Australian Government

Australian Centre for International Agricultural Research

Final report

Small research and development activity

project	**Climate change and Pacific food systems: Decision-making for transformational change**
project number	WAC–2019-148
date published	5 May 2021
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approved by	Veronica Doerr, Research Program Manager – Climate Change
final report number	FR2021-010
ISBN	978-1-922635-05-1

published by ACIAR
GPO Box 1571
Canberra ACT 2601
Australia

Contents

1 Acknowledgments

The financial support of the New Zealand Government through the Ministry of Primary Industries for this project is gratefully acknowledged.

The contributions of the following members of the Steering Committee are also acknowledged:

- Lee Nelson (ACIAR Climate Change Associate RPM)
- Hayden Montgomery (Global Research Alliance)
- Tony Banks and Kara Lok (NZ Ministry for Foreign Affairs and Trade)
- David Ugalde (David Ugalde and Associates)
- Margie Eddington (DFAT – Agricultural Development and Food Security)
- Karen Mapusua (The Pacific Community, Land Resources Division)

In preparing, planning and carrying out the Solomon Islands case study and workshop, we acknowledge the support and expertise of:

- Ethel Tebengi Frances (Permanent Secretary, Solomon Islands Ministry of Agriculture and Livestock)
- Cass Grant (Australian High Commission, Honiara)
- Mark Johnston (DFAT Rural Development Program)
- Anabel Lusk, Sean Buckley and Hannah van Voorthuysen (New Zealand High Commission, Honiara)
- Anne-Maree Schwarz (MSSIF Programme Team Leader, Honiara)
- Delvene Boso (Worldfish Centre, Honiara)
- Itziar Gonzalez (FAO, Suva)
- Nichol Nonga (FAO, Honiara)
- Neil Andrew and Hampus Eriksson (University of Wollongong).
- Masoud and Judith Ali-Akbari (The Hilltop Training Institute, Auki)
- Veronica Doerr (ACIAR Climate Change RPM)
- Florence Rahiria (ACIAR Pacific Manager)
- William Aitkenhead (NZ MPI)

2 Executive summary

Background

As global temperatures approach 1.5^{0}C above pre-industrial levels by 2050, and possibly 2.0^{0}C by 2100, the impact of climate change on the Pacific region will accelerate. Local food systems could be drastically affected, exacerbated by population growth and other drivers of change. While there is uncertainty about the timing and extent of these impacts, there is little doubt that these changes could render current food production less viable, and in some cases impossible, while also impacting other food system components such as infrastructure, markets and waste. Many studies have been conducted on Pacific food crops and fisheries, their vulnerability to climate change, and resilience-building strategies. However, there is a lack of decision-making tools that integrate this information and enable stakeholders to anticipate rapid climate change and uncertainty, and to adapt and transform food systems accordingly.

Purpose of the Project

To meet this challenge, in 2019-2020 the Australian Centre for International Agriculture Research (ACIAR) and New Zealand's (NZ) Ministry for Primary Industries (MPI) funded a proof-of-concept Small Research Activity (SRA). The SRA sought to develop innovative participatory decision-making tools that can map transformational options at a regional level to allow exploration and planning for future food systems. These aimed to integrate up-to-date climate projections with scientific and local knowledge of food systems, as well as determine how existing adaptation pathways planning methods could be modified for application in a food *systems* context, which has not been done to date.

Approach

The SRA established a Steering Committee to guide the process, and a Science Committee of Australian and NZ food system researchers to design and test a conceptual approach. A case study was selected in Malaita Province, the Solomon Islands, following discussions with the Ministry of Agriculture and Livestock, and the Australian and NZ High Commissions in Honiara. Central and West Kwara'ae Constituencies and Langalanga Ward, which surround the provincial capital of Auki, formed the case study area. While the primary purpose of the SRA was to develop pathways planning methods suitable for a food systems context, the use of a case study helped to ground this in a practical context and test the attractiveness of these approaches with key decision-makers and stakeholders in one or more Pacific Island Countries.

In September 2019 – March 2020 the science team collated available downscaled climate projections, sea level rise, cyclone risk and population projection data for the case study, plus an inventory of food and commodities produced in the area. The impact of a 'business as usual' scenario of climate change and population growth was modelled using the Assets Drivers Wellbeing Interaction Matrix (ADWIM), looking forward to both 2030 and 2050.

A conceptual approach to planning with these drivers and their impacts in mind was designed based on the 'adaptation pathways' method, which plans for an uncertain future by identifying impacts and assessing and sequencing response options and actions over time. Adaptation pathways specify which measures, both incremental and transformational, are to be taken now and which are delayed until certain conditions occur, and who should implement them. Depending on the decision context, adaptation pathways can vary from planning a suite of technical climate adaptation responses with clear trigger points for shifting from one option to another, to more general 'pathways of

change' for climate resilient development, which include capacity-building for decision-makers to enable the envisioning and implementation of system transformation.

A two day adaptation pathways workshop to provide key decision-makers with an initial introduction to the approach was to be held in Auki in March 2020. With the onset of the COVID-19 pandemic, there were multiple delays and a fully re-designed workshop was finally conducted in November 2020 with remote participation by the science team, and facilitation by local experts. The workshop process was co-designed with the facilitators, and participants were invited from local farmer groups, the Auki Market Vendors Association, women and youth groups, NGOs and provincial and national government departments. The climate and population projection information, pest and disease, alternative production methods and ADWIM modelling results were presented as part of a decision-into-practice learning cycle. Participants described the current food system, assessed drivers of change, their impacts in 2030 and 2050, agreed an aspirational vision for the food system in 2050, and then began to formulate adaptation pathways to reach the vision by re-designing the food system. Instead of focusing on production alone, the pathways approach addressed many aspects of the food system, including resource conservation, marketing, consumption, waste management, education, land disputes and governance.

Key Results, Lessons and Recommendations

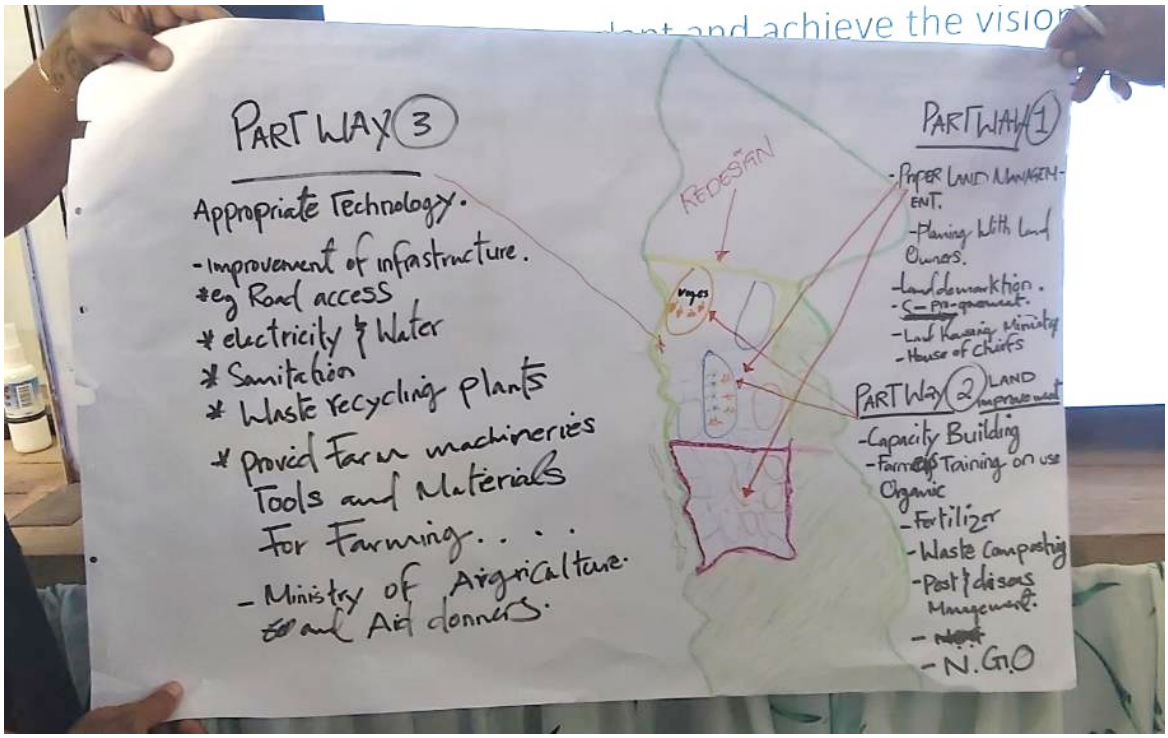
Identifying where transformation is actually needed: The ADWIM results showed that in 2030 and 2050 there would be negative climate change impacts on most food products, but escalating utilisation and land conversion driven by population growth would have a greater negative effect. Most products would experience a moderate decline (<30%). Thus the focus of resulting strategies in the pathways process was less about transforming food production to alternative systems, and more concerned with governing and managing current food growing and harvesting to be more aligned with sustainable intensification (i.e., more integrated, efficient, productive, adaptive and resilient, particularly in response to human population pressure). However, the combined climate and population growth pressures were particularly acute for wild-harvested resources such as inshore and reef fish, with declines >60% projected even as soon as 2030, suggesting that transformation to alternative systems should be explored in these more specific contexts.

Approaches that work at a food systems scale: Through co-production of the workshop approach with the facilitators as well as participant contributions on the day, the pathways process evolved into an identification of broad pathways of change' or thematic areas for reform rather than technical 'road maps'. This suggests that when working at a food systems scale, these broad pathways are an essential starting point. Evaluation of the workshop by the participants suggested that they found the process very valuable and that it significantly enhanced their capacity in terms of understanding food systems, anticipating future change and uncertainty, and engaging with others to catalyse adaptive action. Participants supported the conceptual approach and wished to see follow-up research activities that would refine and deepen the process. Thus, the full process may require linked or nested planning at smaller scales to develop sufficient specificity of actions to drive change.

Participants also recommended that scaling out to other locations could be aided by 'training-the-trainer' through these workshops. This could build a network of knowledge brokers in the Solomon Islands who can apply the method through their professional and community roles. A similar approach in other Pacific island countries could build a community of practice across the region.

The importance of mapping the governance system: Despite scanning of available literature and consultation with various government, donor and NGO stakeholders for the Solomon Islands case study, it was not clear at what socio-political scale food production and food systems are governed, nor how key decisions are made, or by whom. As a result, key decision-makers were missing from the workshop. The approach to mapping the governance system had to be highly modified due to the lack of travel presented by COVID-19, and this result suggests that this may be one aspect of adaptation or transformation pathways work that requires deeper in-country and face-to-face engagement.

Providing longer-term support for pathways planning and action: Finally, it was clear that while participants benefited from workshop participation in terms of building their individual capacity, the ability to specify actions to create change would depend on follow-up workshops. This was not an unanticipated result, and the SRA case study was never intended to provide a full planning process for participants. But given their enthusiasm for the approach once exposed to it, there is a need to consider how to further support them and to ensure that future pathways approaches commenced in other areas are sufficiently resourced to provide the longer-term support required.



An adaptation pathways diagram designed by participants at the Auki workshop, Solomon Islands (*Photo: John Fasi*)

3 Introduction

As global temperatures approach 1.5^{0}C above pre-industrial levels by 2050, and possibly 2.0^{0}C by 2100, the impact of climate change on the Pacific region will accelerate. Local food systems – agriculture, horticulture, fisheries and aquaculture – will be drastically affected, exacerbated by population growth and other drivers of change. It is recognised that there is uncertainty about the timing and extent of these impacts, but there is no doubt that these changes are likely to render current food production less viable, and in some cases impossible, while also impacting other components of food systems such as markets, infrastructure and waste. Consequently, planning is necessary that considers alternatives that go beyond incremental adaptation towards transformational change (see Fig. 1).

Many studies have been conducted on Pacific food crops and fisheries, their vulnerability to climate change, and resilience-building strategies. Climate projections and climate services are rapidly improving, providing better information. However, there is a lack of decision-making tools that integrate this information and enable stakeholders to anticipate rapid climate change and uncertainty, and to adapt and transform food systems accordingly.

To meet this challenge, in 2019-2020 the Australian Centre for International Agriculture Research (ACIAR) and New Zealand's (NZ) Ministry for Primary Industries (MPI) funded a proof-of-concept Small Research Activity (SRA). The SRA sought to develop innovative decision-making tools that can map transformational options at a regional level to allow exploration and planning for future food systems. These aimed to integrate up-to-date climate projections with scientific and local knowledge of food systems.

This report describes the evolution of the SRA, and a process co-designed with stakeholders through a workshop held in Malaita Province, Solomon Islands. The workshop conducted an evaluation with participants which provided proof-of-concept and recommendations for future development of this decision-making approach.

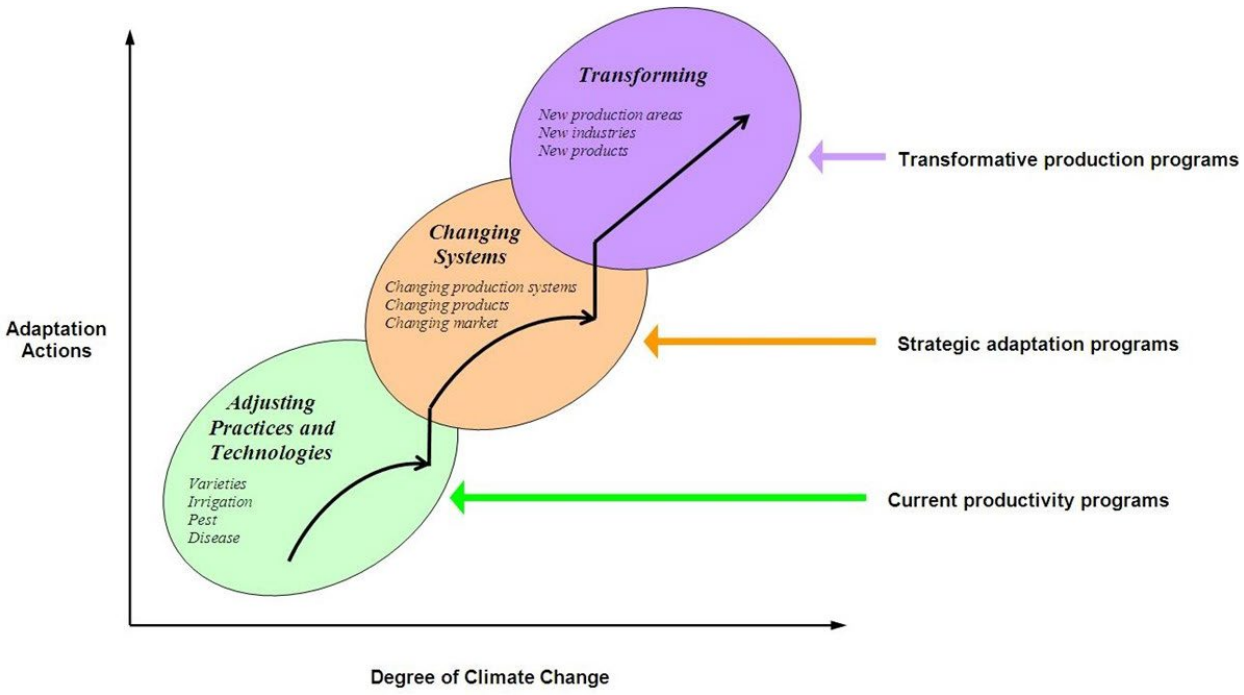


Figure 1. Food systems may have to shift from current to more transformative production systems (figure modified from Howden et al. 2010 by D. Ugalde)

4 Objectives and activities

4.1 Objectives

When initially designed in June 2019, the objectives of the SRA were to:

1. Assess current and required knowledge of long-term impacts of climate change in the Pacific in the context of agricultural livelihoods and food security,
2. Map the identified impacts to broader regional risks, and
3. Develop a framework for designing ACIAR's programmatic initiatives to engage partners in climate change adaptation research and development investments.

Following discussion amongst the project's Steering Committee and Science Committee in July - September 2019, the SRA objectives were refined to:

1. Using island case studies, develop innovative decision-making tools that can map transformational options for future food systems;
2. Integrate up-to-date climate projections with scientific and local knowledge to identify thresholds and strategies that will transform current food systems.

In achieving these objectives, the project would deliver:

1. Information to ACIAR programmes on the long-term impacts from climate change in the Pacific for a planned and systemic response;
2. Material that can guide future long-term research investments and incorporate options for transformational adaptation across ACIAR's programmes.

4.2 Activities

Following re-scoping of the SRA in July-September 2019, activities were refined to:

Activity 1:	Establish a Steering Committee and Science Committee consisting of Australian and NZ representatives.
Activity 2:	Design a draft conceptual approach with the Science Committee for endorsement by the Steering Committee
Activity 3:	Select case studies and engage in-country stakeholders, including Australian and NZ Posts and High Commissions
Activity 4:	Collate previous studies and current knowledge for the case studies, climate and natural hazard data, agricultural and fishery sensitivity data, and prepare material for in-country workshops
Activity 5:	Conduct workshops in the Solomon Islands and Samoa case studies with in-country stakeholders and planners to test and co-develop the approach
Activity 6:	Collate workshop outputs into infographics and communication products
Activity 7:	Conduct a workshop applying the communications products to assess the implications of the results for ACIAR and NZ agricultural and fishery investment, and broader strategic issues
Activity 8:	Produce guidelines for transformational decision-making.
Activity 9:	Final project report and agree next steps for the approach with the Steering Committee and Science Committee

In July 2019 – March 2020, Activities 1 – 4 were completed. An Activity 5 workshop had been organised for the first case study in Malaita Province, Solomon Islands on 12 – 13 March 2020, but due to COVID-19 travel restrictions imposed by the Australian and Solomon Islands Governments, was postponed until 20 – 21 April. Escalation of the COVID-19 crisis necessitated the postponement of the workshop until further notice.

Due to the COVID-19 hiatus, the SRA end date was extended from 30 June to 31 December 2020. In September 2020 a decision was made to limit Activity 5 to one case study workshop in the Solomon Islands, and to carry this out on November 12 and 13 2020. Due to the travel restrictions three local facilitators were engaged to co-design and run the workshop: Pitakia Tikai (Kastom Garden Association), John Fasi (Solomon Islands National University) and Shane Tutua (SME Consulting). On-line contributions would be made by Australian and NZ Science Committee members.

5 Activity 1: Establish Steering Committee and Science Committee

5.1 Steering Committee

On 18 July 2019 a meeting was held with the key Australian and NZ members of the project who had prepared the SRA in June 2019. The aim of the meeting was to:

- Clarify the background drivers for the project
- Share current approaches to climate adaptation in the Pacific
- Clarify the scope of the project
- Identify key partners for the project

From the meeting, James Butler (CSIRO) took over as Project Leader from Lilly Lim-Camacho and Mike Battaglia.

At the meeting it was agreed to establish a Steering Committee and Science Committee consisting of Australian and NZ representatives. Following the meeting the Steering Committee was formed with the following membership:

- Lee Nelson (ACIAR ARPM Climate Change)
- David Ugalde (David Ugalde and Associates)
- Hayden Montgomery (NZ Global Research Alliance)
- Tony Banks (NZ Ministry of Foreign Affairs and Trade - Agriculture)
- Kara Lok (NZ Ministry of Foreign Affairs and Trade - Agriculture)
- Margie Eddington (DFAT – Agricultural Development and Food Security)

At the Pacific Week of Agriculture held in Apia, Samoa on 30 Sept – 2 Oct 2019, David Ugalde met with the Pacific Community (SPC), NZ Ministry of Foreign Affairs and Trade (MFAT), University of the South Pacific (USP) and Secretariat of the Pacific Regional Environment Program (SPREP) to discuss the SRA and its relevance to their work. All wished to be involved in future case study work, particularly in Samoa through the Apia campus of the USP. Following the meeting, SPC nominated Karen Mapusua (Land Resources Division) to join the Steering Committee.

The Steering Committee's agreed Terms of Reference were:

1. Provide input and review for the design and project deliverables presented in the Operational Plan
2. Provide linkages to relevant projects and policy development within their organisations
3. Provide strategic linkages and coordination between this project and other ongoing initiatives in the Pacific
4. Advise on the design of draft outputs to maximise their impact for 2) and 3)

On 27 September 2019 the first full Steering Committee meeting was held at MFAT in Wellington, New Zealand. The draft revised Operational Plan was presented and agreed, and a priority case study in the Solomon Islands was identified subject to DFAT, MFAT and Solomon Islands Government confirmation.

In addition, the Steering Committee agreed that measures of success and 'proof of concept' would be:

1. Applicability in different contexts, proven from two case studies
2. For ACIAR and MFAT: a useful lens to screen current and prioritise future investment
3. For MFAT and DFAT Posts: local buy-in evident
4. For case studies: National Adaptation Plan of Action representatives regard the approach as helpful to the implementation of NAPAs

5. For local decision-makers: evidence of a conceptual shift in the mindset of planners in their approaches to adaptation in agricultural development

5.2 Science Committee

A Science Committee was also formed, initially consisting of the following members with significant experience of working in the Pacific region on agriculture, fisheries and climate change research:

- Steve Crimp (Australian National University)
- Mike Webb (CSIRO Agriculture and Food)
- Leo Dutra (CSIRO Oceans and Atmosphere)
- Ben MacDonald (CSIRO Agriculture and Food)
- Tony Nadelko (CSIRO Agriculture and Food)
- Theresa Wilson (NZ Ministry for Primary Industries)
- Dale Yi (Plant and Food Research NZ)
- Andrew Tait (NIWA Climate Atmosphere and Hazards)
- Suzie Newman (Plant and Food Research NZ)

The Committee's first full meeting was held on 26 August 2019 in Canberra, which included the NZ representatives by video conference. Key steps taken were:

a) Establishment of a Dropbox platform, accessible to all members, for collation of existing climate change, food systems and research studies in the Pacific, and ongoing data generated by the project
b) A draft conceptual approach based around adaptation pathways decision-making, which has been applied successfully in coastal contexts in NZ by NIWA (e.g. Britton et al. 2011)
c) Identifying challenges of suitable down-scaled climate projections, and possible alternatives
d) Gap analysis of data for case studies

This was followed by a second Science Committee workshop held in Wellington on 26 September 2019, which enabled full attendance by the NZ members. The workshop was held the day before the full Steering Committee meeting on 27 September (see above), and had the objective '*to refine methods, sources of data and potential case studies for the proposed project conceptual approach, and plan in-country workshops'*. Key next steps were the inclusion of two new Committee members, Brent Clothier (Plant and Food Research NZ) and Gavin Kenny (MPI), both of whom have extensive experience of agricultural and horticultural systems research in the Pacific.

On 22 January 2020 the Science Committee met in Canberra to carry out a dry-run for the planned Activity 5 case study workshop process, and to identify gaps and refinements of data required. While the conceptual approach for the Solomon Islands workshop had largely been completed at this stage in Activity 2 (see below), the final design of the November workshop was carried out with the in-country facilitators (Pitakia Tikai, John Fasi and Shane Tutua), James Butler and Tony Nadelko (CSIRO), Gavin Kenny (MPI) and Brent Clothier (Plant and Food Research NZ).

The project personnel who were involved through the project are listed in **Appendix 1**.

6 Activity 2: Designing a conceptual approach

Activity 2 designed a conceptual approach with the Science Committee for endorsement by the Steering Committee. Following the Science Committee meetings in August and September 2019, an approach was formulated that would add value to existing research in the Pacific on climate change impacts on food systems, and trial a method of supporting decision-making on how, when and where to transform food systems in response to future change. This aimed to address the following questions:

1. Which food production should be maintained, and which will need transformational change?
2. What strategies are needed to build resilience of current food systems, and what strategies are needed for transformational change?
3. What are the costs and benefits of these strategies?
4. What sequence should strategies be introduced in?
5. How should decision-makers be engaged to implement necessary action?

The approach adopted was based on ‘adaptation pathways’, which is an increasingly popular decision-support tool for achieving objectives under future uncertainty, including climate change (e.g. Haasnoot et al. 2013, Wise et al. 2014, Bosomworth et al. 2017). Adaptation pathways planning prepares for an uncertain future by identifying impacts and assessing and sequencing options and actions over time, which are enacted when certain trigger points are reached. In a plan, adaptation pathways specify which measures, both incremental and transformational, are to be taken now and which are delayed until certain conditions occur, and who should implement them (Kwakkel et al. 2016). By identifying ‘no or low regrets’ interventions which can avoid system ‘lock-in’ or ‘path dependency’, and hence potentially maladaptive consequences, future options and adaptation can be maximised (Reeder and Ranger 2011; Butler et al. 2016a).

Adaptation pathways have been applied to many different contexts, including river flooding (e.g. Reeder and Ranger 2011; Haasnoot et al. 2013), coastal inundation (e.g. Britton et al. 2011; Garcia-Webb et al. 2017) and landscape conservation (e.g. Prober et al. 2017). They have also been applied in development contexts for transforming livelihoods, where the multiplicity of stakeholders involved in decision-making about climate resilient community development creates highly complex planning problems (e.g. Butler et al. 2014, 2016a, 2018, 2020). Across these contexts, adaptation pathways can vary from planning a suite of technical climate adaptation responses with clear trigger points for shifting from one option to another (also termed Dynamic Adaptive Policy Pathways or ‘road maps’), to more general ‘pathways of change’ for climate resilient development, which include capacity-building for decision-makers to enable the envisioning and implementation of system transformation (Werners et al. 2021). While pathways methods have been applied to farmer groups (e.g. Burnham and Ma 2018; Stringer et al. 2020), an approach has yet to be developed for food systems or regions in developing countries. The closest parallel has been a method trialled in NZ’s Hawke’s Bay, which identified adaptation strategies and an implementation ‘road map’ of options generated by a participatory process with stakeholders (Craddock-Henry et al. 2020).

An initial heuristic for how an adaptation pathways ‘road map’ might be visualised for local food production in Pacific island countries was developed by the Science Committee to generate discussion (Fig. 2). This conceptualisation identified commodities and production systems that are resilient to future climate change, those that are not and require transformation, and those which may emerge as feasible under new conditions. This includes key trigger points where alternative strategies should be actioned, resulting in either in the maintenance of current production or transformational change. However, this conceptualisation did not include broader food system issues.

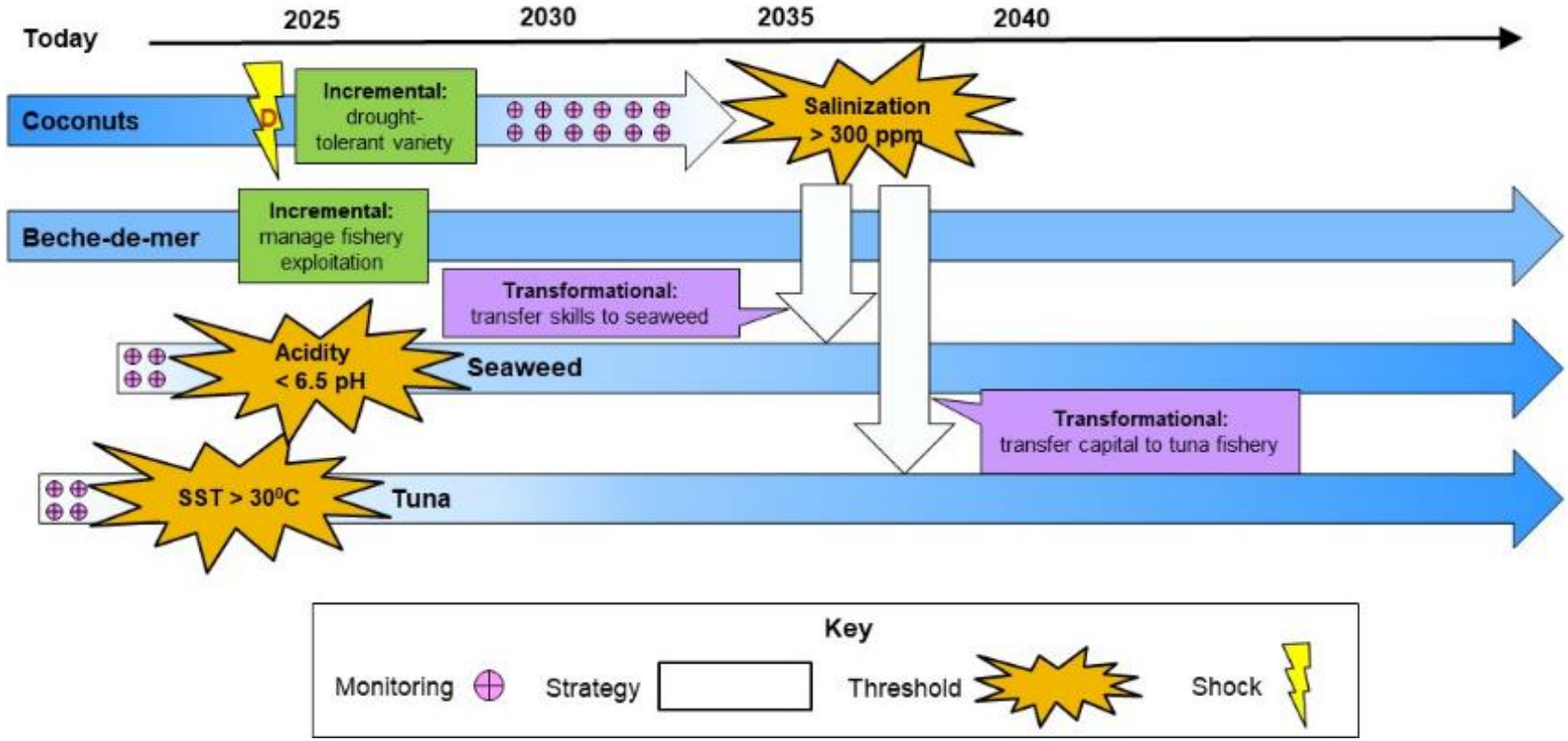


Figure 2. A heuristic pathways 'road map' for a food production system in the Pacific, applying the concepts in Fig. 1. In this example, coconuts may eventually become unviable due to salinization of soils caused by sea level rise after 2035. Droughts may also shock production in the short term. Incremental strategies (e.g. introducing drought-tolerant cultivars) could enable coconut production to be maintained though these shocks until the critical threshold of salinization occurs. Indicators must be monitored that can anticipate the threshold being reached, and transform production into other climate-tolerant commodities. Here, seaweed and tuna may become viable as climate thresholds are passed that favour their production. Transformational strategies could shift farmer skills in coconut growing to seaweed, or shift government capital investment into the tuna fishery. Beche-de-mer, however, may not be impacted by climate change, but is affected by growing fishing pressure. To maintain beche-de-mer production, incremental strategies such as managing exploitation rates driven by human population growth may be important.

Rather than focus on individual food commodities, Craddock-Henry et al. (2020) analysed production systems in two Hawke's Bay catchments in order to develop a regional list of options for agricultural adaptation to climate change. Over 14 months they carried out a participatory, multi-stakeholder planning process which engaged producers from different farm types, government officials from different levels, community and Māori groups to address four questions:

1. What are the likely impacts of climate change for primary producers in Hawke's Bay and how might these impacts be affected by other, non-climatic stressors?
2. To what extent is primary production vulnerable to these impacts?
3. How and when can production adapt to expected impacts?
4. How can adaptation pathways be used to support decision-making and enable stakeholders to take adaptive action?

Activities were organised around four steps:

- Define the objectives and desired outcomes for food production (through three workshops in each catchment);
- Understand the current situation (through mapping of production systems and climate change impacts in the workshops, and then generating a systems dynamics model)
- Analyse possible futures (from downscaled climate projections, interviews with experts about potential impacts and crop modelling used to create potential future scenarios to be used in workshops)
- Develop a Dynamic Adaptive Policy Pathways 'road map' for the region (by integrating the information from the catchment workshops in two regional workshops to identify adaptation options and their timeframes for the region).

A key element of pathways approaches geared to building stakeholder capacity is the need to engage multiple decision-makers in social learning that can integrate knowledge types and catalyse collective momentum for change. In the field of community development, various participatory approaches have evolved to achieve this, based on social-psychology and behavioural science. One of these is Brown and Lambert's (2015) decision-into-practice social learning steps. Butler et al. (2015a, 2016b) adapted these steps to construct livelihood adaptation pathways in emerging economies where climate change intersects with numerous other drivers, creating highly complex decision-making environments, and capacity for action is limited. Subsequent evaluation has indicated that the process is simple and cost-effective, and generates new knowledge and innovation, enhanced social networks and partnerships, and motivation to act (Butler et al. 2015a; 2016c).

The above three approaches formed the basis of our conceptual method. Craddock-Henry et al.'s (2020) questions were woven into Brown and Lambert's (2015) decision-into-practice cycle (Fig. 3) to form a workshop process. A key departure for this SRA, however, was to expand the analysis to a food system, rather than production systems alone.

The intent of the SRA was to develop the methodology and use the case study to test its broad local acceptance rather than conduct a full planning process as Craddock-Henry et al. (2020) did in Hawke's Bay. Due to severe time and logistical constraints caused by the COVID-19 situation, the testing of local acceptance and refining the methodology for local context could only be done in one case study through one workshop. Thus, the process had to be simplified considerably. This was also important in order to deliver the abstract pathways concepts at an appropriate level for the participants, who were likely to range from local farmers to government officials and NGO staff. To achieve this, the workshop activities were co-designed with the workshop facilitators, and with the input of the United Nations Food and Agriculture Organisation (FAO) Solomon Islands office and the WorldFish Centre during the preparation for the original March workshop.

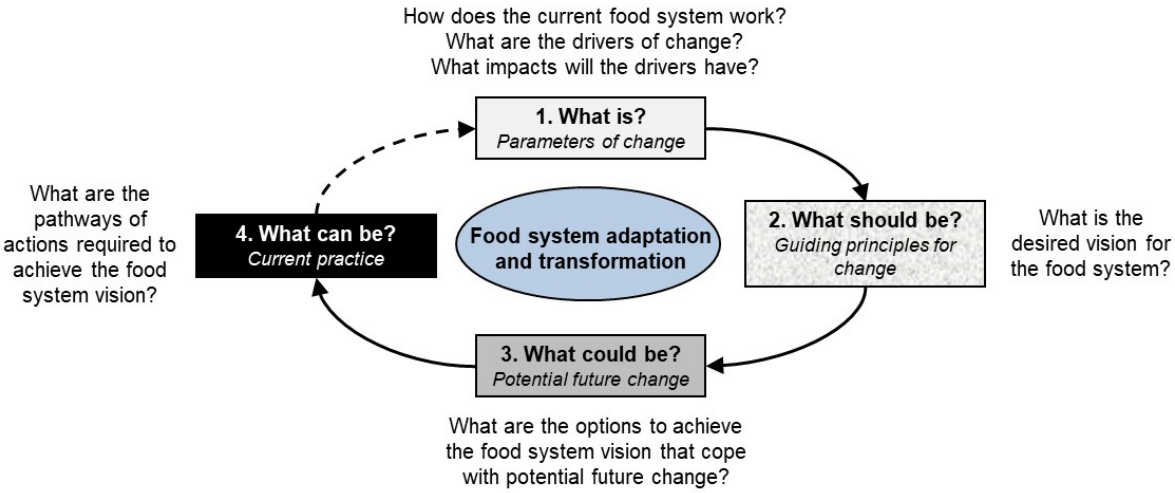


Figure 3. Brown and Lambert's (2015) decision-into-practice social learning cycle and steps, adapted to the question of food system adaptation and transformation for this project

There were two other important considerations that guided the conceptual approach. First, a relevant geographical scale of analysis of food systems had to be found. The decision was made to focus at the 'ridge-to-reef' scale, which would complement the well-established process of integrated landscape planning and management which has become standard practice in the Pacific (IUCN 2004). Although Craddock-Henry et al. (2020) used catchments as their scale of analysis, most river catchments in the Solomon Islands, and Pacific islands in general are very small, and therefore this is probably not practical in many cases.

The second consideration was how to identify and engage with decision-makers in food systems, and which planning and decision-making arenas the project should link with. Since adaptation pathways are fundamentally targeted at decision-making it is important to initially understand the governance of food systems and the processes that the approach will aim to influence. However, despite scanning of available literature and consultation with various government, donor and NGO stakeholders for the Solomon Islands case study, it was not clear at what socio-political scale food production and food systems are governed, nor how key decisions are made, or by whom. Instead, we anticipated that a ridge-to-reef geographical scale was likely to capture two levels of local government within its boundaries (constituencies and wards), and subsequent evaluation of the process would clarify whether this was the most relevant geographical and governance unit for a pathways process to be targeted at.

Ultimately the workshop process was structured into five sessions over two days, following Brown and Lambert's (2015) decision-into-practice cycle (Fig. 3, Table 1). Each session was deliberately designed to engage local decision-maker's knowledge, augmented by information and knowledge provided and presented by the science team and facilitators. Participants would conduct activities to answer the question posed by each session, delivering outputs in the form of diagrams and tables. The final output was prioritised actions constructed into pathways tailored to future impacts of drivers of change, in order to reach the desired vision for the food system in 2050.

Table 1. The pathways workshop process, conceptual basis, information and knowledge types involved, and anticipated outputs

Session	Decision-into-practice step	Local knowledge	Expert information and knowledge	Anticipated outputs
Session 1. How does the food system currently work? What are the main products? Who grows or catches the food, and where?	**Step 1.** What is? (*parameters of change*)	Participant's knowledge of the food system	Definition of a food system, maps of geography and landuse	Diagrams of the key elements of the food system
Session 2. What are the drivers of change for the food system?	**Step 1.** What is? (*parameters of change*)	Participant's knowledge of current drivers of change experienced locally	Downscaled climate change projections, population growth, nutrition and health status, pests and diseases, potential new food production systems (e.g. alternative crops, nutrient management, circular bio-economies, waste management)	Food system drivers of change prioritised by importance
Session 3. What will be the impacts of climate and other drivers on the food system?	**Step 1.** What is? (*parameters of change*)	Current impacts of drivers on the food system; valuation of key commodities and ecosystem goods and services; potential thresholds or 'tipping points'	Modelling of potential future climate and population growth impacts under 'business as usual' scenario on key commodities and ecosystem goods and services; identification of possible future alternatives; potential thresholds or 'tipping points'	Diagrams of most significant vulnerabilities and impacts on food systems, including timelines and potential thresholds or 'tipping points'
Session 4. What is the 2050 vision for food production and the food system	**Step 2.** What should be? (*guiding principles for change*)	Desired food system characteristics for participant's children or grandchildren		Descriptions of desired food system characteristics and values embedded within the vision for 2050
Session 5. What are the options to adapt and achieve the vision for 2050? Can we plan pathways towards the vision?	**Step 3.** What could be? (*potential future change*) **Step 4.** What can be? (*current practice*)	Options and priorities for adapting to the impacts and reaching the 2050 vision, including when actions should happen, stakeholders to be involved, and potential winners and losers	Guidance on constructing adaptation pathways	Prioritised pathways of actions tailored to future impacts of drivers of change, drawn into tables and diagrams of the food system or geography

7 Activity 3: Select case studies and engage in-country stakeholders

Activity 3 focussed on selecting case studies and engaging in-country stakeholders, including Australian and NZ High Commissions. Following earlier consideration by the Science Committee, the Steering Committee meeting on 27 September refined the selection criteria to:

- Comparison of good existing data with poor data
- Comparison of 'high' island versus coral atoll
- Strong existing local partnerships
- Potential to value-add to existing ACIAR, DFAT and NZ projects
- Potential to value-add to other donor's projects

Based on these criteria, four potential case studies were identified:

1. Solomon Islands (good data, high island, good connections, 10-year Agricultural Investment Strategy being completed in June 2020, PHAMA Plus funded by NZ and Australia, NZ Aid's Strengthening Tilapia Farming in Solomon Islands program)
2. Kiribati (poor data, coral atoll, good connections, ACIAR projects, NZ priority)
3. West New Britain Province, PNG (good data, high island, good connections, Market Development Facility funded by Australia)
4. Savai'i Island, Samoa (high island, good data, USP and cocoa grower support)

Considering the SRA's time and budget limitations, it was decided to focus on the Solomon Islands in March 2020, possibly followed by Savai'i Island, Samoa, with additional funding mooted by MPI in July-August 2020.

In October – November 2019 the Australian and NZ High Commissions were engaged to advise on priority locations within the Solomon Islands. They contacted the Solomon Islands Ministry of Agriculture and Livestock who recommended that Malaita Province should be the focus (Fig. 4), as it is a high priority within the 10-year Agricultural Investment Strategy which was due to be completed in June 2020, and the project outputs could be integrated into the Strategy. In addition, NZ Aid have been supporting food system projects in the province (e.g. the Strengthening Tilapia Farming in Solomon Islands program), while the WorldFish Centre and the FAO have been running fisheries, nutrition, market and value chain projects there since 2010 in collaboration with SPC. Most recently, the Worldfish Centre is delivering the ACIAR project *Agriculture and fisheries for improved nutrition: integrated agri-food system analyses for the Pacific region* (FIS/2018/155), which is focusing on Malaita Province in collaboration with the University of Wollongong.

In December 2019 – February 2020 Worldfish, FAO and the University of Wollongong were engaged to identify a ridge-to-reef case study within Malaita Province, which would add value to their existing and future projects. They recommended the peri-urban area around the provincial capital, Auki, with a specific focus on the constituencies of West Kwara'ae and Central Kwara'ae, and Langalanga Ward. The Worldfish Centre and FAO also assisted in organising logistics, designing the workshop agenda and identifying and inviting key stakeholders. The workshop was initially planned for 12 and 13 March 2020 but following COVID-19 travel restrictions was postponed until 20 and 21 April. Finally, it was held on 12 and 13 November at the Hilltop Training Institute, Auki.

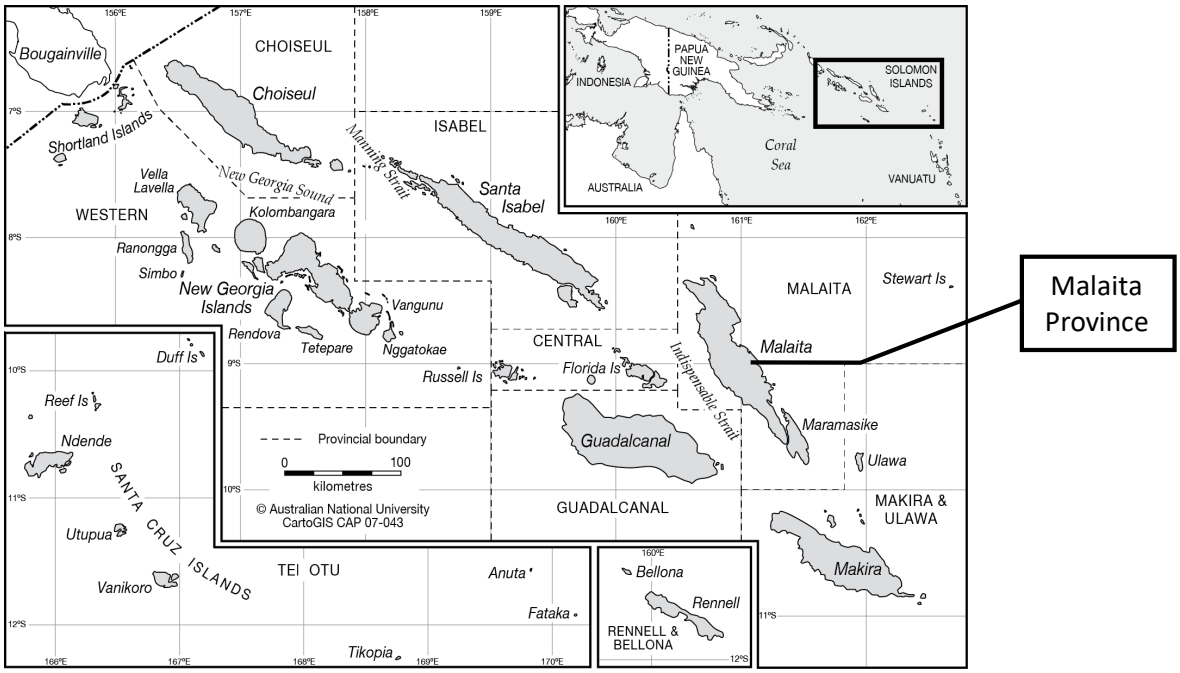


Figure 4. Malaita Province in the Solomon Islands

8 Activity 4: Collate current knowledge, climate data and prepare material for in-country workshops

In Activity 4 the Science Committee collated previous studies and generated the scientific information necessary to be integrated into the Malaita workshop process as expert knowledge (see Table 1). This included downscaled climate change projections, natural hazard data, sea level rise projections, population data and projections, and data on the sensitivity and potential impacts of drivers of change on agricultural and fishery production. Potential alternative crops and production systems were also collated based on the team's expertise and scientific literature. Much of the Pacific regional data collated and analysed would also be potentially applicable to future case studies. Details of the data prepared and presented in the workshop sessions are described in this section.

8.1 Session 1: How do food systems currently work? What are the drivers of change, trends and pressures? What is current land/sea use?

The case study site consisting of West Kwara'ae Constituency, Central Kwara'ae Constituency and Langalanga Ward form the peri-urban food growing area surrounding the provincial capital, Auki. As in the rest of Malaita, this case study site follows a ridge-to-reef form (Fig. 5). The case study site has a total land area of 534 km^2 and had an average population of 34,248 at a density of 64 persons/km^2 in 2009. This was made up of:

- West Kwara'ae with an area of 309 km^2 and a population of 15,053 at a density of 49 persons/km^2
- Central Kwara'ae with an area of 215 km^2 and a population of 17,273 at a density of 80 persons/km^2
- Langalanga Ward, one of two wards in Auki-Langalanga constituency, with an area of 9 km^2 and a population of 1,922 at a density of 204 persons/km^2
- Auki township in Auki-Langalanga Constituency with 4 km^2 area and a population of 5,105 at a density of 1,150 persons/km^2.

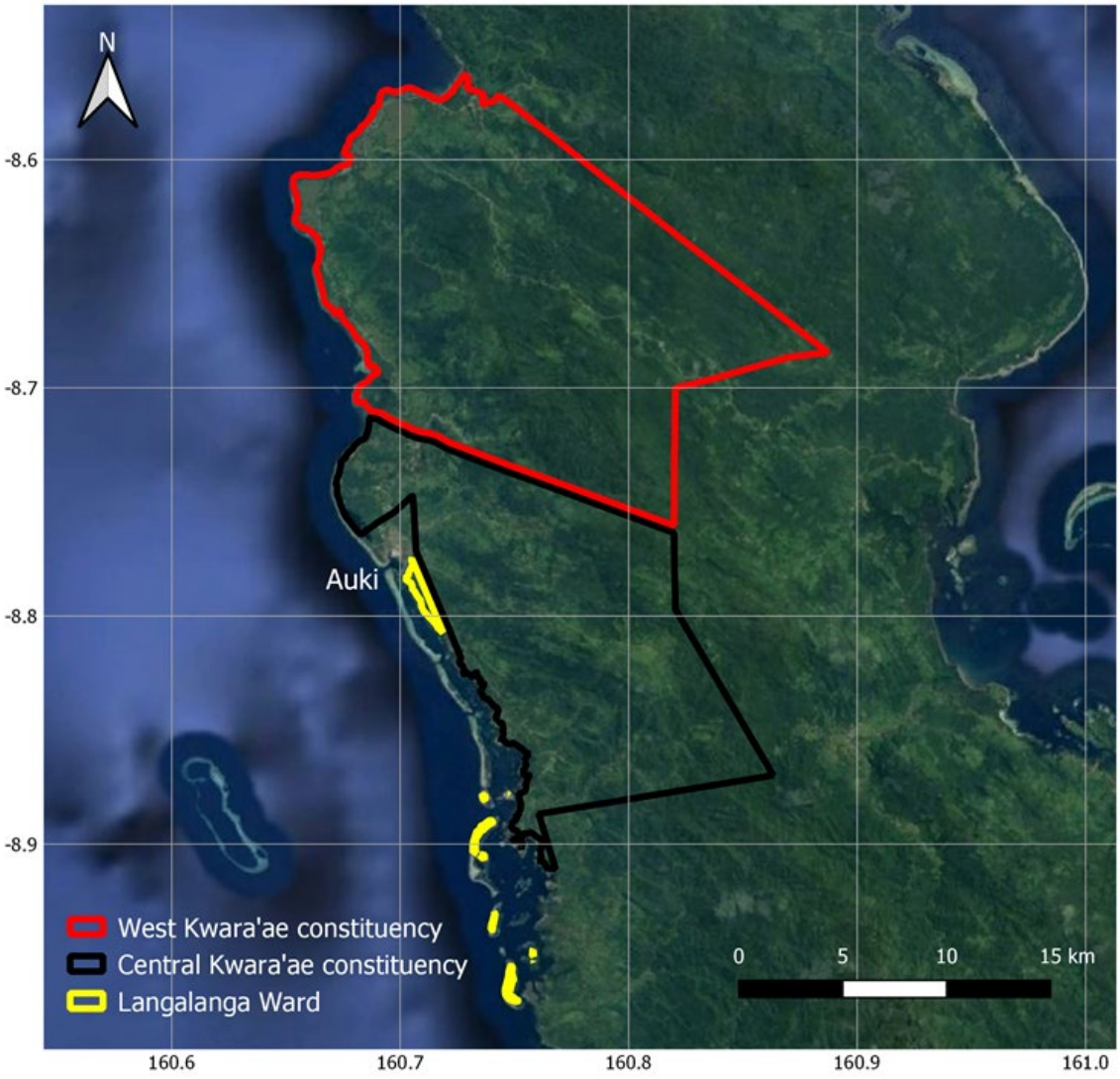


Figure 5. The case study locations of Auki town, West Kwara'ae Constituency (top), Central Kwara'ae Constituency (bottom right), and Langalanga Ward (bottom left), Malaita Province

Land use maps obtained for 1974 and 2010 showed that there has been significant expansion of agricultural activity in Central Kwara'ae, but this was less evident in West Kwara'ae, where the upper catchment remained relatively unchanged (Fig. 6).

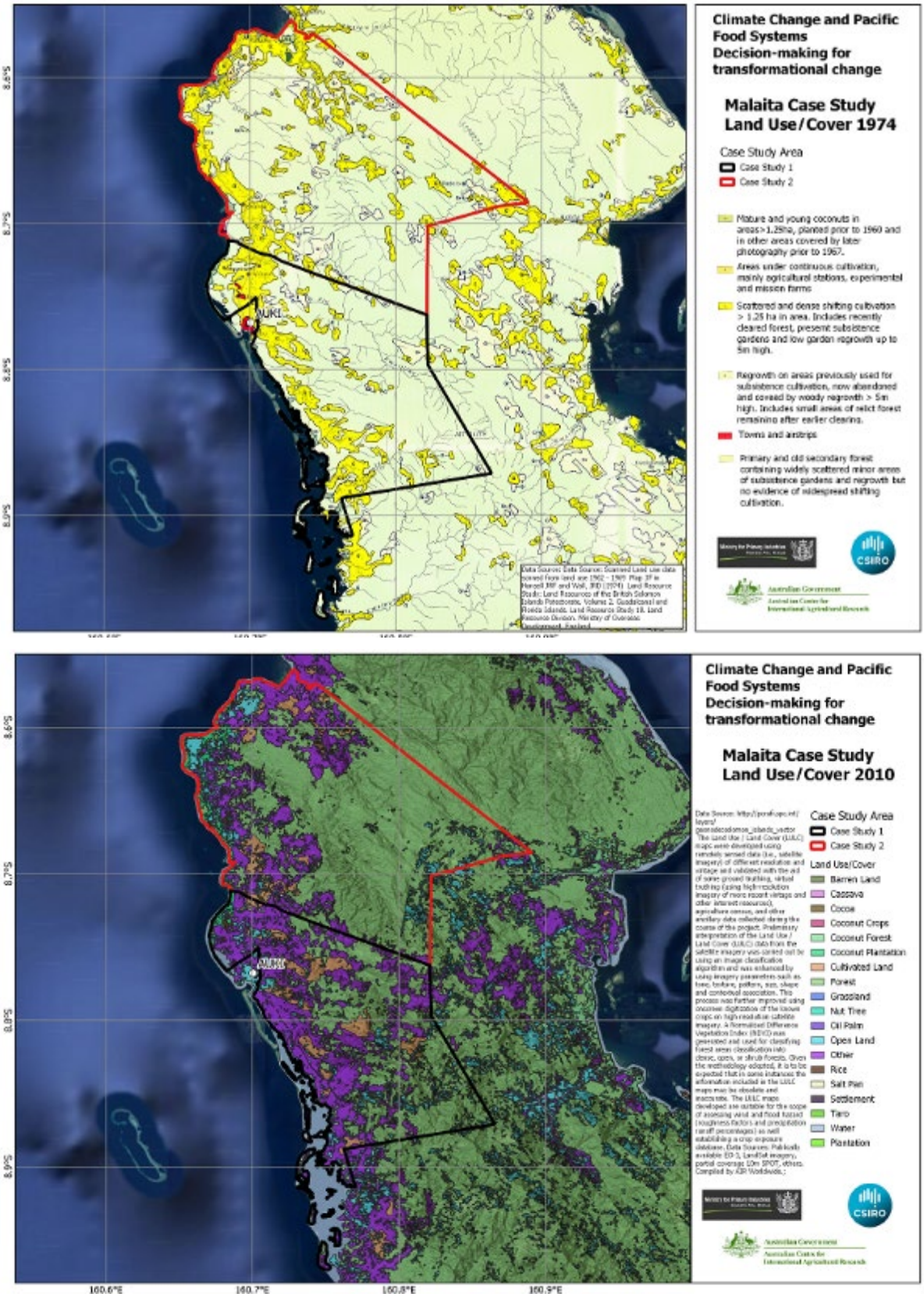


Figure 6. Land use maps for Central Kwara'ae and West Kwara'ae in 1974 (above) and 2010 (below).

8.2 Session 2: What are the drivers of change for the food system?

Climate change

Climate change projections and potential impacts on agriculture and fisheries have been collated and applied by various studies in the Pacific (e.g. Bell and Taylor 2015, Bell et al. 2016, Taylor et al. 2016). In these regional analyses general trends have been highlighted and their implications for food production and food systems, including greater extremes and variability, more intense weather events (storms, rainfall and drought), sea level rise and ocean acidification. However, for the purposes of a specific geographical location at the sub-island scale, more spatially-explicit data were required.

Consequently, up-to-date climate change projection data for the Pacific region were reviewed and tested to assess their suitability and useability for the Malaita case study and the purposes of the adaptation pathways planning process and tools. It was found that data are available at a wide variety of spatial scales across the Pacific. The scale of host general circulation models (GCM) data is 200 to 500 km, which is too coarse to resolve the terrestrial climate of the much smaller case study area, which has steep terrain and therefore likely climate gradients. However, the marine data is adequate due to its much lower spatial variability. Several sources of downscaled climate change data are available at spatial scales as fine as 30 m. These datasets each have different advantages and disadvantages due to their different spatial and temporal scales, climate variable limitations and access limitations:

a) CSIRO Conformal Cubic Atmospheric Model (CCAM) 8 km downscaled projections:

- Advantages
  - existing dataset available for Solomon Islands
  - range of air temperature and rainfall variation captured well
  - includes sea surface temperature and wind speed
  - spatial scale of 8 km grids suitable for case study area focus
- Disadvantages
  - may not include sea level rise or ocean acidification data
  - existing data only includes 1990, 2055 and 2090 projections
  - existing data only for 3 GCM's from superseded CMIP3 ensemble and one emission scenario (SRES A2 High or Business as Usual scenario)
  - costly and time consuming; specialist capability and high-performance computing infrastructure required to generate data that does not already exist

b) Climate Change, Agriculture and Food Security (CCAFS) 1 km downscaled projections (http://ccafs-climate.org/):

- Advantages
  - existing open-access global datasets delta-scaled from WorldClim baseline data
  - fine spatial scale relative to case study area size
  - 33 GCM's and multiple CMIP5 ensemble scenarios available
  - 2030, 2050, 2070, and 2090 projections available
- Disadvantages
  - range of air temperature and rainfall variability not captured well
  - does not include sea surface temperature, sea level rise, ocean acidification or wind speed data

c) WorldClim 1 km downscaled projections (https://worldclim.org/data/index.html):

- Advantages
  - existing open-access global datasets delta-scaled from WorldClim baseline data
  - fine spatial scale suited to case study area size
- Disadvantages
  - terrestrial data only, does not include sea surface temperature, sea level rise, ocean acidification or wind speed data
  - range of terrestrial air temperature and rainfall variability not captured well
  - only 9 CMIP6 ensemble GCM's available, 2030, 2050, 2070, and 2090 projections
  - only 19 CMIP5 GCM's available, 2050 and 2070 projections

d) Pacific Climate Change Science Climate Futures (Pacific Climate Futures v2.1, https://www.pacificclimatefutures.net):

- Advantages
  - existing open-access datasets from host GCM's
  - 2020 to 2090 projections at 5-year intervals available for most CMIP3 and CMIP5 GCM ensembles and emission scenarios
  - GCM model ranking available
- Disadvantages
  - data is integrated to the spatial scale of country exclusive economic zones (EEZ)
  - range of air terrestrial temperature and rainfall variability not captured well
  - only relative change data available, need to apply baseline data
  - sea surface temperature, sea level rise and ocean acidification data only available for CMIP3 A2 scenarios and in graphical form

After consideration of the relative advantages and disadvantages, the CSIRO CCAM data were applied because the dataset was available for the Solomon Islands, and the 8 km gridded data enabled some finer scale resolution projections for the case study area, and captured the possible climate gradients from ridge-to-reef. Also, because CCAM is based on the SRES2 High Global Emissions scenario, it represents a 'business as usual' or worse case prediction of more extreme change. However, the disadvantage was that the projections were only available for 2055 and 2090, and because only three GCMs were available there was limited ability to analyse future uncertainty in the projections.

Data indicate that under the business as usual emissions scenario mean surface temperatures are likely to increase in the two constituencies from approximately 25.5^{0}C to 28.5 ^{0}C by 2090 (Fig. 7). Spatially, temperatures will be higher along the coastal lowlands relative to the upper catchments (Fig. 8). Annual rainfall, however, is projected to decline by mid-century by approximately 500 mm (Fig. 9). Spatially, any changes in mean daily rainfall appeared to be consistent within the constituencies (Fig. 10).

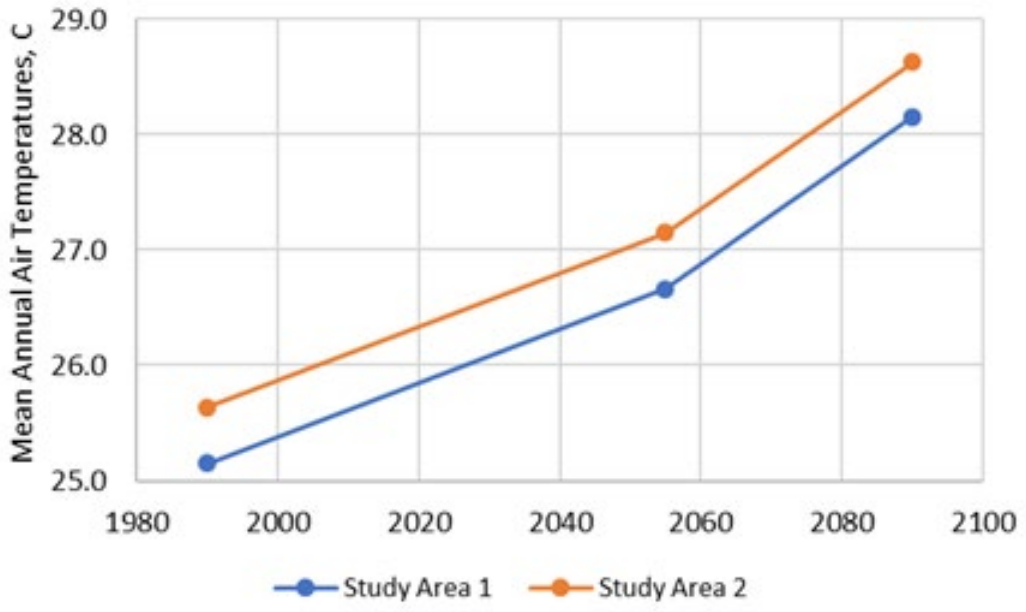


Figure 7. Downscaled CCAM data for northern Malaita Province and the case study constituencies (Study Area 1 is Central Kwara'ae and Study Area 2 is West Kwara'ae), showing changes in projected annual mean surface temperature

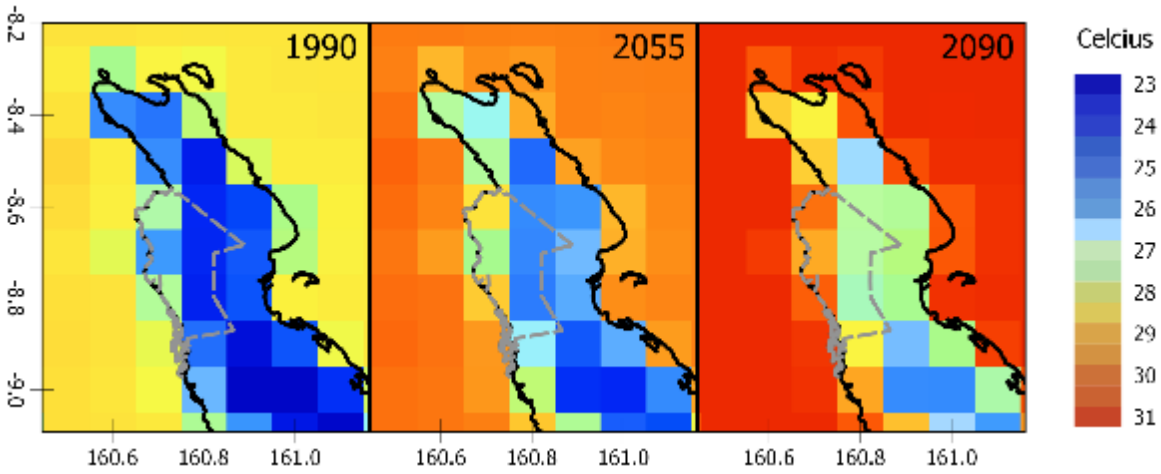


Figure 8. Downscaled CCAM spatial data for northern Malaita Province and the case study constituencies showing annual mean surface temperature in 1990, 2055 and 2090, within 8 km grids

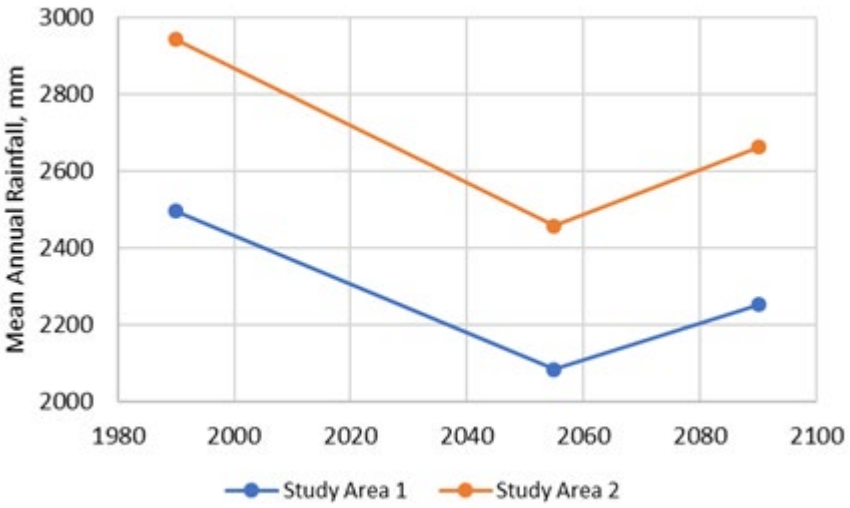


Figure 9. Downscaled CCAM data for northern Malaita Province and the case study constituencies (Study Area 1 is Central Kwara'ae and Study Area 2 is West Kwara'ae), showing changes in projected annual mean rainfall

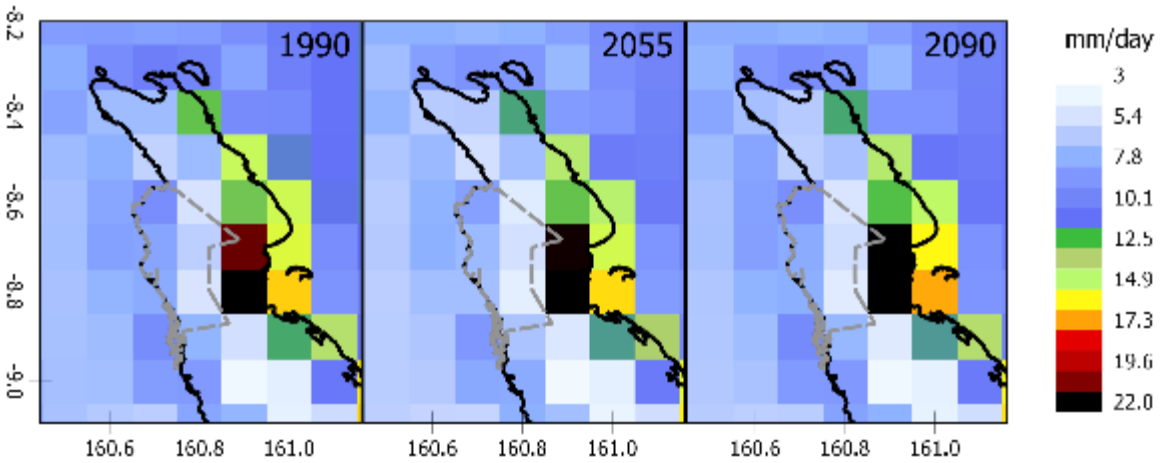


Figure 10. Downscaled CCAM spatial data for northern Malaita Province and the case study constituencies showing daily mean rainfall in 1990, 2055 and 2090, within 8 km grids

Sea level rise

Digital elevation model (DEM) data is required to calculate areas of land inundated due to sea level rise (SLR). Several open-source DEM's from earth-orbit measurement missions are available at spatial resolution as fine as 30 m. These DEMs are suitable for small scale topographic applications such as the case study area, but do not have the vertical resolution or accuracy required for determining land inundation from SLR.

DEM's with high vertical and spatial resolution and accuracy can also be generated locally such as from airborne LIDAR. However, these DEM's are costly to produce, or if existing, are proprietary. No such data was available for the case study area.

CoastalDEM is a licenced DEM covering global coastal zones at 30 m spatial resolution and with adequate vertical resolution and accuracy for SLR applications. It was derived by re-processing the Shuttle Radar Topography Mission (SRTM) DEM to provide ground surface elevation relative to local mean higher high tide levels by removing the elevation artefacts of vegetation and structures. The licence fee is free only for non-commercial users, and the CSIRO licence permits internal use only. As this was the only option, case study inundation areas from SLR projections were estimated using the SRTM DEM with

an elevation offset applied to provide similar results to that using CoastalDEM, referred to as the ‘bathtub’ approach.

Results of this bathtub analysis of apparent 10 m surface (i.e. treetop) elevation, which approximates at 2 m ground elevation, showed that coastal areas at risk with SLR of 1 m and 1 m storm surge are potentially significant (Fig. 11). These areas could be exposed to salinization of soils, and flooding during extreme storms events. More detailed flood mapping is available for urban areas provided by the Climate Central Coastal Risk Screening Tool (https://coastal.climatecentral.org/). Data analysed for Auki township showed that by 2090 much of the coastal strip would be inundated, including the Auki Central Market (Fig. 12), which has implications for food access and distribution. However, due to the wide variations in predictions for rates of SLR globally and within the Pacific region, it is difficult to overlay accurate timelines for these inundation projections.

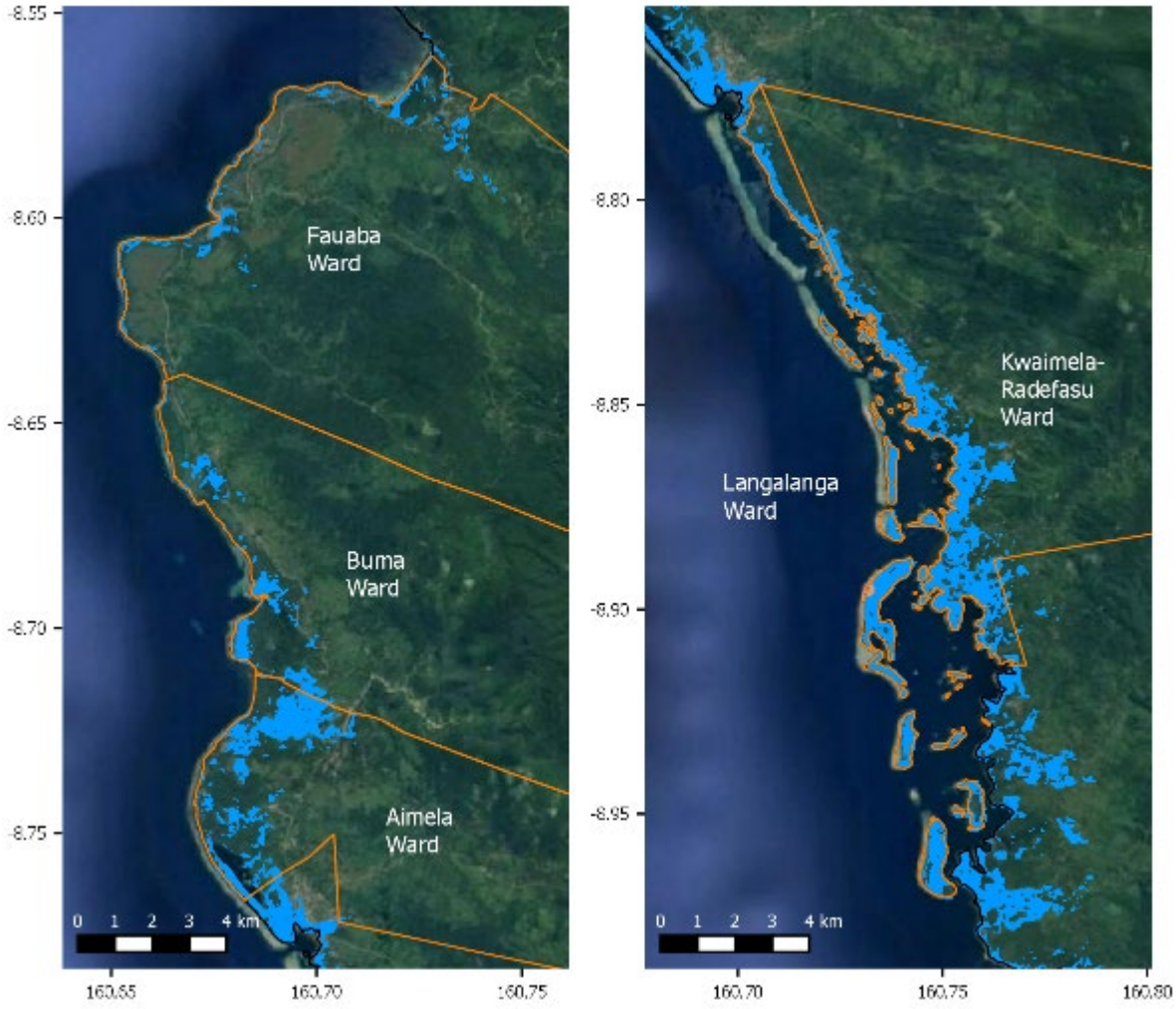


Figure 11. Bathtub estimates of the coastal zones potentially worst affected by 1 m SLR and storm surge inundation in the case study area, showing West Kwara’ae (left) and Central Kwara’ae (right)

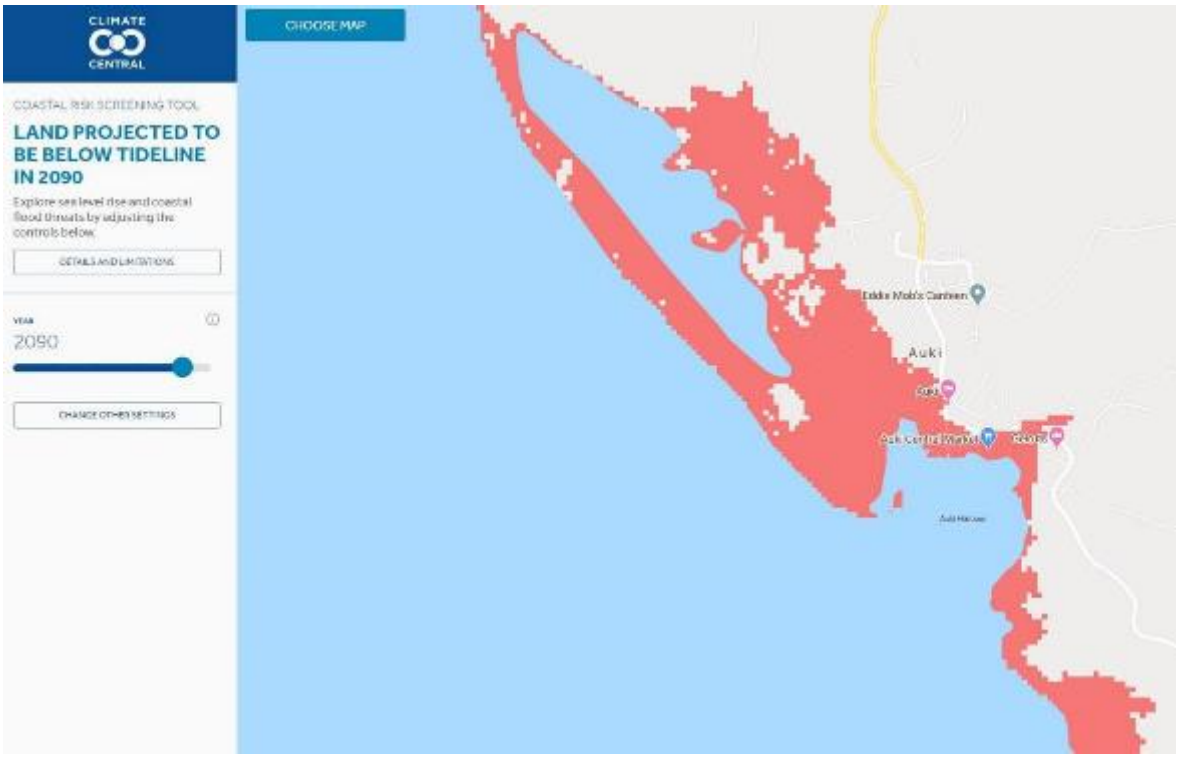


Figure 12. Detailed estimate of the urban area of Auki at risk of SLR inundation by 2090 generated by the Climate Central Coastal Risk Screening Tool

Cyclone risk

The Solomon Islands sit on the edge of the major Pacific cyclone belt to the south, with only the southern provinces regularly struck directly by storms. However, Malaita Province is within the influence of the cyclone belt (Fig. 13), and in March 2015 was impacted by Category 5 Cyclone Pam which caused flooding, erosion, landslips and destruction of agricultural and coastal areas. Projections for the Pacific region suggest that although cyclone frequencies will not increase, their intensity will, posing greater risk to livelihoods and infrastructure. However, although the cyclone tracks have historically not moved directly over Malaita, the province can be affected by heavy rain and storm and wave surges from cyclones at a distance of at least 500 km, as was the case with Cyclone Pam.

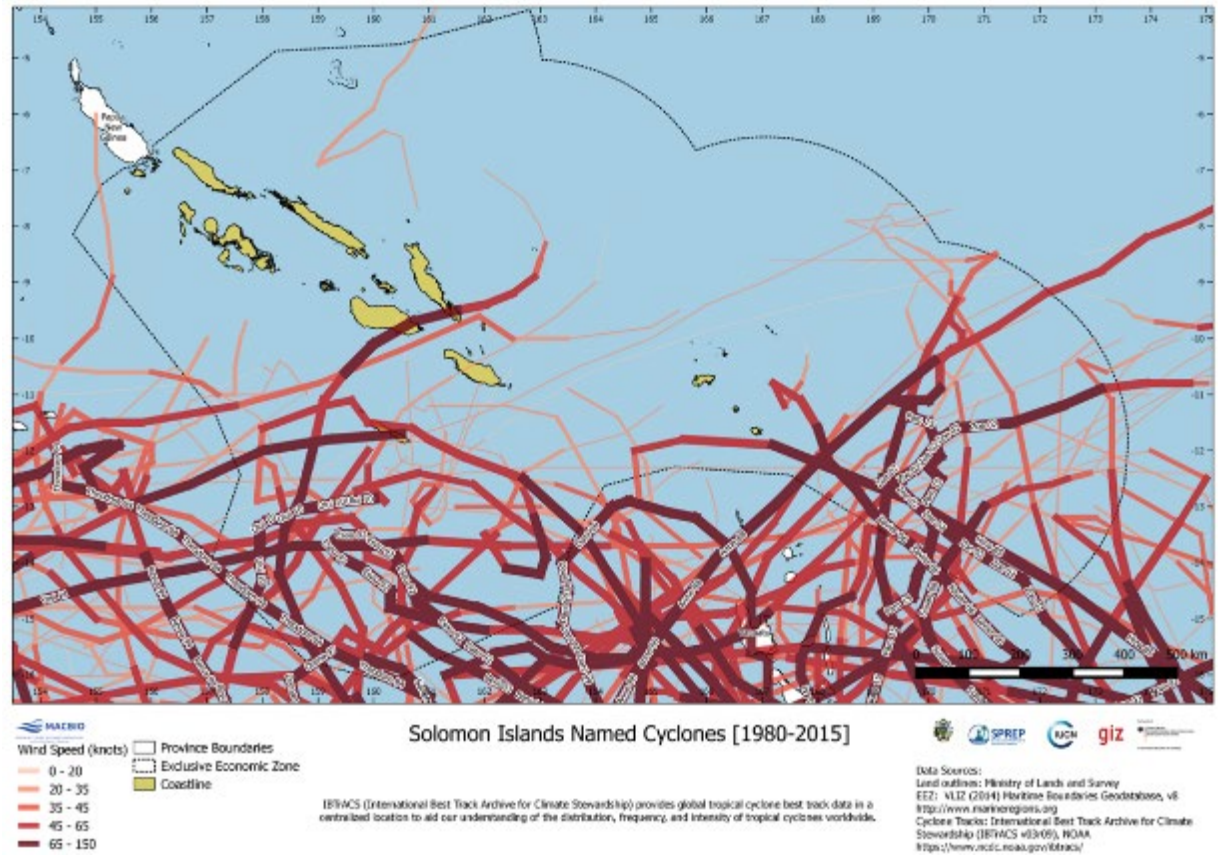


Figure 13. Cyclone tracks and intensity for the Solomon Islands region, 1980-2015

Population

Population density projections were calculated from the United Nations probabilistic population projection variants for logistic growth (https://population.un.org/wpp/Download/Standard/Population/), using the last national Solomon Islands Population and Housing Census data in 2009. Although a more recent census was completed in late 2019, the results and data had not yet been published.

The results showed that at the medium logistic growth rate the 2009 population of approximately 35,000 would double by 2075, and at the high rate of growth would double by 2046 (Fig. 14). However, compared with the United Nation's estimated carrying capacities, the population density is currently low (i.e. < 95 persons/km^2), and at the medium rate is approaching but less than the population carrying capacity (i.e. 171 persons/km^2) at the end of the century. Although these densities are relatively low, the doubling in numbers of people would still have major ramifications for food security, food production, land use conversion and pollution in the area. As well, estimated carrying capacities do not account for the land suitability so conversion of unutilised land to rural land use, assumed to be proportional to population growth, may further limit future growth.

It should also be noted that population densities in rural areas fluctuate through the year, with influxes to villages at holiday periods, and during civil unrest such as the ethnic tensions related to land disputes in 1998-2003, which resulted in the Regional Assistance Mission to Solomon Islands (RAMSI) international intervention, ending in 2017. In addition, the COVID-19 response by the Solomon Islands Government has resulted in many people returning from urban areas to their homes in 2020, which has placed additional pressure on local food sources, particularly in Malaita Province (Eriksson et al., 2020).

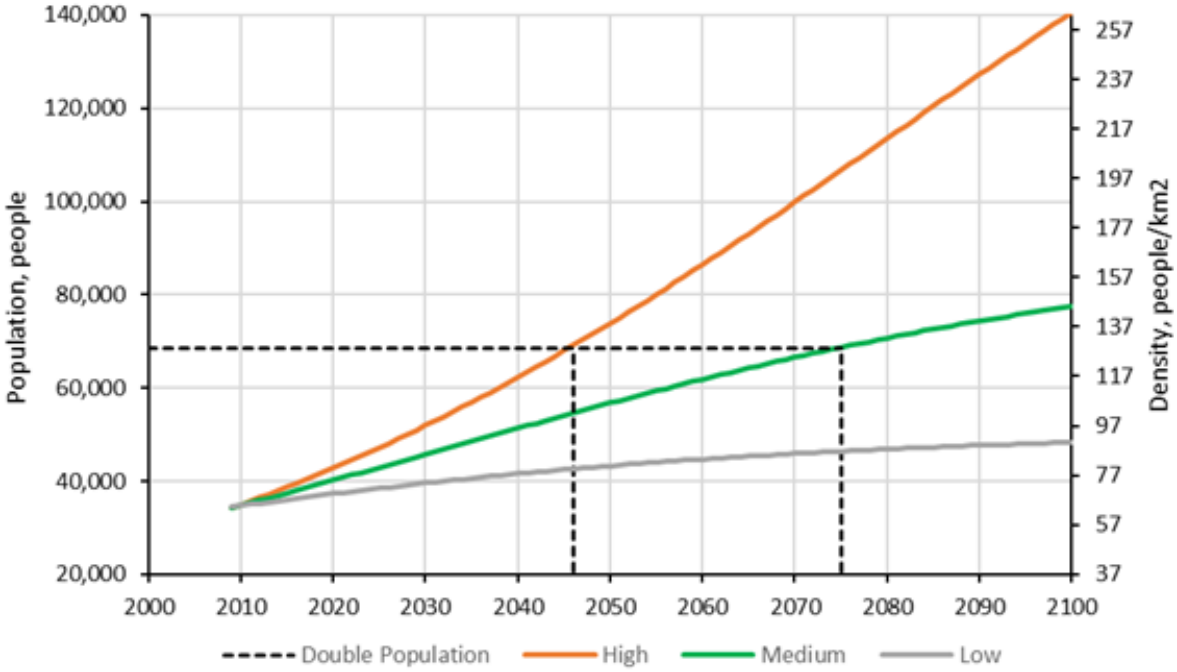


Figure 14. Logistic population growth projections from 2009 for Central Kwara'ae and West Kwara'ae Constituencies and Langalanga Ward combined

New crops and nutrient management opportunities

The science team also collated information about potential alternative crops and/or production systems that are emerging in other regions of the world and the Pacific, and which might be applicable to Malaita Province. These included:

- Rain-fed rice
- Honey
- Aquaponics
- Seaweed
- Kava
- Fruit crops
- Berry crops (both linked to honey)
- Salt tolerant crops near the coast: *Salicornia*, 'sea' rice, quinoa, beets, sorghum, cereals
- Avocados (e.g. growing of Mare variety in the Loyalty Islands, New Caledonia)
- Squash pumpkin
- Managing animal and human wastes with crop residues for composting for nutrients for crops and soil health (e.g. composting toilets in Vanuatu)

Some past unsuccessful experience has been had with rain-fed rice. But of particular interest was aquaponics, which could extend the current Strengthening Tilapia Farming in Solomon Islands program, which is supported by NZ Aid in Malaita. Although modelling of business as usual climate change impacts show that rainfall declines may severely impact freshwater aquaculture by 2050 (see below), aquaponics using closed circulation systems could reduce water requirements, making this innovation more sustainable. In addition, methods of creating 'circular bio-economies', whereby organic human, agriculture and fisheries waste could be converted into compost and fertiliser as an input to boost local food production show great potential.

8.3 Session 3: What will be the impacts of climate and other drivers on the food system?

In order to explore the potential impacts of climate and population drivers on food production, the Assets Drivers Wellbeing Interaction Matrix tool (Skewes et al. 2016) was used. This has two components:

a) Ecosystem goods and services (EGS) valuation and ranking: The EGS underpinning food production and livelihoods are listed. Each EGS is valued semi-quantitatively (score 0-5) by community members in terms of importance for income, food security, nutrition, and culture, and then its relative quantity of production (score 0-5) is also estimated. The product of these scores gives the relative importance of each EGS to livelihoods and the local food system. In addition, emerging or innovative EGS which are not yet established or highly important can be included. Usually participants provide EGS valuations during a workshop, and these are entered into ADWIM's Excel spreadsheets on a laptop computer and analysed in real time, and the results shown and discussed.

b) Climate and population impacts: The CCAM downscaled business as usual climate projections, SLR, ocean acidification and population projection data for the study area are entered into ADWIM. Within the tool an Excel-based model semi-quantitatively assesses the sensitivity of the habitats underpinning each EGS, and the resulting relative positive and negative impacts of these drivers and pressures on each EGS. The relationships are calculated before a workshop, and then in real time during the workshop the impacts are graphically matched against each EGS and discussed with participants.

An inventory of foods and commodities was collated from grey literature for the case study area, and from local experts such as the WorldFish Centre and FAO officers who were initially supporting workshop preparation.

However, in the event it was not possible to carry out the real time valuation of the EGS in the workshop because the science team could only contribute remotely, and time was too limited to undertake the assessment on-line. Instead, valuation data were used from other ADWIM assessments recently carried out by CSIRO research in Malaita Province (Ontong Java), Western Province (Simbu and Nusatuva) and Guadalcanal Province (East Tasimboko), and these were presented as an example.

Thirty important EGS (i.e. foods and/or commodities) were listed (Fig. 15). Valuation scores applied to each of these from the other Solomon Islands assessments showed that the six most important were likely to be coconuts, cassava, bananas, sweet potato and nearshore fish (Fig. 15). Four emerging but so far unimportant EGS were honey, kava, rice and tilapia (supported by NZ Aid's Strengthening Tilapia Farming in Solomon Islands program).

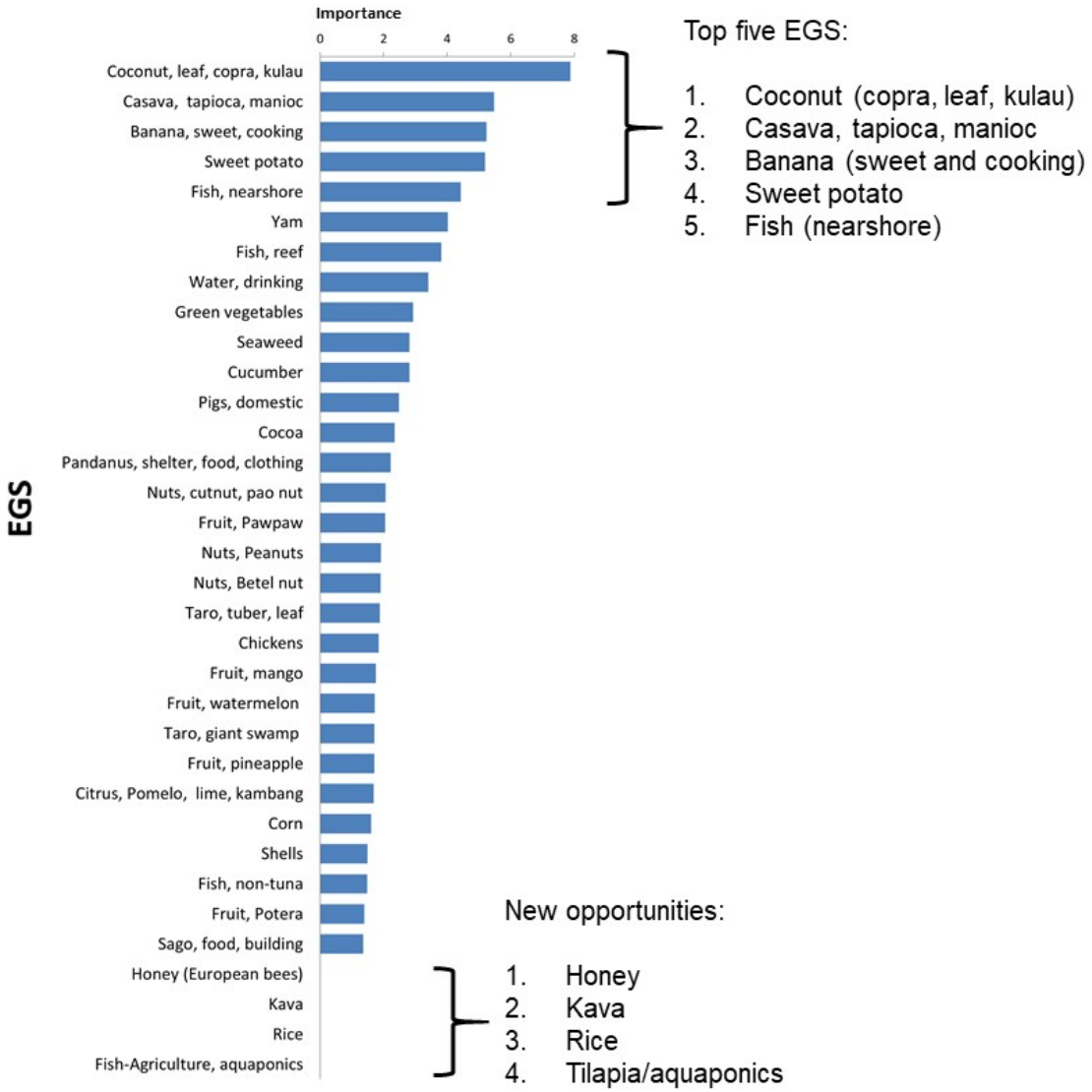


Figure 15. The 30 top-ranked EGS produced in the case study food system, plus emerging EGS: honey, kava, rice and aquaculture/aquaponics for comparison. Note that their values and therefore ranking is taken from four other Solomon Islands locations

For the second impacts component, modelling showed that there is likely to be a negative impact on all EGS by 2030, and this will increase by 2050 (Fig. 16). Although there are likely to be some positive impacts on some EGS (e.g. rainfall reduction for cassava and sweet potato), this will be greatly outweighed by negative impacts. Amongst the five most important EGS, nearshore fish will experience the highest impact by 2050, driven largely by increasing human utilisation linked to population growth. Similarly reef fish, the seventh most important EGS, will be heavily impacted by utilisation, plus ocean temperature change and related coral bleaching.

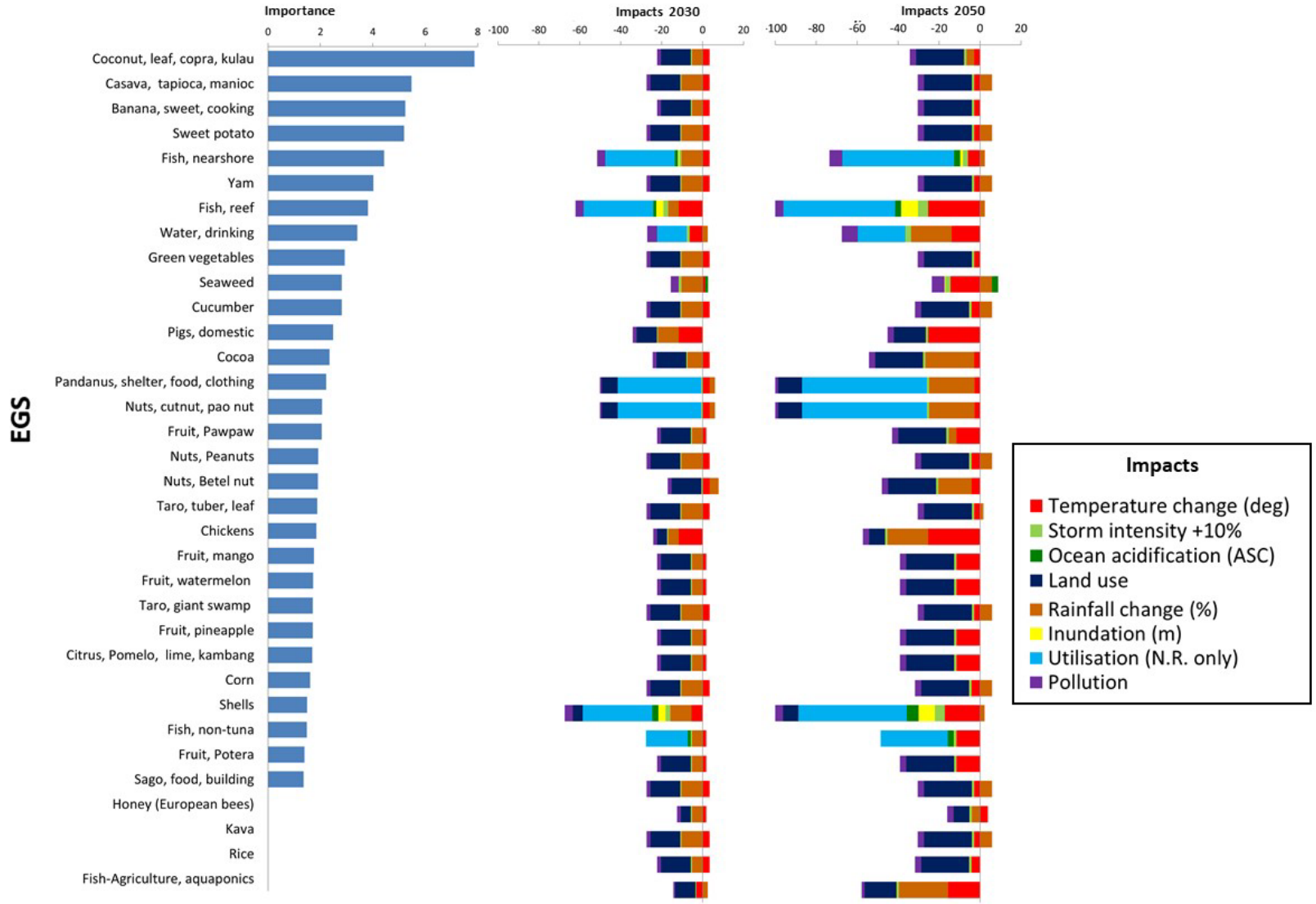


Figure 16. The EGS produced in the case study food system, and relative impacts from climate and human population pressures in 2030 and 2050 under a 'business as usual' global carbon emissions scenario

By comparison the top four EGS of coconut, banana, cassava and sweet potato will have relatively low impacts by 2050, and the negative impacts will primarily be due to land conversion linked to population growth, and rainfall change. Of the potential future EGS, aquaculture/aquaponics are the most vulnerable primarily due to projected declines in rainfall, but this is only likely to be significant after 2030. By comparison, kava and rice are likely to more affected by 2050 due to land conversion and rainfall declines, and honey will only be marginally affected by 2030 and 2050. Seaweed may also experience minimal impacts and will benefit slightly from increased ocean acidification.

Overall, the most impacted EGS were nearshore fish, reef fish, shells, drinking water (from rainwater), pandanus and cutnut or pao nuts. These are all wild-harvested rather than cultivated, and the primary pressure is from utilisation driven by population growth. However, rainfall declines will contribute to negative impacts for pandanus, nuts and drinking water, but only by 2050. Amongst the cultivated food stuffs, impacts from climatic drivers are relatively limited, with the exception of cocoa (rainfall decline), chickens (rainfall declines and temperature increases), pigs (temperature increase) and betel nut (rainfall decline), and land conversion is a more ubiquitous pressure. Thus, in summary the current portfolio of cultivated foods is likely to be little impacted by climate change, and instead land conversion away from agriculture due to population pressure is the primary driver. However, wild-harvested EGS are under far greater pressure due to population growth, and in the case of reef fish and shells this will be exacerbated by sea temperature increases.

9 Activity 5: Solomon Islands case study workshop

9.1 Workshop participation and human research ethics

In the planning of the original March workshop, the WorldFish Centre and FAO identified 20 potential participants who had decision-making roles at different levels of the food system. These included representatives from the Auki Market Vendor's Association, the Malaita Provincial Fisheries, Agriculture and Livestock and Health Departments, the National Disaster Management Office, Ministry of Agriculture and Livestock, DFAT Rural Development Program and the United Nations Women's Program, plus the WorldFish Centre and FAO.

With the reorganisation of the workshop to November, the sub-contracted facilitators (Pitakia Tikai, Shane Tutua and John Fasi) contacted these potential participants. Due to COVID-19 travel restrictions within the Solomons it was impossible to include national government and donors from Honiara. In their place, the facilitators contacted who they thought were appropriate local stakeholders within the case study region. Ultimately 22 participants attended representing the following stakeholder groups:

- Farmers
- Farmers for Young Youth
- Auki Market Vendor's Association
- Lavione Women's Association, West Kwara'ae
- Kinitolo Farmer's Association
- Malaita Provincial Youth Committee
- Malaita Women's Caucus
- Kinitolo Women's Group
- The Hilltop Training Institute
- Malaita Provincial Agriculture and Livestock Department
- Malaita Provincial Health Department
- Ministry of Agriculture and Livestock (Auki Extension Office)

Of the participants, half (11) were women, representing three women's groups. Two participants were youth group representatives (Fig. 17).

Figure 17. Workshop participants and facilitators (*Photo: Masoud Ali-Akbari*)

Human research ethics approval was granted by CSIRO's Social Science Human Research Ethics Committee (approval 008/20). As a condition of the approval, participants' responses were not to be individually identifiable, and at the beginning of the workshop participants were asked to provide verbal free and prior informed consent to participate; all agreed.

9.2 Workshop activities and organisation

In October and November leading up to the workshop, the science team carried out ongoing planning with the facilitators to design the workshop activities within the conceptual framework detailed in Fig. 3 and Table 1. Critical in these co-design discussions was agreeing explanations of conceptual terms (e.g. food systems, tipping points/thresholds, pathways), and the design of learning activities that would be appropriate and engaging for the participants. A powerpoint presentation was constructed as an aide memoire for the facilitators, and to explain the aims of each session, definitions or conceptual terms, and rough guidelines for outputs. However, an effort was also made to allow sufficient latitude for participants to carry out activities as they wished, enabling them to co-design the approach. Details of each session's activities are given in Table 2 relative to Day 1 and Day 2 (and **Appendix 2**).

In preparing and carrying out the workshop activities, the facilitators were encouraged to emphasise four key principles to participants:

- People must think and anticipate the future, which is uncertain, but also presents opportunities, and is not necessarily 'doom and gloom'
- Decision-makers must be supported to anticipate challenges and opportunities for food production, food systems and livelihoods
- People must be encouraged to change their current mind-sets and become innovative
- The workshop is a trial, and participants have an important role in designing a process that will be effective in future planning activities

The following sections of the report summarise the activities and outputs of each session.

Table 2. Details of session times and order of activities in Day 1 and Day 2

Session	Time	Activities
DAY 1 **Introduction**	½ hour	• Participant introductions • Free and prior informed consent • Project introduction, workshop agenda and objective • Participants organised into three groups of mixed gender and roles, with 4-6 people per group
Session 1. How does the food system currently work? What are the main products? Who grows or catches the food, and where?	2 hours	• Define and discuss 'food system' • Groups draw diagrams of case study food system on flip chart paper • Group representatives present their diagrams for plenary discussion
Session 2. What are the drivers of change for the food system?	1½ hours	• Define and discuss 'drivers of change' • Participants write current observed drivers on post-it notes • Powerpoint presentation on-line by science team of climate change, sea level rise, cyclone risk and population projections, potential new production opportunities (e.g. waste management, circular bio-economies) • Participants discuss other drivers (pests and diseases, COVID-19 impacts, health and non-communicable disease) • Participants write other drivers of change on post-it notes • Participants place post-it notes on white board grouped under themes: *Technology, Infrastructure, Political and Social, Climate, Pests and disease, Natural resources, Economics* • Post-its are counted for each theme to identify most important drivers
Session 3. What will be the impacts of climate and other drivers on the food system?	2 hours	• Define and discuss 'tipping points' or 'thresholds' • Presentation on-line of ADWIM results and business as usual impacts of climate change and population growth • Groups draw diagrams of the key vulnerabilities, impacts, thresholds and timelines for the food system under a business as usual scenario • Group representatives present their impact diagrams for plenary discussion
DAY 2 **Session 4.** What is the 2050 vision for food production and the food system?	1 hour	• Define and discuss a vision for the food system • Groups draw or describe their vision on flip chart paper • Group representatives present their vision for plenary discussion
Session 5. What are the options to adapt and achieve the vision for 2050? Can we plan pathways towards the vision?	3½ hours	• Review outputs for Sessions 1, 2, 3 and 4 • Define and discuss 'adaptation pathways' and 're-design' of food systems to reach their 2050 vision • Groups draw tables and diagrams of priority pathways and actions, stakeholders involved, and winners and losers involved on flip chart paper • Group representatives present their pathways for plenary discussion
Evaluation and reflections	1 hour	• Discuss and record answers to three questions in plenary: 1) What were the strengths of the approach? 2) What were the weaknesses? 3) How could the approach be improved? 4) Has the workshop changed your thinking? • Participants complete evaluation sheets • Facilitators and science team discuss on-line the next steps • Workshop close

9.3 Session 1. How does the food system currently work? What are the main products? Who grows or catches the food, and where?

The session started with the facilitators defining and discussing a 'food system', which was taken from HLPE (2020, p. 11): '*all the elements (environment, people, inputs, processes, infrastructure, institutions, etc.) and activities that relate to the production, processing, distribution, preparation consumption of food, and the output of these activities, including socioeconomic and environmental outcomes*'. A diagram was shown to explain the definition (Fig. 18). The groups then drew a variety of interpretations of the case study food system (Fig. 19).

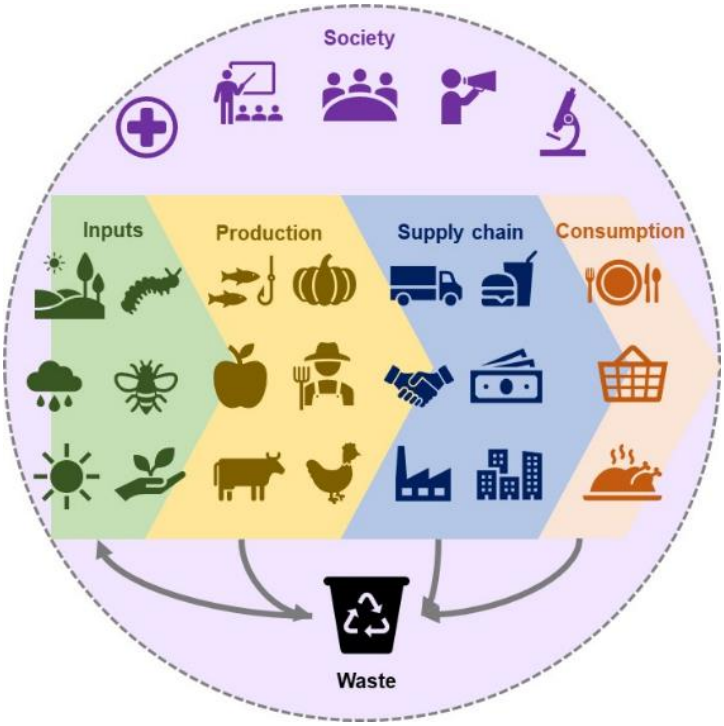


Figure 18. The diagram of a food system used to explain the concept in Session 1

Figure 19. A group drawing their interpretation of the case study food system (*Photo: John Fasi*)

All three groups differentiated between food produced in the highlands and along the coast. There was a wide range of commodities grown, including taro, banana, cassava and fruit. Fish were caught by the coastal communities, and tilapia were farmed inland in Central Kwara'ae. The three primary points of sale and/or consumption were within households (i.e. subsistence or local exchange), Auki Central Market and Honiara Central Market, which was supplied via ferry from Auki. Imported processed foods (e.g. tinned meat, sugar, noodles) and white rice were a second important component of food supply, and this was sold in Auki Commercial Centre. Food waste was either disposed of in the sea, the bush, or in urban public dumps. None of the groups considered the broader societal and policy components of the food system, perhaps due to a lack of time (Fig. 20).

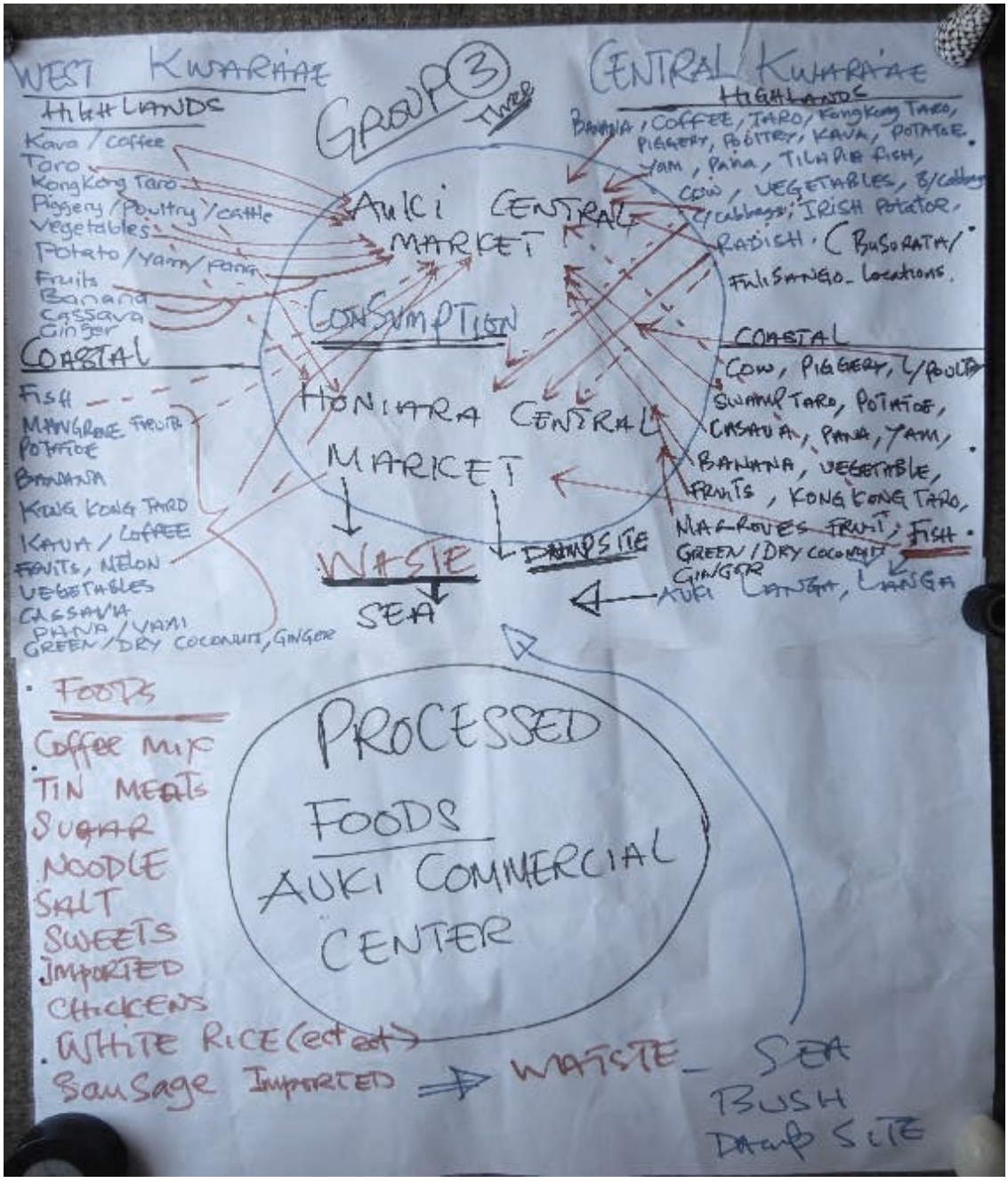


Figure 20. Group 3's conceptualisation of the case study food system

9.4 Session 2. What are the drivers of change for the food system?

Following the presentation of the climate, SLR, cyclone and population projections, the alternative crops and production systems, plus discussion about pests and diseases and COVID-19 impacts, participants identified a range of drivers of change in each driver theme (Table 3, Fig. 21). Political and social drivers predominated, with 21 of the total 54 drivers listed. Amongst these, land disputes, population growth, declining lifestyles, increasing crime and theft and pressure on gardening systems were most often cited. The second most important theme was climate change, with a total of 13 drivers. Higher rainfall was the most frequently mentioned, correlating with the climatic trend towards more intense rainfall events. Flooding, landslides, sea level rise and increasing temperature and humidity were listed twice; flooding and landslides may also have been related to more intense rainfall. Pests and disease were also mentioned, with the African land snail and ongoing coconut rhinoceros beetle outbreak listed multiple times.

Table 3. The drivers of change for the case study food system identified by participants

Driver theme	Driver of change	Total
Technology	• New crop varieties	1
Infrastructure	• High transport costs • Rising fuel costs	2
Political and social	• Increasing violence • Population growth (2) • Ethnic tension • Land scarcity and disputes (4) • Family and cultural obligations • Declining lifestyles (2) • Traditional gardening system under pressure (2) • Increasing crime and theft (2) • Declining human resources (literacy) • Re-sellers who cause price increases • Outdated national food policy • Unregulated logging	21
Pests and disease	• *Alomae* virus in taro • *Colocasia bobone* virus in taro • COVID-19 lockdown in 2020 • Increasing non-communicable diseases • African land snail (3) • Coconut rhinoceros beetle (2)	8
Natural resources	• Declining crop varieties (2) • Declining soil fertility • Salt intolerance in crops • Over-harvesting of resources	5
Economics	• Rising costs and prices (2) • High cost of education • Low cash-flow • High cost of living and reduced purchasing power • High cost of farm inputs • Emerging black markets	6
Climate change	• Higher rainfall events (4) • Sea level rise (2) • Flooding (2) • Landslides (2) • Rising temperatures (2) • High humidity	13

Figure 21. Participants categorising their drivers of change under themes on a whiteboard

9.5 Session 3. What will be the impacts of climate and other drivers on the food system?

Having presented the concept of thresholds or 'tipping points' and the potential impacts in 2030 and 2050 from ADWIM for the business as usual scenario, participants drew or listed the implications for the case study food system (Fig. 22). Most impacts were anticipated in 2030-2050, but many of the political and social drivers (e.g. land disputes, logging, illiteracy, re-sellers) were having immediate effects on all aspects of food security. However, population growth was also expected to have increasing impacts after 2030. Vulnerabilities and impacts mostly concerned food production (e.g. water shortages, loss of productive land), but one group considered climate change impacts on infrastructure (e.g. poor road condition and resulting limited access to markets).

The groups also identified several thresholds in the system, where change would accelerate, causing possibly irreversible positive or negative impacts:

- The resolution of land disputes and related compensation and reduced violence would enable more adaptation options and pave the way for transformation of the food system (positive)
- The impact of logging pollution on coral reefs, combined with over-exploitation and rising sea temperatures causing coral bleaching would result in a collapse in coral reefs and related fisheries, possibly by 2030 (negative)
- Population growth would cause a tipping point in political and social drivers sometime between 2030 and 2050, with knock-on impacts on local food production (negative)
- The current outbreak of coconut rhinoceros beetle would lead to the sudden loss of coconuts and palm trees, and hence production of commodities from these areas (negative)

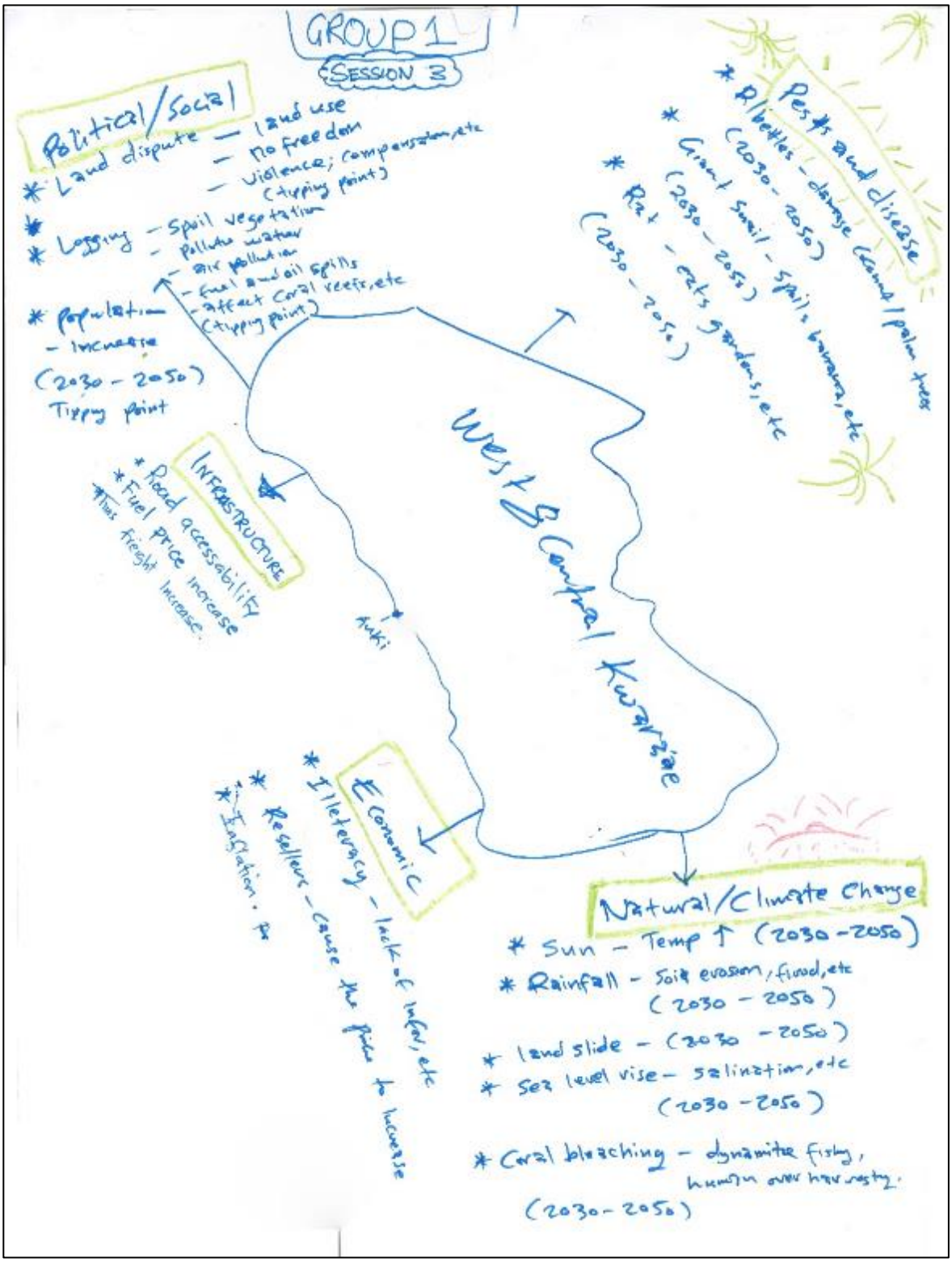


Figure 22. Group 1's depiction of future driver impacts on the case study food system

9.6 Session 4. What is the 2050 vision for food production and the food system?

Having defined a vision as *'how do you want life, livelihoods and food in West and Central Kwara'ae to be in 2050, when your children or grand-children will be living here?',* the groups recorded their visions in writing in tabular form (Fig. 23). Common to all three group's visions were:

- Effective marine resource conservation measures
- Establishment of organic farming
- Reduced reliance on imported foods
- Resolution of land tenure disputes
- Food, farming, fishing and market waste re-cycling

In addition, two groups emphasised the establishment of improved infrastructure (e.g. roads, shipping) to access Auki market, and other markets in the Solomon Islands, and financial innovations such as farmer and women's savings clubs. In general, there was a clear theme of maintaining and increasing the local production of nutritious and healthy food, and the use of waste and organic farming to reduce reliance on imported inputs (Table 4).

Figure 23. A group discussing their 2050 aspirational vision for the case study food system (*Photo: John Fasi*)

T

able 4. Group 3's 2050 vision for the case study food system

Issue	Our Way Forward by 2050 will see….
Agriculture	• All wastes produced being recycled and re-used for other benefits • A green waste management plant established in Auki, managed by Auki Town Council • Traditional gardening skills restored • Organic farming techniques in place accompanied by awareness programs • Slash and burn methods reduced
Conservation of marine resources	• More communities conserving their fishing grounds • Marine pollution discouraged and controlled • People harvesting under-sized fish, shells etc. heavily penalised
Pests and disease	• Government actively engaging with communities to eradicate coconut rhinoceros beetle
Education	• Quality and free education available to all • The government Teacher's Service Scheme implemented • All teachers highly qualified
Food imports	• More brown rice being imported, and white rice discouraged
Land use policy	• Government prioritising agriculture as the No. 1 priority • Government increasing funding to encourage more root crop farming • Rich people discouraged from purchasing land converted out of agriculture • Land dispute issues resolved • Unregulated logging operations banned

9.7 Session 5. What are the options to adapt and achieve the vision for 2050? Can we plan pathways towards the vision?

Participants were reminded about the objectives of the workshop, and the outputs of Session 1, 2, 3 and 4 were revisited to clarify the steps leading to this final session. The concept of adaptation pathways was revisited and defined as '*decisions and actions sequenced over time to reach the 2050 vision by navigating future uncertainty in drivers, tipping points and their impacts*'. Two diagrams were used to explain the concept visually. Fig. 24 highlighted the need to navigate future uncertainty in multiple drivers of change and their impacts on the food system, which had been identified and discussed in Sessions 2 and 3. Fig. 25 illustrated two potential pathways and future scenarios: the business as usual pathway had to be avoided, and instead the food system would need to be re-designed to achieve a scenario akin to the vision. However, a key point highlighted from Session 3 was that although some new production systems (e.g. honey, kava, rice) might emerge as opportunities with minor impacts from future climate and population pressure, and existing unimportant production (e.g. seaweed) might also experience minimal impacts, these were unlikely to substitute for existing food produced locally. Therefore, re-design would have to largely focus on re-organising and improving existing production.

Groups were asked to imagine they had roles as key decision-makers in Malaita Province, and then re-design the food system. Activities were divided into two steps. First, each group drew tables on flip chart paper of pathways for food production, the actions needed to implement these, when actions should happen, and stakeholders who should be involved, and then consider 'winners and losers' resulting from the pathways. Second, they were asked to draw the pathways in whatever form reflected their own framing of the concept. Having completed their pathways, the results were presented in plenary by each group for discussion and clarification.

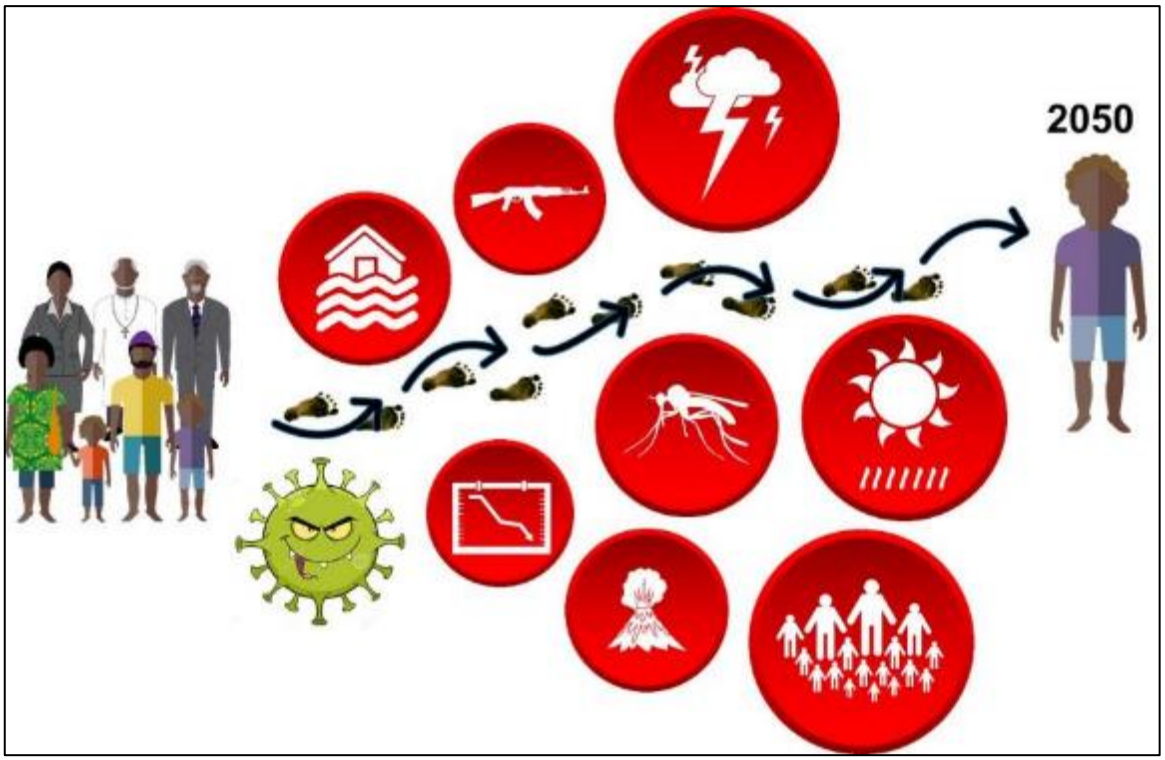


Figure 24. The conceptual diagram shown to explain the concept of adaptation pathways needed to reach the 2050 vision and account for future uncertainty in drivers of change

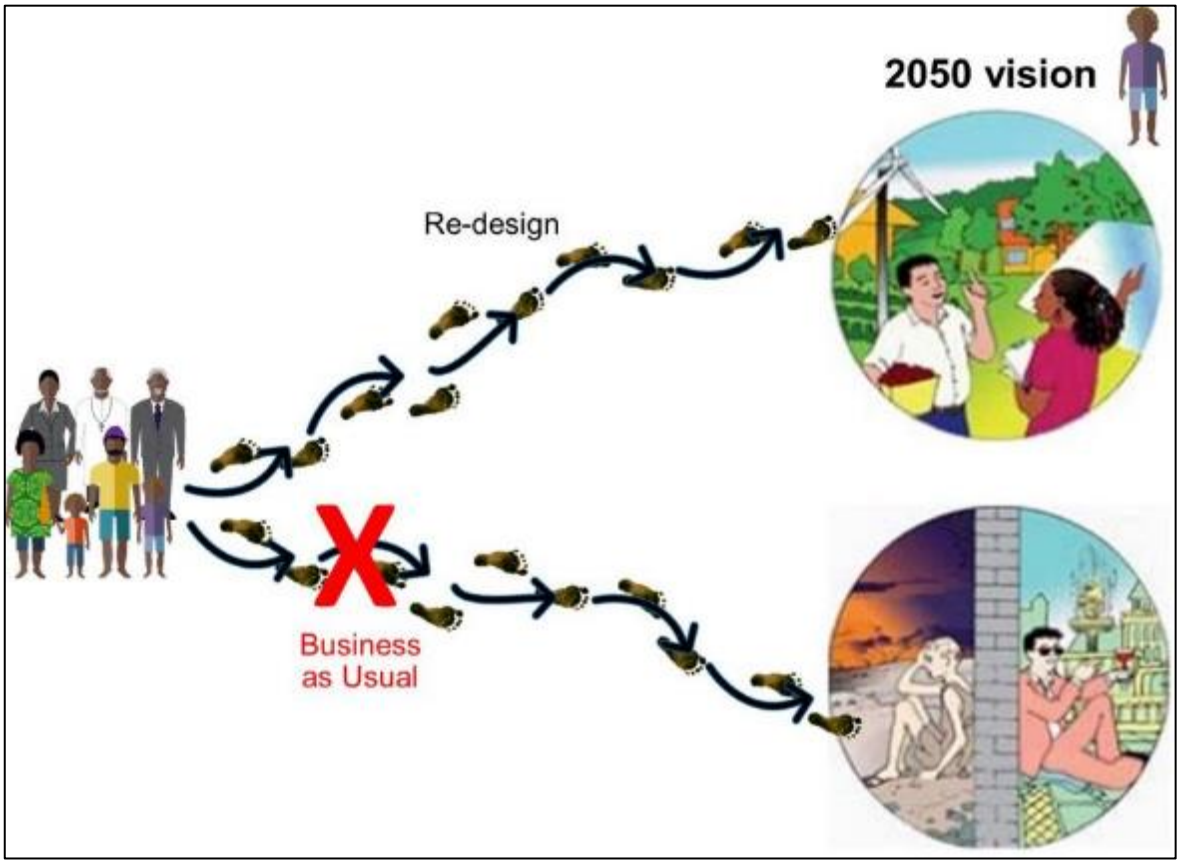


Figure 25. The conceptual diagram shown to explain the concept of adaptation pathways relative to the business as usual scenario and the 2050 vision. Reaching the vision may require re-design of the food system. The re-design and business as usual scenario images are taken from the Millennium Ecosystem Assessment (MEA 2005)

Group 1's six pathways were constructed around different components of the food system: Food and Security, Good Governance, Research and Monitoring, Adaptation, Technology and Infrastructure (Table 5). All actions were required to start immediately in 2021 and necessitated multi-level partnerships between landholders, farmers, communities, NGOs (such as the Kastom Garden Association), the Ministry of Agriculture and Livestock (MAL) and donors. There were some trade-offs inherent in the pathways where landholders might be disadvantaged. This was particularly evident for the Food and Security pathway, where a move away from swamp taro production on flood-prone and SLR inundation-risk land to inland tilapia aquaculture would be at the expense of landowners in those areas.

Group 1's depiction of these pathways illustrated a sequence of stakeholder engagements and partnerships necessary for their implementation (Fig. 26). This started from the bottom-up, with communities, farmers and individuals, and then clan chiefs and landholders and Ward Members enacting reforestation and limitation of logging to only managed timber milling. The MAL and the Kastom Garden Association would then join the partnership to educate and promote organic farming methods, followed by government and NGOs. At this point production from swamp and flood-prone land would be shifted to tilapia aquaculture, and pineapple, banana and coconut production would be concentrated on higher ground.

Table 5. Group 1's table of adaptation pathways for the case study food system

Pathway	Actions	When	Stakeholders involved	Winners and losers
Food and Security	• Research and monitoring • Landholder consultation • Shift swamp land from agriculture to tilapia aquaculture	2021	• MAL • Kastom Garden Association • Farmers • Provincial Government • NGOs • Landholders • Communities • Donors	Winners: Communities and farmers Losers: Landholders
Good Governance	• Establish committees to involve all decision-makers (NGOs, communities, MAL, Provincial Government)	2021	• MAL • Kastom Garden Association • Landholders • Provincial Government • NGOs	Winners: Communities Losers: Landholders
Research and Monitoring	• Identify new types of crops and soil management • Identify pests at early stages for prevention • Secure funding	2021	• MAL • Kastom Garden Association • Farmers • Provincial Government • NGOs • Landholders • Communities • Donors	Winners: Communities, farmers Losers: Landholders
Adaptation	• Apply traditional knowledge and beliefs • Innovative farm management • Organic farming	2021	• MAL • Kastom Garden Association • Farmers • Provincial Government • NGOs • Landholders • Communities • Donors	Winners: Communities, farmers Losers: Landholders
Technology	• Market on-line • Savings facilities for rural areas	2021	• Telecom • B-Mobile • MAL • Provincial government • Banks	Winners: Telecom, farmers Losers: Landholders
Infrastructure	• Mobile transport to farmers • Cold storage facilities	2021	• Provincial government • Farmers • MAL • Ministry for Infrastructure and Development • Auki Market Vendors Association	Winners: Farmers

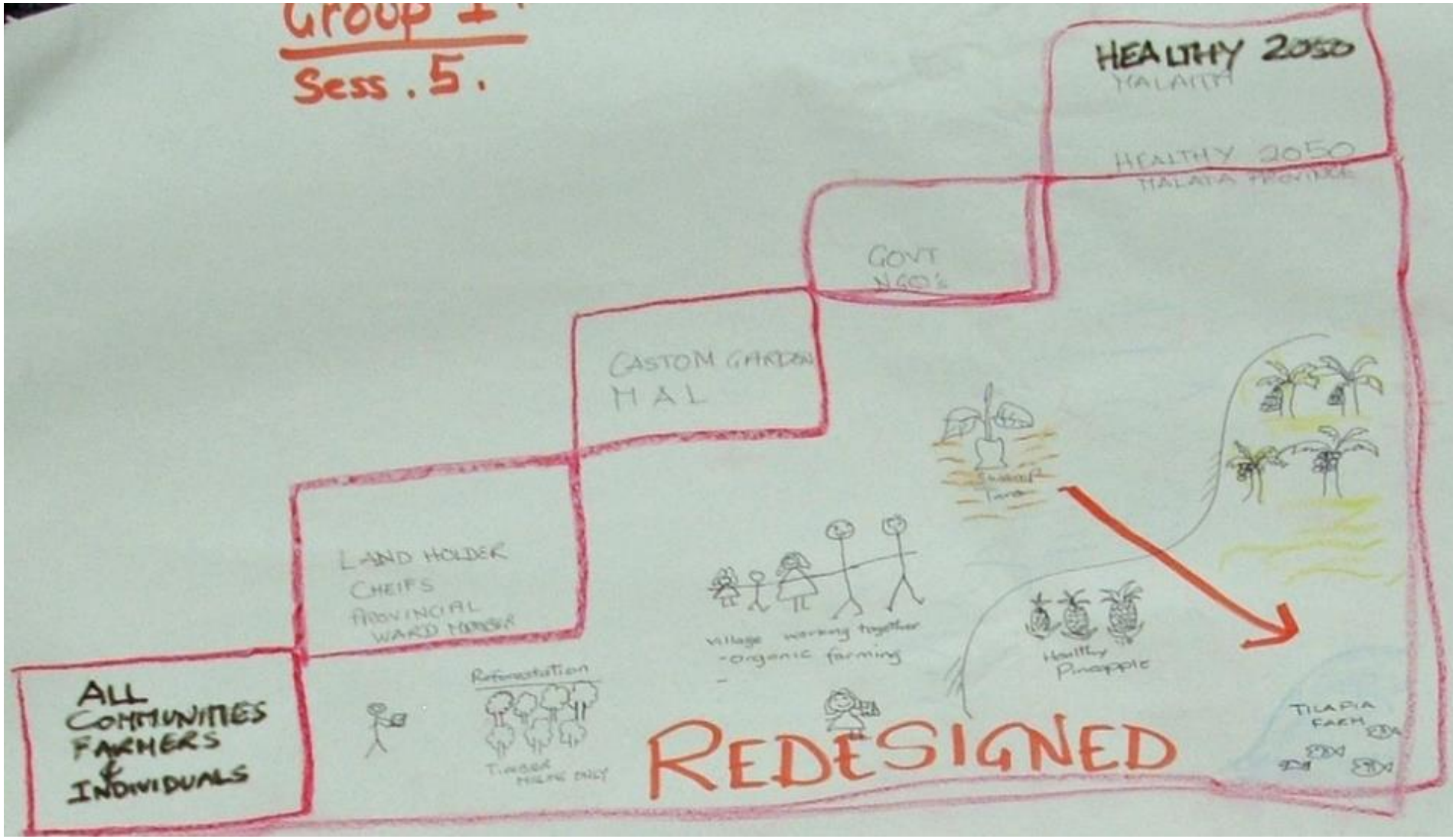


Figure 26. Group 1's depiction of their pathways towards the 2050 vision

Group 2's pathways focussed on three portfolios of actions: Conservation, Re-planting Mangroves, and Shifting from Slash and Burn (Table 6). As for Group 1, all actions were immediate, starting in 2021. However, their depiction of the pathways showed that these strategies were to be phased, although all would start in 2021. Conservation of resources would be the first step, followed by Re-planting Mangroves and then Shifting from Slash and Burn agriculture to improved farming systems (Fig. 27). To implement the actions there was a general need for multi-level partnerships between resource owners, the Solomon Islands Government, donors and NGOs. In the case of Conservation, it was considered that some resource owners would lose income from the discontinuation of inshore fishing.

Table 6. Group 2's table of adaptation pathways for the case study food system

Pathway	Actions	When	Stakeholders involved	Winners and losers
Conservation	• Develop MoU with resource owners • Discourage in-shore fishing	2021	• Resource owners • NGOs • Solomon Islands Government • Donors	Winners: NGOs, Solomon Islands Government, donors Losers: Resource owners lose income
Re-planting Mangroves	• Re-establish mangroves and other coastal tree species for coastal SLR protection and in-shore fisheries	2021	• Resource owners • NGOs • Solomon Islands Government • Donors	Winners: NGOs, Solomon Islands Government, donors Losers: Resource owners lose income
Shifting from Slash and Burn	• Establish demonstration plots for alternative soil and cultivation practice	2021	• Resource owners • NGOs • Solomon Islands Government • Donors	Winners: NGOs, Solomon Islands Government, resource owners

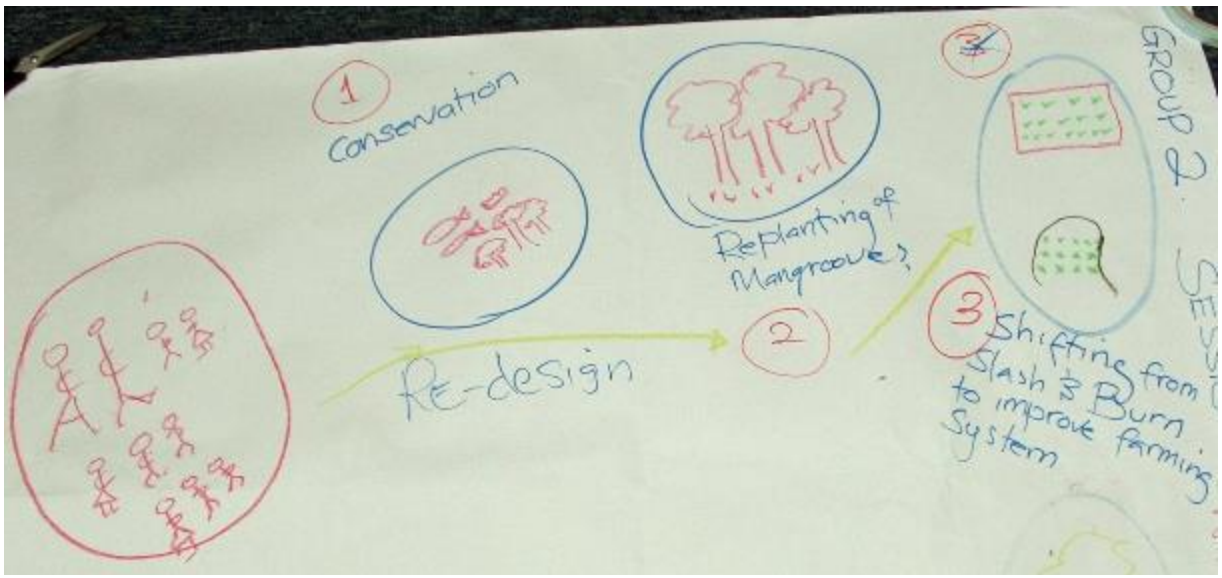


Figure 27. Group 2's depiction of their pathways towards the 2050 vision

Group 3 also focussed on three pathways: Proper Land Management, Capacity-building and Appropriate Technology (Table 7). However, these were more nuanced and clearly sequenced, with Proper Land Management being initiated in 2021-2022, followed by Capacity-building in 2023, and Appropriate Technology from 2024 onwards. Actions required partnerships between landowners, NGOs, appropriate national government ministries and NGOs. The first pathway, Proper Land Management focussed on the potentially positive transformational threshold of resolving land demarcation issues, but a trade-off from this would be settlers and property owners who could lose land and homes. Unlike the other groups, Group 3 highlighted that youth would benefit from capacity-building actions, including training in organic farming techniques, waste composting and pest and disease management.

This group also added a spatial dimension within the case study area (Fig. 29). Proper Land Management needed to be focussed on the core inland areas of Central and West Kwara'ae, where existing food production is concentrated. Capacity-building was to focus on key vegetable gardening areas in West Kwara'ae, and Appropriate Technology was necessary throughout the case study area.

Table 7. Group 3's table of adaptation pathways for the case study food system

Pathway	Actions	When	Stakeholders involved	Winners and losers
1. Proper Land Management	• Land planning with landowners • Resolve land issues • Land demarcation	2021-2022	• Ministry of Lands • Provincial Government • Landowners • MAL	Winners: Farmers, landowners, MAL Losers: Settlers and property owners
2. Capacity-building	• Survey of needs • Training on organic farming, waste composting for fertiliser, pest and disease control	2023	• MAL • Donors • Local farmers • NGOs	Winners: Farmers, youth
3. Appropriate Technology	• Improve infrastructure: road access, electricity and water supplies • Waste recycling plants • Providing materials and tools • New machinery	2024 onwards	• SOLPower • Ministry of Infrastructure and Development • WASH programs • MAL • Farmers	Winners: Farmers Losers: Landowners

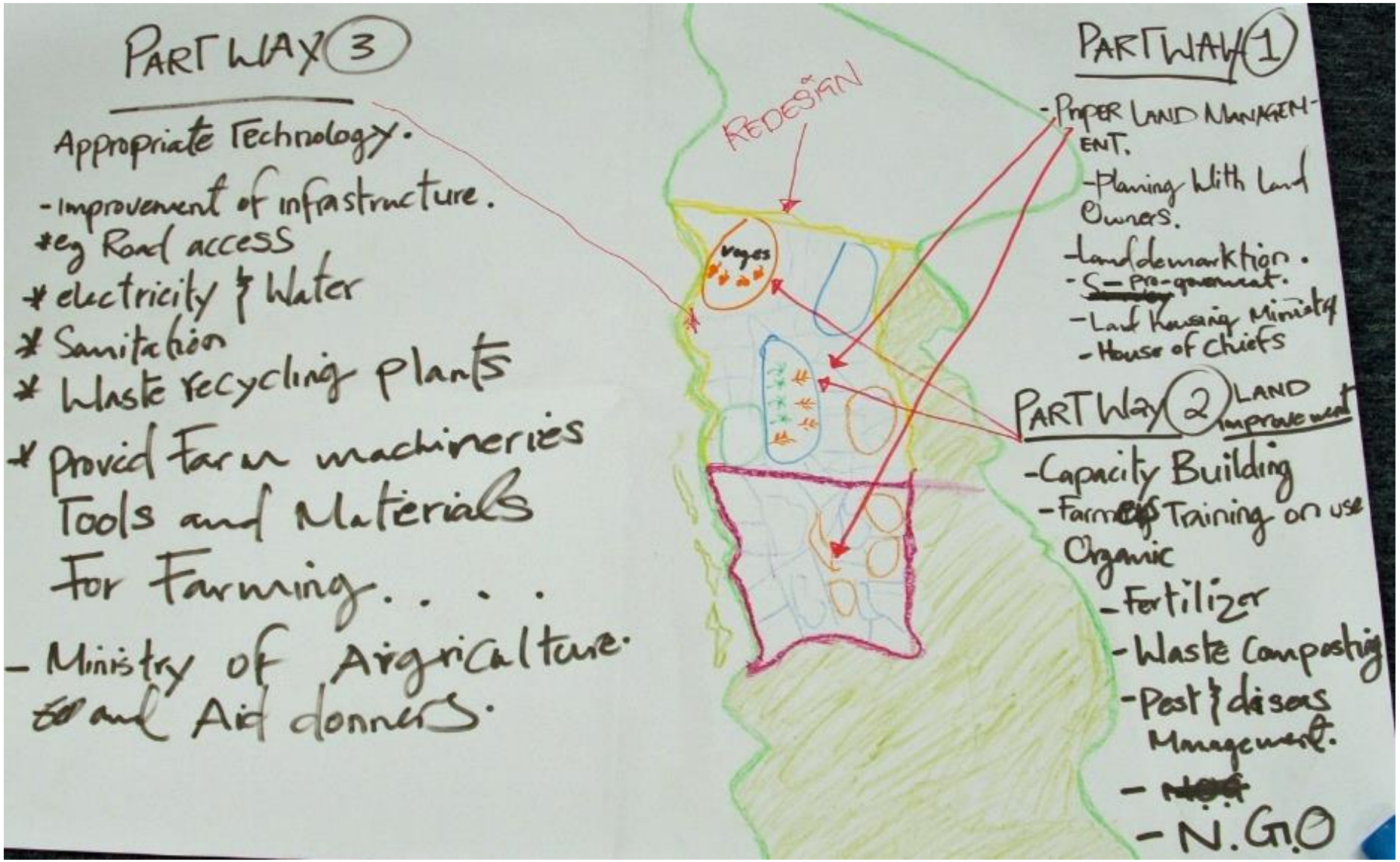


Figure 28. Group 3's depiction of their pathways towards the 2050 vision

9.8 Evaluation and reflections

To complete the workshop, the facilitators sought participants' reflections on five questions, and recorded notes on the white board:

1) What were the strengths of the approach?

- Sharing of ideas
- Identification of drivers and pathways
- Good make-up of participants (youth, gender, locations, partners)
- Good teamwork
- Good methods (teaching and activities)
- Clear instructions from the facilitators

2) What were the weaknesses of the approach?

- Some people had a problem with drawing
- No involvement of people with special needs
- Need printed handouts
- Need more stakeholders related to the drivers of change
- The same people did the session presentations for each group
- Two days is not enough – the process needs three days

3) How could the approach be improved?

- Case studies are needed from different locations (e.g. coastal and inland), and at the ward level because decisions are largely made at the community level
- Involve tribal leaders and clan chiefs, who are important decision-makers
- Continue to involve the participants from this workshop to 'train the trainer' to enable scaling out of the process
- Involve more NGOs (e.g. WorldFish Centre, World Vision, farmer's groups)
- House all participants in one location for the workshops to enable them to mix

4) Has the workshop changed your thinking?

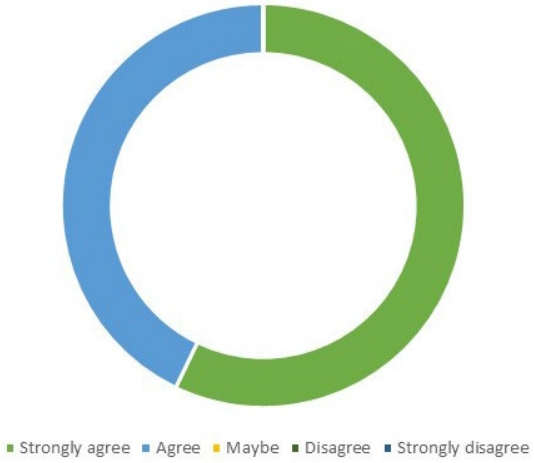
- Need to maximise food production, land use and land use planning
- It is possible to integrate traditional and scientific knowledge
- Encouraged thinking about mixed cropping and alternative farm management

5) What should the next steps be?

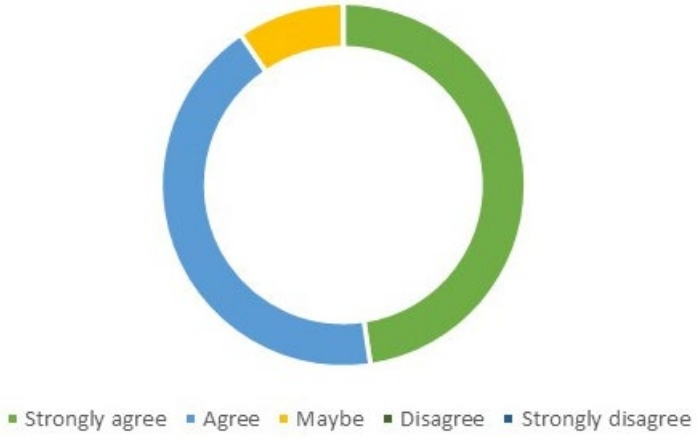
- Actions should be implemented in 2021
- Update participants with progress and a report
- The pathways and actions should be implemented immediately
- Waste management issues should be addressed immediately

Evaluation sheets were then distributed for participants to complete. These consisted of nine questions with answers given on a 5-point Likert score (i.e. strongly disagree (1) to strongly agree (5)), and three open-ended questions (see **Appendix 3**). The 22 participants' responses were collated and analysed, and the results are shown in Fig. 29.

Q1. *The pathways approach is useful for planning food system adaptation in Malaita*



Q2. *The climate projection information was understandable and useable*



Q3. *The population projection information was understandable and useable*

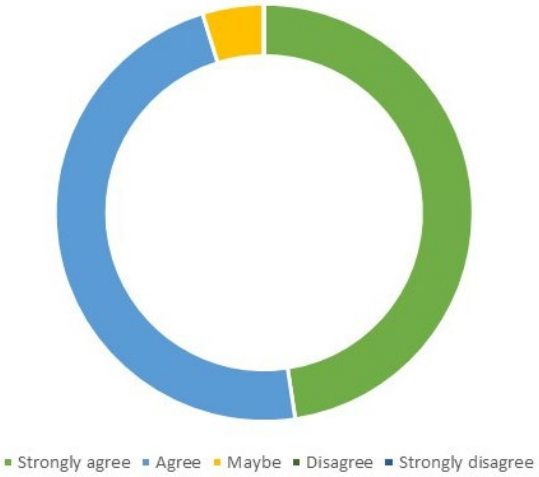
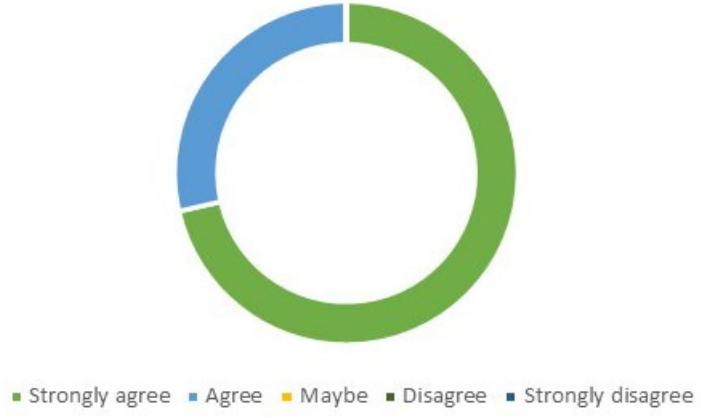
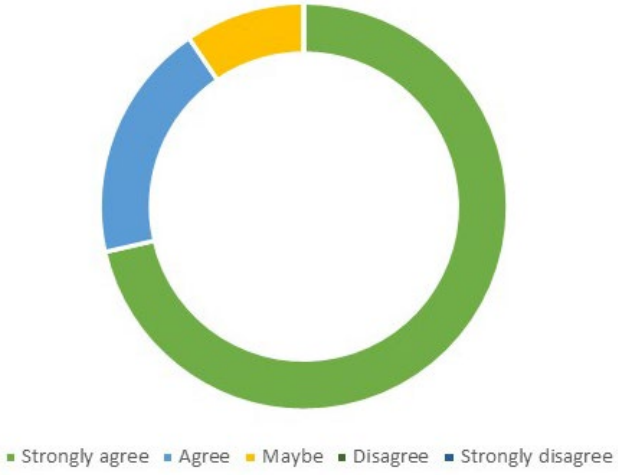


Figure 29. Responses to the evaluation Questions 1 - 3 (% of 22 responses)

Q4. *The food product (EGS) importance information was understandable and useable*



Q5. *The food (EGS) impact information for 2030 and 2050 was understandable and useable*



Q6. *The right decision-makers were present in the workshop*

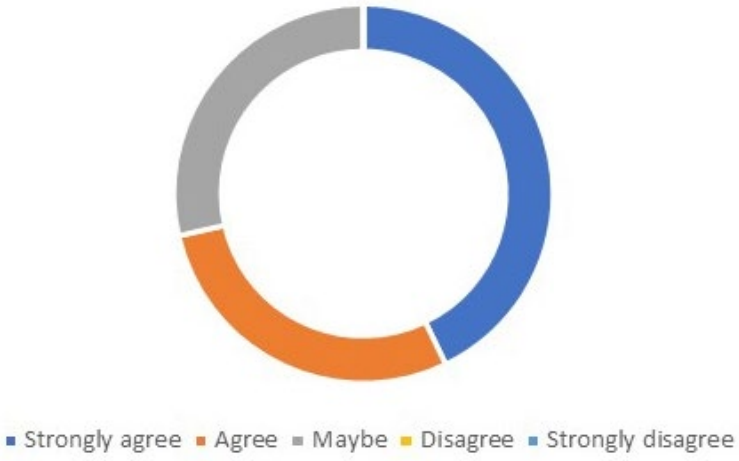
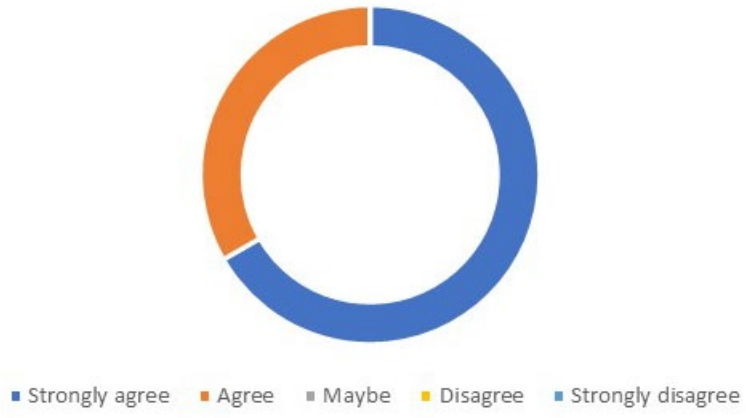
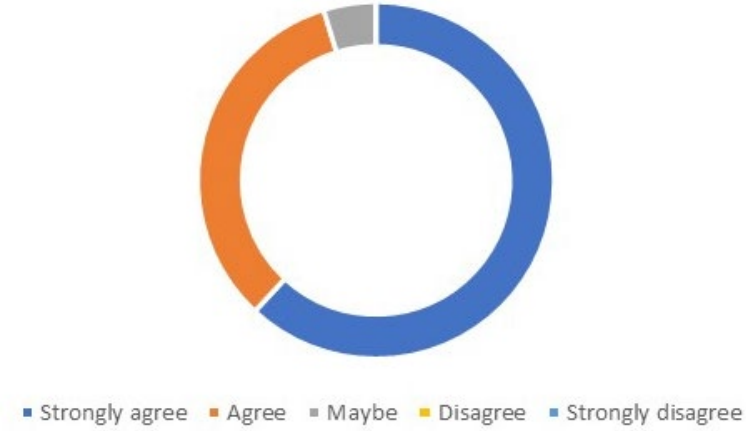


Figure 29 (cont.). Responses to the evaluation Questions 4 - 6 (% of 22 responses)

Q7. *My knowledge about food systems and future risks and opportunities in Malaita has grown*



Q8. *I am motivated to follow-up on the actions identified in the workshop*



Q9. *I made new contacts and useful networks*

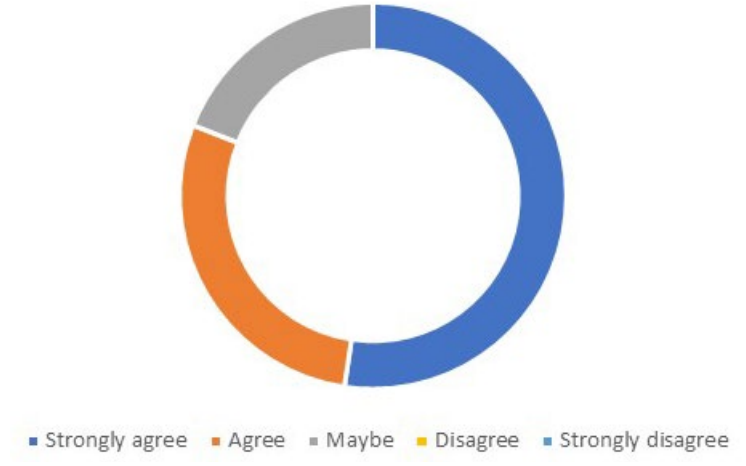


Figure 29 (cont.). Responses to the evaluation Questions 7 - 9 (% of 22 responses)

The responses to the nine questions were largely ‘strongly agree’ or ‘agree’. Importantly, all participants gave these answers to Q1 *The pathways approach is useful for planning food system adaptation in Malaita*. A small minority responded ‘maybe’ to Q2, 3 and 5 relating to the technical climate, population and ADWIM impact information presented, but all agreed or strongly agreed that the ADWIM food (EGS) importance information was useful.

Perhaps echoing the reflections recorded above, the greatest doubt was for Q6 *The right decision-makers were present in the workshop*, where 27% replied ‘maybe’. The point was made in the reflections that most decision-making is made at the ward and community level, and tribal leaders and clan chiefs should be engaged in future planning, plus more NGOs.

In terms of knowledge generation, all agreed or strongly agreed that they had learned more about the case study food system and were largely motivated to follow-up on the actions. However, 20% responded that they had ‘maybe’ made new contacts and useful networks.

The responses to the final three open questions were as follows, grouped into themes:

Q10. How would you improve the planning approach?

Theme: *Expanding mix of participants/ contributors*

- To improve the planning approach, stakeholders, NGOs and donors should be the front line of the planning process
- Through group discussions with the right people
- Through discussions with leaders and landowners
- Get information from farmers first before going into planning; the reality is with the farmers
- Begin with target communities in the target constituencies
- Identify farmers who use market outlets most of the time

Theme: *Sharing ideas/actions arising from the workshop*

- Share workshop ideas with the participants and communities
- By educating other members of Auki Market Vendors Association and my communities on what I’ve learned today and yesterday, and to really practice it myself at home
- Take serious action on the pathways discussed during the workshop
- Forward the planning results to MAL and donors
- By encouraging Malaitans to work together
- Through training or working with other groups
- Disseminate the workshop information and work with community stakeholders
- Working together to improve planning
- Work together with stakeholders and community people; involve Kastom Garden Association and others; heavily engage youths

Theme: *No changes*

- Agree with the participatory approach used in the workshop

Theme: *Workshop duration*

- More days needed for training

- Longer duration for the workshop would be nice

Q11. What are your recommended next steps?

Theme: *Establish connections*

- Implement and establish farm linkages with farmers through the Auki Market Vendors Association
- Consult with actors and donors; talk with communities; implementation
- Share ideas with farmers and youths
- Share ideas with young people/youths

Theme: *Recommendations for workshop process*

- Maintain good facilitation approaches
- Field visits

Theme: *Project-related suggestions*

- Carry out the workshop again as training
- Update stakeholders on the project before implementation
- I would like to be part of the project and get ongoing support
- Use practical sites

Theme: *Continuity/selection of participants*

- Involve the same participants to continue with next steps or training
- Select participants who are able to contribute to the sessions, or be involved in discussions and presentations
- Proper selection of participants for equal participation throughout the workshop
- Choose right decision-makers to attend this kind of workshop next time

Theme: *Personal next steps*

- To attend any other food security workshop and climate change workshops to acquire more knowledge and be prepared for uncertainty

Q12. What was your most memorable part of the workshop?

Theme: *Collaboration; working together*

- Group work and activities
- Sharing of knowledge
- Discussions and sharing
- Working together to improve farmers' futures

Theme: *Understanding drivers and pathways*

- Drivers and impacts with regards to food production system
- Food system; drivers/impacts and pathways/visions
- Identifying the drivers
- Drivers of diseases
- Identifying the drivers; presenting

- Adaptation pathways
- Looking for next steps

Theme: *Learning and thinking differently*

- Meeting new friends and learning new things
- Learning new knowledge from the facilitators; tipping points; encouraging youth to plan ahead for the future
- I came to realise the important idea is not to think the usual way but to think of new ways of thinking in order to survive
- Increasing my knowledge by knowing more innovative ways and ideas

Theme: *Specific*

- The food product (EGS) importance information
- Adaptation pathways

10 Discussion, conclusions and recommendations

10.1 Discussion

The objectives of this SRA were to 1) develop innovative decision-making tools that can map transformational options for future food systems, and 2) integrate up-to-date climate projections with scientific and local knowledge to identify thresholds and strategies that will transform current food systems. Due to the COVID-19 pandemic's outbreak in March 2020 not as much progress was made as had been planned, with only Activity 5 having been reached, and this was restricted to one case study workshop in the Solomon Islands. In addition, the workshop had to be re-scoped to account for the remote participation of the Australian and NZ Science Committee members. As a consequence, it was not possible to run it as intensively as had originally been planned, but the engagement of the local facilitators, Pitakia Tikai, Shane Tutua and John Fasi provided an opportunity to co-design a process that suited the resource- and time-constrained situation and their interests and expertise. As a result, the adaptation pathways process and tools that were ultimately tested have been well-aligned to conditions in the Solomon Islands. An additional bonus is that the facilitators now have many of the skills and ownership to carry out similar exercises in their own professional roles.

When the conceptual approach was initially devised in Activity 2 it was assumed that climate change posed a significant risk to food production. Hence the first research question focussed on identifying which food production systems should be maintained, and which will need transformational change. The second question asked what kinds of strategies are needed to build resilience or transform current food systems. In Activity 4 significant effort was applied to scan existing climate projection data, and to model potential impacts under a 'business as usual' carbon emissions scenario (SRES A2) using the CSIRO CCAM data which downscales projections to 8 km grids. At this resolution it was possible to combine climate change and population growth pressures at the scale of the case study, which included two constituencies and a ward which form the peri-urban area around the Malaita Province capital, Auki.

Applying these downscaled projections in the ADWIM tool indicated that while there would probably be largely negative impacts from climate change-related pressures by 2030 and 2050, resource utilisation (particularly for wild-harvested foods and commodities) and land conversion caused by population growth were generally more significant than climate change factors. Consequently, in this case study the focus of resulting strategies was less about transforming food production to alternative systems, and more concerned with governing and managing current food growing and harvesting to be more integrated, efficient, productive, adaptive and resilient, particularly in response to human population pressure. However, it is likely that in other geographical contexts in both the Solomons and the wider Pacific region the extent of and interactions between climate and social pressures may be different, and responses may vary markedly between locations, as has been demonstrated in Papua New Guinea and Indonesia (Butler et al. 2020). Hence this SRA underscores the importance of downscaled climate change projections which are available at a resolution that enables such detailed analysis, and we found that the CSIRO CCAM data was best suited to this.

The conceptual foundation of adaptation pathways has never been applied to food systems in developing economies, where decision-making contexts are complex and stakeholder capacity and resources for such planning are generally low. This SRA provided an opportunity to adapt and test a pathways approach as an innovative decision-making support tool. While in Activity 2 it was envisaged that 'road maps' of strategies,

trigger points and related decisions could be used, as also applied by Craddock-Henry et al.'s (2020) Dynamic Adaptive Policy Pathways method in Hawkes Bay NZ, ultimately the approach evolved towards one of more general 'pathways of change', which have an emphasis on capacity-building for decision-makers to enable their envisioning and implementation of system transformation (Werners et al. 2021). The three adaptation pathway diagrams produced by the groups in Session 5 of the workshop process did not specify pathways for specific foods or commodities, but instead presented pathway themes (e.g. Proper Land Management, Capacity-building, Appropriate Technology) and groups of actions and decision-makers necessary to implement them. Timeframes were included, and spatial differentiation in one group's example, but the sequencing of decisions around trigger points was not evident. However, instead of focusing on production alone, the pathways did cover different aspects of the food system, including resource conservation, marketing, consumption, waste management, education, land ownership and governance, suggesting that participants embraced the broader food systems framing of the approach.

Three reasons may account for the lack of specificity and detailed sequencing of options, actions and trigger points. First is the possibility that participants lacked time to conduct in-depth mapping of pathways, with only 3 ½ hours allocated to the activity. Indeed, the workshop was only intended to provide an introduction to the methods, but this reinforces that the process requires more significant time dedicated to collective planning and decision-making. Second is that at the food system level, even when relatively constrained to the case study's scale, the complexity is so great that only broad themes or areas of intervention are possible. When focussing on individual farms or farmer types (e.g. Stringer et al. 2020) or catchments and regions (e.g. Craddock-Henry et al. 2020) it is possible to map out specific technical options in production-orientated adaptation pathways, but this is less feasible and less appropriate at the scale of analysis attempted here. This may result in overlooking specific localised details (for example, the potential SLR inundation of Auki Central Market (see Fig. 12) was not addressed) but capture key systemic issues which must be tackled (e.g. the resolution of land demarcation and related disputes and conflict). Thus, applying pathways approaches to whole food systems may require a nested approach, with broad themes of intervention identified at a whole-of-food-systems scale to capture systemic issues and then more specific options and pathways developed within each broad theme. Finally, it is likely that the urgency of the situation in Central and West Kwara'ae demanded a suite of interventions to be introduced simultaneously across the food system, all of which were 'low or no regrets' and therefore did not require sequencing in order to maintain options and avoid mal-adaptation and 'lock-in', which is one of the core principles of pathways thinking (Reeder and Ranger 2011, Kwakkel et al. 2016). The screening of strategies as 'low or no regrets' is a step that has been part of livelihood adaptation pathways processes (e.g. Butler et al. 2016b; 2018), but there was insufficient time to include it in this workshop.

Unfortunately, due to the disruption caused by the COVID-19 crisis, there were two aspects of the planning approach which were not undertaken as originally intended. First was an in-depth analysis of the decision-making context that the process aimed to engage with, which is necessary if any adaptation planning process is to influence current decision-making (Butler et al. 2016c). CSIRO has begun developing a participatory method to carry out such an analysis in Pacific island contexts (Dutra et al. 2019), but due to logistical constraints local expert opinion had to be canvassed instead. This did not definitively identify key decision-makers or processes that govern food systems in Malaita Province, perhaps due to the complexity of the food system, which Session 1 indicated includes multiple local producers, local and external markets and imports. Although workshop invitees included farmers, the Auki Market Vendors Association, women and youth groups and provincial and national government representatives from agriculture and health departments, it became clear that although these were stakeholders, they were not necessarily key decision-makers. Instead, participants suggested in the workshop

evaluation that future planning processes should focus at the ward level, and include clan chiefs, plus greater representation from youth groups and relevant NGOs.

The second shortcoming was the valuation of local food and commodity production using ADWIM. Usually the exercise of listing and semi-quantitatively valuing EGS underpinning livelihoods is carried out in real time during workshops, which encourages social learning generated by the results (Skewes et al. 2016), but this was impossible due to time constraints. Instead, values had to be applied from other locations in the Solomon Islands, which may have mis-identified the most important EGS in the case study area, although the inventory of EGS was based on local information. Another drawback was that the facilitators were unable to be engaged in the use of ADWIM, and therefore did not develop this skill. However, there are future opportunities to involve them in knowledge broker training currently being designed by CSIRO, including the use of ADWIM. Despite the inability to use the tool to its full potential, the workshop reflections and evaluations showed that most participants still found the results understandable and useable.

In September 2019 the Steering Committee agreed five 'proof of concept' criteria for the approach and tools developed and tested by the SRA:

1. Applicability in different contexts, proven from two case studies
2. For ACIAR and MFAT: a useful lens to screen current and prioritise future investment
3. For MFAT and DFAT Posts: local buy-in evident
4. For case studies: National Adaptation Plan of Action (NAPA) representatives regard the approach as helpful to the implementation of NAPAs
5. For local decision-makers: evidence of a conceptual shift in the mindset of planners in their approaches to adaptation in agricultural development

It was impossible to assess the first criterion because the COVID-19 crisis only allowed one case study to be conducted, and the potential second site in Samoa was shelved. However, earlier proto-versions of this pathways approach have been successfully applied for livelihoods in different socio-cultural contexts and scales (i.e. wards, sub-districts, districts, provinces), and also for large-scale mining, tourism, fisheries, palm oil and urban development decision-making in other regions of the Solomon Islands (Butler et al. 2018), plus Papua New Guinea, Indonesia and northern Australia (Bohensky et al. 2014a; 2014b; Butler et al. 2015b; 2016a; 2016b; 2020; in review; Meharg et al. 2014). Detailed evaluations of these processes have clearly demonstrated capacity-building outcomes in terms of enhanced knowledge, innovation and social networks which have resulted in significant shifts in participants' mind-sets and decision-making (Butler et al. 2015a, 2016c, in review, Meharg et al. 2014). Hence it seems probable that the approach developed so far by this SRA, while still requiring refinement, may be easily transferable to other food systems in the Pacific region.

The second criterion has yet to be tested because Activity 7 (a workshop applying the communications products to assess the implications of the results for ACIAR and NZ agricultural and fishery investment) has not yet been arranged. However, it is notable that the ADWIM analysis indicated that freshwater aquaculture is likely to be stressed by declining rainfall, particularly by 2050. Hence NZ Aid's Strengthening Tilapia Farming in Solomon Islands program may not be sustainable in the long term, although a shift to aquaponics may reduce a reliance on external water supplies. Furthermore, Group 1's Food and Security pathway indicated that a move away from swamp taro production on flood-prone and inundation-risk land to inland tilapia aquaculture was necessary.

More broadly, the actions and stakeholder partnerships listed for each pathway by the groups do provide a logical and justified portfolio for donor engagement, including the Australian and NZ governments. While the workshop outputs require consolidation,

perhaps through a second integration exercise with the external stakeholders identified, priorities for agricultural and fisheries research and development agencies are embedded within the pathways. These include identifying new types of crops, organic farming, applying traditional knowledge and beliefs, and innovative farm management systems (Group 1), establishing demonstration plots for practices alternative to Slash and Burn (Group 2), and farmer training in organic farming, waste composting for fertiliser, and pest and disease control (Group 3). In the case study area some research effort is clearly warranted to develop alternative crops and commodities including kava, rain-fed rice, honey and seaweed, plus circular bio-economy techniques which may be climate change compatible and diversify local food production, fostering greater food system resilience.

The third criterion requiring evidence of MFAT and DFAT Posts' buy-in was clear in Activity 3's planning for the Solomon Islands case study. Joint discussions were held that identified Malaita Province and the Auki region as a priority for both the NZ and Australian governments due to NZ Aid's investment in the Strengthening Tilapia Farming in Solomon Islands program, DFAT's Rural Development Program and their joint funding of the PHAMA Plus initiative. In addition, both High Commissions facilitated linkages with the ongoing work in the case study by the Worldfish Centre and FAO and engaged with the Ministry of Agriculture and Livestock to seek endorsement and encourage a potential synergy with the 10-year Agricultural Investment Strategy. Related to high-level policy engagement by the SRA, the fourth criterion was relevance to the implementation of the Solomon Islands NAPA. The NAPA (UNDP 2008) highlights agriculture, water and sanitation and human health as vulnerable sectors of the economy and had instigated various projects to address the issues raised. This SRA did not engage with the Ministry of Environment, Conservation and Meteorology, which is responsible for implementing the NAPA, but this gap could be addressed in any follow-up work in the Solomons.

The final criterion, evidence of a conceptual shift in the mindset of planners in their approaches to adaptation in agricultural development, was demonstrated clearly by the workshop evaluation. This is the key characteristic of the 'pathways to change' form of adaptation pathways, which emphasises the building of decision-makers' capacity to anticipate and then act on future uncertainty. Hence there is greater focus on social learning processes, rather than technical outputs, which can catalyse stakeholders to understand the need for and then implement collective action to solve highly complex problems (Werners et al. 2021). The design of the workshop process aimed to achieve this by adapting Brown and Lambert's (2015) decision-into-practice learning cycle, framed in this case around food system adaptation and transformation (see Fig. 3).

When asked "has the workshop changed your thinking?", responses included: "there is a need to maximise food production, land use and land use planning", "it is possible to integrate traditional and scientific knowledge", and the approach "encouraged thinking about mixed cropping and alternative farm management". The vast majority agreed or strongly agreed that the workshop process had increased their knowledge about food systems and future risks and opportunities in Malaita, that they were motivated to follow-up on the actions identified in the workshop, and that they had made new contacts and useful networks. When asked "what was your most memorable part of the workshop?", participants listed understanding drivers and impacts with regards to food production, visions, adaptation pathways and identifying actions. Several also mentioned learning and thinking differently, such as tipping points and encouraging youth to plan ahead for the future. One participant summarised by saying: "I came to realise the important idea is not to think the usual way, but to think of new ways of thinking in order to survive."

Finally, participants made suggestions about how to improve the method, and next steps for the research. Firstly, there was agreement that workshops needed to take more time and be run over three days rather than two. In addition, the scale of focus should be wards, and clan chiefs, youth and stakeholders related to the broad spectrum of food

system drivers should be included. Second, there was a recommendation that the workshop process should become 'training-of-the-trainer', whereby participants learn how to facilitate the process and scale-out the approach to their own communities with ongoing support from brokers such as Pitakia Tikai, Shane Tutua and John Fasi. Third, participants wished to receive feedback and materials from the workshop. For the process to continue, it is important to recognise that the decision-into-practice learning cycle which framed the workshop (see Fig. 3) only represented the first cycle of collective decision-making in the case study area. Careful thought should be given to planning further cycles that will effectively connect with ongoing decision-making and maintain continuity and momentum for implementation of actions. Given that the first workshop only produced an initial set of pathways and did not engage many important decision-makers and stakeholders, some form of follow-up process would be warranted if Malaita Province were to be the focus of investment in building the efficiency and resilience of current food systems (as opposed to transformation), perhaps linking across scales from wards to the Central and West Kwara'ae constituencies.

10.2 Conclusions

Despite the disruption of the COVID-19 crisis to the SRA plan, the collation of climate projection data and its application in the Solomon Islands case study generated early success. The co-design of an adaptation pathways process between Science Committee members, in-country facilitators and workshop participants was productive, and the resource and time constraints which necessitated the simplification of the method was partially an opportunity rather than an obstacle. Evaluation of the process suggested that the conceptual approach, which evolved into a 'pathways of change' rather than technical 'road map' format, significantly enhanced the capacity of participants in terms of understanding food systems, anticipating future change and uncertainty, and engaging with others to promote adaptive action.

The results indicated that under a business as usual global emissions scenario, there will be climate change impacts on most food and commodity production by 2050, but human population pressure and related social issues are likely to have a greater impact. Therefore, the SRA has demonstrated that in order to promote food system sustainability, both climate and social drivers should be considered, and adaptation pathways processes and tools which enable a systems perspective can assist such assessments. Downscaled climate change projection data must be available at a suitably fine spatial scale to support such planning, and the CSIRO CCAM outputs are currently the most suitable. Questions remain as to how the process can be refined and scaled-out, potentially through knowledge brokers trained in the method, and how Australian and NZ government investment portfolios in Pacific food systems can be aligned to the outputs of such pathways processes.

10.3 Recommendations

1. The adaptation pathways method should be refined, with three days allocated to workshops, and improved prior analysis of decision-making in food systems. Follow-up workshops should be undertaken in the Malaita Province case study area to build on the first workshop, with linked planning exercises carried out at the ward and constituency scale.

2. Consideration should be given to scaling-out the process by 'training-the-trainer' through these workshops. This could build a network of knowledge brokers in the Solomon Islands who can apply the method through their professional and community roles. A similar approach in other Pacific island countries could build a community of practice across the region.

3. Any further Australia and NZ government support of food system research, development and capacity building in the Auki region of Malaita Province should be informed by the case study workshop's outputs.

4. Outputs from the case study workshop should be collated and provided to participants to support their implementation of the adaptation pathways' actions.

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11.2 List of publications produced by project

Climate change and Pacific food systems: Decision-making for transformational change Proof-of-Concept. 2-page Information Sheet, September 2019.

12 Appendices

12.1 Appendix 1: Project personnel

Commissioned agent and collaborating organisations

Name	Sex (m/f)	Agency and position	Discipline and role in project	Time input (%)	Funding
James Butler	M	CSIRO, Principal Senior Research Scientist	Project leader and coordinator, strategy development, climate adaptation and livelihoods	25%	CSIRO ACIAR
Tony Nadelko	M	CSIRO, Research Scientist	Data management and analysis, modelling, infographics	30%	CSIRO ACIAR
Ben MacDonald	M	CSIRO, Principal Research Scientist, Group Leader	Agricultural systems, soil science, climate adaptation	10%	CSIRO ACIAR
Mike Webb	M	CSIRO, Principal Research Scientist	Agricultural systems, climate adaptation	10%	CSIRO ACIAR
Leo Dutra	M	CSIRO, Principal Research Scientist	Coastal fisheries, livelihoods and governance	10%	CSIRO ACIAR
Monica van Wensveen	F	CSIRO Project Support	Agricultural systems	5%	CSIRO ACIAR
Steven Crimp	M	ANU, Research Fellow	Advisory, climate adaptation, agricultural systems		ANU in -kind
David Ugalde	M	David Ugalde and Associates	Advisory, policy and stakeholder synthesis	15 days	ACIAR/ CSIRO

Partner country institution(s) or collaborating IARC

Name	Sex (m/f)	Agency and position	Discipline and role in project	Time input (%)	Funding
Theresa Wilson/William Aitkenhead	F/M	Senior Policy Analyst, Global Research Alliance and NZ Ministry for Primary Industries	Technical guidance		MPI in-kind
Dale Yi	M	Plant and Food Research New Zealand, Value Chain Economist	Agricultural and value chain economist	10 days	MPI
Suzie Newman	F	Plant and Food Research New Zealand, Head International Development	Technical guidance		P&FR NZ in-kind
Brent Clothier	M	Plant and Food Research New Zealand, Horticulturalist	Horticulture expertise	10 days	P&FR NZ in-kind
Gavin Kenny	M	NZ Ministry for Primary Industries	Farming systems	10 days	MPI

Name	Sex (m/f)	Agency and position	Discipline and role in project	Time input (%)	Funding
Andrew Tait	M	Chief Scientist - Climate, Atmosphere and Hazards National Institute of Water & Atmospheric Research Ltd (NIWA), New Zealand	Advisory on climate data, developing climate products		NIWA in-kind
Pitakia Tikai	M	Kastom Garden Association, Honiara	Workshop design and facilitation	10 days	MPI
John Fasi	M	Solomon Islands National University	Workshop design and facilitation	5 days	MPI
Shane Tutua	M	SPE Consulting, Honiara	Workshop design and facilitation	5 days	MPI
Tim Skewes	M	Tim Skewes Consulting	ADWIM modelling	6 days	ACIAR

12.2

12.3 Appendix 2: Solomon Islands workshop agenda

Australian Government
Australian Centre for International Agricultural Research

NEW ZEALAND
FOREIGN AFFAIRS & TRADE

Climate change and Pacific food systems: Decision-making for transformational change

November 12th and 13th 2020

Hilltop Training Institute, Auki, Solomon Islands

Workshop objective

"To develop an approach that supports decision-makers to anticipate rapid climate change and uncertainty, and to transform food systems, using West Kwara'ae and Central Kwara'ae Constituencies as a case study"

AGENDA

Day 1 Thursday 12th November

9:00 – 9:30	Introductions, project background and objectives
9:30 – 10:30	Session 1: How does the food system currently work in the West Kwara'ae, Central Kwara'ae and Langlanga Constituencies case study? What are the main products? Who grows or catches the food, and where?
10:30 – 11:00	Morning tea
11:00 – 12:00	Session 1 continued
12:00 – 1.00	Session 2: What are the drivers of change for the food system?
1:00 – 2:00	Lunch

2.00 – 2.30	Session 2 continued
2:30 – 3.30	Session 3: What will be the impacts of climate and other drivers on the food system?
3:30 – 4:00	Afternoon tea
4:00 – 5.00	Session 3 continued

Day 2 Friday 13th November

9:00 – 9:30	Start and recap Day 1
9:30 – 10:30	Session 4: What is the 2050 vision for food production and the food system in West Kwara'ae and Central Kwara'ae Constituencies?
10:30 – 11:00	Tea
11:00 - 1:00	Session 5: How do we adapt and achieve the vision for 2050? Can we plan 'pathways' towards the vision?
1:00 – 2:00	Lunch
2:00 – 3:30	Session 5 continued
3:30 – 4:30	Reflections, evaluation, next steps

12.4 Appendix 3: Solomon Islands workshop evaluation form

EVALUATION FORM

Name (optional):……. Organisation (optional):……..

Scoring:

Strongly disagree	Disagree	Maybe	Agree	Strongly agree
1	2	3	4	5

Question (please tick a score)	**1**	**2**	**3**	**4**	**5**
1. The **pathways approach** is useful for planning food system adaptation in Malaita					
2. The **climate projection information** was understandable and useable					
3. The **population projection information** was understandable and useable					
4. The **food product importance information** was understandable and useable					
5. The **food impact information** for 2030 and 2050 was understandable and useable					
6. The **right decision-makers** were present in the workshop					
7. **My knowledge** about food systems and future risks and opportunities in Malaita has grown					
8. I am **motivated to follow-up** on the actions identified in the workshop					
9. I made **new contacts** and useful networks					

10. How would you **improve the planning approach**?.....

11. What are your **recommended next steps**?.....

12. What was your **most memorable part** of the workshop?.....

THANK YOU