumala vines/ or cuttings before planting. Moreover, these planting materials were generally collected from mature plants (Kirchhof, 2009). Traditional varieties were preferred to provide planting materials. For example, traditional kumara (kumala) varieties cultivated by Māori include Taputini, Rekamauroa, Hutihuti (Burtenshaw & Harris, 2007) and are actually early contact varieties rather than pre- European.

In Vanuatu famers select healthy cuttings from two to three month old plants primarily because they tend to produce higher yields than those taken from four to five month old plants (Kaoh et al., 2014). According to Kaoh et al. (2014), the best planting material are taken from the tips of the kumala vines. This is consistent with findings from previous studies which showed that the apical portion can limit the spread of pests and diseases such as scurf and it can also grow quickly compared to the middle portion (Bashaasha et al., 1995; Kirchhof, 2009). Diseased or pest- infested vines are rejected because they can reduce yields (Bashaasha et al., 1995) . Many farmers allow the kumala vines to wilt or pre-root for a few days in a cool place before they are planted as it promotes quicker initiation growth. In Uganda, the kumala vines are stored under a tree, or the farmers cover them in seedbed and they are also stored inside the house (Bashaasha et al., 1995). In New Zealand, Māori often place the bundles of tipu

(kumala cutting) into a *paru* (clay) bath, mixture of *parakowhai* (a type of mud) and water, this will protect the fragile roots during planting as well as retain moisture until the new roots take hold[9].

Farmers also used traditional knowledge in the planting action for kumala vines. In Uganda the mound size determines the number of kumala vines that are planted (Bashaasha et al., 1995). They further stated that planting is done by hand or using a forked stick. Different numbers of kumala vines are planted in one mound or ridge and more vines are planted as an assurance that if one fails, then the others can grow. In Uganda, the majority of farmers plant two vines in one mound (Abidin, 2004). The sizes of the vines also play an important role in the number planted per mound. In Papua New Guinea, in one planting hole, two to four vines are planted and two large vines are planted together while three or four smaller vines are planted in one hole (Kirchhof, 2009). Moreover, "when planting, the vines are either pushed vertically or horizontally into the soil" (Kirchhof, 2009, p. 18). According to Roskruge (2008), Māori picked up the t*ipu* with the roots facing away and then the index finger is extended to adjust the *tipu*. He further stated that the index finger is inserted at 45 degree angle on the mound and the hand is removed from the mound leaving the *tipu* standing straight with its roots covered with soil (Roskruge, 2008). Māori also used the "Quincunx"[10] pattern in planting their kumala[11] and the tipu are planted facing the east (Te Warihi Taiapa, personal communication, 11 March 2018).

3.5.4 Crop maintenance

Traditional knowledge was also applied in kumala crop maintenance and includes the following: weeding, mounding or hilling up, and soil fertility management. Firstly, weeding was carried out on kumala crops during establishment. Kirchhof (2009) stated that farmers in Papua New Guinea carried out three weeding activities which are done during the establishment, vegetative, and root development phases. He also reported that weeds are not removed from the garden but are used as mulch on the mounds. Moreover, weeding is done by hand or hoe to minimise damage to the developing crop (Agbede & Adekiya, 2009; Bashaasha et al., 1995). Similarly, farmers in Uganda believe that three weeding activities are required but they only weed twice and this is due to the kumala vines covering the soil, there is no labour to carry out the work, and they do not want to damage root development (Abidin, 2004). In New Zealand, Māori usually carry out two weeding activities (Te Warihi Taiapa, personal communication, 11 March 2018). However, more than two weeding is required in

[9] Stated by W. Taiapa, personal communication, Palmerston North, New Zealand (March 11, 2018)
[10] A pattern of 5 kumala tipu planted in one mound
[11] As stated to N. Roskruge, personal communication (February 7, 2018)

wetter areas (Bashaasha et al., 1995). The reason for weeding is primarily to reduce competition for nutrients.

Another cultural practice implemented by farmers is hilling up and this is done at the same time with weeding. Hilling up is important because it improves the supply of nutrients, allows expansion of tubers and it is likely that higher yields are achieved (Bashaasha et al., 1995). Hilling up is understood to reduce exposure of roots to pest damage for instance rats and sweetpotato weevil (*Cylas formicarius)*. In addition, hilling up prevents tubers from sprouting and being directly exposed to weather conditions (Bashaasha et al., 1995).

Soil fertility management is another important practice undertaken by farmers. As stated farmers use manure, leaves, compost, ashes and other material during soil preparation in Uganda, Papua New Guinea, and New Zealand (Bashaasha et al., 1995; Bishop, 1924; Hargreaves, 1963; Kapal et al., 2010). Similarly, a common method used in many Pacific countries is fallowing, for example in Papua New Guinea it "is achieved by abandoning gardens and returning to them to cultivation at a later time" (Kirchhof, 2009, p.16). The well-known practise of shifting cultivation is used in the planting of kumala. According to McGrath (1987). Shifting cultivation depends on a fallow period in which vegetation and soil are exploited for nutrients and crops are shifted around fields. A similar definition states that shifting cultivation involves continuous cultivation of kumala for some seasons then the land is left to fallow with "the farmers return after the fallow period to cultivate further crops" (Kirchhof, 2009, p.16). Fallowing was traditionally practised in other countries for instance Papua New Guinea and New Zealand (Bishop, 1924; Hargreaves, 1963; Kirchhof, 2009). However, the fallow period is reduced in contemporary society due to population pressure and the need for cash crops (Melteras, 2007; Siméoni & Lebot, 2012).

3.5.5 Harvesting

Traditional knowledge is used in the harvesting of kumala especially in determining the time for harvesting and the harvesting techniques used. Firstly, kumala is harvested generally between three to five months after planting depending on the location and varieties planted. It is also important to harvest at the right time because yields will be less if harvesting is too early. However, there can be high incidences of weevil/or pest damage in late harvesting (Bashaasha et al., 1995). Continuous harvesting is commonly done for example, in Uganda (Bashaasha et al., 1995), Papua New Guinea (Kirchhof, 2009), and Vanuatu (Kaoh et al., 2014). Conversely, kumala planted for the market are harvested all at one time (Bashaasha et al., 1995).

For successive or continuous harvesting, farmers look for cracks on the mounds, which indicate harvestable tubers which are then "removed using a sharp metallic rod or stick, then the mound is properly covered with soil" (Bashaasha et al., 1995, p.30.). Kumala roots are harvested by stick or hand and "people dig gently around the plants and only remove" fully developed roots (Kirchhof, 2009, p.21).

There are also differences in the length of continuous or piecemeal harvesting (Bashaasha et al., 1995). It was reported that harvest practices are determined by the variety, type of soil, size of households, infestation by pest or disease incidence, and weather conditions (Bashaasha et al., 1995; Kirchhof, 2009). Other studies have shown that continuous harvesting can be done for 3 to 6 months (Bashaasha et al., 1995; Kirchhof, 2009) and that there are certain varieties that are suitable for piecemeal harvesting while others are not, for example, longer maturing varieties are good for piecemeal harvesting (Bashaasha et al., 1995).

3.6 Storage methods

3.6.1 Field storage and piece meal harvesting

Traditional methods are used to store kumala and the most common method is field storage which is combined with piecemeal harvesting. Field storage is defined as the removal of large sweetpotato roots that are ready for harvest several times when the plants are growing without uprooting the plants (Ebregt, Struik, Odongo, & Abidin, 2007). Cracks appearing on the sweetpotato mounds indicate the root to be harvested (Ebregt et al., 2007). Results have shown that more cracks are observed in the first few harvests and this reduces by the 6th harvest and 4 months after planting, the weight and number of roots decrease (Ebregt et al., 2007). The harvesting decision is based on the previous rainfall because roots are known to grow bigger following rain (Ebregt et al., 2007). In addition, feeder roots are not damaged when the roots are harvested when the soil is wet and there is ease when harvesting compared to harvesting in dry soil (Ebregt et al., 2007).

Field storage and piecemeal harvesting provide a continuous food supply for the people. The kumala roots are used primarily for home consumption and also for the domestic markets and subsistence farmers benefit from this storage method because there is continuous supply of roots over a long period (Ebregt et al., 2007). This method also allows the continuous supply of kumala during the off-season (Motsa, Modi, & Mabhaudhi, 2015a).

3.6.2 Open air conservation

Open-air conservation is another indigenous storage technique used by smallholder farmers and kumala is commonly stored using this method. In addition, the leaves harvested are used for feeding pigs either

fresh, dried or ensiled (Dom & Ayalew, 2010; Hong & Lindberg, 2004). Open-air conservation is practiced in countries such as Malawi (Chipungu et al., 2010), Uganda (Bashaasha et al., 1995), and Vanuatu (Sardos, Muller, Duval, Noyer, & Lebot, 2016). According to Sardos et al. (2016), most root crops stored using this method can last only for several days. However, another root crop, yam tubers stored in yam houses are stored longer and are used for consumption and planting. This is consistent with the findings of a previous study which found that kumala stored in sacks, baskets or on the floor of the house can only last for almost 4 days (Bashaasha et al., 1995). Kumala can be stored longer using this method if they are cured. In tropical countries curing is carried out to heal the wounds and toughen the skin of kumala which reduces infection and decay (Ray,Misra, & Ghosh, 1997:Sowley & Oduro, 2002). Ray and Balagopalan (1997) (as cited in Ray & Ravi, 2005) stated that "a simple technique for curing of sweet-potato was covering the freshly harvested roots with a polythene sheet raised 6-8" [15-20cm] above the roots spread open in a well-ventilated place" (p. 636-637). In New Zealand the temperate climate means curing is inevitable for any storage period. New Zealand growers will cure in the open air for at least ten days to heal cuts or wounds and condition skins in preparation for storage (Roskruge, 2017).

3.6.3 Drying

Traditional knowledge was used in drying of kumala to extend its shelf-life which enables it for later use. Drying of kumala was done in some parts of Uganda, which are very dry especially to reduce crop losses to sweetpotato weevil (Bashaasha et al., 1995). According to Bashaasha et al. (1995), farmers dried the kumala between October to December and the produce is used from February to May. A similar method was also used by Māori where they prepared and stored *kao* or dried kumala (Macnab, 1969; Turei & Kapiti, 1912). They scrubbed the kumala and then laid them outside to dry in the sun for two to three days (Te Ao Hou as cited in Roskruge, 2014). The kumala were steamed in the *hāngi* or earth oven followed by sun drying again. Macnab stated that "*kao* was a prized food, eaten raw, or soaked or mixed with water into a kind of porridge" (1969, p.91).

3.6.4 Pit storage

Traditional knowledge enables people to store kumala in pits in tropical countries to some extent. However, its use is not, as successful as practised by Māori, which is worth noting. The climate of New Zealand is very temperate and seasonal which is why Māori has developed a more effective way or culture on the curing and storage of kumala. In addition there is only a single harvest based on the season. Their traditional knowledge and skills enabled them to successfully cultivate kumala, a tropical crop (Burtenshaw & Harris, 2007) beginning in traditional society until today's contemporary society. Māori used pit storage only after curing first to preserve food and planting material during winter

(Lancaster & Coursey, 1984; Law, 1999). *Rua* is the generic term for pits and other terms such as *rua kai* (food pits) and *rua kumara* (sweetpotato pit) are also used (Best, 1974).

In both tropical countries and New Zealand, kumala was stored in different pit structures. Firstly in tropical regions as stated by Gooding and Campbell (1964), bamboo was used in pit storage with a thatched roof built over it. Pits can also be located in an open area or they can be located inside the corner of a house (Ray & Balagopalan, 1997).

Best, revealed the following storage structures used by Māori: "(1) Semi-subterranean stores on level land, (2) Rectangular excavation in a hillside or on the brow of a terrace (See Figure 3), (3) Excavated pits, entered through hole on top, and (4) Caves" (1974, p.77). Elevated storage platforms known as *timanga* were also used to store kumala (Best, 1974). In New Zealand for successful storage the crop must firstly harvested from dry ground and the skin must be fully dry with no damage (Roskruge, 2017).

The kumala roots are cured before they are stored in the pits with different storage materials (Law, 1999; Tortoe et al., 2008). For example, Māori cure the kumala to dry the skin before storing them in subterranean pits or hillside (See Figure 3) (N. Roskruge, personal communication, 7 February 2018). They also used *tikanga* (best practices) to judge and select the best roots for storage (Hargreaves, 1959; Yen, 1961). It is crucial that roots had no damage before storage. The roots are stored in pits with different materials for example wood ash was used in Malawi and Zimbabwe (Kwapata, 1983; Lancaster & Coursey, 1984), grass was used in Ghana (Tortoe et al., 2008), moist sawdust and river sand were also used in Nigeria (Dandago & Gungula, 2011). Similarly, Māori used the fronds of *rarauhe* (*Pteris aquiline*) and arborescent fern (*Dicksonia fibrosa)* in pit storage (Best, 1974). In addition, the following activities were carried out by Māori: lighting fires, opening the rua for air exchange and periodic removal of any rotting kumala (Davidson, Leach, Burtenshaw, & Harris, 2007).

Kumala roots can be stored for a long time in pit storage. According to N. Roskruge (personal communication, 7 February 2018), in New Zealand kumala can be stored up to 9 months in pit storage based on holding them at an even temperature with no damage as that encourages rots which enhance temperatures. A study done in Tanzania found pit storage to have extended the shelf-life of kumala up to 12 weeks (Van Oirschot et al., 2007). In a study in Nigeria, best results were observed using moist sawdust in a wooden box or in pits with layers of river sand, and kumala could be stored for up to 5 months (Dandago & Gungula, 2011). In Malawi, pit storage extended the shelf-life of kumala to 6.5 months (Abidin et al., 2016).

Figure 3: Māori rua in the hillside. Source: Roskruge (2018)

3.7 Extending traditional knowledge

Traditional knowledge on kumala and crop production is documented, preserved, and managed in information institutions and libraries. Both sources can help indigenous communities by preserving and managing traditional knowledge (Stevens, 2008). For example in Nigeria agricultural traditional knowledge was documented and disseminated by agricultural research libraries (Abioye et al., 2011). Similarly in Zimbabwe, traditional knowledge in agriculture are kept in libraries (Chisita, 2011). However, both studies indicated more work needed by the libraries in documenting, managing and disseminating agricultural traditional knowledge (Abioye et al., 2011; Chisita, 2011). This concurs with the findings of Coombe (2001), especially if libraries and information institutions should change their systems so that they are competent in the collection, storage, retrieval and management of traditional knowledge. Therefore it requires both information professionals and indigenous communities to work together to produce solutions regarding documentation and access to research information traditional knowledge (Stevens, 2008). Despite that, the work of Okore et al. (as cited in Anyira,Onoriode, &

Nwabueze,2010), shows that libraries in Nigeria were making progress in preserving local culture using paper and digital formats. The rate of change in information technology means constant changes in any library or retrieval system. Museums are another information institution that can store and manage traditional knowledge. Most countries in the Pacific have museums, for instance Fiji, Samoa, Cook Islands, New Zealand, Vanuatu, The Solomon Islands and others (MacLeod, 1998) and they can use used as an important source to keep and access vital information.

The growing recognition of traditional knowledge has led to some documentation in Vanuatu in recent years through different projects. For instance traditional knowledge has been included in the school curriculum for year 11-13 students at Lycée Louis Antoine de Bougainville since 2013 (B. Iati, personal communication, 26 February 2018). According to Iati, traditional knowledge classes were carried out for 2 hours once a week. He also stated that one theme in the curriculum is "Agriculture and culinary arts" and it includes the following topics: names and cultivation of fruits, vegetables, roots and tuber crops in Vanuatu, traditional calendar and traditional dishes. Furthermore, there are plans for the development of the curriculum so traditional knowledge can be delivered in other schools[12].

Another project that was used to extend traditional knowledge in Vanuatu is known as *Tanna ecological gardens and youth projects*. This was coordinated by Jean Mitchell an anthropologist from Canada with the aim of involving young people on Tanna to record and document traditional foods and *kastom* gardens in 2016 and 2017 (Giles, 2016). This project was an extension of the *Vanuatu Young People's project* developed by Jean in 1997 which was done in collaboration with the Vanuatu Culture Center (Giles, 2016). According to Proboscis (2016), this project also uses the Traditional Knowledge Reite Notebooks (TKRN), "a toolkit used to document and practice traditional knowledge for future generations" (Para 1). This was developed by James Leach a social anthropologist, Giles Lane and people from Reite, Madang province of Papua New Guinea. TKRN was also taught to 16 female field workers of the Vanuatu Culture Center, including youths from Wan Small Bag Theatre and Vanuatu Land Defense Desk members (Proboscis, 2016).

Slow food Vanuatu (*Siloa Vanuatu Netwok*) is a movement that is used to revive and preserve traditional food in contemporary societies. On 22-26 August 2016 the *Tupunis* (Slow food) Melanesian Regional Slow Food festival took place on Tanna. This festival took participants from the Melanesian countries

[12] Stated by Bergsman Iati, project coordinator at Lycée Louis Antione de Bougainville, Port Vila. (February 26, 2018)

and a Declaration was also signed[13]. This declaration promotes the cultures in food production systems such as production, preparation, storage and consumption in Melanesian countries (A. David, personal communication, 1 March 2018). He further stated that this declaration is intended to promote diverse traditional agricultural systems. Other forum include the Silo Vanuatu Network festivals which occurs every year in August and the monthly session where women in rural communities in Port Vila come together to share their knowledge on traditional foods with the public (David, 2018).

3.8 Application of traditional knowledge on food security

Traditional knowledge has been used for different purposes in both traditional and contemporary societies. People of ancient times used traditional knowledge to conserve crops, which are then utilised for food, sale, as planting materials, and for animal feed (Malekani et al., 2014). According to Warren (1991), traditional knowledge forms the foundation in agricultural decisions, preparation of food, health, education and management of natural resources in indigenous societies and is very useful for solving problems (Woytek, 1998). Traditional knowledge also plays a very important role in sustaining different communities (Millar et al., 2006). Roeling (2007) stated that local knowledge is more resilient, promotes sustainable forms of agriculture, and has supported communities for many centuries. Furthermore, the application of local knowledge systems can help communities to adapt to the effects of climate change.

Food security is achieved when all people have access to enough food that is nutritious and safe in order to live a happy and active life (Reutlinger, 1985). The policies of the Vanuatu government are targeted at promoting food security at the national level. According to the Vanuatu Government (2014), there are four policy directives on food security which are:

- Increase production of sufficient and nutritionally adequate food at national level;
- Improve access to and availability of sufficient, safe and nutritionally adequate food;
- Encourage the utilization of sufficient and nutritionally balanced diets; and,
- Enhance the sustainability of food supply at national level (p. 31).

These policy directives concur with recommendations by FAO (2008), which were to:

> … *promote the use of traditional food crops, provide support to make food gardens more sustainable and the Ministry of Agriculture should improve and expand its plant breeding programme by broadening the genetic base of traditional crops as well as by proving basic training for rural farmers* (p.29).

[13] Stated by Amino. David, Officer, Vanuatu Lands Defence, Port Vila. (March 1, 2018)

Therefore, traditional knowledge and traditional food crops are important in achieving and sustaining food security.

3.9 Sustainable livelihood approach

Traditional knowledge relative to kumala production can sustain people's livelihoods. Findings from previous studies have shown clear links between traditional knowledge and livelihoods in different countries, for example India, Tanzania and Zimbabwe (Immanuel, 2017; Malekani et al., 2014; Shava et al., 2009).

A clear definition of selected terms is crucial to aid the general understanding of what constitutes 'sustainable livelihood'. A livelihood "comprises of the capabilities, assets (including both material and social resources and activities) required for a means for living" (Scoones, 1998, p.5). The sustainable livelihood framework is used to understand the livelihood of marginalised people so that assistance can be provided for them (DFID,1999 as cited in Mahalaya,2011). It has five related components; Livelihood Assets, Vulnerability Context, Livelihood Strategies, Livelihood Outcomes, and Transforming Structures and Processes (Ashley and Carney,1999 as cited in Wilson, 2013) (See Figure 4). It was revealed that this framework, " illustrates how livelihoods are built from a specific set of aspirations and context, are shaped through access to a range of livelihood resources including natural, physical, financial, social and human capital and are influenced by institutions and organisations" (Wilson, 2013, p.249). In addition, a livelihood is sustainable when it can " cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resources base" (Scoones, 1998, p.5).

Figure 4: Livelihood framework (Ashley and Carney, 1999 as cited in Wilson,2013)

3.9.1Traditional knowledge of kumala and its contribution to sustainable livelihoods

Traditional knowledge of kumala can contribute towards sustaining people's livelihoods. As stated by Shava et al. (2009), traditional knowledge and practices of traditional crops can and does sustain livelihoods. Immanuel (2017) evaluated the livelihood capital of tuber crop farmers' in two districts in eastern India and found that out of the five livelihood capital, social and physical capital have the highest value in both districts followed by financial capital index and a lower value for the natural index. The study evaluated the livelihood assets of farmers who planted tuber crops especially cassava, kumala, yams and elephant foot yam (*Amorphophallus paeoniifolius*) but did not include the livelihood *outcomes* which are very important indicators in the sustainable livelihood framework.

Traditional knowledge and practices related to crops including their cropping systems are important in sustaining livelihoods, indigenous knowledge of agro-biodiversity and its contribution in climate change adaption and livelihoods were assessed in two Tanzania districts: Masasi and Nachingwea (Malekani et al., 2014). They found that farmers consistently use indigenous knowledge to improve their livelihood,

adapt to climate changes and manage agro-biodiversity (Malekani et al., 2014). This is consistent with the findings of Munyua and Stilwell (2013) who showed that the combination of scientific and traditional knowledge systems improves livelihood and economies in local communities.

Similar results have shown that crops and trees grown in home gardens[14] improve livelihoods, bring economic growth, reduce poverty and improve people's quality of life (Maroyi, 2009). These results also concur with Minh et al. (2015) findings on occasional income and continuous harvesting provided by sweetpotato, lemongrass, taro and papaya in home gardens in five villages in Vietnam. It is evident that traditional knowledge of sweetpotato or kumala used in home gardens provides food security and improves cash income in household livelihoods (Minh et al., 2015). These studies illustrate the use of traditional knowledge of kumala with other crops and their contribution in sustaining people's livelihoods.

Traditional sharing or hospitality in indigenous cultures also contributes to sustainable livelihoods. A study by Wilson (2013) evaluated the macro economical changes that occur and, it also analysed people's access to different livelihood resources and long term future livelihoods of people on Aniwa, Vanuatu. The results show that while households in Aniwa, experienced high inequality in cash income, however all villagers continued to have food and shelter due to traditional sharing, relationships exchange between households on the island including other islands and migrants. This is an example of how livelihoods are sustained and the community is resilient through migration and diversification (Wilson, 2013). This aligns well with McFarlane (2007) who found traditional values such as *whanaungatanga* (kinship, togetherness) and *manaakitanga* (hospitality, giving) in production of taewa also contributed to sustainable livelihood of Māori. Wilson's study provides a basis for different livelihood resources. However, it does not include any discussion on the contribution of traditional knowledge of kumala or sweetpotato in sustaining livelihoods of people on Aniwa in Vanuatu. This is because a lack of land for cultivation makes it necessary for people to find other resources to sustain their livelihoods.

[14] Generally gardens <1000m^2

3.10 Contemporary kumala systems

Contemporary kumala systems are successful in responding to commercial needs and contributing to the economy. These systems include the marketing and trading of the crops. As machinery and high technology are involved, there is less involvement of labour or less manpower is required. Research and development are the most essential part of these systems. Kumala is produced using these systems in many countries such as China, Africa, New Zealand and elsewhere (Essilfie et al., 2016; Lewthwaite, 2005). For example in New Zealand, the introduced kumara [kumala] varieties from America were used for commercial production (Savage & Bolitho, 1993). Production is concentrated in the Northland region (Roskruge, 2009), using three commercial cultivars: Tokatoka Gold, Owairaka Red and Beauregard and they have provided customers' selection choices for colours, textures, and flavours (Lewthwaite, 2005; Savage & Bolitho, 1993). Kumala were sold in the markets according to the colour of their skin which are gold or orange and red, and in recent years there was high demand for processed kumala products (Lewthwaite, 2005). Kumala was an important cash crop because it contributed to economic development during the early colonization days until now (Roskruge, 2009).

The use of high technology is useful in contemporary kumala systems because it enables the sustainable production of kumala. Additionally, the use of modern storage methods can help extend the shelf-life of the crops (Pankomera, 2015). Irrigation is another technology that is widely used, for instance drip irrigation is the main type of irrigation used for kumala in the United States of America (Smith, Stoddard, Shankle, & Schultheis, 2009).

Contemporary kumala systems are also useful in responding to biosecurity risks associated with the production of kumala. The introduction of exotic pests or diseases of kumala can be devastating if not detected and controlled (Rodoni, 2009). Therefore, the risks of spreading pests or diseases to other places can be minimised. In addition, pest control is also implemented which is essential in achieving optimum production. It will be difficult to achieve the benefits derived from the use of modern technology for kumala production stated above if only traditional production systems are utilised.

3.11 Summary

Traditional knowledge of sweetpotato contributes to sustain livelihoods of indigenous people and this is evident in both traditional and contemporary societies. Here livelihood is defined as assets (material and social resources), capabilities and required living activities (Scoones, 1998). A livelihood is sustainable when it can recover, can cope with shocks and stresses in order to enhance or maintain its assets, capabilities for present and future use without weakening the base of natural resource (Wilson, 2013).

A better understanding of traditional knowledge in Vanuatu agriculture will help farmers to contribute to kumala cultivation and hence achieve food security in Vanuatu, it is evident that the introduction of western knowledge has caused a lot of change in the use of traditional cultivation techniques. Encouraging farmers to continue their use of their traditional knowledge to cultivate kumala is invaluable in order to contribute to improve or improving food security at the household and national level, and generate sustainable income for farmers.

The literature reviewed has shown that traditional knowledge of kumala can and does contribute in sustaining people's livelihood. Published work discussed has shown that livelihood resources are important. However, there is limited published work on traditional knowledge due primarily to its oral transmission. In addition, previous studies accessed did not include the livelihood outcomes as the focus was on home gardens rather than large cultivations. The specific contribution traditional knowledge to kumala production systems has not been included in previous studies, highlighting a clear gap in the current literature.

4 Results

4.1 Introduction

This chapter presents the results from the surveys undertaken to evaluate the contribution of traditional knowledge and food value of kumala in Vanuatu agriculture. The surveys were conducted on Lorevulko and Sara 1, (refer to Figure 2) on Santo in Vanuatu. A total of 17 participants were interviewed, 10 in Lorevulko and 7 in Sara 1. Across both settings, the participants' age ranged from 20 to 76 years old. Both male and female participants participated in the surveys with 53% and 47% respectively. The results are presented under the following headings: Pre-production, Production, and Post-production of kumala.

4.2 Extending traditional knowledge

Traditional knowledge plays a crucial role in shaping farming knowledge, practices and contributing to sustainable livelihood in Vanuatu. It is still widely practiced in Lorevulko as evident in the practices applied at different phases of kumala production. Farmers continue to adopt traditional knowledge owing to stated observed benefits such as higher yields of kumala. Traditional knowledge is an integral part of the farmer's daily job, and it is relatively easy to use and there is also the benefit of sustainability. It is also a way of maintaining and passing on valuable knowledge from one generation to the next. Given its importance, participants suggest that ways to extend traditional knowledge include the following: first, the younger generations should be educated on these knowledge and skills and secondly, efforts should be made to ensure the documentation of traditional knowledge. Parents play an integral role by teaching their children these skills and knowledge; this is important in order to extend if not retain traditional knowledge. Similarly, traditional knowledge is still practiced in Sara 1 and has been the case for many generations. The findings reported in both regions were very comparable in regards to the use of traditional knowledge.

4.3 Pre-production of kumala

4.3.1 Planting calendar

Traditional knowledge on different phases of the moon form a traditional or lunar calendar used for determining best months for planting kumala. Respondents were asked to indicate whether or not they use a traditional calendar. At Lorevulko, 6% of respondents indicated that they use a traditional or lunar calendar. The age of these respondents ranged from 35 to 68 years old. According to their lunar calendar, the appearance of a full moon indicates the best times for planting kumala. They believed that kumala planted during this time would produce bigger and good quality roots. Similarly, in Sara 1, only

4% of those interviewed reported to have used a traditional calendar. These respondents were 39 to 57 years old. Full moon was also used by respondents in Sara 1 as a guide for optimum planting period. Past experiences from respondents in both Lorevulko and Sara 1 indicated good yields of kumala that were planted during full moons. *Ratatia* is the local name of traditional calendar.

Knowledge in flowering and fruiting of trees were commonly used in traditional societies to indicate different cropping activities. An indicator used to determine the optimum planting times for kumala is the *Navasvas* tree (*Alphitonia zizyphoides*) (See Figure 5). Respondents in both locations planted kumala when the *navasvas* tree flowers (See Figure 6). According to the modern calendar, the main flowering season of *navasvas* is from January-March. Respondents also planted kumala when the fruits of *navasvas* are black (See Figure 7). The main fruiting season is from August – September in the modern calendar.

Figure 5: A navasvas tree (Alphitonia zizyphoides) at Sara 1, Santo. Source: Author

Figure 6: Flowers of navasvas[15]

Figure 7: Black fruits of navasvas[16]

In comparison with contemporary kumala systems, the traditional calendar was not used but the modern calendar was used. This is reflected in both Lorevulko and Sara 1 where the findings have shown that 90% of respondents used a modern calendar to plant their kumala. The best months to plant kumala in Lorevulko are from March-September and year round. Similarly, participants in Sara 1 agreed that the best months to plant kumala were from March-April, May, July-August, and December.

4.3.2 Site selection and land clearing

Traditional knowledge was also used in selecting the best sites to establish kumala gardens. Respondents were asked to give information about the criteria used for site selection for kumala gardens. In both Lorevulko and Sara 1, the majority of the respondents identified fallow land as the best site for a kumala garden. A fallow land with primary forest which consisted of trees such as navenue (*Macaranga tannarius*) and many others including area with weeds such as merremia (*Merremia peltata*), mile-a-minute (*Mikania micrantha*) are preferred or selected (See Table 1). These are young trees and according to the respondents they indicate soil fertility. Old yam gardens were also selected for planting kumala. The first reason given for selecting a fallow land is high soil fertility. For example, the leaves of merremia and navenue provide thick organic matter after decomposing. Participants also revealed ease in clearing the land in areas with merremia and mile-a-minute weeds as a reason for land selection. In addition, less labour is needed when old yam gardens were used. However, site selection is not a problem in contemporary kumala systems as the use of fertilizers and machinery can make any site suitable for kumala production.

[15] Available at: https://c1.staticflickr.com/5/4144/5057243646_4845ba7d7b_z.jpg. Accessed on 21st February 2018
[16] Available at: https://c1.staticflickr.com/5/4144/5057243646_4845ba7d7b_z.jpg. Accessed on 21st February 2018

In both sites, modern tools are used instead of traditional tools for clearing land for kumala. The majority of the participants in both locations reported to use axe, bush knives, chainsaws and other tools for clearing land for their kumala gardens. Firstly, trees, shrubs and weeds on the selected site were cut down and left to dry for some days. In addition, doing this is important as it allows the nutrients that are contained in the weeds or trees to return into the soil. After drying, the farmers then removed the debris to the sides of the garden for the duration of the crop and use as future mulch. While this stated land clearing technique is practised by 70% of the participants, the rest still use the slash and burn technique.

4.3.3 Soil preparation

Traditional tools used in soil preparation for kumala were common in traditional societies before the introduction of modern tools and machinery. Findings from Lorevulko and Sara 1 have shown that the majority of the participants used modern tools to prepare mounds for kumala. Modern tools used by participants include: spade, hoe, pick and crowbar. The results also showed a small number of respondents using wooden sticks for example wooden sticks made from the trunk of *namamaua* tree (*Flueggea flexuasa*) (Figure 8). *Namamaua* sticks were used because they are strong (See Table 1).

Findings from both settings have shown that the participants prepare mounds using the following method. Firstly, all remaining debris such as leaves, rocks, sticks and others were removed. Secondly, the soil is dug up using spade, hoe, pick and wooden sticks for those using modern and traditional tools respectively. They then prepare mounds making sure to till the soil well. Both small and large mounds were also prepared by the participants in Lorevulko and Sara 1. It was also stated by the participants that the diameters of the mounds ranged from 30 to 70cm and 15 to 20cm in height. In contrast, modern production systems use machinery such as tractors, ploughs and others to prepare ridges for kumala and these result in a different plant population and resource utility for the crop. A large area containing ridges can be prepared by these machines in a relatively short time.

Table 1: Trees and their relationship with kumala activity in Vanuatu

Local name	**Latin Name**	**Relationship to kumala**
Navasvas	*Alphitonia zizyphoides*	*Navasvas* indicates the planting times for kumala. Planting is done when it produces flowers and also when the fruits are black.
Namamaua	*Flueggea flexuasa*	Wooden sticks made from *namamaua* are used for planting kumala.
Navenue	*Macaranga tannarius*	It indicates a rich soil in which kumala and other crops can be planted.

Figure 8: Regrowth of namamaua tree (Flueggea flexuasa) at Vanuatu Agriculture College, Santo. Source: Author

4.4 Production of kumala

4.4.1 Kumala cultivars in Vanuatu

Respondents were asked about the names of kumala cultivars they plant and their characteristics. The majority of participants in Lorevulko and Sara 1 indicated that they cultivate only a few of the following kumala cultivars: *Baby*, *Tumanis, Tunala*, *Solomon*, *Paama*, and *Sul*. Findings revealed that *Baby*, *Tumanis* and *Solomon* are the most common cultivars in both settings. *Baby* was also recommended to farmers by Department of Agriculture and Rural Development. The findings show that some old cultivars such as *nro, sarwur and nial* have been lost because they were replaced by new hybrids (pink, orange and yellow flesh) which are early maturing. In addition, these cultivars can withstand drought when they are established before the dry season.

A further description and explanation about a few of these cultivars are outlined below.

4.4.1.1 Baby

Participants stated that the name baby in the local language means kumala that is used to feed babies. This name is also connected to their knowledge on the cultivar. An example of this includes its softness once cooked and is very sweet. These attributes make it ideal for babies. *Baby* kumala can also be harvested 3-4 months after planting. Furthermore, kumala from this cultivar stores well both after harvesting and in-field storage. The findings have shown that the baby cultivar can be planted in both wet and dry conditions. There is a high demand for the baby cultivar in the local markets where it is highly sought by consumers (Figure 11). The description given by the participants about baby cultivar during the field visits shows its leaves as cordate (heart-shaped) in shape and the leaves and leaf petiole are light green in colour (Figure 9). Both the skin and flesh of this cultivar are orange (Figure 10).

Figure 10: Baby kumala cultivar growing in a field at Sara 1, Santo. Source: Author

Figure 9: A root of Baby kumala cut lengthwise at Sara 1, Santo. Source: Author

Figure 11: Basket of baby kumala (and other cultivars) at local Vanuatu market. Source: Mael, 2013.

4.4.1.2 Tumanis

In the local language t*umanis* means that the kumala can be harvested after two months. Respondents also possess knowledge about this cultivar for example as an early maturing cultivar. They also revealed that it is suitable for dry conditions and can grow well in a variety of soil types that are well drained. In both Lorevulko and Sara 1, participants from the survey and field visits provided the following descriptions about *tumanis* kumala. It has lobed leaves that are green. The leave petioles are also green (Figure 12). *Tumanis* kumala has a red skin and a white flesh (Figure 13). Its flesh is not as sweet as like "baby" variety, and it has a high demand in local markets (Figure 14). This cultivar can be harvested after two months per its name.

Figure 12: A mound of growing tumanis kumala at Lorevulko, Santo. Source: Author

Figure 13: A root of tumanis cut lengthwise. Source: Moses (2018)

Figure 14: A basket of tumanis kumala: Source: Moses (2018)

4.4.1.3 Tunala

The *tunala* cultivar was cultivated only in Sara 1 and respondents stated that the name refers to the person who first brought the cultivar to Sara 1. It was also revealed to be a new hybrid that was recently introduced. This name is also connected to participant's knowledge about the cultivar. Participants were also knowledgeable about this cultivar for example its attribute as an early maturing cultivar (3-4 months). Respondents also revealed the ideal planting times for *tunala* for instance it is best planted at the end of the wet season and harvest is done at the beginning or middle of the dry season. The cultivar can withstand drought if planted before the dry season. Participant's description and field visits shows that the *tunala* cultivar has lobed leaves that are green in colour and it has reddish leaf petiole (Figure 15). The cultivar has red skin and white flesh with purple pigments (Figures 16 &17). It also has a strong and consistent market demand.

Figure 15: Tunala growing in a field at Sara 1, Santo. Source: Author

Figure 16: A tunala root at Sara 1, Santo. Source: Author

Figure 17: A root of tunala cut lengthwise at Sara 1, Santo. Source: Author

4.4.1.4 Solomon

Solomon is another cultivar that is planted in both villages. The knowledge associated with this cultivar includes the following: It originated from Solomon Islands and it can be harvested from 3- 4 months. *Solomon* is suitable for both dry and wet conditions and it is resilient to the impacts by cyclone damage. This cultivar regrows easily. As such it is a good cultivar that is planted by farmers for food security especially after droughts or cyclones. Participants in both Lorevulko and Sara 1 describe this cultivar as having lobed green leaves, the leaf veins are slightly purple and the roots are ovate medium to large in shape. In addition, the skin colour is white and the flesh is creamy white. There is also a high demand for *Solomon* in local markets (Figure 18).

Figure 18: Baskets of Solomon cultivar at local Vanuatu market. Source: Mael (2013)

4.4.2 Division of labour

Communal work is common in traditional Vanuatu society and activities are assigned to different members of the community based on their social class, gender and social structure. There is a division of labour for different kumala activities starting from land clearing to harvesting. Respondents identified that men and women have different tasks in both settings. It is the responsibility of men to clear the land and prepare mounds. Women on the other hand collect the kumala cuttings and plant them. These roles are slowly changing from the past where only women were involved in kumala cultivation. However, today, many men are involved in kumala production. In addition, women do not, or cannot, depend too much on the men to do all the work because they find other sources of income and are not always available.

4.4.3 Planting

Respondents in Lorevulko and Sara 1 also have traditional knowledge on different planting methods for kumala. It was revealed that kumala cuttings were collected from relatives, friends and parents. Cuttings of 30cm are taken from the tips of the kumala vines in new gardens (2-4 months old). Many respondents preferred cuttings with 5-6 nodes. The cuttings are kept in a cool place to wilt for a day or even one week before they are planted. About 58% of those surveyed used the more common planting method which involves taking 4 kumala cuttings and planting them evenly in one mound. Moreover, 24% of the participants used the second method in which 3-4 cuttings were twisted around their hand and pushed into the mound at a depth of 20 to 25cm in a slanted or upright position. Eighteen percent of those interviewed have use a third planting method. This involves wrapping the bases of 3-4 kumala cuttings in one leaf of high bearing pawpaw and planting them in a mound. Respondents believed that the kumala planted using this method will produce high yielding tubers like the pawpaw.

The findings also show that participants know the reasons and benefits of using the three planting methods. For instance planting the cuttings at the depth of 20-25cm allows good development of the tubers and easy harvesting. Shallow planting is not good because it exposes the tubers to sun, which makes them green thus rendering the tubers unpalatable. In addition, deep planting makes it difficult for harvesting especially in clay soils. Sandy soil is the preferred soil for kumala due to its good drainage properties. The participants explained that using the three planting methods helps produce the following benefits: high yields, upright kumala plants, rapid rooting and ease in harvesting. There is also crop assurance when multiple vines are planted because if one vine dies the others will grow. Replacement is easy as cuttings are easily sourced.

4.4.4 Crop maintenance

The use of traditional knowledge is important in effective maintenance practices to achieve quality harvest. In Lorevulko, the majority of the participants responded that weeding and hilling up are maintenance practices they used. They stated that weeding is important because it helps to protect the kumala tubers from rats, allows sufficient sunlight into the kumala crops, and makes the garden looks neat as the overall presentation or appearance of one's plantation forms others' perception of a farmer. This is an important point from a cultural context. Weeding also prevents competition between the kumala plants and weeds, and most importantly, improves yields. Respondents also stated that they weed the crops before the vines cover the ground. Furthermore, they reported that hilling up is

important because it allows good development of the tubers and prevents damage by rats. It also prevents the tubers from turning green due to exposure to sun.

Weeding and mounding were carried out by the majority of participants in Sara 1 as it offers the following benefits: achieve higher yields, protects the kumala crops from rats, prevents competition between weeds and the crops, and improved growth. In contemporary kumala systems while weeding is carried out, hilling up (manual) is not and this is because the kumala are planted in ridges or mechanized ridges.

One of the unique traditional elements for all Pacific cultures associated with crop production are garden taboos or rules, which are also important in traditional cultivation of kumala for high yields and protection against pests and diseases. According to the respondents, failure to comply with or observe these taboos will result in poor yield. In the past serious punishments were imposed on the offenders. However, these days few garden taboos appear to still used in kumala cultivation in Vanuatu. Additionally 12% of respondents in both locations stated one of the taboo as one must not continuously go to the garden anytime he/she wishes to. It is also considered a taboo for a woman to go to the garden while she is having her menstruation. During visits to the garden it is common practice for farmers to talk to the plants like they are humans (give them compliments). The same taboos were also stated by a few participants in Sara 1. Compared with contemporary kumala systems, garden taboos are generally not implemented.

4.4.5 Preparation and management of kumala during droughts and cyclones

Given the severe impacts of climate change on agriculture production and food security, proactive preparation and management on the part of farmers is crucial. In Lorevulko, the majority of the participants undertook specific practices to manage kumala plants. When planting the cuttings, only a shorter portion of the planting material is exposed while the rest are covered in the soil. During periods of drought 60% of those surveyed stated that they water their kumala plants and no weeding is carried out and this is to maximise shade and also retain soil moisture. Matured kumala are harvested early and are used for consumption. Kumala tubers are not ground stored but cocoyam are stored in soil or in dry or rotten *narara* (*Erythrina variegata*) bark. Cocoyam can be stored up to one year using this method and the shoots have to be cut off. Wild yam (*Dioscorea villosa*) is also buried during droughts and these can last for 2-3 months. However, 40% of the participants did nothing to the kumala crops during drought. Similarly, 57% of the respondents in Sara 1 did not weed their kumala crops during drought

while 43% of respondents did nothing during a dry time. Notably however, kumala crops that were managed appropriately during droughts and cyclones survived and continued to grow.

Only 70% of those interviewed in Lorevulko managed their kumala crops during cyclones and this included the following: harvested mature kumala, chopped down trees that were in close proximity to the garden, and stored kumala in a safe place away from the rain. The remaining 30% of the participants did nothing to their kumala during cyclones. Only 60% of the participants in Sara 1 manage their crops during cyclones, while 40% did not manage their crops during cyclones.

In preparation for droughts, 88% of those surveyed in both settings reported that they: harvested mature kumala, stored water, did not do any weeding and/ or intercropped with cabbage and banana. Furthermore, in preparation for cyclones, participants in Lorevulko and Sara 1 harvested mature kumala, prepared sufficient food supplies, and stored food. They also pruned trees growing near the gardens to minimize any damage caused.

It was reported by the respondents in Lorevulko that kumala could sustain them and their families during extreme weather conditions because it is more tolerant to droughts and cyclones, and if stored well, kumala tubers can last for some weeks. Similarly, in Sara 1, kumala has also sustained their lives during extreme weather conditions. This is because when compared with other crops that are commonly grown in Vanuatu, kumala is more tolerant to droughts and cyclones, can be harvested at any time and can be stored for several weeks.

4.4.6 Harvesting

Participants also have traditional knowledge on the harvesting of kumala. Results from Lorevulko and Sara 1 show that kumala can be harvested all year. However, there might be some priority periods, which depend on the planting date and variety. Farmers determine the ideal time for harvest by identifying cracks on the mounds. It was reported that harvesting is done manually. They use their hands to scrape out soils from the mounds to expose the roots. Respondents also revealed that a spade or knife is sometimes used in heavy soils. When using the mentioned tools care must be taken because the roots are very close to the ground surface. Respondents also stated that extreme care is taken to avoid damaging the roots when using a knife or spade because this can reduce the storage length of the tubers.

A final point to note from the respondents is that they also plant kumala especially for social purposes e.g. marriages, Independence Day, Christmas and New Year festivals. In this case the crops are harvested directly for use in these festivals.

4.5 Post-production of kumala

4.5.1 Storage

After harvesting kumala crops the storage methods used are crucial either for short or long-term purposes. The majority of the participants stated the common storage methods they use are: field storage, bag storage, basket storage and food bed storage. All can be considered traditional practices. Participants provided more detail on these storage methods including their benefits and disadvantages.

4.5.1.1 Field storage

Field storage is used when the kumala crops are kept in the field and the mature tubers are harvested on demand. Participants in Lorevulko and Sara 1 stated that the benefits of using field storage include the following: There is continuous supply of food for sustenance, and it ensures easy and convenient access to food when needed. However, the disadvantages are rats may damage to the tubers; the tubers can become fibrous, and/or lose their flavour. In addition, damage can also be done by the sweetpotato weevil (*Cylas formicarius*).

4.5.1.2 Bag storage

Bag storage is another common method that is used by farmers for short -term storage of kumala. It involves storing the kumala in empty rice or flour bags. The benefits of this method are as follows: prevent damage by rats and chickens, easy access to food when needed, and easy transportation to the market. Despite these benefits, the disadvantages of this method are: high level of tuber decay due to damage when harvesting, and it can induce fast germination and growth of tubers in the dry season which affects the eating quality of the crop.

4.5.1.3 Basket storage

Kumala is also stored in baskets made from coconut fronds however this is for short- term storage only. This is a common practice among the participants who produce kumala for sale. Moreover, over half of those surveyed reported that this method is preferred because it is easy for the produce to be transported to the market. In addition, participants stated that stored kumala are sweeter than freshly harvested ones and enables farmers and their families, easy access to food. However, rats and chickens can damage the kumala.

4.5.1.4 Food bed storage

Another storage method of kumala that is used is food bed made from wood. This method is used by only a small number of respondents. Its advantages according to respondents are stored tubers are sweeter and it enables easy access to food when needed. Due to the exposure of the crops, this method suffers high damage by rats and chickens.

Out of the above storage methods, field storage is the most common. It also helps the roots to have the longest shelf life compared to the other storage methods. Despite this, the quality of kumala roots stored in field also deteriorates with time. All four storage methods were easy to use and are cheap.

4.6 Traditional knowledge contribution to sustainable livelihood

Participant responses confirm that traditional knowledge plays an important role in contributing to sustainable livelihoods of farmers. Participants in Lorevulko stated that kumala can sustain the livelihood of people in their community. This is because it provides a sustainable food supply for them during good and extreme weather conditions. It also provides a constant source of income, is the main source of food during community feasts, can be sustainably produced, and it ensures a continuous supply of food throughout the year. Kumala is also widely used in cultural ceremonies. Likewise, in Sara 1, the use of traditional knowledge in kumala production has and will continue to sustain the livelihood of the people in the community. It is also important to note that in Lorevulko, there are other sources of livelihood. These include copra, sale from other crops, cattle, pigs, and timber. Some family members also earn an income from seasonal work in New Zealand. Similar results were reported from Sara 1 too where copra, cattle, crops, chickens, pigs and kava are other important sources of livelihood.

Figure 19: Example of mounds being prepared for kumala planting in the Pacific
Source: I Leweniqila, 2018

4.7 Summary

While there are common practices undertaken by participants in this study, there are also different practices due to age differences. In pre-production of kumala, only a few participants in both Lorevulko and Sara 1 still use a traditional calendar whilst the majority prefer to use the modern planting calendar. This showed the best months to plant kumala is from March to September. In the case of Sara 1, the best months to plant kumala is from March to April, and July to August. In addition, the best months for harvesting are based on planting times, which could be 2 to 5 months after planting depending on the cultivars, for instance the *tumanis* cultivar has a short production period and can be harvested after two months but is capable of good establishment.

The important criteria used to guide farmers in selecting the best sites for kumala gardens are primary forest, fallow land, old yam gardens and slope areas. The participants mainly use modern tools to clear land for kumala gardens. Trees, shrubs and weeds are cut down and left to dry before soil preparation is carried out. Only a small number of respondents use wooden sticks from the *namamaua* tree to prepare kumala mounds. The majority use modern tools for preparing kumala mounds.

Participants preferred certain kumala cultivars. While there are 6 cultivars that are commonly planted the three highly favoured ones are *Baby*, *Tumanis,* and *Tunala* and this is because of their unique characteristics. There are also three different planting methods used by farmers in both settings. The first method involves four cuttings evenly planted in one mound. In the second method, 3-4 cuttings are twisted around the grower's hand and then pushed into the soil. The third method involves wrapping 3-4 cuttings in one leaf of high bearing pawpaw and planting them. Weeding and hilling up are the two maintenance activities carried out to ensure good plant growth and high yield. In addition, the participants undertake several practices in the preparation and management of the kumala crops during climatic events such as droughts and cyclones.

After harvesting of kumala participants in both locations used bag storage, field storage, food beds and/or basket storage. Each method has its advantages and disadvantages. The findings in this study show that traditional knowledge plays a crucial role in kumala production in the two settings. It is also evident that traditional knowledge in kumala production has contributed towards sustaining the livelihoods of farmers in both Lorevulko and Sara 1. In addition to kumala production, other agricultural activities such as copra, selling of crops, cattle or chickens are other additional sources of livelihood for farmers and their families in these two villages.

5 Discussion

5.1 Introduction

Traditional knowledge and practices of traditional crops have proved to make a significant contribution towards sustaining the livelihoods of people (Shava et al., 2009). Many cultures have depended on it for their survival and wellbeing. For instance in Vanuatu eighty percent of the rural population still depend on subsistence agriculture for their livelihood (Vanuatu Government, 2014) and the same trend also applies in other Pacific nations (Chand, 2005). The main findings of this study are summarised with regard to the research question and conclusions are based on the findings. The primary question in this study sought to determine the contribution of traditional knowledge of sweetpotato in sustaining livelihoods in Vanuatu. The research objectives are as follows: to identify the use of traditional knowledge in production of kumala in Vanuatu, to identify the application of traditional knowledge of kumala to food security and/ or sustainable livelihood, and to give examples of how traditional knowledge contributes to Vanuatu horticulture.

5.2 Extending traditional knowledge

Traditional knowledge can be extended through education. As such the younger generations should be taught traditional knowledge and skills. This concurs with the findings about traditional knowledge being taught at Lycee Louis Antoine de Bougainville since 2013 (B. Lati, personal communication, 26 February 2018). In addition, the Slow Food Vanuatu organization also revive knowledge to educate people on traditional foods during their festivals (A. David, personal communication, 1 March 2018). The younger generations can also educate themselves on traditional knowledge from information institutions and libraries.

Traditional knowledge must be documented for the future generations. Both libraries and information institutions are tasked with this. For examples agricultural research libraries in Nigeria document and disseminate agricultural traditional knowledge (Abioye et al., 2011). Moreover, in Zimbabwe, traditional knowledge is kept in libraries (Chisita, 2011). Furthermore, museums also store and manage traditional knowledge. Traditional knowledge was also recorded using the TKRN notebooks on Tanna in 2016-2017 (Giles, 2016). The trend of new technology means that all knowledge retrieval systems need to be prepared for the changes which are constantly being put on them.

5.3 Traditional and contemporary knowledge for kumala pre-production

Traditional knowledge can be defined as a knowledge that a specific society held or holds (still applies) and has developed over a long period of time by experimentations with natural phenomena in their environment and through observations (Malekani et al., 2014; Naess, 2013; Warren, 1991). Contemporary knowledge on the other hand is produced through research and educational networks (Warren, Sikkerveer, & Brokensha, 1995). Both traditional and scientific knowledge are currently being used in preparation for kumala production in Vanuatu. They are now blended in order to optimise production. However, while both knowledge systems are used the findings indicate that the elderly farmers are more experienced and proficient in traditional knowledge and its use than younger farmers and hence are more likely to apply this in their farming practices. Firstly, both traditional and modern calendars were used to determine the best planting months for planting kumala. For instance, using a traditional calendar, indicators such as the full moon, or flowering and fruiting of the *navasvas* tree were used. Similarly findings were reported by Roskruge (2007) that Māori used *maramataka* (Māori calendar for fishing & planting) in the production of kumala (See Appendix 5). Secondly, for those using a modern calendar, kumala is planted year- round based on environmental needs of the crop. This finding is consistent with reports about kumala being planted in other tropical or semi-tropical regions taking account of rainy seasons (Abidin, 2004; Bashaasha et al., 1995). Furthermore, year- round cultivation of kumala also depends on the varieties, for instance, some can only be planted from March-June[17].

Traditional knowledge is also used in selecting the planting sites for kumala. The criteria used include: primary forest or fallow land, old yam gardens, and slope areas. These are considered the best because of high soil fertility, less labour requirements, and good drainage. This finding is in agreement with what Māori used in selecting a suitable site for their kumala gardens (Best, 1930, 1976; Roskruge, 2012) . It is common for farmers to use land that was fallow for short time as fallow periods have been reduced due to reasons such as an increase in population pressure on the land (Melteras, 2007). There is also continuous pressure in Vanuatu from agricultural policies, smallholder farmers and contemporary funding agencies for perennial cash crops such as coconut, cocoa, coffee, and permanent cattle pasture (Siméoni & Lebot, 2012). Reduction in fallow periods affects soil fertility which can result in decrease in crop production for example as reported by farmers about the reduction in yam production in Vanuatu (Melteras, 2007). This has established the need to consider inputs of organic or synthetic fertilizers to increase yields of kumala and other crops.

[17] Stated by Tari Molisale, Root Crop Officer, DARD, Luganville (March 28, 2017)

Both traditional and contemporary knowledge were used in land clearing for kumala. This was as expected for example, modern tools were used to clear the land from weeds, shrubs and trees. There is also a traditional belief associated with this practice, which is to allow the soil nutrients contained in the weeds, trees, and vines to return into the soil. This allows the nutrients to be used by the kumala crops later. The waste is left to dry for a few days before soil preparation is done. The waste plant material is then moved to the sides of the garden and are allowed to compost naturally. The majority of the farmers carry out this method of land clearing whilst only a few use the slash and burn method. This provides blending of the two knowledge systems used in land clearance.

Similarly, the results show the use of both knowledge systems in soil preparation for planting kumala. Farmers are increasingly using modern tools to prepare mounds or ridges for the kumala cuttings. Examples of these tools include: spade, hoe, pick and crow bar. These modern tools have the advantage of making work easier and help to increase the area of production. The majority of the farmers prefer to use these tools instead of traditional tools. For farmers who used traditional tools the most commonly used material was *namamaua* sticks, these were used for digging the soil because they are strong and they are also freely available. According to farmers' traditional beliefs, the *namamaua* sticks is used because it is a high yielding tree and its use will contribute to high yields for the kumala. Similar findings were reported by Best (1930, 1976) and Roskruge (2012) about the traditional tools such as *hoto* (blade like spade), *puka* (shape of spade), *akeake*, *kanuka* and wooden spade used by Māori which have been generally been superseded by modern tools/equipment. Moreover, both small and big mounds were prepared and this depended largely on the number of cuttings to be planted. For example, a small number of cuttings were planted on small mounds while a higher number of cuttings were planted in large mounds. The diameters of the mounds ranged from 30 to 70cm and are 15 to 20cm in height. A spacing of 1m x 1m was used by the farmers. This is because it allows good ground cover and reduces weeding times for those cultivars with long vines compared to the bushy cultivars with only short vines. The use of mounds is a common practise across Pacific. In NZ, commercial producers use rows because of scale but non-commercial farmers use mounds (N. Roskruge, personal communication, 23 February 2018).

5.4 Traditional and contemporary knowledge for kumala production

Traditional knowledge and beliefs were commonly used in the production of kumala. It is evident that traditional knowledge was used in the selection and planting of kumala cuttings. Farmers also select cultivars based on their knowledge of each cultivar's attributes. For instance, farmers preferred cultivars with a sweet taste, high yields, high market demand, early maturity and drought tolerance. Attributes of cuttings such as age and leaf count were also identified. These cultivars are generally new hybrids that have been adopted by the farmers in recent years (V.Lebot, personal communication, 16 March 2017). While six kumala cultivars were commonly planted by farmers, there are three that were clearly popular for the market; *Baby*, *Tumanis*, and *Solomon*. The attributes that make these three cultivars superior include; high market demand, sweet taste, early maturity, and drought tolerance. In other producing countries such as Tanzania, farmers also prefer cultivars for attributes such as early maturity, pest and disease resistance, high yield, dry matter content, drought tolerance and elliptic root shape (Ngailo, Shimelis, Sibiya, & Mtunda, 2015). In Uganda new cultivars were adopted because of their maturity period, taste and high yield (Zawedde, Harris, Alajo, Hancock, & Grumet, 2014). In the case of Vanuatu and according to the literature in countries where kumala is cultivated, farmer's in-depth knowledge of each cultivar's attributes and market intelligence were the biggest factors that help them determine the best cultivars to cultivate.

This study also revealed a division of labour involved at the different stages of kumala production in Vanuatu. There are activities specifically assigned to men or women, for example, it is the men's task to clear the land, prepare mounds and planting, whereas women carry out planting, tend the plants and harvesting. These findings concur with practices elsewhere. A division of labour is evident for different crop activities among Māori in New Zealand for example the *rangatira* or chief assigned to a family the responsibility of taking care of the crop or plot (Roskruge, 2007). In addition " the *rangatira,* dressed with modesty, who leads his people as a garden worker with his *ko* or implement stick, a valuable tool of the times" (Roskruge, 2018, para. 13; see also Appendix 7, page 88).

Young men carried out the physical work such as digging and soil preparation and grading of taewa and storage was carried out by women and older people (Roskruge, 2007). According to Ngailo et al. (2015), there are changes in responsibilities and traditional roles in kumala production due to increased market demand and some effects of changes in society e.g. urbanisation. There is also strong participation of men in kumala production (Ngailo et al., 2015). For example, findings in Nigeria have shown more males

participating in kumala production than females (Olagunju, Fakayode, Babatunde, & Ogunwole-Olapade, 2013). This study also revealed that for labour needs, groups comprised of women, men and youths were also engaged. Similarly, in Fiji farmers use *Solesolevaki* (farmer's scheme or work party) for the different activities (I. Leweniqila, personal communication, 12 February 2018). In Chile the women of the Mapuche people (See Appendix 6) look after the crops as their men have left for work opportunities so are not available for agronomic activity (N. Roskruge, personal communication, 22 March 2018). This concurs with a previous finding about Mapuche women being the main player in agriculture (Faron, 1986).

The kumala cuttings for planting are collected from existing gardens using certain criteria. However, it was found that in some instances, farmers have limited knowledge on current problems affecting kumala production in Vanuatu (V.Lebot, personal communication, 27 March 2017) which include the sweetpotato weevil (*Cylas formicarius*) and sweetpotato little leaf [virus] (*Candidatus Phytoplasma aurantifolia).* Therefore, some planting material selected would likely be infested with weevil and/or virus diseases, which ultimately affect plant establishment, growth and production.

Three planting methods were commonly applied. The first method involves planting four fresh cuttings evenly on the mound. The second method uses cuttings that are left in a cool place for a couple of days thus allowing the cutting to wilt and makes establishment easier. Farmers in Uganda also employ the same method of storing the cuttings in a cool place to wilt or pre-root before planting (Bashaasha et al., 1995). Similarly, in New Zealand Māori put the tipu in a mud pool for a day before planting them (Te Warihi Taiapa, personal communication, 11 March 2018). Then 3-4 cuttings are planted in either a slanted or an upright position. These findings are consistent with planting methods used by farmers in Papua New Guinea where two to four cuttings were planted in an upright or slanted position (Kirchhof, 2009). The final method involves planting 3-4 cuttings wrapped in a pawpaw leaf taken from a high yielding pawpaw plant. This is done in the belief that high yields of kumala will be produced like the pawpaw from which the leaf is derived. There are numerous benefits of each of the different planting methods and the main ones are higher yields, crop assurance, and rapid rooting. Many respondents preferred to plant *Baby, Tumanis, and Solomon* cultivars using the first planting method in fallow land because it reduces overcrowding of the roots due to the large tubers these cultivars can produce. In addition, all the cultivars can be planted using the second method in less fertile soils.

The application of traditional knowledge and beliefs were also evident in crop maintenance. For instance, weeding was one of the common practices carried out by farmers and this was done to: promote pest control, allow sufficient sunlight for good root development, avoid competition for nutrients, promote high yields and make the garden look neat. Note this last point is a reflection on their expository status, aligns also to traditional Māori and other Pasifika practices based on orderliness and visual etiquette. Hilling up is another crop maintenance activity that was practiced and this was done to promote good root development, prevent rat damage, and prevent the kumala from turning green. Two weeding rounds were done by the farmers. This is similar to the practice of farmers in Uganda (Abidin, 2004), and also by Māori (Te Warihi Taiapa, personal communication, 11 March 2018). In some production systems three weeding rounds are sometimes carried out as necessary, for example in the highlands of Papua New Guinea (Kirchhof, 2009). Weeding depends largely on the cultivar planted and environmental factors such as rainfall. Another important finding revealed that farmers do not carry out soil fertility, pests, and disease management techniques. A possible explanation for this is limited knowledge that farmers may have. In old times the pressure on land used rotation will have been much less than now. It is also evident that farmers are knowledgeable in specific cultivar needs.

Farmers also have garden taboo[18] and beliefs associated with kumala production, with high yields, and protection against pests and diseases. For example, no unnecessary visits should be made to the garden; women in their menstrual period cannot go to the garden; and talking to the kumala crops are seen as important aspect of farming. Strict adherence to these beliefs and taboos for instance is crucial to avoid bringing bad spirits to the kumala crops and possible contamination to the crops. Similar taboo were also carried out by Māori because kumala is a sacred crop that was especially important as a marginal growing area supported by the gods. When the kumala was planted, it was a major offence for people to trespass the kumala gardens and in some instances people were killed for trespassing (Best, 1976). The kumala gardens were under the god's benevolence or tapu and it was considered a terrible act to make the gods angry (Best, 1930). In Fiji, it is taboo also for other farmers to go to the kumala gardens[19]. Taboos are important from a cultural perspective to protect the kumala crops and obtain a good harvest.

[18] Also referred to as tapu

[19] As stated by Ilisoni Leweniqila, Agriculture Extension Officer, PhD candidate (February 12, 2018)

Traditional knowledge is also used in determining the harvest of kumala crops. The ideal harvesting time of the crop depends on the cultivar planted. Generally, for all cultivars, this occurs when the cracks start appearing on the mounds and the vine colour also indicates tubers. This can be at any particular time period from 2-5 months after planting. These tubers are then harvested by scraping out the soils from the mounds. The farmers also use contemporary tools such as bush knives, spades or other tools to harvest kumala in heavy clay soils. Kumala root selection is also done and this is to identify those ideal for consumption, market, and cultural ceremonies. In addition, one-time harvesting is done for roots intended for the markets while piece-meal harvesting is done for home consumption. The harvesting technique used is vital in maintaining the quality of the roots. Similar findings were reported by Bashaasha et al. (1995) where about one-time and piece-meal harvesting are practiced in the case of kumala in Uganda. Poor harvesting techniques can also lead to losses from decay which reduces the storage period from a food security perspective storage factors and harvest criteria are therefore crucial in maintaining root quality over time.

5.5 Traditional and contemporary knowledge for kumala storage

It is evident from the findings in this study that farmers use their traditional knowledge in the storage of kumala. The methods used include: field, bag or basket storage, and food bed. Similar findings were found about field storage and piece meal harvesting of kumala in Uganda (Ebregt et al., 2007). The most preferred storage method used is field storage because it provides continuous supply of food for farmers' sustenance and easy access to when the crops are needed. Similar findings about continuous supply of roots over time were reported in Uganda (Ebregt et al., 2007) and the availability of kumala during the off season (Motsa et al., 2015a). The field storage method is very suitable when climate is conducive so soil type is important because poor drainage will affect the kumala roots. For example in heavy clay soil, water logging can occur resulting in rotten roots.

Other benefits of using the bag, basket and food bed storage include easy access to food when needed, easy for transport to the market, and sweeter kumala so higher sugar levels which is achieved through curing when starch is converted to sugar. However, there are limitations to the existing storage methods used such as damage by rats, sweetpotato weevil (*Cylas formicarius*) and chickens, decay and sprouting. Based on the findings, it is evident that storage is not considered very important to the farmers. A possible explanation for this is that kumala is cultivated year-round and farmers do not recognize the

importance of storing the crops after harvesting. However, this can be a problem due to the increase in the prevalence of extreme weather events caused by climate change.

Fermentation and pit storage methods were not used by farmers in Vanuatu, yet they could adopt pit storage because it can increase the storage period of kumala compared to the current methods. The adoption of pit storage can help increase the storage period of kumala compared to the current methods. Previous studies have shown that pit storage can extend the shelf life of kumala, for instance in New Zealand kumala can be stored up to 9 months if cured properly (N. Roskruge, personal communication, 9 February 2018). In Tanzania they found that kumala can be stored up to 12 weeks (Van Oirschot et al., 2007) without curing. Similarly, in Nigeria, kumala could be stored for up to 5 months using moist sawdust in a wooden box or in pits with layers of river sand (Dandago & Gungula, 2011), and, in Malawi, pit steps storage extended the shelf-life of kumala to 6.5 months (Abidin et al., 2016).

5.6 Preparation and management of kumala during climate change events

The findings in this study have shown that some practices were applied by farmers in preparation for, and management of, their crops in response to extreme climate change events for example, droughts or tropical cyclones. In preparation for droughts, Vanuatu farmers harvest matured tubers, store water, refrain from weeding, and intercrop kumala with cabbage and banana. The following were carried out to better manage the crops during droughts. When planting the kumala cuttings, only a short portion were exposed, the crops were watered, no weeding was done and only matured tubers were harvested. Respondents stated that they planted early maturing varieties, which have the following flesh: orange, yellow, and purple. This is consistent with the recommendation by DARD[20] for farmers to plant early maturing varieties (T.Molisale, personal communication, 28 March 2017). Furthermore, according to Mael (2013), “early varieties allow planting at the end of the wet season and harvest at the beginning or middle of the dry season” (p.87).

Recent studies also show that kumala is generally drought resistant (Lebot, 2010). This is partly because of its prolific root system, however, in order for sprouting and establishment of the plants, additional irrigation is needed (Leighton, 2007; Mukhopadhyay et al., 2011). Different kumala responds differently to water stress and yields can be reduced (Jaleel et al., 2009). For example cultivars that have small

[20] Department of Agriculture and Rural Development (Vanuatu)

leaves, short stem length, and small canopies are capable of producing higher yields compared to those with broad leaves and long stems (Wilson et al., 1989). A possible explanation could be "the higher yields in small canopy varieties might be a result of plants optimising storage root development and expansion over shoot extension" (Motsa et al, 2015, p.4). Therefore both the traditional and contemporary knowledge is useful for farmers to consider during periods of droughts.

Similar practices were also used in the preparation and management of kumala crops for cyclone season. Farmers harvest and store matured kumala, prepare and store sufficient food supplies and they prune trees growing near the gardens. Kumala tubers stored in short-term storage methods are found to be very useful during the cyclone season, which is from November to April in Vanuatu, as there were generally sufficient supplies for consumption. In addition, saltwater inundation is not a problem in Lorevulko and Sara 1 because in Vanuatu most gardens are established on the first upper plateaus, on tropical soils (V.Lebot, personal communication, 1 March 2018).

However, it was evident that farmers do not preserve any planting materials as a backup if their gardens are destroyed by flooding or strong winds during cyclones. A possible explanation is due to limited knowledge in best practices for dealing with extreme climate events. These practices were carried out by farmers in Papua New Guinea. For example, different sizes of mounds were used in the lowlands, highlands and very highlands to grow kumala[21]. The large composted mounds were used in the highlands mainly for soil fertility, retain heat and reduce soil moisture (Kirchhof, 2009; Taraken & Ratsch, 2009). Similarly, in Fiji kumala were planted in different altitudes and different zones for insurance purposes (I. Leweniqila, personal communication, 12 February 2018). In New Zealand, Māori traditionally have more than one garden for their tribe (N. Roskruge, personal communication, 23 February 2018). These practices serve as a backup for farmers which they can use. Vanuatu farmers can also get planting materials from kumala germplasm that is managed ex-situ in fields at Tagabe and Montmartre on Efate and on Santo at VARTC[22].

[21] As related by Boney Wera, Crop Breeder, NARI, Papua New Guinea (February 6 2018)
[22] Stated by Dr. Vincent Lebot, Scientist, CIRAD, Port Vila, Vanuatu (March 16 2017)

5.7 Contribution of traditional knowledge to sustainable livelihood

Traditional knowledge of kumala also contributes towards sustainable livelihood with food, income and in meeting cultural obligations. It provides a continuous supply of food for the people living in both settings and thus provides and enhances food security. This is consistent with the findings of Minh et al. (2015) about continuous harvesting of kumala and other crops in home gardens. It is also evident that the blending of both traditional and contemporary knowledge systems provides each household with a constant source of income or income opportunity. When the kumala crops are harvested in Vanuatu, farmers sell them in the local markets around Luganville. These findings concur with previous studies by Minh et al. (2015) and Munyua and Stilwell (2013) about knowledge systems improving economies in local communities and improve cash income. It is also important to note that there are other sources of livelihoods that people are involved with such as sale from copra, sale and other crops, cattle, pigs, timber, kava and wages from seasonal work. These additional sources of income help the people adapt to droughts and cyclones or better prepare the people for extreme weather events. This concurs with a previous study about traditional knowledge helping farmers to adapt to climate change (Malekani et al., 2014). Traditional sharing or hospitality in both Lorevulko and Sara 1 also contributes to sustainable livelihoods where kumala are a key food item. Similar results were reported in Aniwa, Vanuatu where villagers share food and shelter with those in need (Wilson, 2013). This is common across the Pacific such as traditional values such as *whanaungatanga* (kinship, togetherness) and *manaakitanga* (hospitality, giving) practiced among Māori in the production of taewa also contributed in sustaining their livelihood (McFarlane, 2007). Traditional knowledge used in the production of kumala also helps meet cultural obligations such as its use in feasts, and in the exchange of gifts during weddings, deaths, and others times.

5.8 Summary

The discussion of this study is important because it will enable a better understanding of traditional knowledge and its use in the production of kumala in Vanuatu. It has shown that there is a blended use of indigenous and contemporary knowledge in the production of kumala. The blending of the two knowledge systems has contributed to optimising kumala production. In addition it also provides food security and contributes towards sustaining people's livelihood. Participants used these knowledge systems in preparation activities such as planting calendar, site selection, land preparation and soil preparation. They also used them in production such as kumala cultivars that are planted, division of labour, planting and crop maintenance. Respondents in Lorevulko and Sara 1 used traditional knowledge in preparation and management of kumala during droughts and cyclones. They also used traditional storage methods for their kumala crops.

The primary question in this study sought to determine whether the use of traditional knowledge of kumala contributes to sustaining livelihoods in Vanuatu. Firstly, the results show that traditional knowledge of kumala contributes to sustainable livelihood of the people by ensuring a continuous supply of carbohydrate food throughout the year and ensuring the availability of planting material and also maintaining the cultural association of crops to livelihoods. Kumala is also the primary food source used in feasts and is also widely used in cultural ceremonies in Vanuatu such as weddings, deaths and other events.

It is evident there is a blending of traditional knowledge and contemporary knowledge, which in the case of the community researched have provided immense benefits for farmers and their community. This is crucial in order to continue to optimise the production of kumala especially in ensuring food security in response to climate change events such as droughts and cyclones. Assimilation of knowledge systems has created a cultural output which is unique to space/ location (spatial context) and also time (temporal context). This provides a good example of cultural dynamics which never stands still and has to respond to environmental and other pressures.

6 Conclusion

Traditional knowledge is widely used in the production of kumala in many countries in both traditional and contemporary societies. In order to answer the question about its contribution in sustaining the livelihood of people living in Vanuatu, firstly, people in both Lorevulko and Sara 1 use traditional knowledge in the pre-production activities of kumala. Farmers are knowledgeable in both traditional and contemporary knowledge and they apply it in the production of kumala through activities such selecting cultivars, the best planting method, and most effective crop maintenance practices. They also know how to prepare and manage their crops as a response to climate change events such as droughts and cyclones. Farmers know that poor harvesting techniques can also lead to produce decay which reduces the storage period of kumala and thus affects food security. Furthermore, in post-production of kumala, Vanuatu farmers generally carry out one-time harvesting for kumala intended for the markets while piece-meal harvesting is done for home consumption. Findings from this study concur with earlier studies about the contribution of traditional knowledge of kumala in sustainable livelihood.

Secondly, previous findings have shown that traditional knowledge improves people's livelihood, helps them adapt to climate change, and manages agrobiodiversity (Malekani et al., 2014). In addition, traditional knowledge is not always used alone but generally in combination with contemporary knowledge. The blending of both knowledge system further improves livelihood, economies, communication in local communities and increased development of community participation (Munyua & Stilwell, 2013). According to Maroyi (2009), from an overarching perspective, traditional knowledge improves livelihoods, brings economic growth, reduces poverty, and improves people's quality of life. It is also evident that it provides food security for the people (Minh et al., 2015). Therefore, this is evidence that traditional knowledge in kumala improves food security in Vanuatu and other countries.

Thirdly, it is important that traditional knowledge is valued and recognised in contemporary societies. Due to its unrecorded nature and limited published literature, this study is unique because it documents traditional knowledge on kumala within Vanuatu society. Previously some aspects of the Vanuatu culture were recorded and kept at the Cultural Centre but this study is one of the first. This is important for future reasons such as food security, identity, language and many more. Finally, at it is evident the use of traditional knowledge in kumala production helps to improve food security and sustainable livelihood in Vanuatu, increased efforts must be made to revive, practise, and document it. In addition, a key output from this study shows the dynamics and evolution of traditional knowledge. The matriarch influence is an important factor to understand going forward. A future issue in succession and transfer

of traditional knowledge between generations is technology. This can contribute to a reduced interest in traditional knowledge. Another future issue is biosecurity threats which can affect the succession and transfer of knowledge between generations.

6.1 Limitations

Though this research has achieved its original aims, there are still some limitations noted. First, due to the time limit, this research was conducted only on a small size of population and certain location within three age groups (young, middle and elderly) in Vanuatu, but it respects the value of what each individual offered especially as this is a new research direction within Vanuatu. Therefore, in order for results to be generalised for larger groups, any future study should involve more participants within the different age groups, and also cover more locations within Vanuatu. Second, the surveys were conducted, in December when all the cultivation activities of kumala were in decline. Therefore, the results should not be generalised or should be interpreted with caution due to the small number of existing kumala gardens covered. Future studies should be done mid-year at the peak of the cultivation period. This study did not focus on gender opportunities so future study can do that.

6.2 Recommendations

The first recommendation is for capacity and capability development for farmers in some areas in the production cycle of kumala. For instance, training is required in the preservation of planting materials and better crop management techniques during droughts and cyclones given that the majority of farmers did not do anything to prepare and manage the crops during droughts and cyclones. Farmers also need training in storage methods. This is important in assisting them to adapt to climate change events that are now becoming a part of their lives and to continue building knowledge base.

The second recommendation is for further research be done to investigate the damage caused by sweetpotato virus diseases to assist farmers make good selection of planting material and so improve production and productivity including the quality of kumala especially in preparation or in response to climate change induced events. The third recommendation is for research on pit storage given its benefits pit storage of kumala can be trialled in Vanuatu to extend the storage period and availability of kumala. Finally, future research on the planting of kumala in different altitudes and different climate zones in order to preserve both the crops and planting materials as a response to climate change would be useful.

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Personal communications

Mr. Aminio David, Officer, Vanuatu Land Defense Desk, Port Vila. March 1, 2018.

Mr. Bergsman Iati, Project Coordinator at Lycée Louis Antione de Bougainville, Port Vila. February 26, 2018.

Mr. Boney Wera, Crop Breeder at National Agricultural Research Institute (NARI), Master Student, Palmerston North. February 6, 2018.

Mr. Buha Laban, Chief, Wusi, West coast Santo, Vanuatu. March 5, 2014.

Mr. Ilisoni Leweniqila, Agriculture Extension Officer, PhD student, Palmerston North, New Zealand. February 12, 2018.

Associate Professor Nick Roskruge, Senior horticulture Lecturer, School of Agriculture and Environment, Massey University, Palmerston North. Various dates.

Mr. Tari Molisale, Root Crop Officer, DARD, Luganville. March 28, 2017.

Mr. Te Warihi (Frazer) Taiapa, Kaumatua (elder), Ngāti Porou tribe, New Zealand. March 10 & 11, 2018.

Dr Vincent Lebot, Scientist, CIRAD, Port Vila. Various dates.

Appendices

Appendix 1: Low Risk Notification Approval by Massey University

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Date: 03 July 2017

Dear Patricia Setak

Re: Ethics Notification - **4000018074** - **Extending the food value of sweetpotato through pit storage in Vanuatu as a response to climate change**

Thank you for your notification which you have assessed as Low Risk.

Your project has been recorded in our system which is reported in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

If situations subsequently occur which cause you to reconsider your ethical analysis, please go to http://rims.massey.ac.nz and register the changes in order that they be assessed as safe to proceed.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:
"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Dr Brian Finch, Director - Ethics, telephone 06 3569099 ext 86015, email humanethics@massey.ac.nz. "

Please note, if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to complete the application form again, answering "yes" to the publication question to provide more information for one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

Dr Brian Finch
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

Research Ethics Office, Research and Enterprise
Massey University, Private Bag 11 222, Palmerston North, 4442, New Zealand T 06 951 6841; 06 95106840
E humanethics@massey.ac.nz; animalethics@massey.ac.nz; gtc@massey.ac.nz

Appendix 2: Individual consent form

CONSENT FORM TO BE PART OF THIS RESEARCH

Extending knowledge system and food value of sweetpotato in Vanuatu as a response to climate change

I'm inviting you to be part of this research that Patricia Setak, a student from Massey University. Ms. Setak is doing this study as part of her Master Degree thesis. Associate Professor Nick Roskruge is supervising Ms. Setak on this research.

Your participation in this study is voluntary. You must carefully read the information contained in this form and you can ask any questions if you are not sure about anything. This is before you can decide whether you will be part of this research or no.

- **Purpose of the study**
  The purpose of this study is to identify the traditional knowledge that are used in cultivation of kumala. And how traditional knowledge has sustain our lives in the past until now.

- **Procedures**
  If you are willing to be part of this study then the following are the procedures that will be used:
  1. You will be asked some questions and will provide answers to them.
  2. Field visits will be carried out to your kumala gardens.

- **Risks**
  If there are risks or discomforts during the survey, these will be minimise and I believe that this will not happen. If you feel bad about a problem then you can stop and not take part in this survey.

- **Potential benefits**
  This study will benefit you because we will preserve traditional knowledge about kumala for the future generations to use.

- **Compensation to take part**
  You will not be compensated when you take part in this study and also it will not cost you anything.

- **Confidentiality**
  The information that you will provide in this survey will be kept with me only and I will not give them to any person. I can only give them away if you give me the right. Due to confidentiality issue there is a number code that will let Ms. Setak and Associate Professor Roskruge to know about you. Your personal information will not be release to any person. In addition collected information will be used by Ms. Setak in her thesis and any other publications only.

- **Participation and withdrawal**
  You can stop anytime when you feel that you cannot continue to be part of this survey.

I have read the information and details of this study were explained to me. The interviewer has answered my questions well, I understand that I can ask more questions if needed to.

- I agree / disagree to have my interview recorded.
- If I choose to be interview, I agree / disagree for my photos to be taken during the interview.
- I agree / disagree for my photos to be taken during this research.
- I agree / disagree for my garden photos to be taken during this research.
- I want/ do not want my photos to be given back to me.
- I agree to be part of this study based on the conditions that were outlined in the information sheet

Signature: _____ **Date:** _____

Name: _____

Appendix 3: Survey questionnaire (Bislama language)

QUESTIONAIRE BLONG OL FARMA

Questionaire yia hem i blong helpem yu mo mi blong mekem wan gud decision blong yumi save continue blong usum ol local fasin blong mekem karen we yumi stap valuem olgeta olsem wan bigfala part blong heritage blong yumi ol Melanesians mo tu ol citizen blong Vanuatu. Ol improve fasin blong farming we ol white man oli karem i kam i mekem se yumi nomo stap usum ol local save blong yumi. Ol new fasin blong faming ya oli kam but yumi save se ol local save blong yumi ya now i been fidim ol pupu blong yumi long taem blong bifo kasem nao ya mo ol save ya oli no spoilem environment blong yumi. I mekem se olgeta questions ya nao bae i helpem yumi blong finem aot ol gudfala save mo ol practices blong kumala we ol farmas oli stap usum long East Santo.

Ol personal infomasen

Nem:

Famli nem:

Yia:

Sex:

Deit:

Village:

Namba kode:

Ol general informasen

1. Wanem nem blong ol crops we yu planem mo namba blong karen we yu gat?

Crops	**Namba blong karen**

2. Yu stap usum ol crops ya blong wanem?

3. Wanem faming system nao yu usum? Mono cropping/ intercropping/ organic / pesticides.

4. a. Tokbout hao yu mekem faming system (Mono cropping / intercropping) (usum organic or ol sprays).

   b. From wanem nao yu usum system ia?

Ol kind kumala we yu planem mo prodaksen blong olgeta

5. Hamas year nao yu been stap planem kumala?

6. Hamas kind kumala nao yu stap planem?

7. Talem nem blong ol kind kumala yia, oli luk olsem wanem mo from wanem nao yu likem olgeta?

Kind blong kumala	**Oli luk olsem wanem**	**From wanem yu likem about kind kumala ya**

8. Yu stap karem ol kind kumala we yu stap planem ya long wea yia?

9. Who nao i talem long yu blong yu planem ol kind kumala ya?

10. Hamas kumala nao yu stap harvestem long ol karen blong yu? (bags/ baskets)

Local save blong planem mo storem kumala

11. Hao now yu chusum wan ples blong mekem karen kumala blong yu long hem?

12. From wanem yu chusum ol ples ya?

13. Wanem nao wok blong ol man mo woman long time blong mekem karen kumala?

14. Explainem fasin we yu usum blong mekem wan karen blong kumala.

15. Wanem local tuls or tuls blong white man nao yu usum blong preparem ples blong karen?

16. Yu stap usum traditional calendar blong planem ol kumala blong yu?

17. Wanem nao something we traditional calendar ya i showem se hem i stret time blong planem kumala?

18. Wanem now ol samthing we yu luk long kumala blong yu taem we yu planem follem traditional calendar?

19. Follem calendar blong white man wanem nao hem i ol stret manis blong planem kumala?

20. a. Expainem hao nao yu planem kumala.

    b. From wanem nao yu planem olsem.

    c. Yu usum wanem kind tuls blong planem kumala mo from wanem?

    d. Yu likem planem which kind kumala usem technique we yu talem ya mo from wanem?

21. a. Wanem nao ol wok we yu mas mekem long karen kumala blong yu?

    b. From wanem nao bae yu mas mekem ol wok ya.

22. Wanem nao ol tabu blong karen kumala?

23. Wanem nao hem i ol stret manis blong diggem kumala?

24. Hao nao yu save se kumala i ready blong yu diggem?

25. Wanem tuls nao yu usum blong diggem kumala?

26. Wanem nao ol storage techniques we yu stap usum after we yu stap diggem ol kumala long karen blong yu?

27. Wanem now ol gud sides blong ol storage techniques ya?

28. Wanem nao ol rabis sides blong ol storage techniques ya?

Ol local save blong kumala long taem blong dry taem mo ol cyclones

29. Wanem nao yu mekem long ol kumala long dry taem?

30. Wanem nao yu mekem long ol kumala long taem blong cyclones?

31. a.Wanem nao somethings we yu save mekem blong preparem yu before dry taem?

b. Wanem nao somethings we yu save mekem blong preparem yu before cyclone i kam?

32. Long experience blong yu, you think se kumala i save fidim yu long dry time mo time blong cyclone. Explainem why nao yu talem olsem.

Preservem kastom save

33. Yu still practisem ol local save ya tedei?

34. Explainem why nao yu talem olsem.

35. Wanem nao somethings we yumi save mekem blong preservem local save blong yumi?

Contribution blong kastom save blong sustainem livelihood blong yu

36. Yu think se kastom save blong kumala i save sustainem live blong yu?

37. Wanem nao ol ways we kastom save i save sustainem live blong yu?

38. Talem ol nara somethings we yu stap usum blong winim mani long hem?

39. Eni nara comments we yu wantem talem.

Appendix 4: Survey questionnaire (English translation)

QUESTIONNAIRE FOR FARMERS

The following is a questionnaire that will help you and I make the best alternative decision for continuation of the traditional practices we value and cherish as a major portion of our heritage as Melanesians and ni-Vanuatu citizens. Due to farming changes brought about by westerners, our traditional knowledge is becoming less practiced nowadays. Despite the innovations our traditional knowledge has successfully sustained our people's through generations past without depleting effects on the environment. The following questions will help us identify the valuable knowledge, information and practices of kumala that are currently available in selected study sites in East Santo.

Demographic data

Name:

Surname:

Age:

Sex:

Date:

Area/ Village:

Number code:

General information

1. What crops do you grow?

Crops	**Number of** gardens (area)

2. What do you use these crops for? (E.g. Home/market/exchange etc.)
3. What are the farming systems that you practice? (E.g. Use of organic or sprays etc.)
4. a. Briefly describe the methods you use?

b. Why do you use the methods above?

Kumala production and cultivars

5. How long have you been cultivating kumala?
6. How many cultivars of kumala do you cultivate?
7. Name the cultivars, describe their characteristics and state the reasons why you like them.

Kumala cultivar	Characteristics	Why do you like about this cultivar

8. Where do you source these kumala cultivars?
9. Who recommend these kumala cultivars for you to plant?
10. What is the yield of kumala that you harvested from your gardens?

Traditional cultivation and storage of kumala

11. What are the criteria that you use to select a site for a kumala garden?
12. Why do you select these sites?
13. What are men and women's responsibilities in kumala cultivation?
14. Explain the method used to establish a kumala garden.
15. What are the local tools or modern tools that you use in site preparation?
16. Do you use a traditional calendar to plant kumala?
17. Identify and explain indicators of this traditional calendar.
18. What is the yields of kumala like when you plant them using a traditional calendar?
19. When is the best month to plant kumala in a modern calendar?
20. a. Explain traditional planting method of kumala.

b. State the reasons for using the above method.

c. Name the tools that you use in planting and give reasons why you use them.

d. Which preferred cultivar will you plant using the above method and why?

21. a. State the maintenance activities that were carried out.

b. State the reasons for carrying out these maintenance activities.

22. What are some garden taboos that are used in kumala cultivation?

23. What are the best months to harvest kumala?

24. How do you know that your kumala are ready for harvesting?

25. What are the tools that you use when harvesting kumala?

26. What are the storage methods that you used?

27. What are the advantages of these methods?

28. What are the disadvantages of these methods?

Traditional practices of kumala during climate change events (droughts, cyclones)

29. How do you manage your kumala crops during droughts?

30. How do you manage your kumala crops during cyclones?

31. a. What are some things that you do in preparation of droughts?

b. What are some things that you do in preparation of cyclones?

32. From your experience, can kumala sustain you during these extreme weather events? Explain why.

Extending traditional knowledge

33. Is this traditional knowledge still practised today?

34. Give reasons to answer above.

35. What are some things that can be done to extend this traditional knowledge?

Traditional knowledge's contribution to sustainable livelihood

36. Can traditional knowledge of kumala sustain your livelihood?

37. What are the ways that traditional knowledge can sustain your livelihood?

38. Name other activities that you used to sustain your livelihood.

39. Any additional comments that you want to make.

Appendix 5: Māori Maramataka. Source: Roskruge (2009)

MARAMATAKA MĀORI CONTINUED

Māori calendar for fishing and horticulture

DAY	NAME	NOTES
24	**Tangaroa piri ā roto**	**He rā pai tēnei ki te ono kai, ki ngā mahi hī ika koura.** A very good day for fishing, crayfish and eels. This is the best day for planting kūmara, taewa and other root crops, in general the best day for any planting in the garden. Also excellent for deep-sea fishing.
25	**Tangaroa ā kiokio**	**He rā pai tēnei ki te ono kai, ki te hī ika, koura, tuna.** A very good day for planting, fishing, crayfish and eels.
26	**Ao tāne**	**He rā pai tēnei ki te ono kai, ki te hī ika, koura, tuna.** A very good day for planting, fishing, crayfish and eels. Also excellent for deep sea fishing.
27	**Ōrongonui**	**He rā tino pai tēnei mō te ono kai hī ika, koura, tuna. He pai mō te waihanga whakaaio.** A very good day for planting, fishing, crayfish and eels. Also a good day for business.
28	**Mauri**	**E hara i te rā pai tēnei he oro mauri te kai ka oma.** Not a very good day for planting or fishing. Fish, eels and crayfish are very elusive.
29	**Ōmutu**	**E hara i te rā pai tēnei.** It is not a good day at all!
30	**Mutuwhenua**	**E hara i te rā pō pai tēnei kua hinapouri te ao e ai ki ngā kōrero ō neke rā.** It is not a good day at all: the world is in darkness!

Appendix 6: Mapuche women standing with potatoes. Source: Roskruge (2018)

Appendix 7: Mural of kūmara [kumala] planting in Māori society
Source: Roskruge, 2018