Climate Resilient Honiara

WP7b: Climate Resilient Spaces: Nature based Solutions
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Abbreviations and acronyms

CRH – Climate Resilient Honiara

DRR/M – Disaster Risk Reduction/Management

HCC – Honiara City Council

GHA – Greater Honiara Area

HURCAP – Honiara Urban Resilience and Climate Action Plan

MECCDM – Ministry for the Environment, Climate Change and Disaster Management

MLHS – Ministry of Lands, Housing and Survey

MHMS – Ministry of Health and Medical Services

NbS – Nature-based Solutions

RMIT – Royal Melbourne Institute of Technology

SINU – Solomon Islands National University

UNFCC – United Nations Framework Convention on Climate Change

UN-Habitat – United Nations Human Settlement Programme

Executive Summary

Honiara is being adversely affected by the consequences of rapid urbanisation and the growth of informal settlements. Climate change will act to amplify many of these human stresses into the future. In response, a new project 'Climate Resilient Honiara' (CRH), funded by the UNFCCC Adaptation Fund and administered by UN-Habitat, has been set up to address many of these critical issues. This report examines the potential role of Nature-based Solutions (NbS) in contributing to a portfolio of actions aimed at enhancing the climate resilience of Honiara's urban residents; as well as proposing specific NbS actions that are appropriate for local context.

The conceptual designs highlighted in the report have been informed by a number of site visits; consultations with local and national Government, NGOs and CSOs, and local communities; and participatory design studios held in both Honiara and Melbourne [using 2017 LiDAR data provided by the SI Ministry of Health and Medical Services (MHMS)]. The analysis was also framed by two important local agendas: the potential for Honiara City Council (HCC) to develop an urban greening / liveability strategy, and SPREP's 'Planning for Ecosystem-based Adaptation' project. The developmental process for the designs has also been cognisant of Honiara's Local Planning Scheme (2015, to be updated in 2020) and the Greater Honiara Urban Development Strategy and Action Plan (promoted by the ADB and Solomon Islands Government).

Based on the above approach, a total of 12 landscape architecture and urban planning actions / designs have been proposed. These have been categorised according to: 1) Planning and spatial analysis; 2) Ecosystem-based adaptation (specifically targeting identified climate-related hazards); and 3) Design of climate resilient open spaces and urban villages.

There are 4 actions under planning and spatial analysis. These include the development of a formal NbS framework and action plan for HCC, a review of the local planning scheme, GIS analysis in support of other actions in the Climate Resilient Honiara project, and GIS training for local NGOs. Ecosystem-based adaptation actions include establishing a baseline of the city's urban trees, greening measures for Kukum Highway (for the Pacific Games), Koa Hill flood resilient community space (public space and flood mitigation measures), piloting retention basins to reduce riverine flooding, and a mixture of measures to reduce the risk of landslides. The actions proposed under climate resilient open spaces and urban villages include the co-design of a linear park in the Mataniko River corridor, design options for upgrading existing informal settlements, and the planning of new urban fringe settlements e.g. Noah Hill's suburban project.

It is intended that each of these measures will contribute to a strengthened local resilience to climate-related impacts as well as improving the liveability of the city for all Honiara's residents, especially the urban poor.

1. Introduction

The ‘Climate Resilient Honiara’ Project (CRH) is a four-year project funded by the UNFCCC Adaptation Fund and administered by UN-Habitat. RMIT University provides scientific support to a range of different urban climate resilience activities (actions and capacity building). Professor Darryn McEvoy leads the project and a large multi-disciplinary team of lecturers and researchers from six different schools at RMIT. The project also engages with multiple local partners, NGOs and consultants. The project is implemented locally by the Solomon Islands Ministry for the Environment, Climate Change and Disaster Management (MECCDM), the Ministry of Lands, Housing and Survey (MLHS), and Honiara City Council (HCC).

The aim of CRH is to reduce the vulnerability of those living in informal settlements in the fast-growing capital city of the Solomon Islands, Honiara. RMIT commenced work on the project in 2019 and are involved with 15 different components. This report details Work Package 7b **‘Climate Resilient Spaces - Nature based Solutions (NbS)**.’ The aims, approach, and background information are outlined in this report, as well as the scoping activities conducted in 2019. The report concludes with proposed actions for nature-based solutions that have been identified during field visits and in consultation with key local stakeholders. These are to be considered for funding in 2020/2021. The report has been authored by Mittul Vahanvati, Ata Tara, Yazid Ninsalam, and Fiona Lawry, and reviewed by Darryn McEvoy.

2. Project aims

2.1. Aims of the Climate Resilience Honiara project

The aim of the CRH project is to:

- Enhance the resilience of Honiara for current and future climate impacts and natural disasters;
- Focus on the most vulnerable communities in Honiara.

2.2. Aims of Work Package 7b: Climate Resilient Spaces – Nature-based Solutions

The original intention of project component 7 was to consider climate resilient spaces in general, however due to the differing expertise required this component was split into two separate work packages: 7a) hard infrastructure (evacuation centres) and 7b) nature-based solutions (NbS).

WP7b – NbS aims to develop:

1. A nature-based solutions framework and action plan (with short, medium- and long-term actions) to support Honiara City Council (HCC) in moving towards a more climate resilient Honiara;
2. Spatial mapping and analysis at the city-scale, with downscaled analysis of selected pilot sites;
3. Conceptual designs to pilot NbS (including identifying relevant local partners to support the implementation of actions).

This research aim is set in relation to identified knowledge gaps among stakeholders in Honiara, matching the specifics of ‘what needs to be done’ with ‘what options exist’ to address the challenges from natural hazards, climate change and rapid urbanisation. It is intended that detailed actions will be co-designed with local stakeholders, based on comparative metrics of what has worked in surrounding small island developing states (SIDS).

3. Research approach

A participatory action-based research approach was adopted for this WP, with the use of co-design workshops to devise nature-based solutions for Honiara. The researchers employed a multi-tiered, multi-disciplinary, and multi-scale problem analysis approach; which included:

AIM 1: A nature-based solutions framework and action plan to support Honiara City Council (HCC) in moving towards a more climate resilient Honiara

- Development of a nature-based solutions framework and action plan;
- Provision of NbS baseline and actions.

AIM 2: Spatial mapping and analysis at the city-scale, with downscaled analysis of selected pilot sites

- Spatial mapping and analysis of ecosystems and ecosystem services;
- Capturing existing information about climate vulnerability of Honiara city and other community vulnerability hotspots.

AIM 3: Conceptual designs to pilot NbS

- Co-design studios to develop a vision of future Honiara through NbS, with:
    - Solomon Islands National University (SINU) graduates (needs-based designs);
    - RMIT undergraduate and post-graduate students (conceptual designs);
- Field visits to 'community vulnerability hotspots' (September 2019);
- Consultations with stakeholders (the Honiara City Council, MECCDM, SPREP, SINU) about their current initiatives, priority needs, and aspirations.

4. 'Nature-based Solutions' (NbS)

4.1. The concept and timeline of nature-based solutions and its timeline

Nature-based solutions (NbS), although a relatively new scientific concept, is the practice of working closely with the natural environment [that] is inherent to many global indigenous practices (Bryant-Tokalau, 2018). NbS also aim to enable humans and human settlements to adapt to climate change through conserving and restoring nature and natural systems. As outlined by Pedersen Zari *et al. (*2019), the aims of NbS are to: "produce societal, cultural, health and economic co-benefits for people while conserving or generating increased ecological health" (p. 2). Elsewhere, nature-based solutions are defined as:

> *"Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham et al. 2016, p.5).*

The definition places emphasis on 'actions' that have multi-layered benefits – transcending from ecosystems to society. This indicates that NbS utilises natural systems (terrestrial and ocean ecologies) to improve human well-being.

Many concepts and terms, like NbS, exist; such as 'ecosystem services', 'green-blue infrastructure', 'ecological engineering', 'ecosystem-based management', 'natural capital', 'ecosystem-based adaptation', and potentially 'biomimicry' and 'biophilic design' (Nesshöver et al., 2016; Nature Editorial 2017; Pedersen et al., 2019; Raymond et al., 2017). These concepts and terms are widely used in the disciplines of urban design, planning and landscape architecture, academia and policy debates, despite differences in their meanings. Other commonly used terms are defined below:

Ecosystem services provide benefits to humans through the utilisation of natural processes like pollination by insects; soil fertility created by microorganisms, fungi and available nutrients; insect control – through natural predators; and erosion control, through water, soil and vegetation management. Ecosystems provide these services and essential functions as clean air, water, and food (Constanza et al., 1997, Department of the Environment, Water, Heritage and the Arts, 2009). In the Pacific, coral reefs also support fish and provide the benefit of reducing storm surges.

Issue-specific ecosystem approaches include ecosystem-based adaptation or ecosystem-based mitigation or ecosystem-based disaster risk reduction by "investing in the maintenance of the ecosystem functions and services that we depend on for our survival" (SPREP 2018, p.1).

Infrastructure-based approaches include blue and green infrastructure or biophilic designs. These approaches are typically used in relation to urban environments, which are dominated by grey infrastructure or human engineered solutions such as housing, roads and services. Green infrastructure are natural and semi-natural green spaces such as parks, rows of trees or forests; blue infrastructure include swimming pools, ponds, rivers and water features.

Biophilic design is used mainly in relation to building design that provides better connection between humans and the natural environment, incorporates natural motifs or materials, or are inspired by processes or species in the natural environment e.g. Council House 2 building in Melbourne inspired from the functioning of termite mounds.

These approaches predate NbS and share many similarities, however, NbS has become an umbrella term (NbS framework by IUCN, 2015) that brings these well-established approaches together and is the term that has been used for the CRH project (Figure 1).

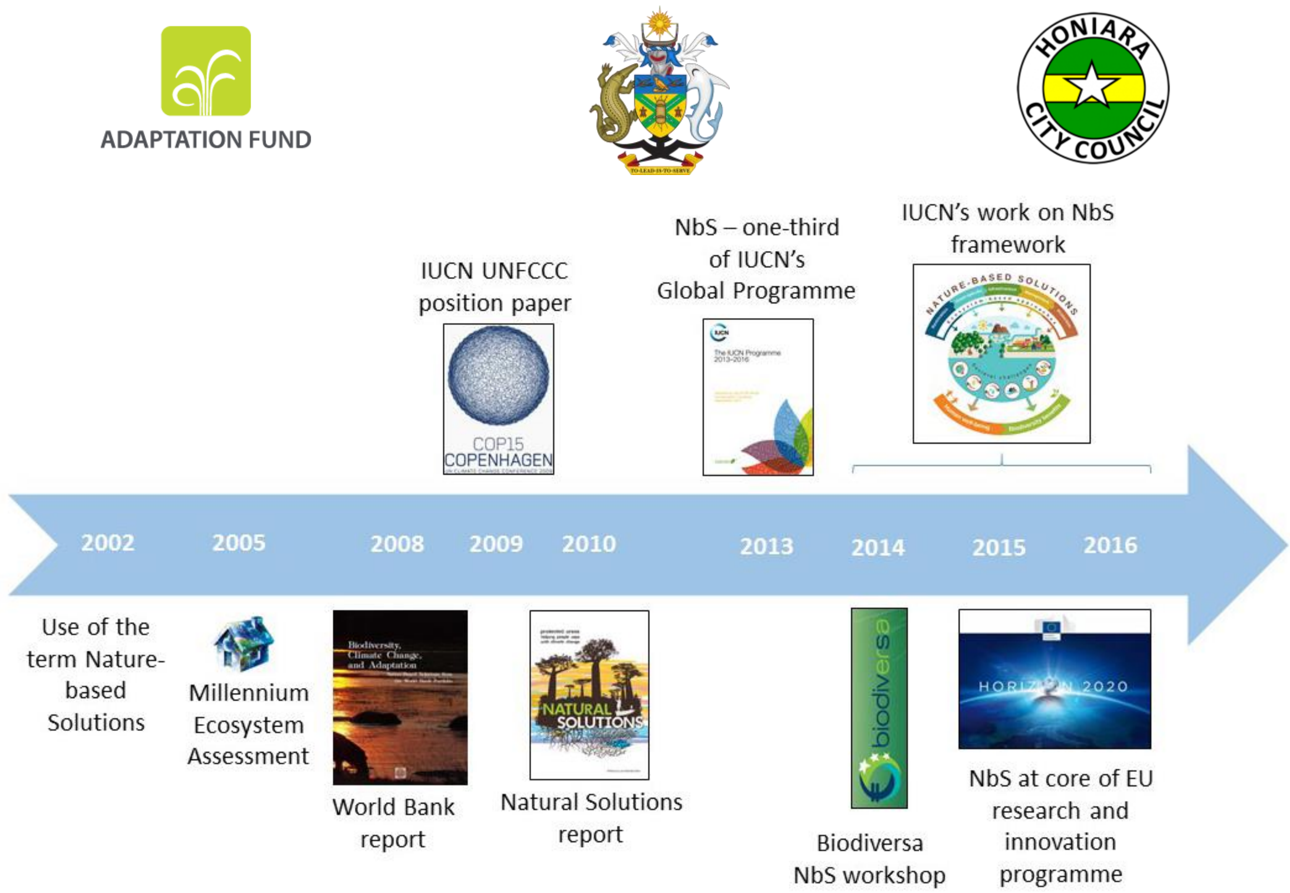


Figure 1: Timeline for the development of NbS concept (Source: Cohen-Shacham 2016)

4.2. Benefits and challenges of NbS

In their Ocean Cities Policy Brief (2018), the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) describe how weakening cultural connections to the ocean can be reinvigorated through harnessing NbS and engaging traditional solutions through a 'Pacific Way'.

> *"An Ocean Cities approach engages the people of Pacific islands and integrates a 'Pacific Way' to building solutions. A systems approach is needed in Ocean Cities, at multiple scales, to enable analysis of trade-offs and support decisions that deliver multiple benefits – to society, economy and environment" (p.3).*

Benefits of nature-based solutions include (Figure 2):

- Protection of coastlines and biodiversity by rehabilitating mangroves;
- Reduction of wave impacts by planting coastal vegetation;
- Reduce in soil erosion and reductions of flooding by replanting stream or watershed areas;
- Water management by combining natural and engineered infrastructure;
- Addressing challenges of land tenure, health, food security and unemployment by urban agroforestry;
- Encouraging ownership by young people by the establishment of educational managed marine areas;
- Supporting ecosystem services, as well as economy, by wetland construction and restoration of forests.

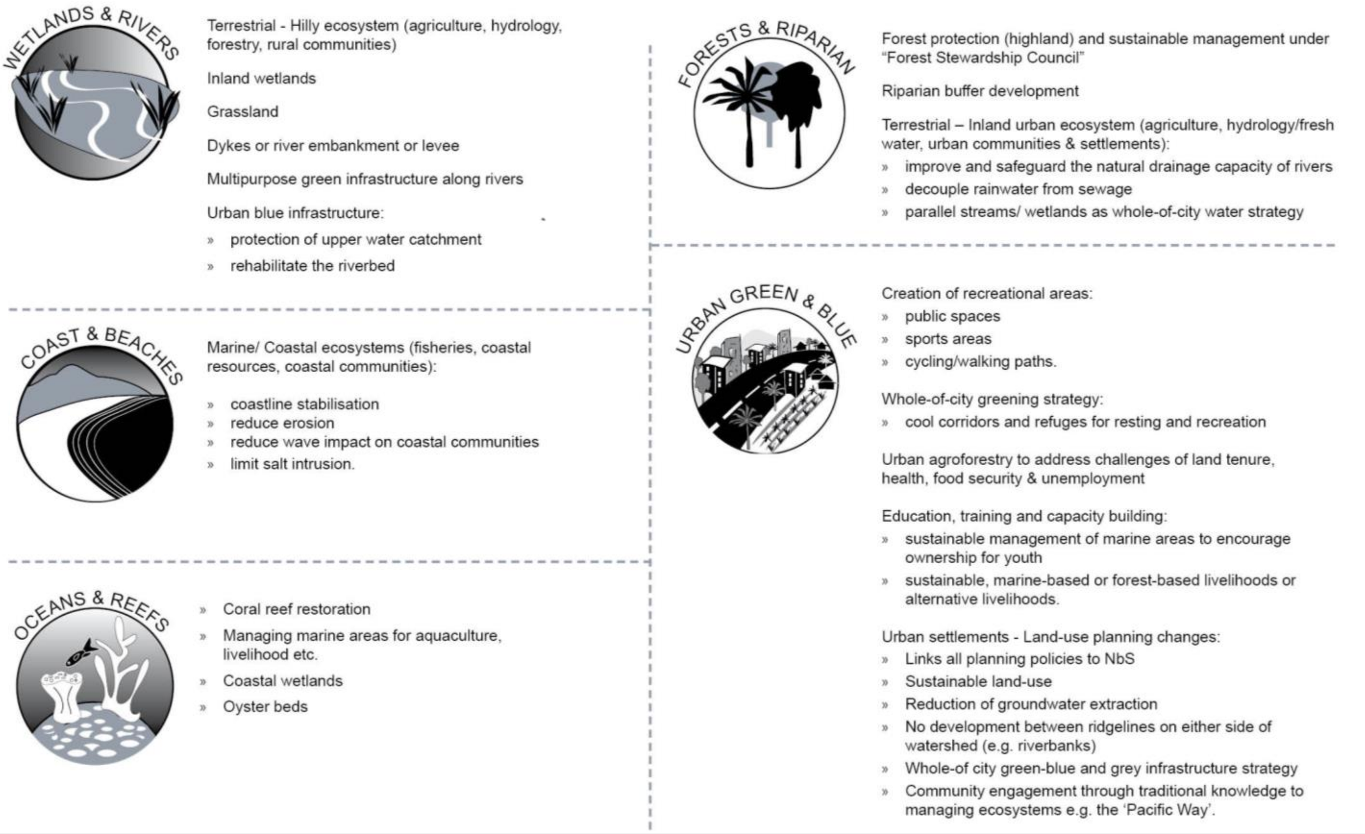


Figure 2: Nature-based Solutions for various ecosystem types and communities (adapted from Harms et al. 2018)

Secondary benefits can flow from these examples and may include the provision of food, shelter, water, medicine, or income (known as ecosystem services). These secondary benefits are important because they capitalise on the primary benefit in cost-effectiveness and self-sustenance. There can be many challenges to designing and implementing NbS but the majority of them are place specific. However, time and time again, one major challenge that has been identified is the need for external resources (financial, skills, human capacity).

4.3. A conceptual framework for NbS

Several conceptual frameworks have been proposed since 1970s, including those by organisations such as the International Union for Conservation of Nature (IUCN); Naturvation[1]; Nature based Solutions (NbS) initiative[2], and academic scholars including Raymond et al., 2017. Each of the frameworks incorporate a variety of natural processes to generate climate resilience in urban environments; aiming to enhance human wellbeing and the liveability of cities. The IUCN has been conducting research on nature-based solutions since 2009. Based on a comprehensive review of existing literature and practical use of NbS, IUCN (2013-2016) has proposed an overarching conceptual framework to cluster together various approaches to NbS.

[1] https://naturvation.eu/
[2] https://www.nature-basedsolutions.com/

Some of the common elements incorporated in the above-mentioned conceptual frameworks, and more specifically, by Cohen-Shacham (2016) are:

- Ecosystem functions and services (e.g. issues-specific, infrastructure-related, ecosystem restoration, ecosystem-based management, ecosystem protection);
- Societal challenges specific to a particular context:
    - Hazards (natural and climate-related);
    - Urban environment.

Based on this understanding, and tailored to the context for Honiara (relating to the major challenges from climate change and rapid urbanisation), a conceptual framework for nature-based solutions was developed for Honiara (Figure 3). The proposed conceptual framework for NbS to the challenges facing Honiara relates to: i) Ecosystem services, ii) natural hazards and climate change and iii) urban environment.

1. Ecosystem functions and services (land and water-based);
2. Natural hazards and climate change (Honiara is highly exposed to a range of hazards);
3. Urban environment (rapid urbanisation is posing major challenges given the shortage of land, limited resources, customary land rights outside the municipal boundary, growth of informal settlements etc., as discussed further in the report).

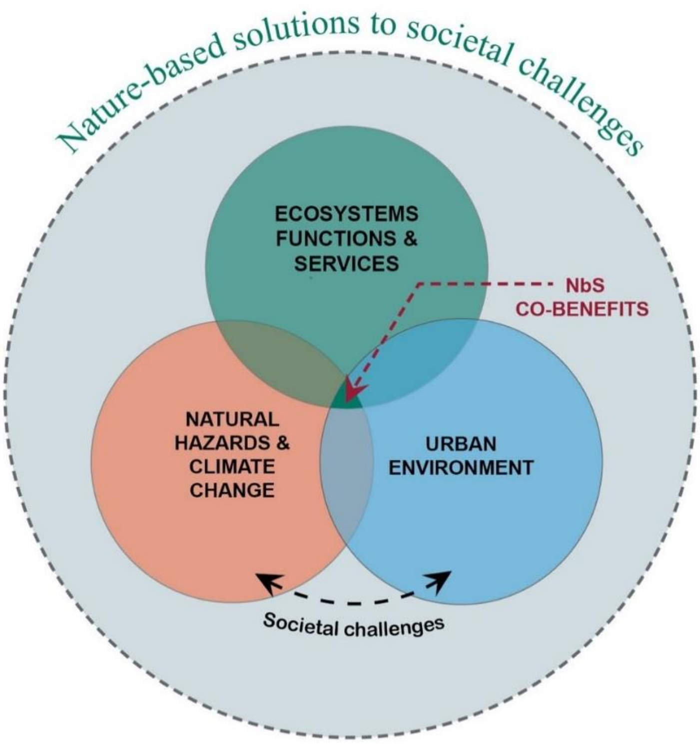


Figure 3: Conceptual framework for nature-based solutions in Honiara (Source: Vahanvati)

Approaches to NbS are categorised by Cohen-Shacham (2016) into three types, based on the level of engineering applied to biodiversity and ecosystem settings. These three typologies include (Figure 4):

i) Protection of what is existing;
ii) Restoration or management of natural or modified ecosystem; and
iii) Creation of new ecosystems (hybrid of grey, green and blue infrastructure).

These different mechanisms are important considerations when designing nature-based solutions for Honiara.

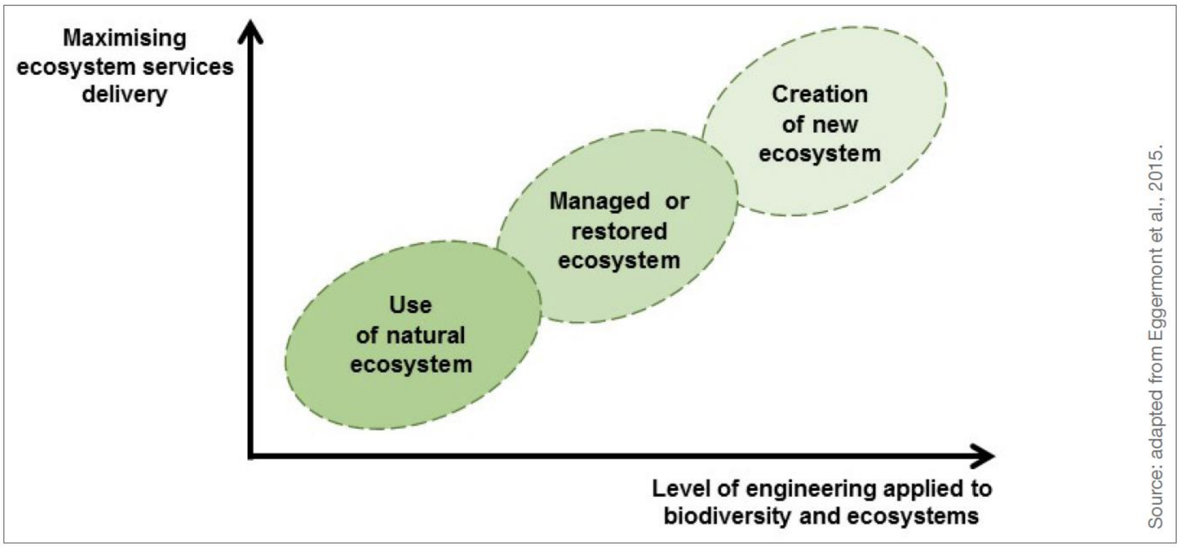


Figure 4: Typology of nature-based solutions (Source: Cohen-Shacham 2016, p.9)

4.4. Operational framework for NbS

Operationalising nature-based solutions in a real-world context or for on-ground implementation (which typically requires commitment of 50 years or more) is a challenging task. We discuss the steps required in implementation by drawing upon what has been proposed by scholars and practitioners; followed by a discussion of observed success factors.

Raymond et al. (2017, p.15-24) proposed a seven-stage process for undertaking and measuring NbS in policy and project implementation:

1. Identify problem or opportunity in a particular context;
2. Select and assess NbS and related actions;
3. Design NbS implementation processes;
4. Implement NbS;
5. Frequently engage stakeholders and communicate co-benefits;
6. Transfer and upscale NbS;
7. Monitor and evaluate co-benefits across all stages.

This seven-stage process "represent a valuable tool for guiding thinking and identifying the multiple values of NBS implementation", (Raymond *et al.* 2017, p. 15). Similarly, the World Bank (2017) has proposed an eight-stepped process to implement nature-based solutions in a sustainable and effective manner, as:

1. Define problem, project scope and objectives (study area, key beneficiaries and stakeholders, scale of natural system suitable for problem solving);
2. Develop financing strategy (funding source, timeline, risk, feasibility, incentives);
3. Conduct ecosystem, hazard and risk assessment (ecosystem presence, health and functioning, model current and future hazard risk);
4. Develop nature-based risk management strategy (ecosystem potential option identification);
5. Estimate the costs, benefits and effectiveness (effectiveness of ecosystem measure);
6. Select and design the intervention (green and hybrid option design);
7. Implement and construct (conservation, restoration and/or establishment of ecosystem elements);
8. Monitor and inform future practices (monitor ecosystem performance, resilience and stability).

The main difference in the implementation steps proposed by Raymond et al. (2017) and the World Bank (2017) is an emphasis on financing strategy (by the latter). We have adapted these frameworks to create an operational framework for this project (Figure 5).

Table 1

Figure 5: Operational framework for NbS implementation

The operational framework is also detailed and presented in table format (Table 1). It can be used to provide a checklist of processes and outputs when deriving effective nature-based solutions for a specific context.

Table 1: Operational framework for NbS implementation (Source: Vahanvati, adapted from Raymond et al. (2017) and the World Bank (2017)

Step 1: Define the problem, project scope & objectives	
1.1	Identify the study area, problem, key stakeholders & beneficiaries (get buy-in)
1.2	Define the project scope and boundaries
1.3	Set project objectives, reasoning (constrains & benefits) and clear targets
	Outputs: 1. Stakeholders engaged & needs defined 2. Project objectives captured
Step 2: Conduct ecosystem, hazards & risk assessments	
2.1	Conduct an integrated system assessment of the intervention area: » ecosysystem types (land, vegetation, ocean) (hilly, coastal or urban) » their hazard risk reduction potential
2.2	Gather data for risk assessment: » Hazard » Exposure » vulnerability
	Outputs: Spatial maps and analysis indicating: 3. current & future hazards, exposure & vulnerability 4. land use, ecosystems & importance of ecosystem for risk reduction (GIS modelling and baselines maps)
Step 3: Develop nature-based concept design for identified problem	
3.1	Select adaptations & risk reduction targets
3.2	Identify NbS options (green or hybrid)
3.3	Co-design NbS strategies with local stakeholders to incorporate existing/traditional knowledge in managing ecosystem
	Outputs: 1. Concept designs 2. Development of their potential phasing in time
Step 4: Develop financing strategy	
4.1	Identify sources of funding
4.2	Quantify risk reduction cost-benefit analysis
	Output: 1. Cost-benefit analysis delivered
Step 5: Develop design of selected intervention	
5.1	Select effective & flexible intervention with stakeholders
5.2	Design a robust monitoring system starting with baseline monitoring
5.3	Produce engineering design
5.4	Draft maintenance plan
	Outputs: 1. Developed design 2. Monitoring & maintenance plan with target values, roles & responsibilities, timeframes & monitoring methods.
Step 6: Implement and construct in a participatory manner	
Step 7: Monitor & inform future actions	

4.5. Success factors

Based on a comprehensive review of different modes of NbS implementation in varied contexts and the lessons learnt [including projects in the Pacific SIDS such as the Ridge-2-Reef river restoration program for biodiversity conservation at Wanang Conservation Area, Papua New Guines and Gau Island, Fiji (Cohen-Shacham et al. 2016; Raymond et al. 2017; World Bank 2017)], Cohen-Shacham et al. (2016) identified key elements that contributed to a project's success: i) ecological complexity - maintain or promote NbS at different ecological scales; ii) long-term stability; iii) scale of ecological organisation; iv) direct societal benefits; and v) adaptive governance.

These key elements highlight the importance of social benefits, weighing between short and long-term benefits, and understanding complexity within a system. However, governance poses major challenges, as Raymond et al. (2017) notes:

"Multiple knowledge gaps inhibit delivery of this holistic approach to policy development. […] The involvement of various stakeholders [and] participatory and multidisciplinary process is still rarely adopted; mainly resulting from the general perception that multi-stakeholder initiatives slow down urban planning and policy development processes due to lack of consensus and different sectoral interests. Future research would benefit from applying the framework presented here within established projects and initiatives that attempt to coordinate across projects".

5. The Honiara context

5.1. Societal and urban development challenges in Honiara

Recent reports, including the Honiara Urban Resilience and Climate Action Plan (Trundle and McEvoy, 2016) and SPREP's Planning for Ecosystem-based Adaptation (2017), have documented the myriad of challenges facing Honiara. These findings were based on extensive participatory community consultation processes. Figure 6 illustrates the range of societal challenges and vulnerabilities to natural and climate-related hazards as experienced by local communities.

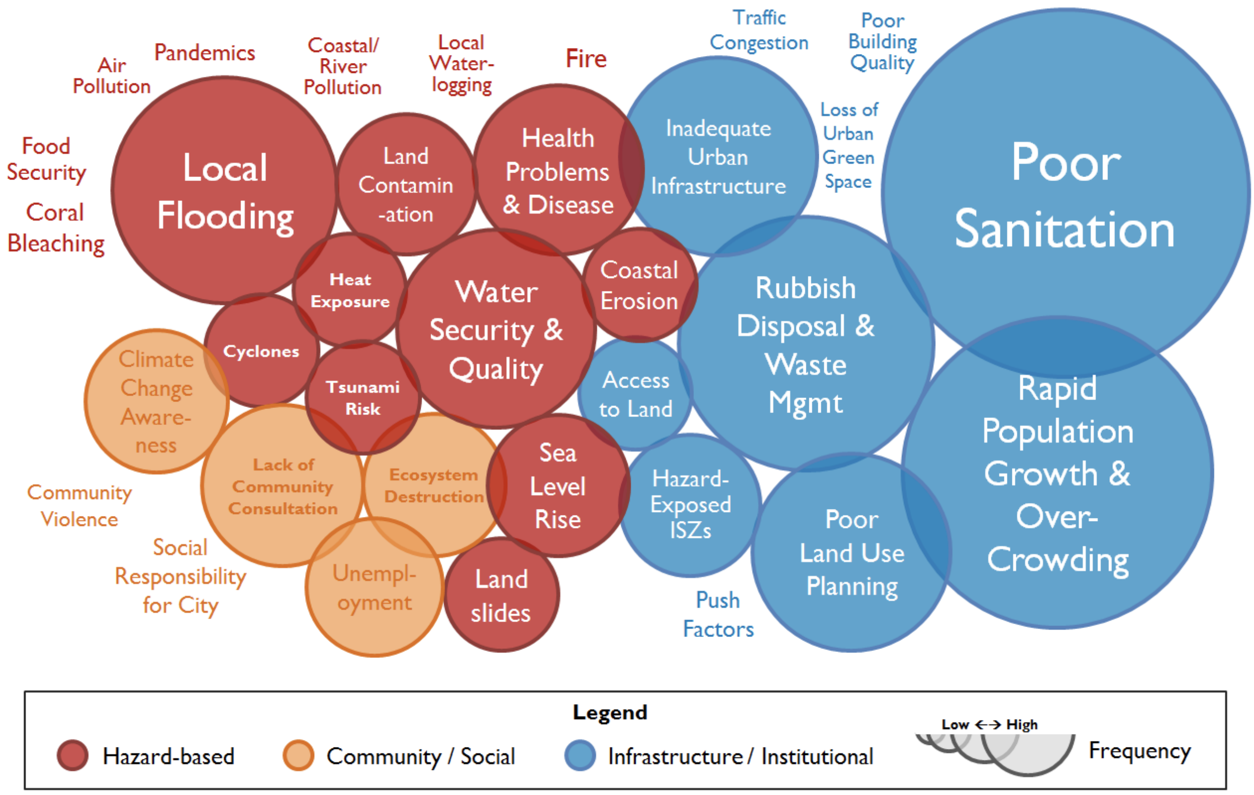


Figure 6: Key challenges in Honiara; as identified by participatory workshops

As illustrated in Figure 6 above, Honiara is facing significant challenges (Trundle and McEvoy, 2016 p34). Some of these will be exacerbated by climate change (shown in red) whilst others relate more to the impacts of rapid urbanisation and development deficits (shown in blue). Honiara's most pressing challenges, as highlighted by Trundle and McEvoy (2016), were categorised into the following:

- Urban development challenges (planning, design and infrastructure)
  - Lack of, or poor, services including water, sanitation and waste management (e.g. polluted internal drainage systems, poorly maintained sewer outfalls);
  - Over-crowding from rapid population growth (access to land, high density);
  - Poor land-use planning;
  - Inadequate infrastructure such as road networks.
  - Poor housing (lack of building codes that integrate disaster risk, less durable construction materials and methods);

- Water quality (e.g. waste being burned or dumped in waterways, saltwater inundation);
- Health problems and diseases.

〉 Hazards and climate change impacts
- Local flooding (coastal, low-lying areas, flood plains, riverbanks);
- Sea level rise and coastal erosion;
- Landslides (e.g. steep slopes of up to 45 degree);
- Heat exposure (no night-time cooling due to limited penetration of sea breeze in overcrowded spaces).

〉 Community-Social challenges
- Lack of climate change awareness;
- Unemployment;
- Lack of community consultation;
- Undernourishment (increased over the past 12 years; FAO et al., 2018).

〉 Ecosystem threat and destruction for food, water, income generation and cultural meaning.

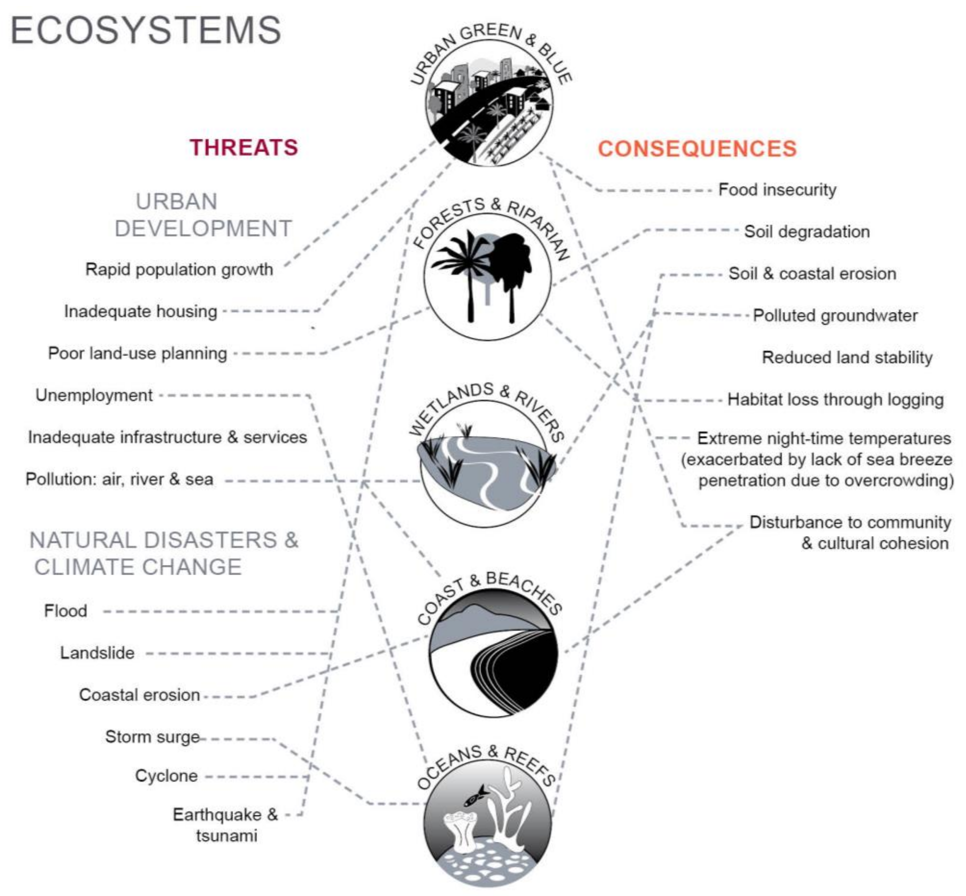


Figure 7: Human impacts on local ecosystems (informed by SPREP and HURCAP)

Ecosystems in Honiara are under immense pressure from rapid urban development (physical and socio-economic systems), as well as from climate change impacts (biophysical). Degradation in ecosystems and ecosystem services is simultaneously increasing the vulnerability of societal systems (Figure 7). Thus, there is a clear need for NbS which can help maintain and restore ecosystem health, whilst strengthening the resilience of communities in Honiara.

5.2. The value of NbS for Honiara

The Pacific region is where the urban and ocean environments come together. Ocean cities in Small Island Developing States (SIDS), like Honiara, are at the forefront of climate change impacts, urbanisation, and other development pressures (Hills et al., 2013). A report from the Intergovernmental Panel for Climate Change (IPCC, 2014) suggests that we have just over a decade before we see major catastrophic events. It is expected that in the next decade, Pacific SIDS:

> *"…will face increasing threats to sustainable development from climate change impacts on marine and terrestrial ecosystems, human health, infrastructure, coastal resources, fresh water availability, agriculture, fisheries, forestry, and tourism. High levels of connectedness between our socioeconomic and biophysical environments make it important that adaptation strategies include a strong focus on the management of natural ecosystems" (SPREP 2018, p.1).*

In Honiara, *"…the health of land and marine ecosystems and the ecosystem services derived from them, is intimately connected to individual and societal wellbeing, in terms of physical, psychological, and cultural health" (Bryant-Tokalau, 2018; in Pedersen Zari et al., 2019)*.

Honiara would therefore benefit from NbS that draw on traditional cultural management practices of the environment and strengthen connections with "a Pacific Way" (Harms et al., 2018), with potential to enhance community-level climate resilience. Currently, community connections with nature (terrestrial and ocean) are being weakened through urbanisation, poverty, lack of infrastructure, and inadequate planning mechanisms. EbA approaches are particularly appropriate in Honiara, "which has a high poverty rate, with high reliance on the natural environment such as forests, rivers, wetlands, and coastal marine ecosystems for household supply of essential needs" (SPREP 2018, p.2). Many households in Honiara rely on marine and land-based ecosystem services to provide or supplement their livelihoods (Trundle and McEvoy, 2016, p.38). Thus, NbS and actions for enhanced climate resilience need to adopt an integrated approach (UNESCAP 2017), including considerations for:

- urban development (sensitive urban design and planning);
- land-ocean-focussed;
- climate-responsiveness;
- socio-cultural and livelihood considerations.

"For Ocean Cities, the process of carefully and strategically conserving, or designing new green and blue urban spaces into the fabric of urban settings requires urban design and planning based not only on important social and cultural considerations, but also on the preservation of inter-linked ecological processes and ecosystem services both on land and in the ocean" (Pedersen Zari et al., 2019).

5.3. Study areas – vulnerability hotspots and priority sites

NbS were considered for pilot sites either aligned to the project's vulnerability hotspot settlements (Figure 8), were supportive of HCC's urban development agenda, or else contribute to SPREP's case studies as part of the *Planning for ecosystem-based adaptation in Honiara, Solomon Islands* project. Other considerations included pertinent local planning documents e.g. the Greater Honiara Urban Development Strategy and Action Plan (ADB, 2018) and the Honiara Local Planning Scheme (MLHS, 2015). The following community vulnerability hotspots were confirmed as high priority areas during consultation with Honiara City Council (HCC) in September 2019:

1. Kukum Fishing Village
2. Ontong Java Settlement
3. Aekafo Planning Area (7 zones)
4. Wind Valley (White River)
5. Jabros (Gilbert Camp)

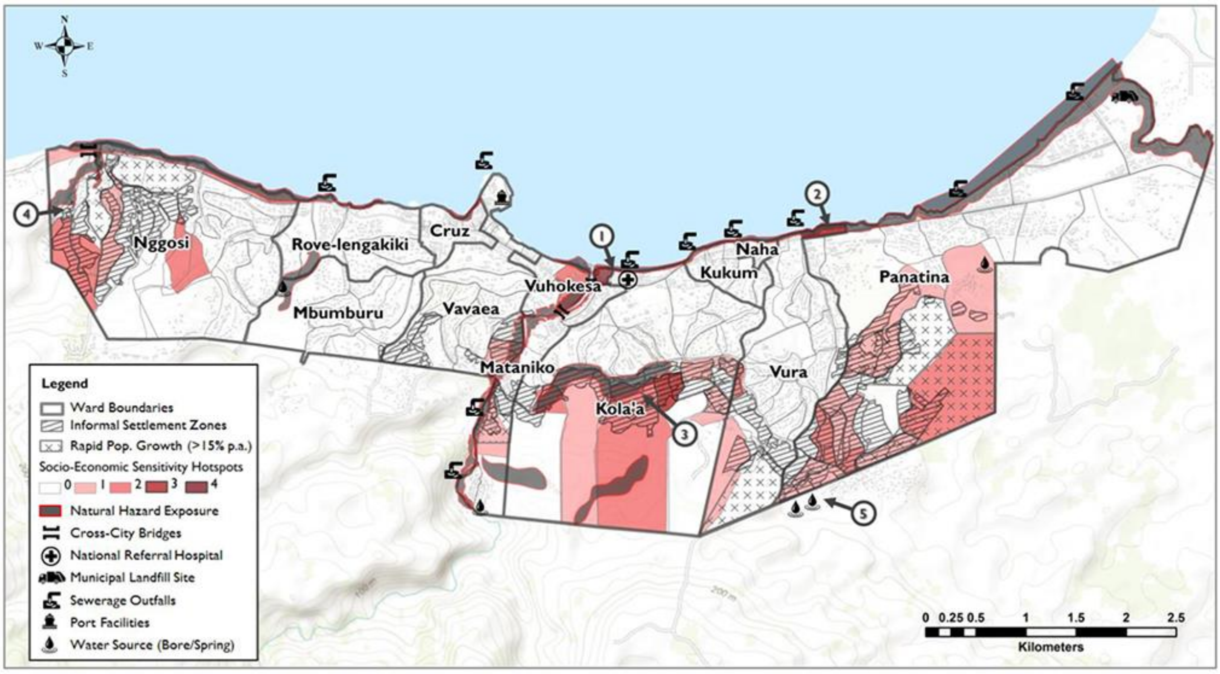


Figure 8: Vulnerability hotspots in Greater Honiara

Furthermore, based on extensive community participatory processes to prioritise NbS for Honiara and cost-benefit analysis, SPREP (2017a) identified the following three priority sites:

1. Barana and Queen Elizabeth Park management plan;
2. Supporting the Botanic Gardens to be a formal protected area and formulate a management plan;
3. Mataniko Parklands, riverbank rehabilitation, and information centre;

Further actions included:

4. Environmental compliance training for government staff and stakeholders;
5. Beautifying and creating green space in the Honiara CBD.

5.4. Scoping and design activities

Scoping activities were underpinned by a field visit from RMIT experts to better understand priorities at a ward-level. This included consultations with key ministry personnel, Honiara City Council, MECCDM, SPREP, and Solomon Islands National University (SINU), to inform WP scoping and assess city-wide capacity development needs. Scoping assessments included: public spaces for multi-purpose land use, urban greening, options for landscape design, and updating Honiara's local planning scheme. This report now details participatory research and design activities undertaken for NbS, including design studios held in both Honiara and Melbourne, based on a comparison of the vulnerable settlements:

- Literature review
  - Development of a preliminary nature-based solutions framework and action plan.
- Co-design workshops (September 2019), with Solomon Islands National University (SINU) graduates (needs-based designs) for:
  - Koa Hill/Mataniko River Pilot Study (Vavaea Ward);
  - Barana and Queen Elizabeth Park – a new nature park and community education centre;
  - Botanical Gardens – formal protected area and a management plan.
- RMIT undergraduate Design Studio (July – November 2019)
  - Aekafo-Feraladoa Informal Settlement Zone.
- RMIT undergraduate Design Research Seminar (July – October 2019)
  - Honiara.

6. Co-design workshop

In September 2019, 16 graduates from Solomon Island National University took part in envisioning a 'Liveable Honiara' co-design workshop. They began by identifying the root causes of climate vulnerability and carrying out spatial mapping at both a city-wide and site scale. Outcomes of the workshop were then disseminated to local stakeholders. The designs were driven by a participatory approach as this not only allows local people to be involved in the prioritisation of community needs but also to be involved in the co-design of climate resilience actions. Three sites (mirroring the SPREP case studies) were investigated, namely:

- Koa Hill along Mataniko River;
- Barana and Queen Elizabeth Park;
- Botanical Gardens.

Figure 9 and Figure 10 show engagement of graduates from SINU in the workshop, facilitated by the RMIT project team.

Figure 9: Co-design workshop with SINU students in September 2019 (Photo credit: Vahanvati)

Figure 10: SINU students marking their homes on a topographic map (Photo credit: Vahanvati)

Figure 11 illustrates examples of what SINU graduates identified as root causes of societal challenges and urban development, based on their own experiences. A lack of policies to manage uncontrolled urban growth and natural resource management were highlighted as key concerns. Graduates also envisaged the consequences of inaction, with major impacts on people's livelihoods that are reliant on natural systems.

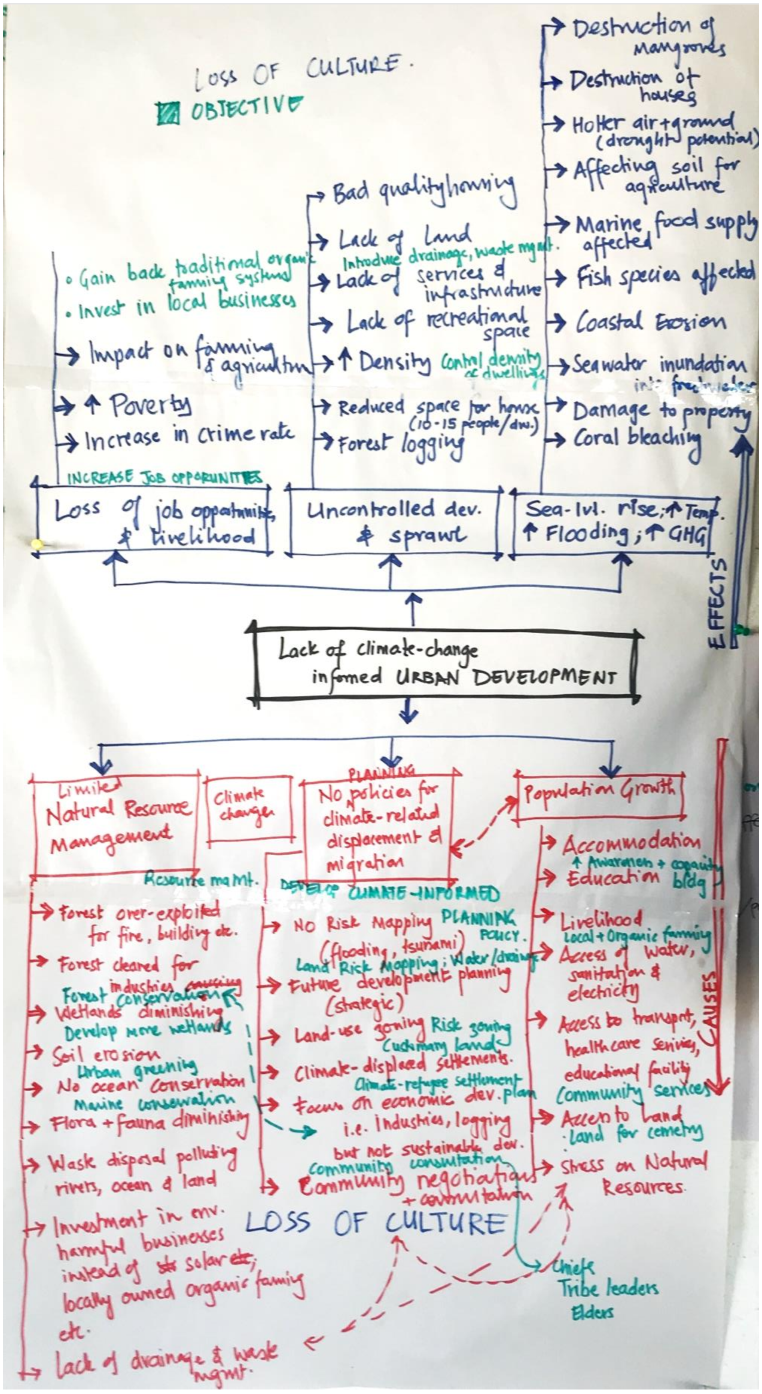


Figure 11: Problem-tree analysis by SINU students (Photo credit: Vahanvati)

6.1. Koa Hill along Mataniko River

A number of spatial risk analyses were overlain to develop a risk map (Figure 12). As shown in the figure, two areas (as shown in dotted blue circles) were identified as high-risk areas along Mataniko River (red colour indicates slope> 45 degrees; blue indicates river flood zone; green is vegetation and black is the road network). They set the following objectives for the Koa Hill site along the Mataniko River:

- Stabilise riverbed to reduce flood impact;
- Protect residents by enforcing no house construction in floodplains, rather open the area for farming and recreational areas;
- Improve sewage and waste management to secure water quality.

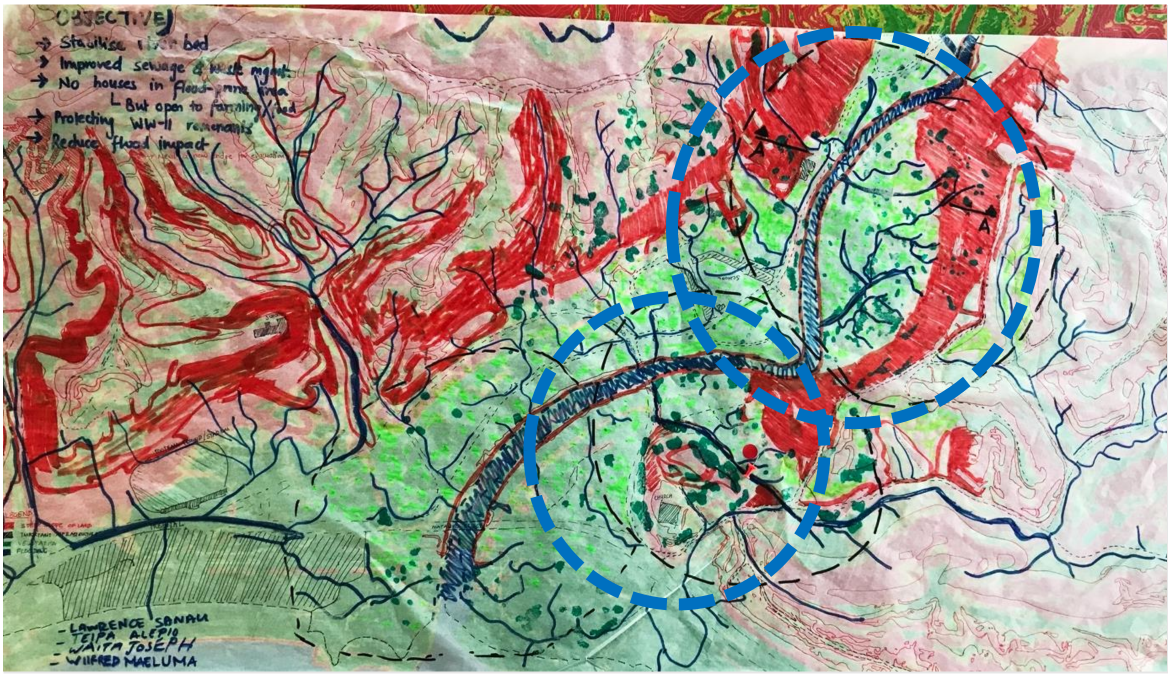


Figure 12: Risk mapping for Koa Hill

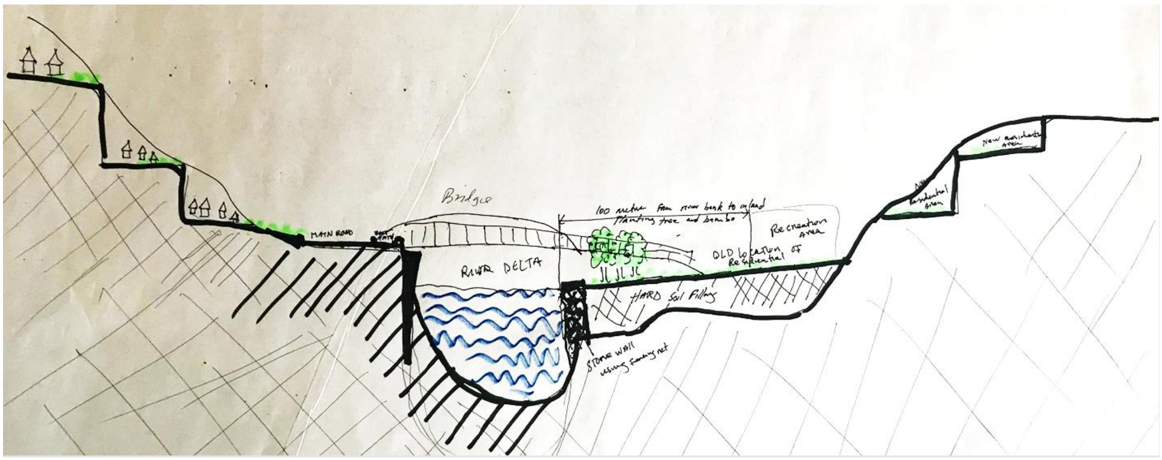


Figure 13: Design section for Koa Hill

Figure 14: Koa Hill design team

As shown in Figure 13 and Figure 14, and in response to their objectives, SINU graduates proposed solutions that involved both hard and soft infrastructure, as:

- Retaining wall (made out of stone and fishing net) along Mataniko riverbank;
- Build a bridge linking east and west side of the riverbank;
- Terracing land for houses and food farming;
- At least 100m from the new riverbank to be replanted and reserved for recreation (e.g. soccer, benches and walking track along the river).

6.2. Barana and Queen Elizabeth Park

The goal for SPREP for Barana and Queen Elizabeth Park's management plan is to improve the Upper Mataniko and Lungga catchment area's provision of fresh water supply and other ecosystem services. During the workshop, the SINU graduates identified three key sites along the road to Barana and Queen Elizabeth Park. The graduates speculated that if the site was to support future growth, it is important to demarcate exclusion development zones along the transport corridor. An exclusion zone in this context is defined by a territorial region which consists of rich biodiversity and consists of a range of high vegetation and smaller order streams that feed into larger order streams in the lower stream. To safeguard the existing flora and fauna, a speculative development buffer was drawn along the road that connects the Japanese War Memorial (site 1) and Barana and Queen Elizabeth Park (site 3), with a proposed development site (site 2) in between the sites mentioned above.

As highlighted in Figure 15, the aim to keep the watershed intact to allow for provision of food, materials, income generation (tourism), might be achieved through the strategic placement of development buffers and exclusion zones. Further work is needed to achieve:

- Hazard reduction through stormwater regulation and flood control, reducing sedimentation into waterways;
- Support for habitat and biodiversity provisions;
- Provision of freshwater and recreation;
- Water quality, land stability, erosion, and sediment control.

Figure 15: Risk mapping for Barana and Queen Elizabeth Park

6.3. Honiara Botanical Gardens

The design workshop for Botanical Gardens aimed to expand habitat connectivity and biodiversity; and provide a well-defined space for socialising, recreation, and traditional cultural practices. A mapping and overlaying exercise identified several sections and actions for further design resolutions (Figure 16):

- **Section 1** Upgrade entrance corridor to the botanical gardens by providing way finding elements, carparks etc.;
- **Section 2** Improve and expand visitor centre by adding more facilities for recreation, gathering, events, cultural activities and gathering;
- **Section 3** Define and expand the botanical garden boundary with access to surrounding neighbouring communities; regenerating the vegetation habitats; sitting areas and track improvements, and stabilisations and flood mitigation measures upstream (See Figure 16: Botanical Gardens main sections inside Rove Creek Catchment (Source: Tara)).

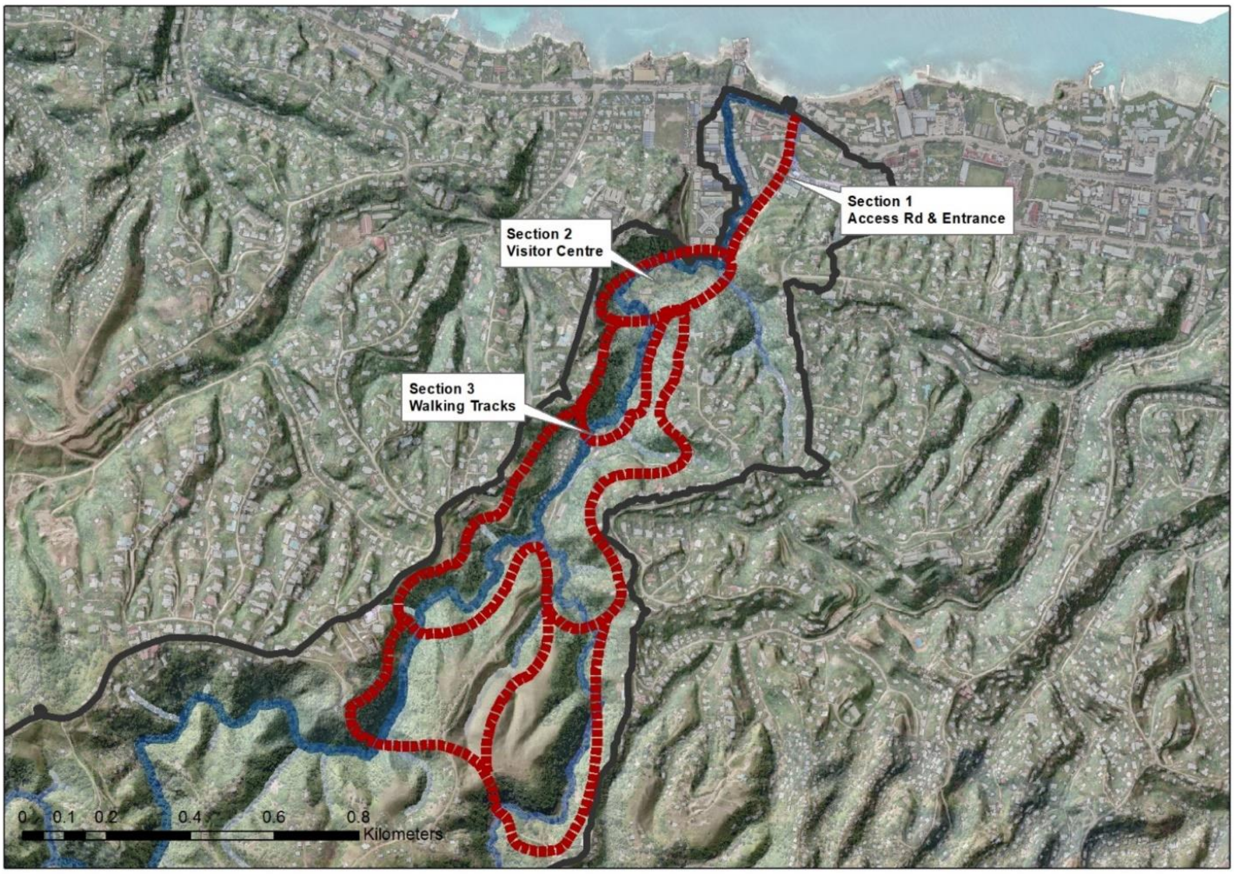


Figure 16: Botanical Gardens main sections inside Rove Creek Catchment (Source: Tara)

A well-defined visitor centre can be achieved by adding more buildings and public spaces for gathering and events. Figure 17 presents a cross section of the main visitor centre with more facilities to support cultural, social, recreational, and educational activities. In order to identify the boundary of Botanical Gardens (and potential areas to extend the walking tracks) steep slopes, vegetation canopy and neighbouring communities were mapped. As the result, three circuits with different lengths and difficulties were proposed (Figure 18).

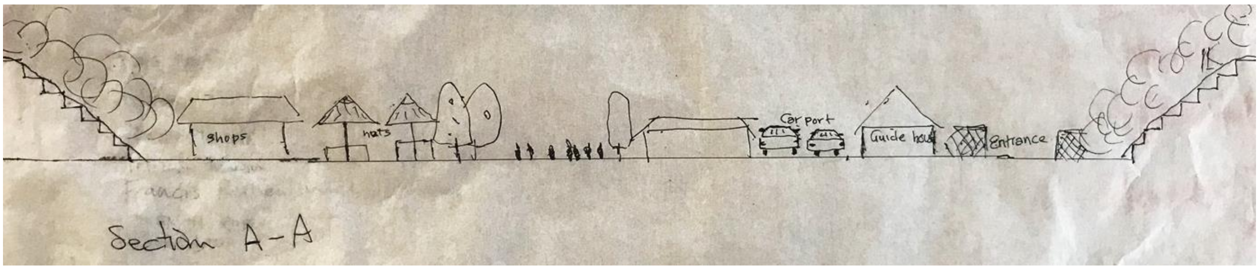


Figure 17: Design section for Botanical Gardens

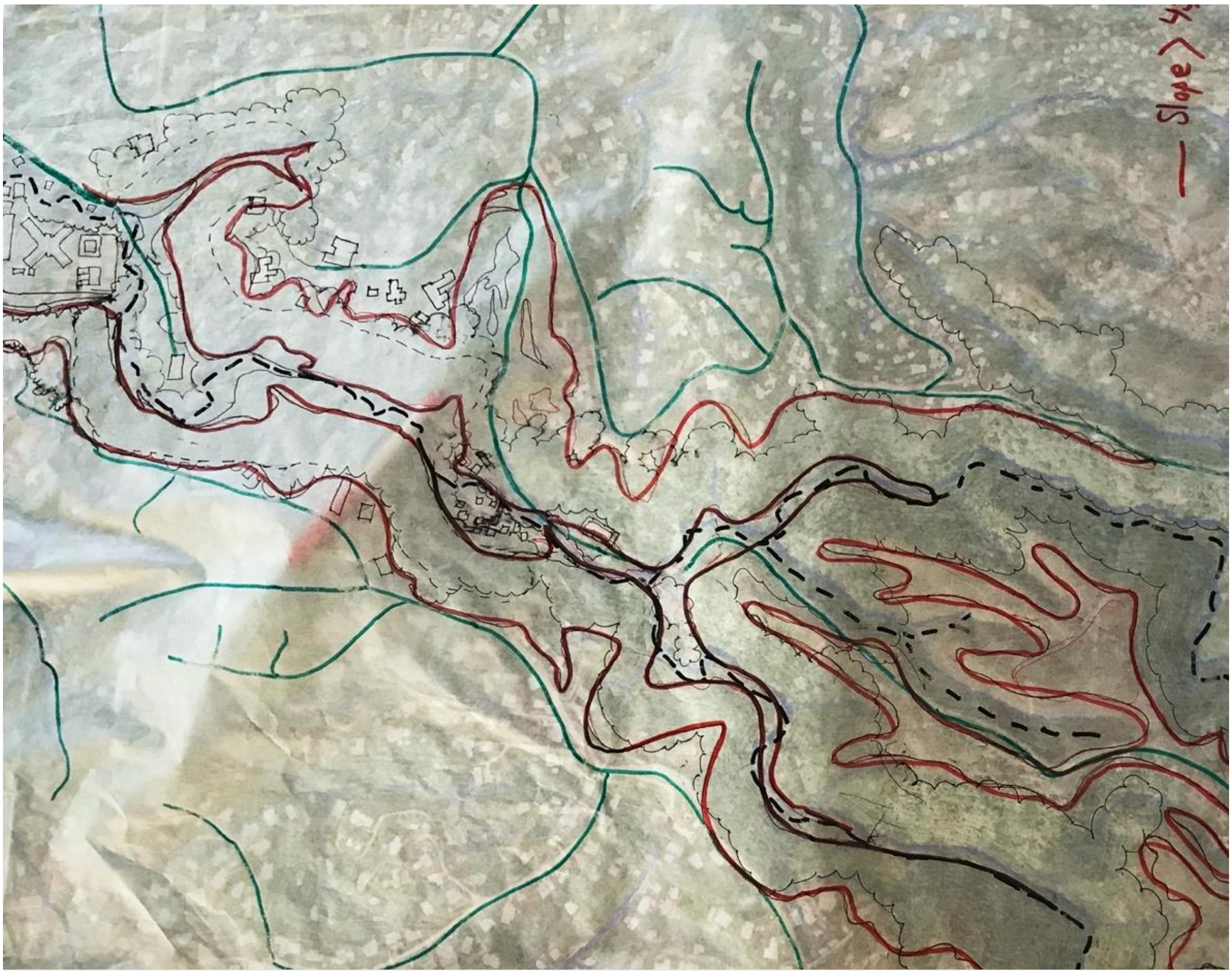


Figure 18: Risk mapping for Botanical Gardens

Figure 19: Botanical Gardens design team at SINU (Photo credit: Vahanvati)

7. City-level spatial analysis and NbS

A design research seminar was conducted in the Master of Landscape Architecture, RMIT University, in the second semester of 2019. The course focused on using Geographic Information Systems to conduct design research for Landscape Architecture. 22 Master students conducted their design research on various topics related to climate change issues in Honiara (Section 5.1 previously). The research topics were defined in three distinct streams: 1) earth-geology, 2) vegetation-biology and 3) water-hydrology. The design research projects were studied at provincial, regional, and city level scales to inform intervention sites at the local scale. Students presented their research outputs in an exhibition and delivered a visual essay as the final outcome (Figure 20).

Figure 20: Design research seminar poster exhibition at the Design Hub, RMIT University (October 2019)

Note: Each poster shown in this report is also replicated in an Appendix to allow for A3 printing and improved readability.

7.1. Earth-Geology

Research topics investigated in this category and final outcomes are listed below:

- Landslides: various parameters were considered in developing a landslide risk map to control future urban growth;
- Suitability analysis for future urban growth: mapping of environmental factors and climate change impacts on the future urban growth area;
- Climate change impacts on health care facilities and hospital relocation scenarios: investigating the vulnerability of existing infrastructure and identifying potential new locations for future centres;
- Suitability analysis of existing evacuation centres, and siting of future community centres (Figure 21: Sample designs for evacuation centres in Honiara (Prepared by Zhao)).

7.2. Vegetation

Research topics investigated in this stream were:

- Greening Honiara: identifying suitable locations and strategies for urban greening;
- Bush fire risk analysis and development design solutions to reduce the risk of bushfires in Honiara;
- Deforestation and logging impacts;
- Ecological Corridors: by looking at the vegetation cover changes during the last 50 years using satellite imagery to identify riparian corridors and regenerate the degraded ecology (Figure 22).

7.3. Hydrology

Research topics investigated in this stream included:

- Flood mitigation in Mataniko River Catchment;
- Soil erosion and materials flow;
- Salinity and saltwater intrusion to underground and freshwater resources by sea level rise and storm surge;
- Climate change impacts on reefs;
- Nature-based solution for riverine flooding by conducting suitability analysis for upstream dams and checkpoints (Figure 23).

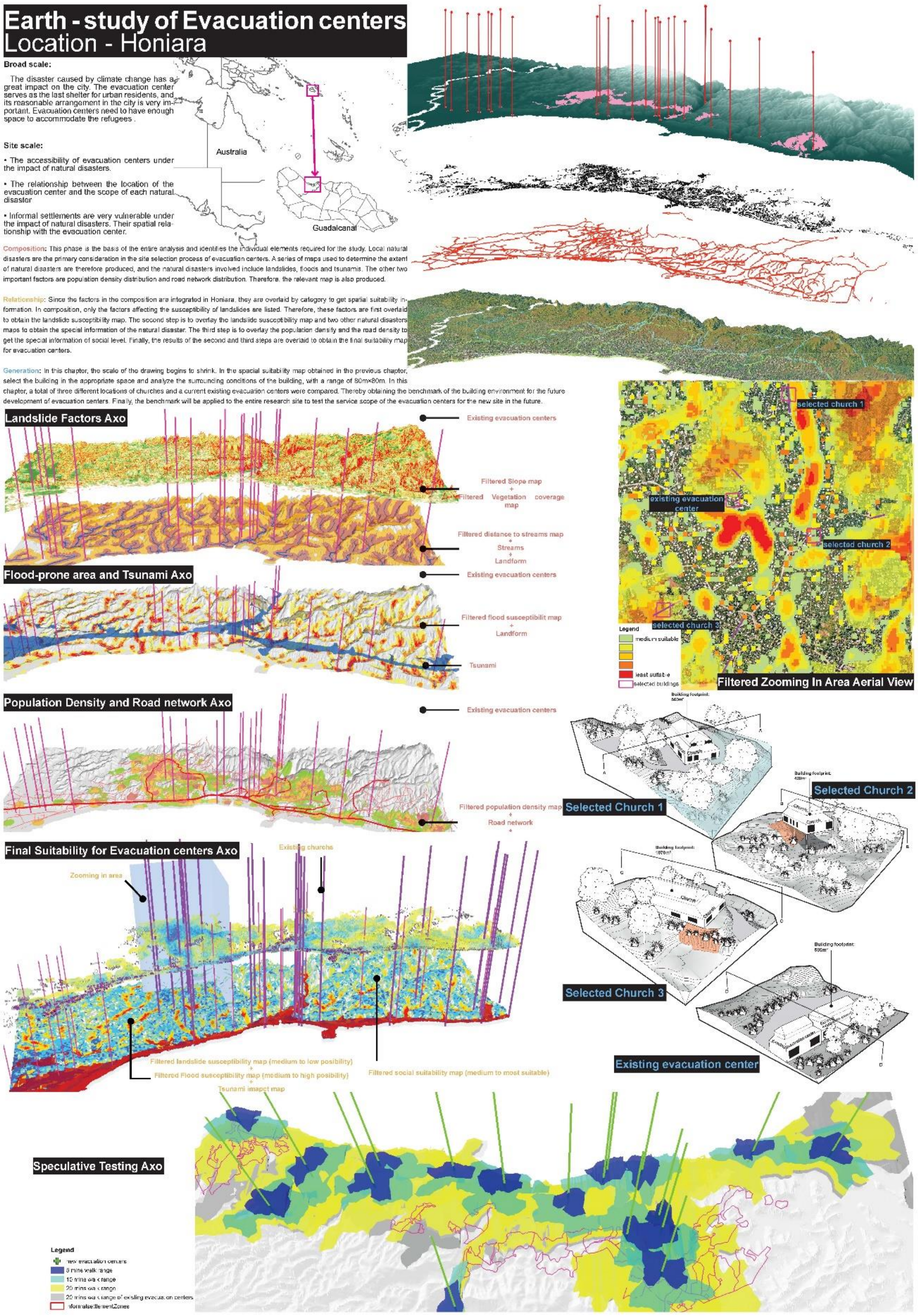


Figure 21: Sample designs for evacuation centres in Honiara (Prepared by Zhao)

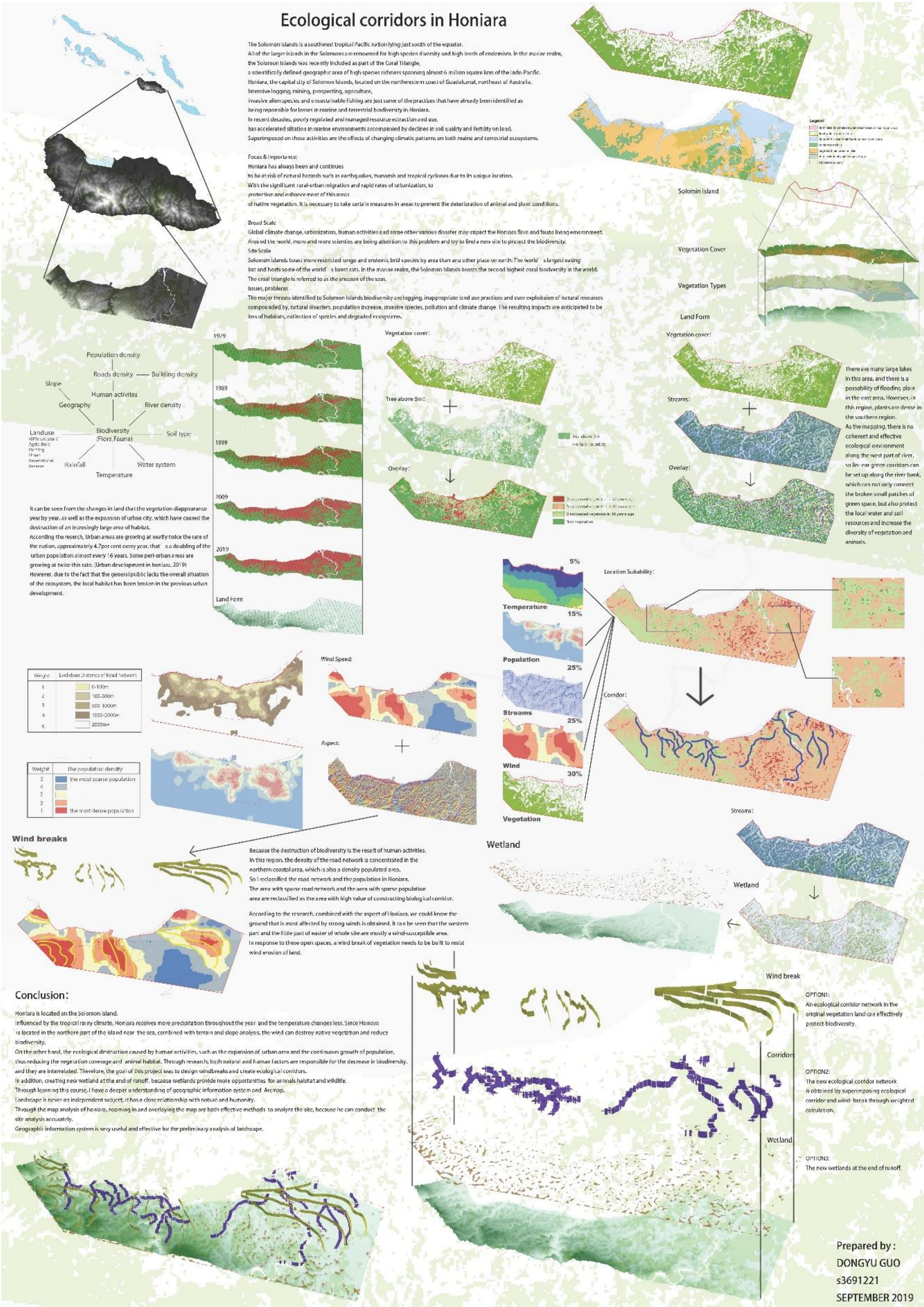


Figure 22: Sample designs for ecological corridors in Honiara (Prepared by Guo)

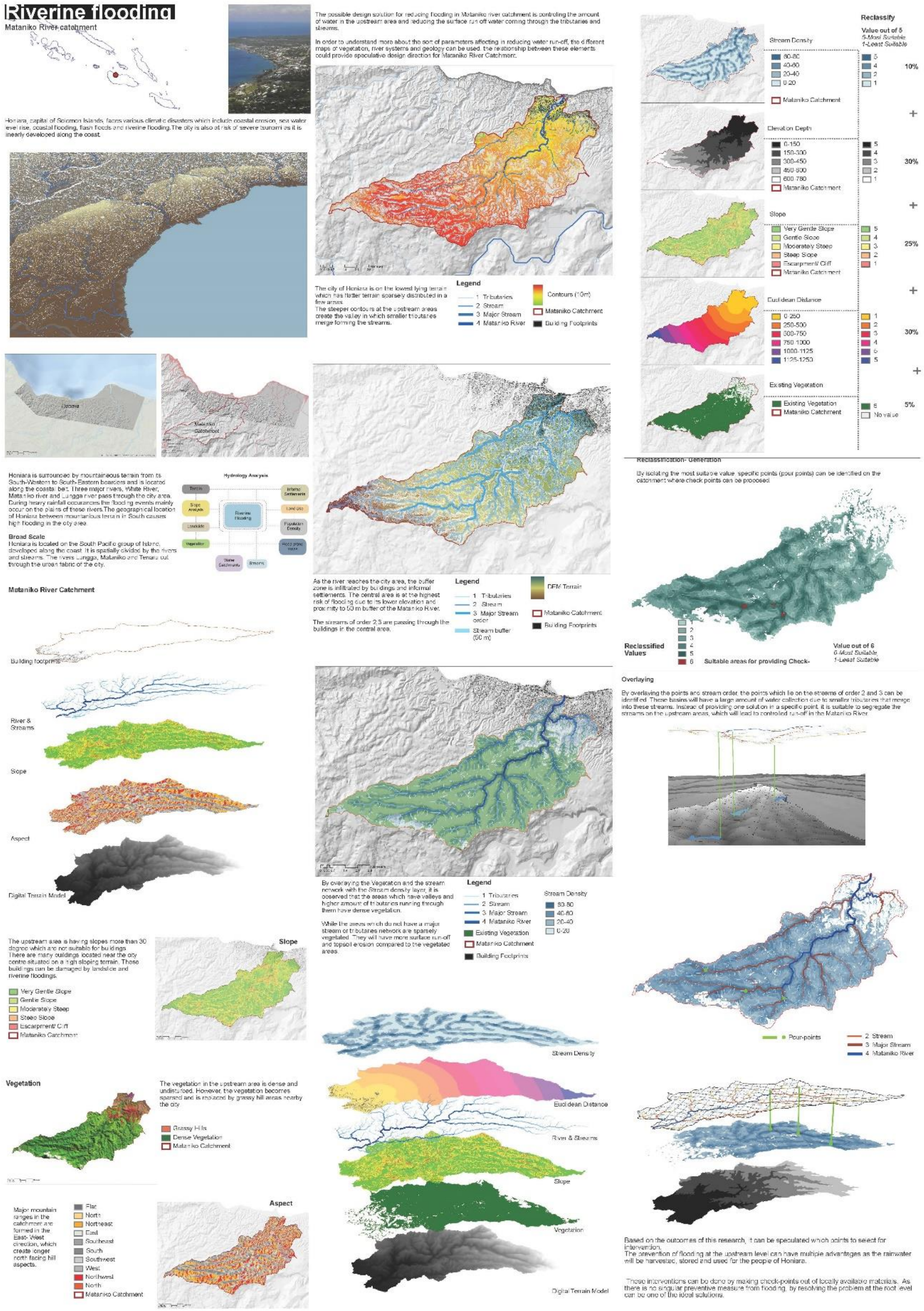


Figure 23: Sample designs for flood mitigation in Honiara (Prepared by Muni)

8. NbS for Aekafo Informal Settlement Zone

From July to November 2019, 15 undergraduates from RMIT University took part in a landscape architecture design studio course entitled 'Aekafo'. Students investigated sites within the Aekafo-Feraladoa informal settlement zones following the valley along Vara Creek, an east-west tributary that flows into the Mataniko River. Students used fabricated physical models that were made through subtractive prototyping generated from the LIDAR data provided by the SI Ministry of Health and Medical Services (MHMS). Aekafo-Feraladoa is characterised by steeply graded slopes and a valley floor exposed to regular flash flooding.

Figure 24: Students analysing the site remotely using fabricated physical models (Photo credit: Ninsalam)

The following example now illustrates how the proposed NbS framework can be operationalised within the context of design studios.

8.1. Step 1: Define the problem, project scope and objectives

Identify the study area, problem, key stakeholders & beneficiaries

As a result of its topography, and the lack of road access for much of the area, services are limited with solid waste being frequently deposited into Vara Creek. Many community members are dependent on footpaths and Jacobs ladders for access to schools, clinics, the bus network, and access to the commercial areas of Honiara. Exposure to flash flooding and other secondary hazards associated with heavy and prolonged rainfall events (such as landslides and vector-borne and skin diseases resulting from stagnant water) are some of the primary climate-related vulnerabilities for the Aekafo-Feraladoa communities.

The site is located east of the Mataniko River and consists of 7 government-classified Informal Settlement Zones (ISZs 19 to 25) which are inhabited almost exclusively by untenured urban migrants, with many occupying the land through Temporary Occupation Licenses (TOL), many of which are no longer current (Figure 25).

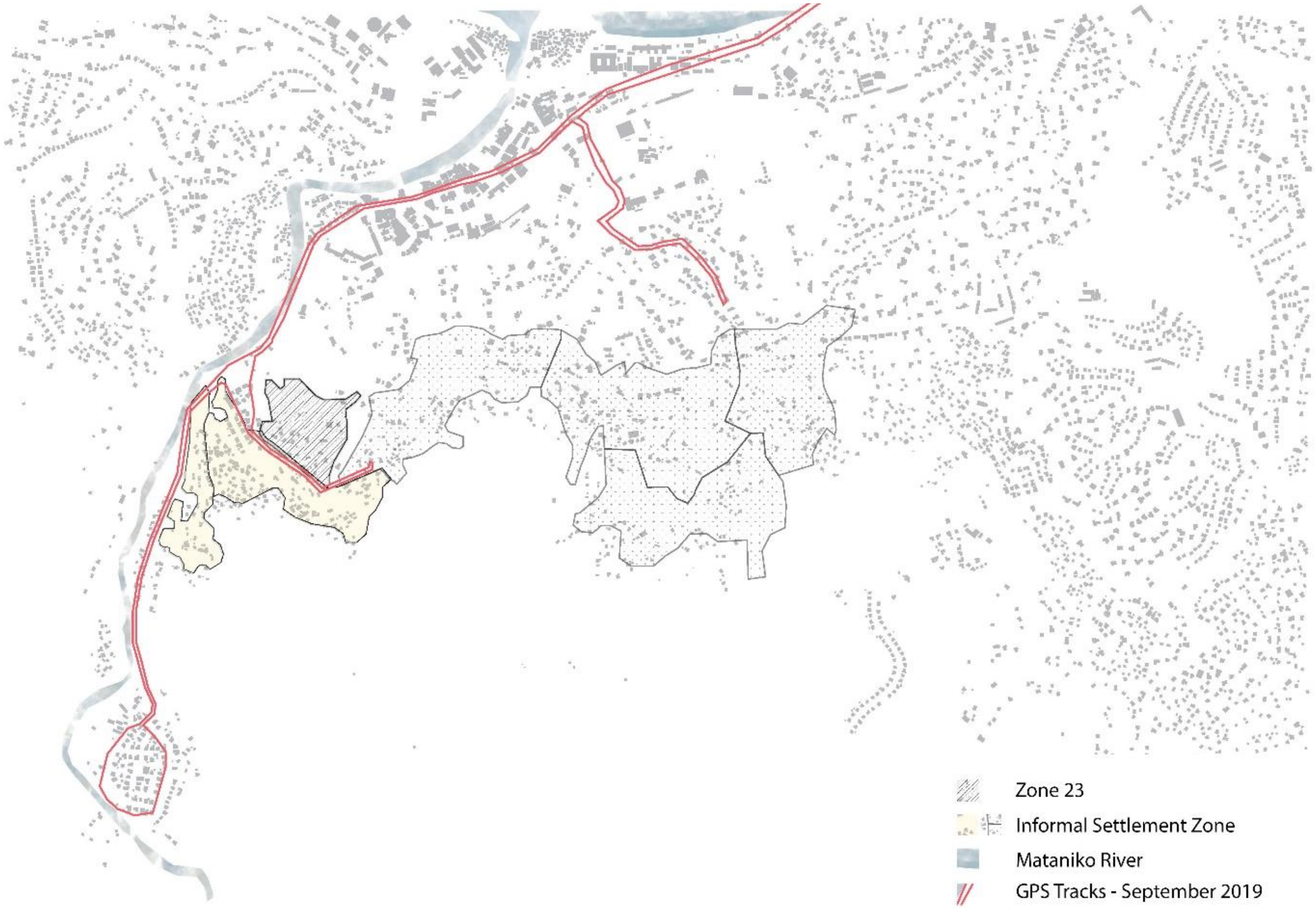


Figure 25: Aekafo-Feraladoa informal settlement zone (Prepared by Chen)

The designs produced aim to support upgrading / formalisation processes that are currently underway, with many of the area's allotments having been surveyed and Letters of Offer forthcoming from the Ministry of Lands Housing and Survey. The following work examines the intersection between landslide management and access within Zone 23. Data from the field visit in September 2019 and aerial LIDAR campaign initiated by the Honiara Ministry of Health and Medical Services in 2017 (MHMS) were used to speculate the following proposals:

- Identifying roads and access at risk for improving existing infrastructure and identification of potential access;
- Examining landslip risk zones and building construction in the settlement (noting the legislated requirements for engineering assessments for buildings in areas steeper than 45 degrees);
- Identifying flood risk areas & return periods for extreme rainfall events (the key risk facing the valley's inhabitants) and uncovering potential evacuation sites.

8.2. Step 2: Conduct ecosystem, hazards and risk assessments

Landslides are defined as a mass movement of rock. They result from the intrinsic variables such as geological conditions and slope structures, and extrinsic variables such as rainfall and human activities. From aerial imagery, zone 23 has a count of 88 households and is densely populated in relation to the other sites within the ISZ. The main point of access to the site and adjacent communities is highlighted below (Figure 26). Footage from the field work in the form of time-stamped screen capture of the road is integrated with the LIDAR data to inform the production of the axonometric drawing of zone 23. This image allows us to locate potential hazards and risks (highlighted in yellow outline) within the site. Based on the data from the Strahler stream order analysis, slope mapping, and location of existing housing and human activities, three pilot test sites for landslide mitigation measures were identified within zone 23.

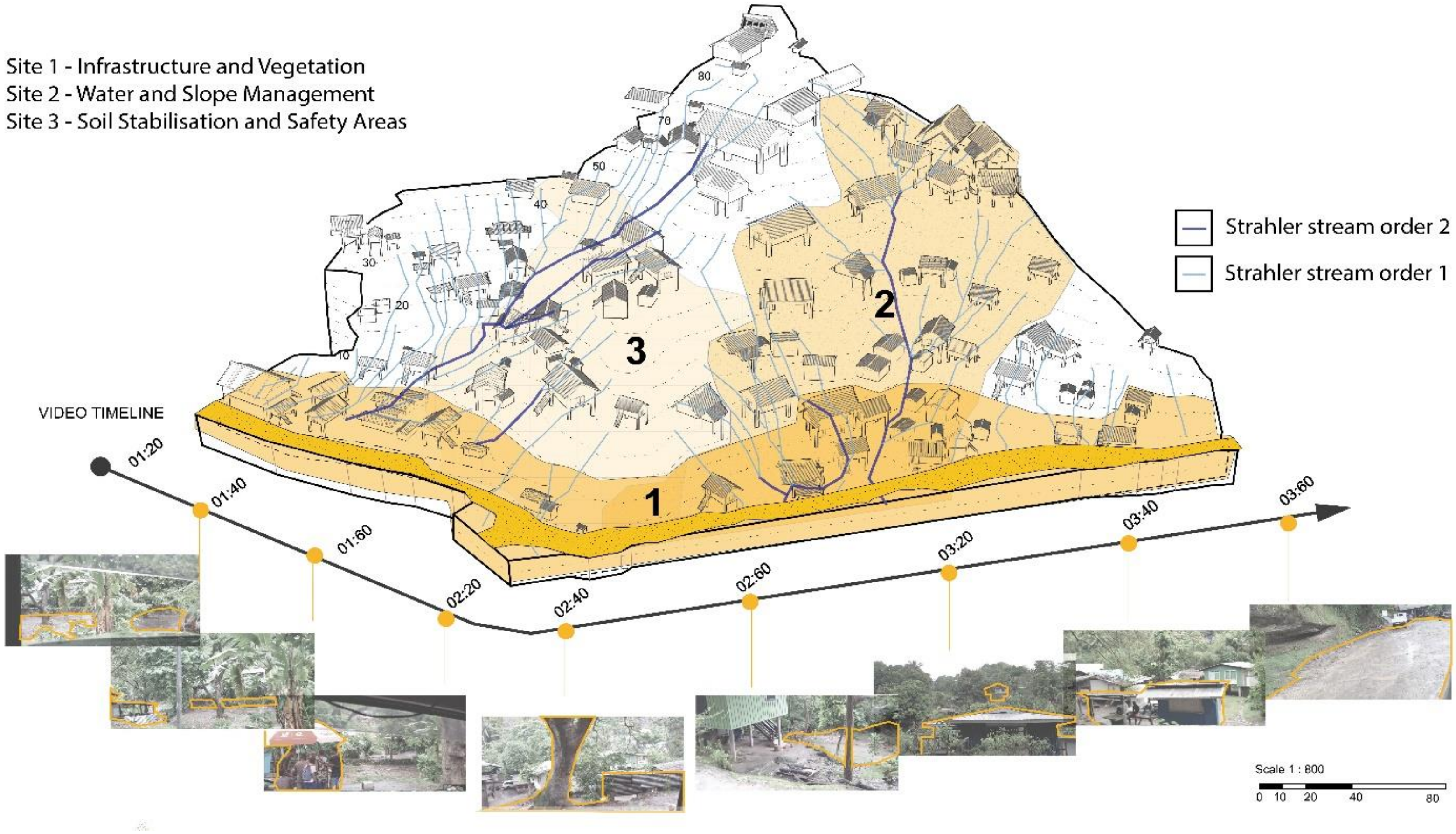


Figure 26: Three pilot test sites identified within zone 23 (Prepared by Chen)

Outputs through spatial mapping of current and future hazards, exposure and vulnerability

In order to uncover the existing hazards, exposure, and vulnerability to threats on site; spatial mappings of site-specific areas were undertaken. For example, the following series of maps illustrates a preliminary landslide spatial analysis in relation to the position of existing houses located on site (Figure 27; Figure 28; Figure 29; Figure 30). Caveat: These maps only take into consideration data acquired from the 2017 MHMS LIDAR information and require further ground truthing. In particular, further geological investigation will need to be conducted for more informed risk mapping.

In addition to the risk assessment studies, a preliminary landslide spatial analysis was undertaken to classify the site into safe (0-8%), low (8-15%), medium (15-30%), high (30-45%) and extreme (>45%) risk zones in relation to the existing houses located on site. Furthermore, using GIS modelling and baseline maps, the landslide risk zone was integrated with other environmental metrics such as rainfall and drainage, speculated water catchment area, terrain aspect (left of image) and shortest path analysis to ascertain potential shortest distance evacuation routes (right of image) (Figure 31).

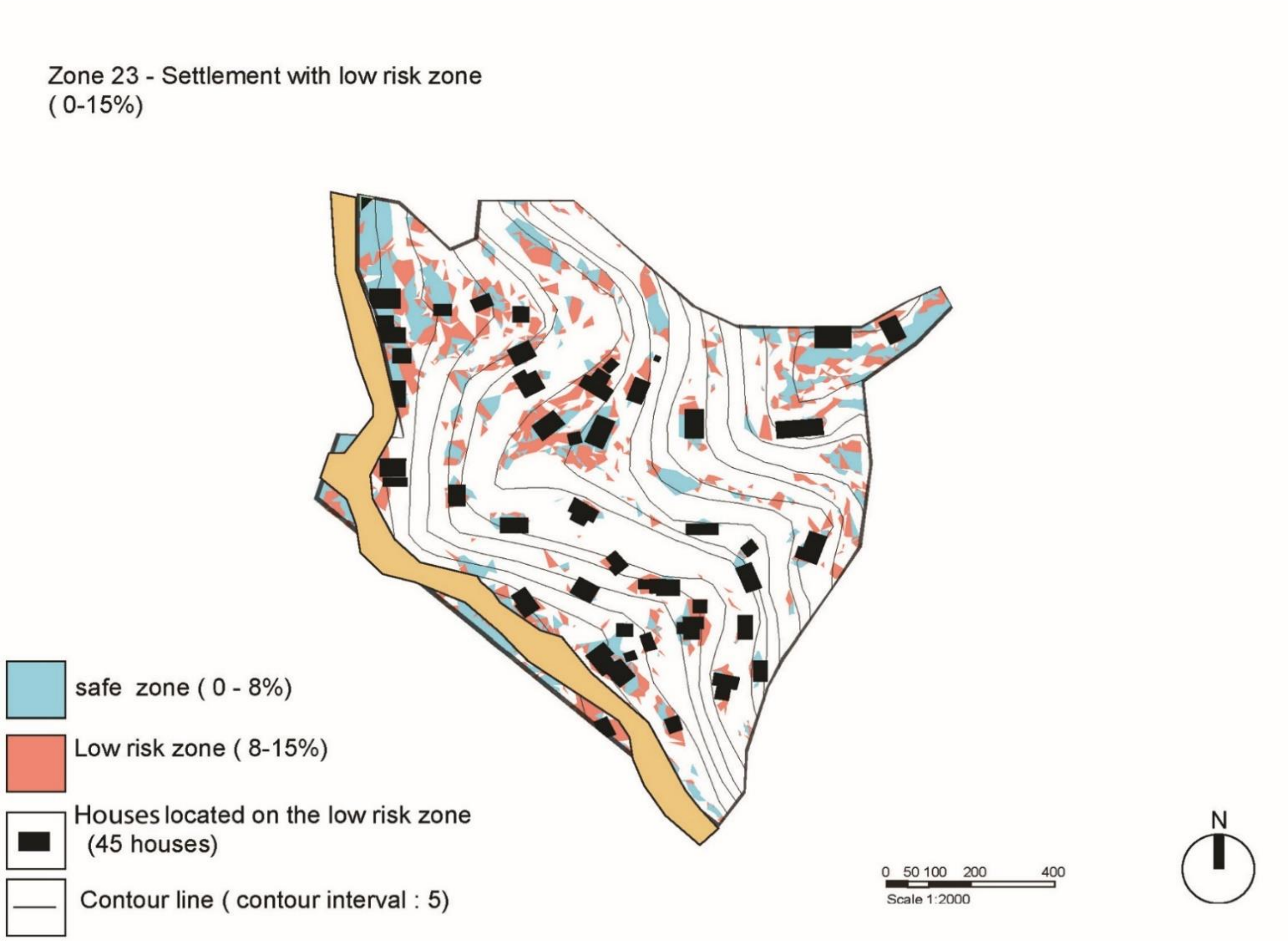


Figure 27: Preliminary landslide spatial analysis (Prepared by Chen) continued….

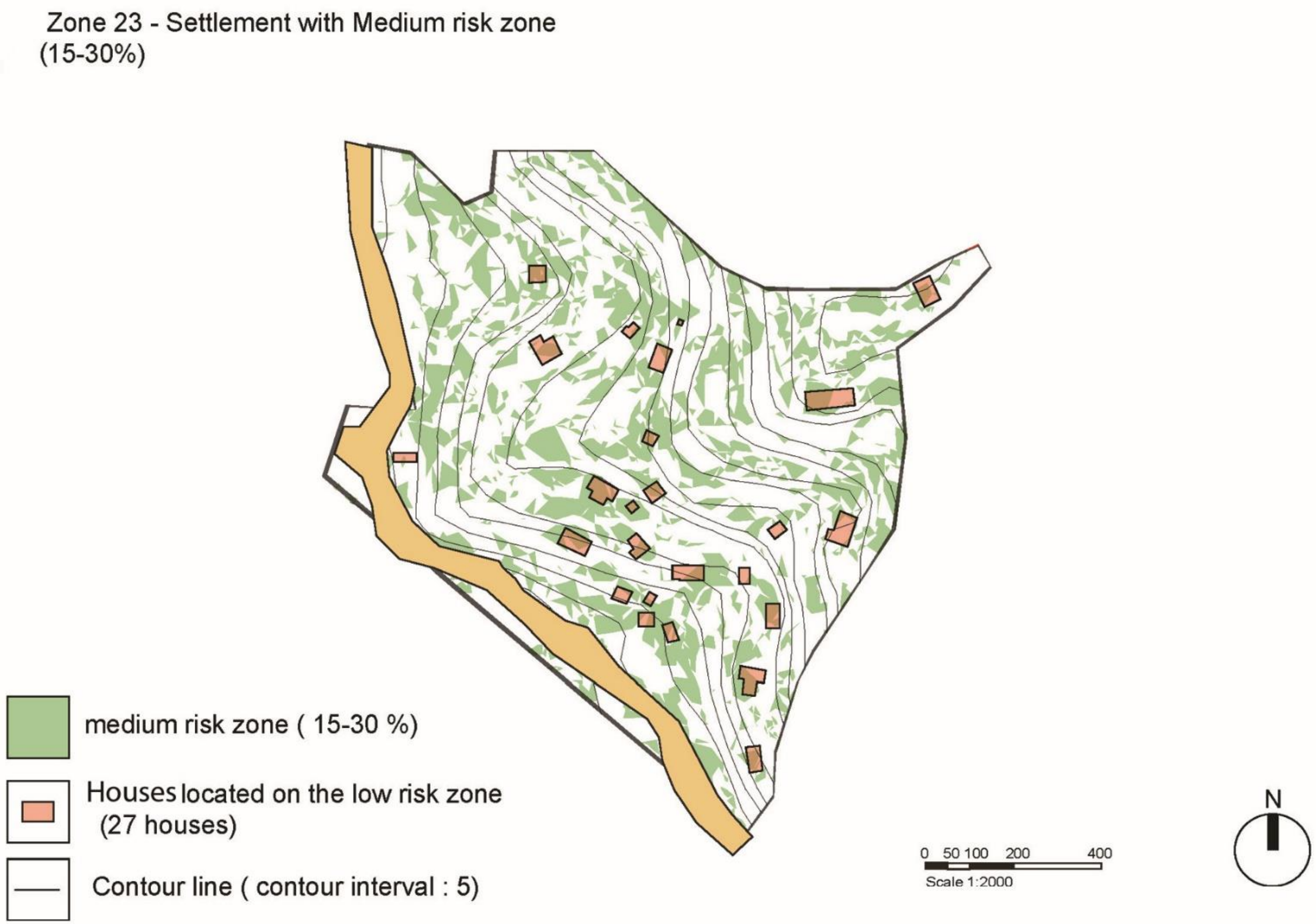


Figure 28: Preliminary landslide spatial analysis (Prepared by Chen) continued….

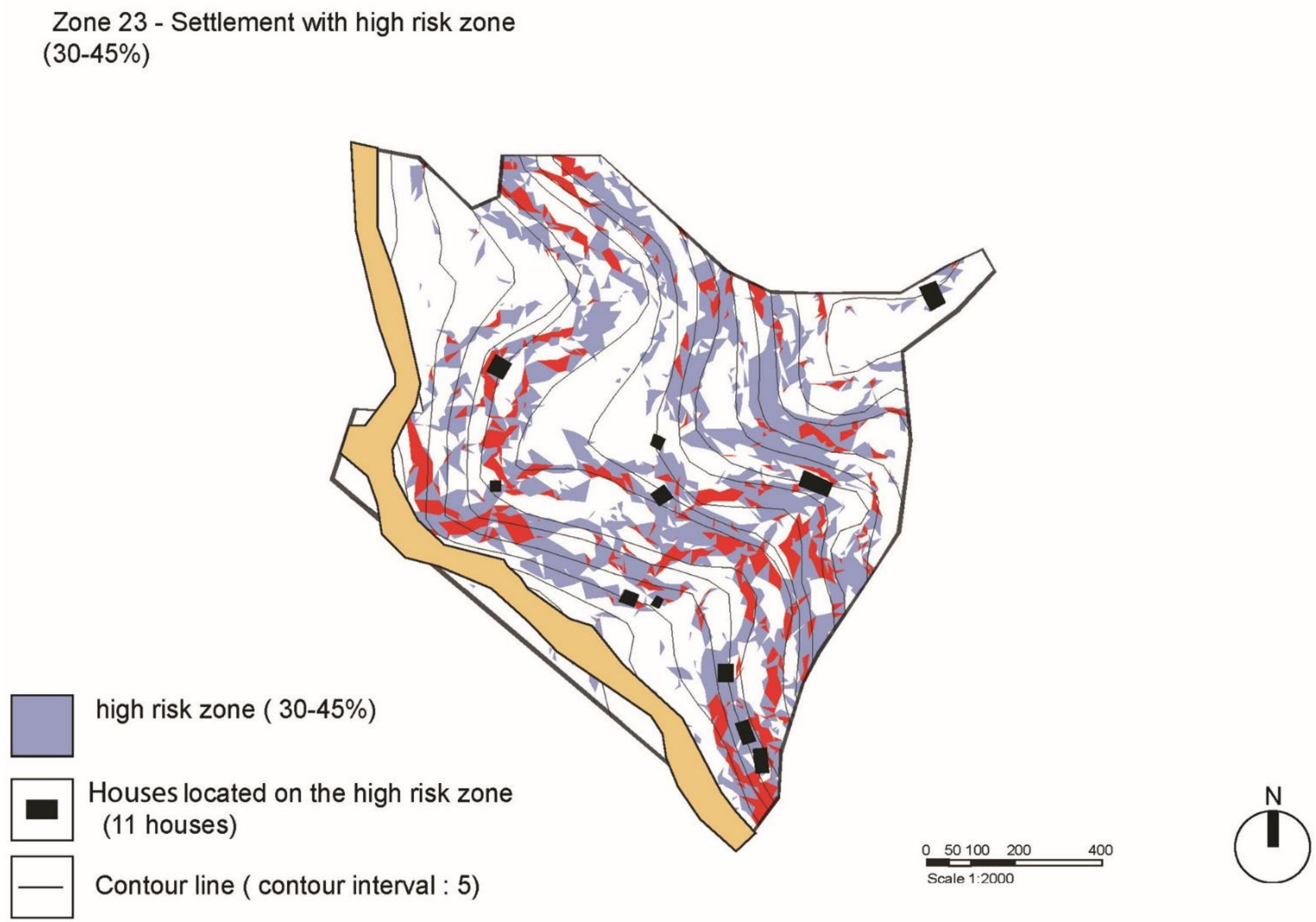


Figure 29: Preliminary landslide spatial analysis (Prepared by Chen) continued….

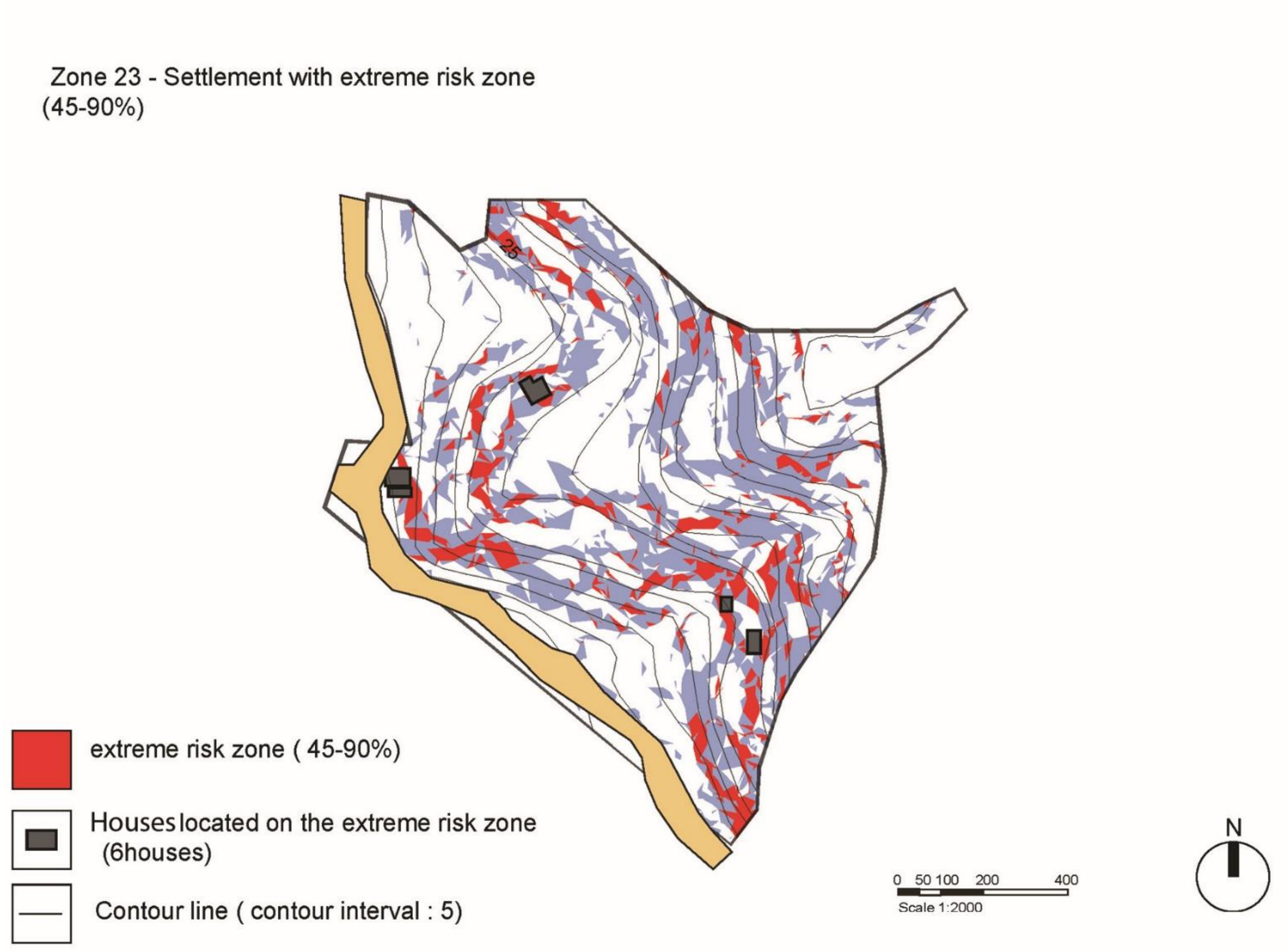


Figure 30: Preliminary landslide spatial analysis (Prepared by Chen).

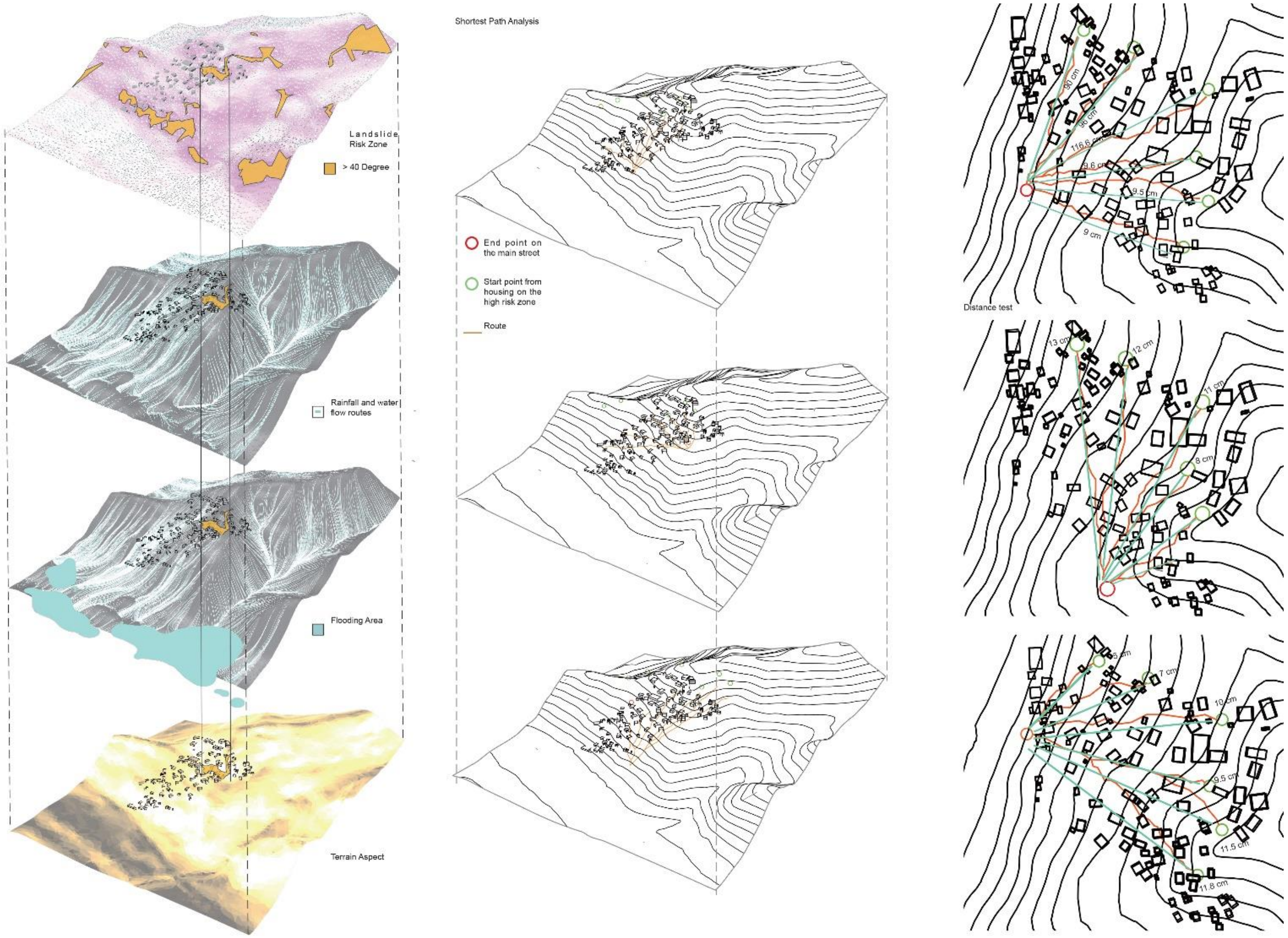


Figure 31: The landslide risk zone and environmental metrics (left of image) and path analysis for shortest evacuation routes (right of image) (Prepared by Chen).

8.3. Step 3: Develop nature-based concept design for identified problem

Once the ecosystem, hazard and risk assessments were conducted, the selection of NbS and risk reduction sites were undertaken. In order to identify NbS options (either green or hybrid solutions), cross-sections of zone 23 was derived from the LIDAR data.

It is important to note that this stage requires further ground-truthing and consultations with local stakeholders (including community) to incorporate existing/traditional knowledge into ecosystem management or proposed NbS. However, the drawings below will inform conversations with regard to the feasibility of implementation, maintenance regimes, and allocation of resources and assets within the site. 7 cross-sections (Figure 32) were derived along and across key sites, as identified from the ecosystem assessment in step 2. NbS design options were considered in relation to three types of intervention: 1) infrastructure and vegetation, 2) water and slope management, and 3) soil stabilisation.

ADAPTATION FUND

HONIARA CITY COUNCIL

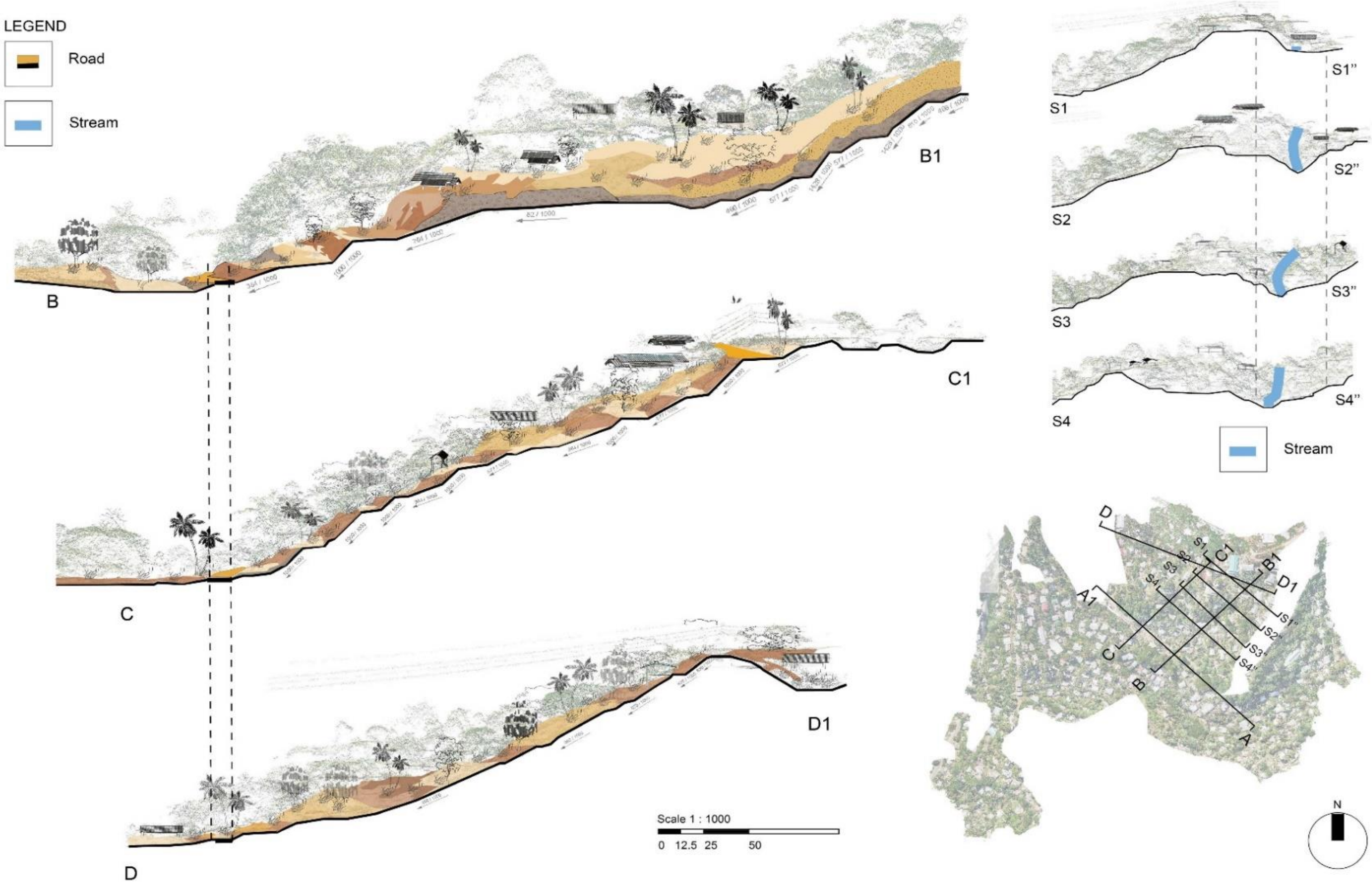


Figure 32: 7 cross-sections for NbS designs: 1) infrastructure and vegetation, 2) water and slope management and 3) soil stabilisation. (Prepared by Chen)

8.4. Identification of NbS options (green or hybrid) and concept designs

The following concept designs, in the form of cross-sections, illustrate the methodology to identify potential sites for NbS solutions.

Figure 33 shows a hybrid solution that integrates infrastructure and vegetation to reinforce the foothill and main access road into the ISZ. Based on the risk assessment, sites that act as conduits for stream order 2 flow would need to be inspected and rectified through revegetation and structural reinforcements.

Figure 34 identifies key drainage lines and at-risk slope sites. The implementation of a hybrid solution that includes various soil stabilisation solutions, directional drilling and retaining wall systems, to reinforce the slope in anticipation of high rainfall events and increased human activities.

Figure 35 illustrates soil stabilisation options and the identification of potential safe zones to allow for strategic soil reinforcement embankments for housing located along high-risk zones. The aim for this design is to reduce the potential impact of increased human activity within identified high risk zones. Furthermore, through the rainfall and drainage analysis, stakeholders will be able to identify sites which are more susceptible to channel run-off in the upper site catchment. Through the ecosystem assessment, discussions with local stakeholders (and needs to be ground truth-ed), strategic placement and distribution of stabilisation mechanisms will ensure that limited resources are managed, and key sites prioritised.

Pilot Site 1

Pilot Site 1: Infrastructure and Vegetation

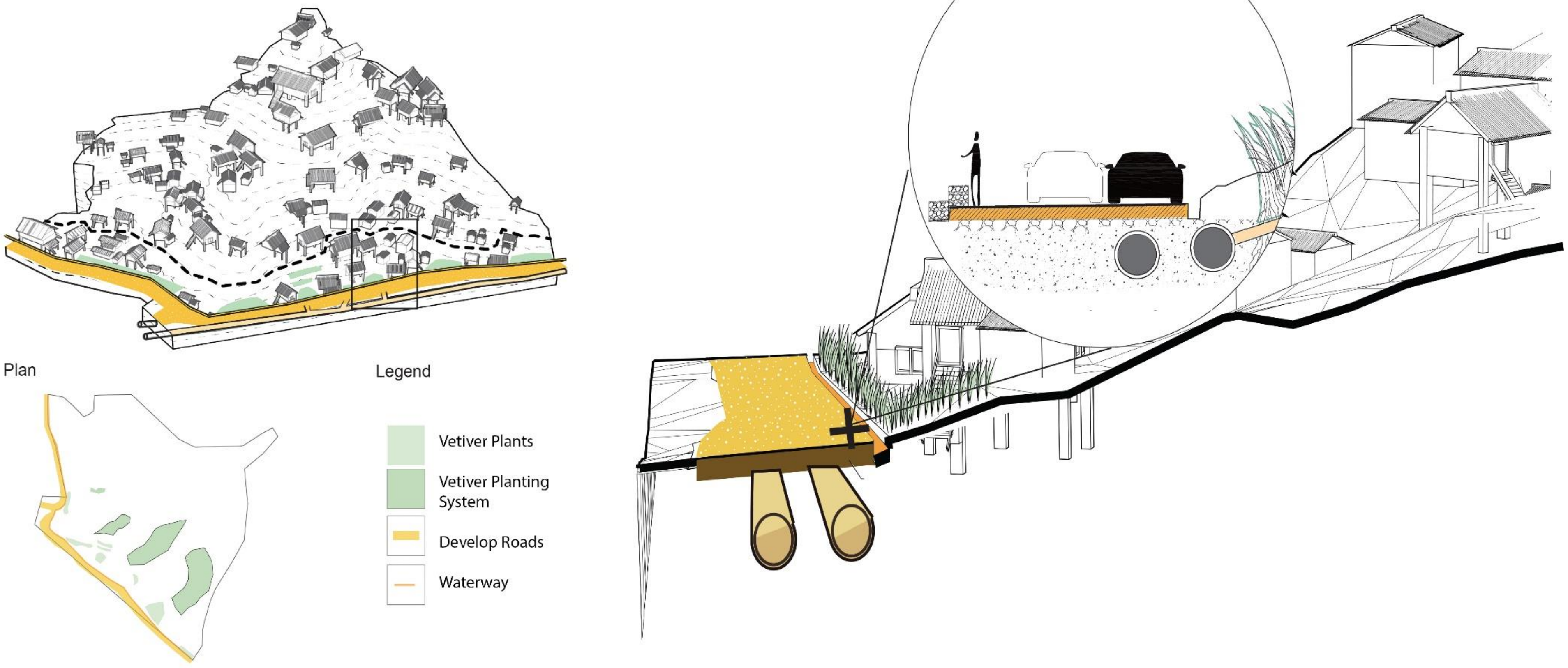
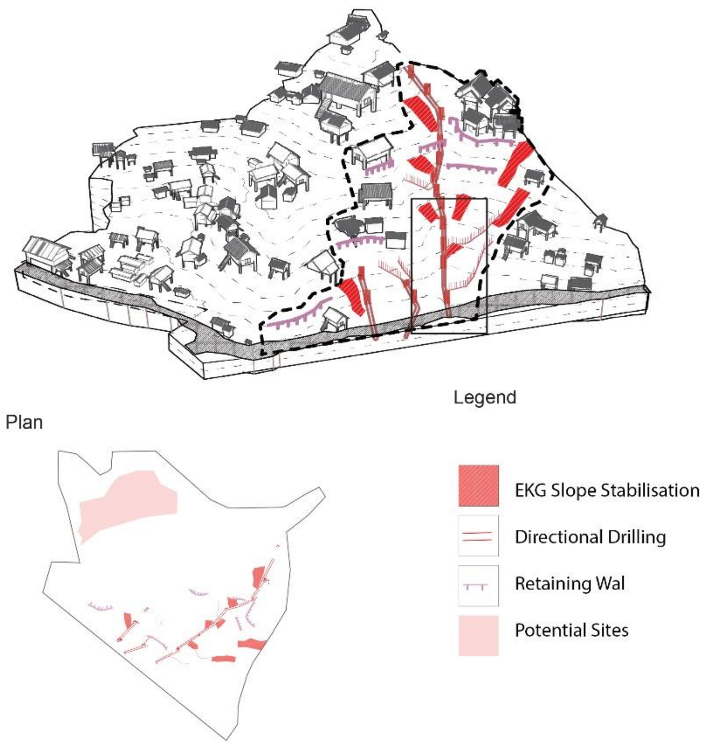


Figure 33: A hybrid solution to reinforce the foothill and main access road into the ISZ (Prepared by Chen)

Pilot Site 2

Pilot Site 2 - Water and Slope Management



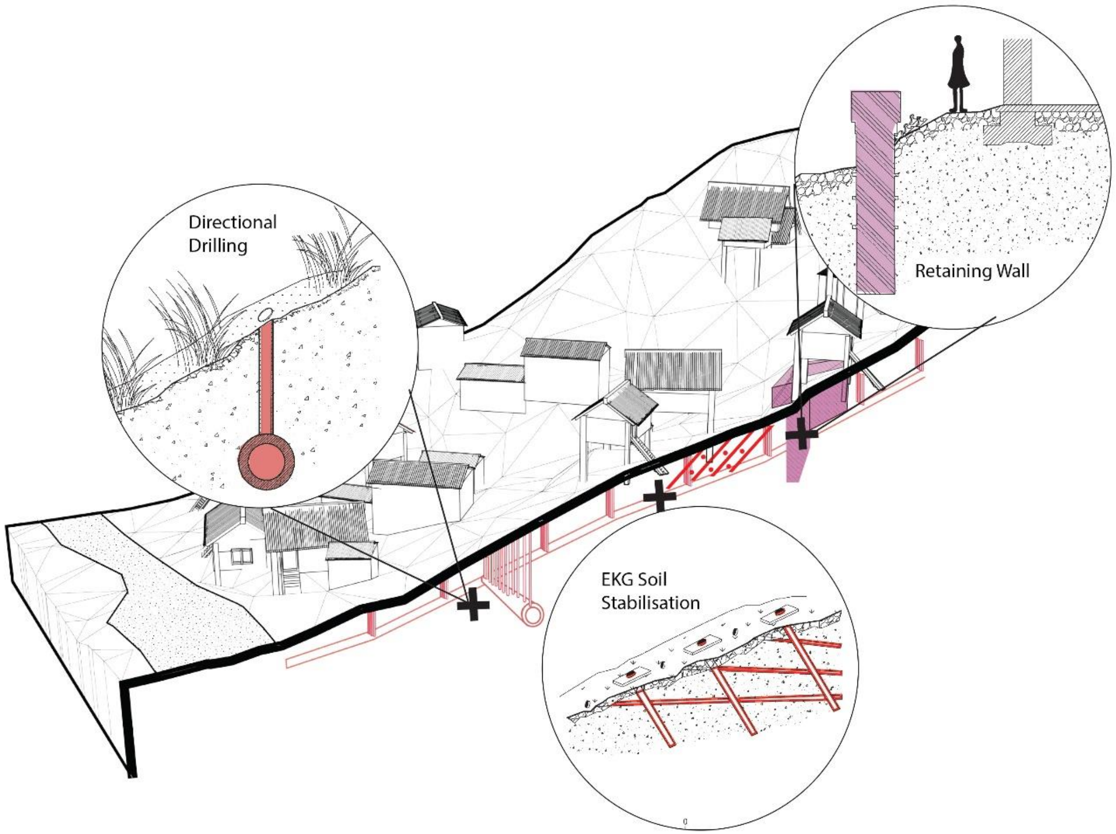


Figure 34: Key drainage lines and at-risk slope sites (Prepared by Chen).

Pilot Site 3

Pilot Site 3 - Soil Stabilisation and Safe Zones

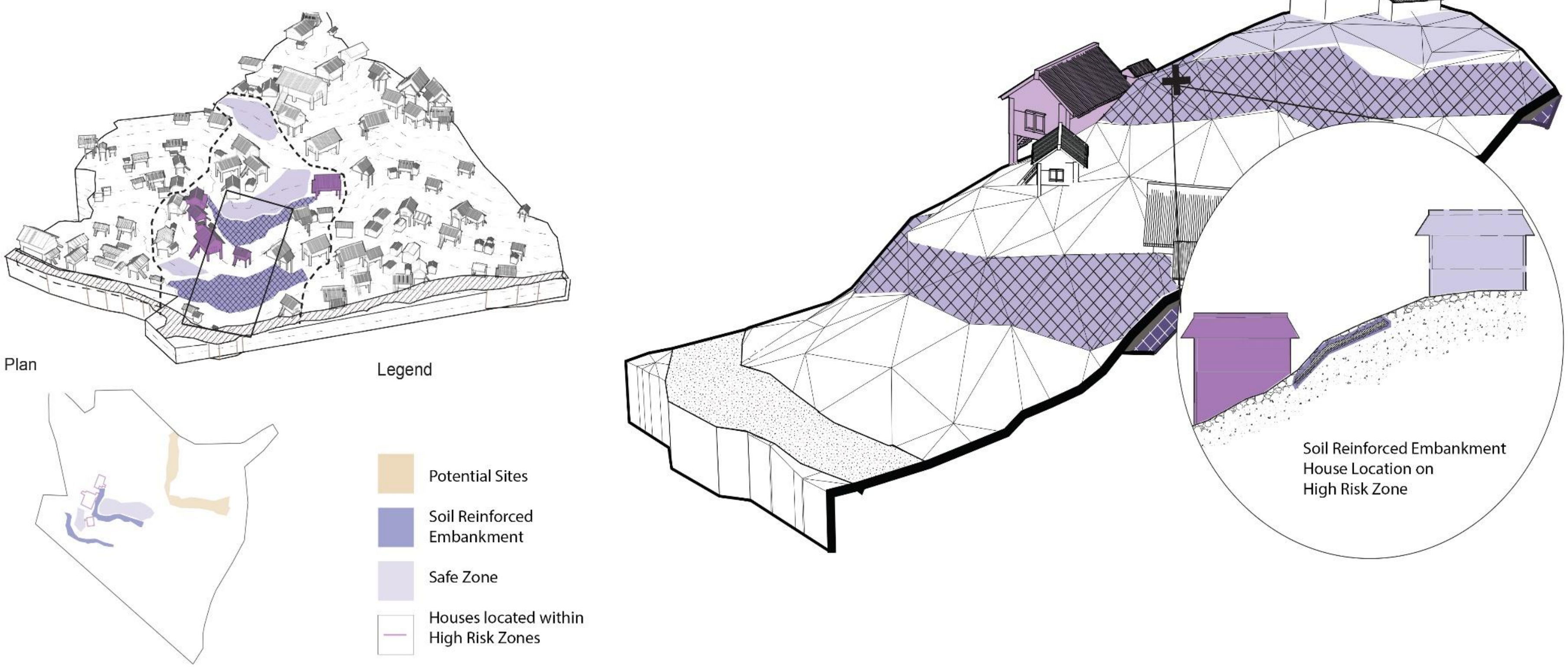


Figure 35: Soil stabilisation and the identification of potential safe zones (Prepared by Chen).

8.5. Flood mitigation measures

In order to propose NbS to mitigate flooding in Honiara, the detailed hydrological analysis was conducted in the city-level based on LiDAR data to identify stream order, hierarchy and catchments (Figure 36). Furthermore, a hydraulic analysis was delivered to identify prone areas for flooding in extreme weather conditions (Figure 37).

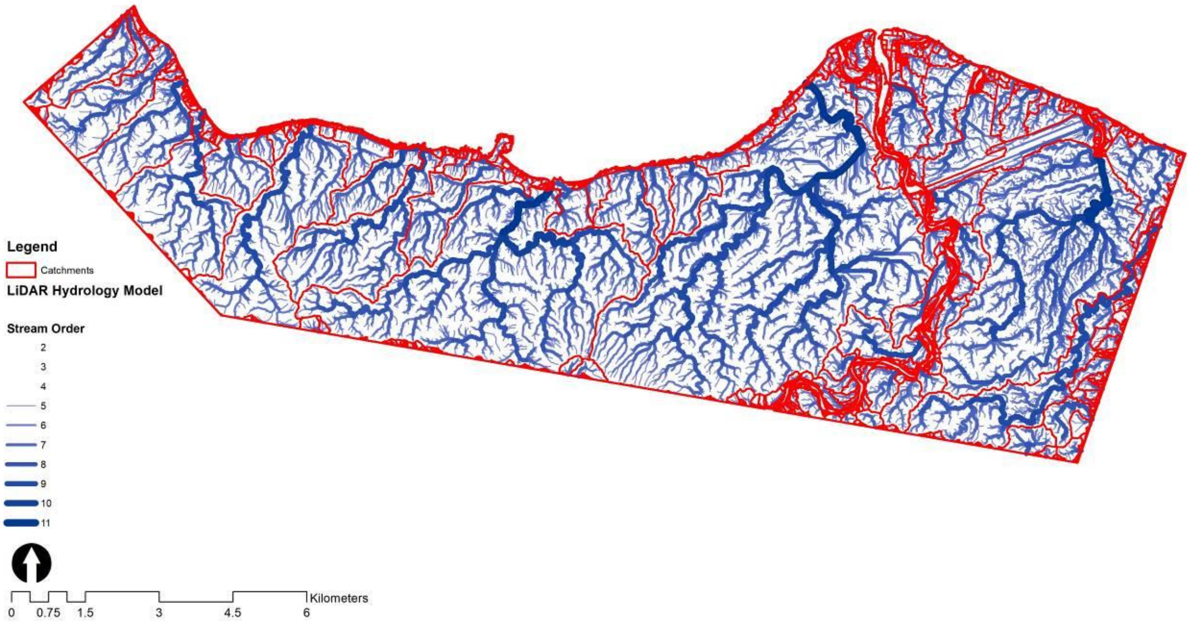


Figure 36: Hydrological model of Honiara identifying stream orders and major catchments

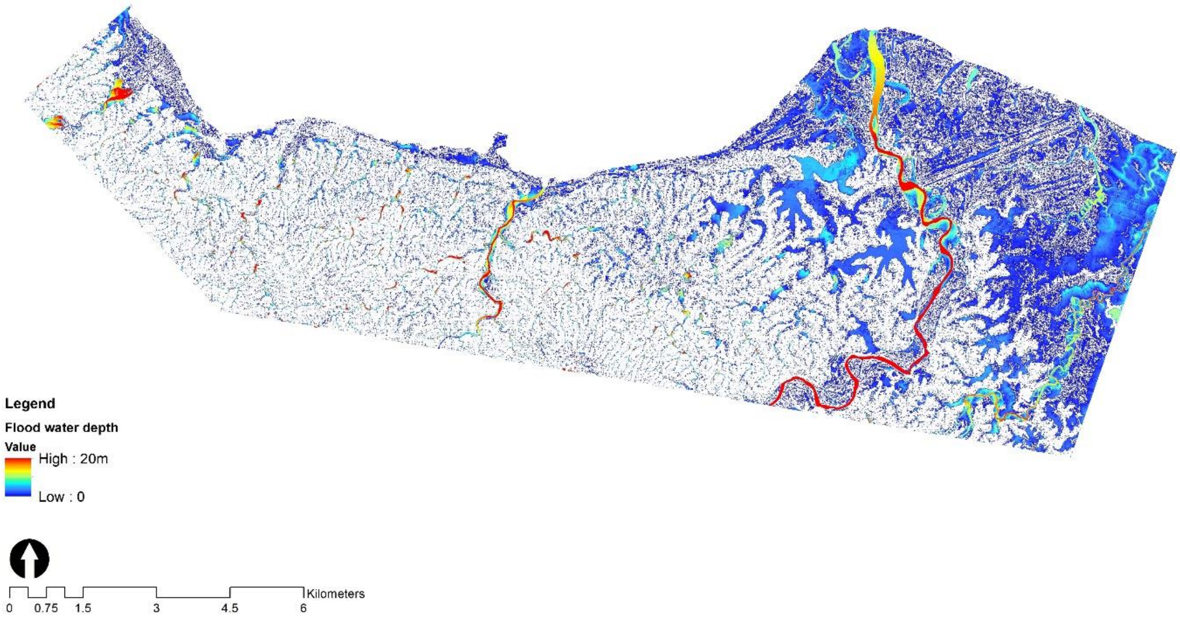


Figure 37: Flood modelling in 1 to 500 ARI rain event

Informed by these assessments, the design studio focused on Vara Creek, a flood-prone tributary gazetted by informal settlement zones (Aekafo) (Figure 38). The scenarios aimed to identify appropriate detention basins in tributaries connecting to the Vara Creek to detain run-off and mitigate flooding in vulnerable informal settlements (Figure 39). Furthermore, two scenarios were tested in the catchment for up to 80 dam locations with 2.5m and 5m dam wall heights (that could be implemented as part of the engineering actions). Areas that potentially can be inundated and the volume of captured water were calculated in the developed workflow in ArcGIS (Figure 40 and Figure 41). [The developed workflows and application of workflows were published as a research paper in the peer-reviewed journal of Digital Landscape Architecture].

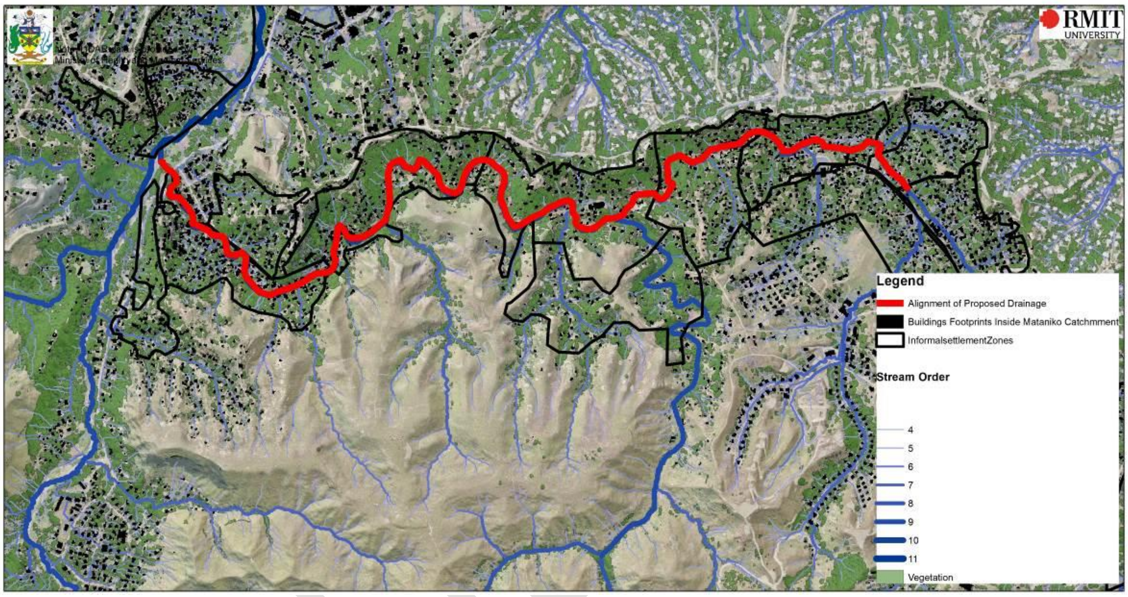


Figure 38: Vara creek and alignment of informal settlement zones (Aekafo) and major tributaries

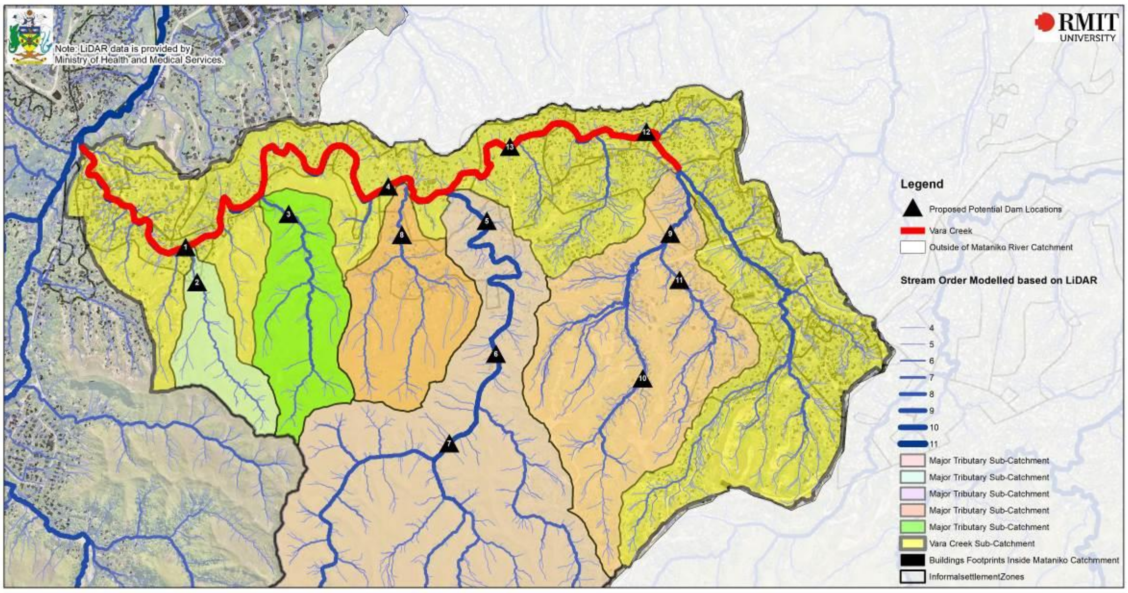


Figure 39: Identification of major watersheds connecting to Vara Creek and proposed detention ponds in upper catchment to mitigate flooding.

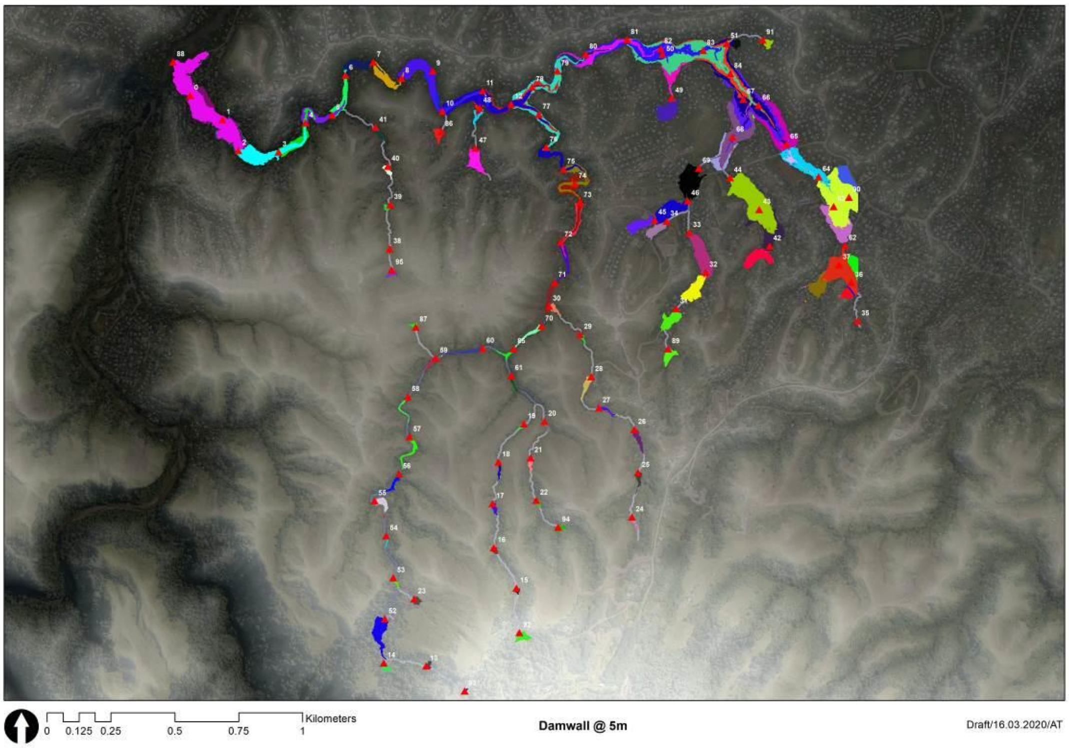


Figure 40: Modelling of inundated areas for 80 potential locations to measure to detention basin capacity (volume) with 5m dam wall.

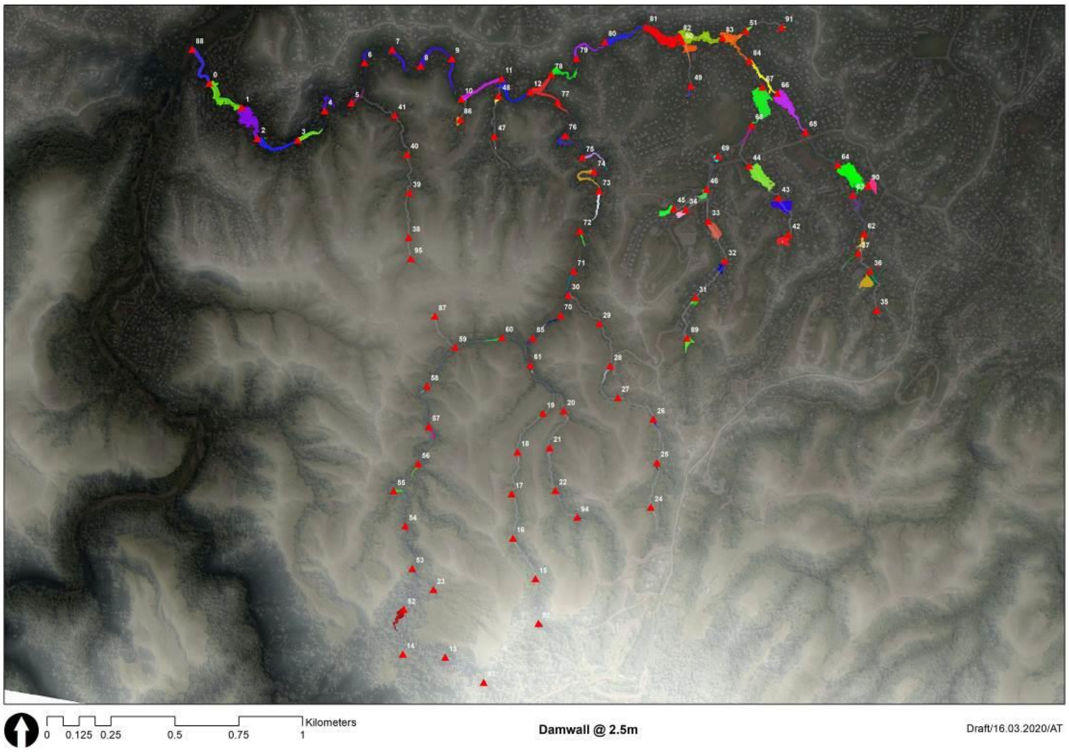


Figure 41: Modelling of inundated areas for 80 possible sites to identify the detention basin capacity (volume) with 2.5m dam wall.

8.6. Steps 4 to 7 of the NbS framework

The design studio conducted over the period of three months produced 15 individual conceptual designs, with varying degree of resolution, to progress from steps 1 through 3 of the implementation framework. The most pertinent of these have been included in this report.

Note: All student designs are contained in the Appendix to allow for A3 printing and improved readability.

The next steps in the implementation of the NbS framework involve:

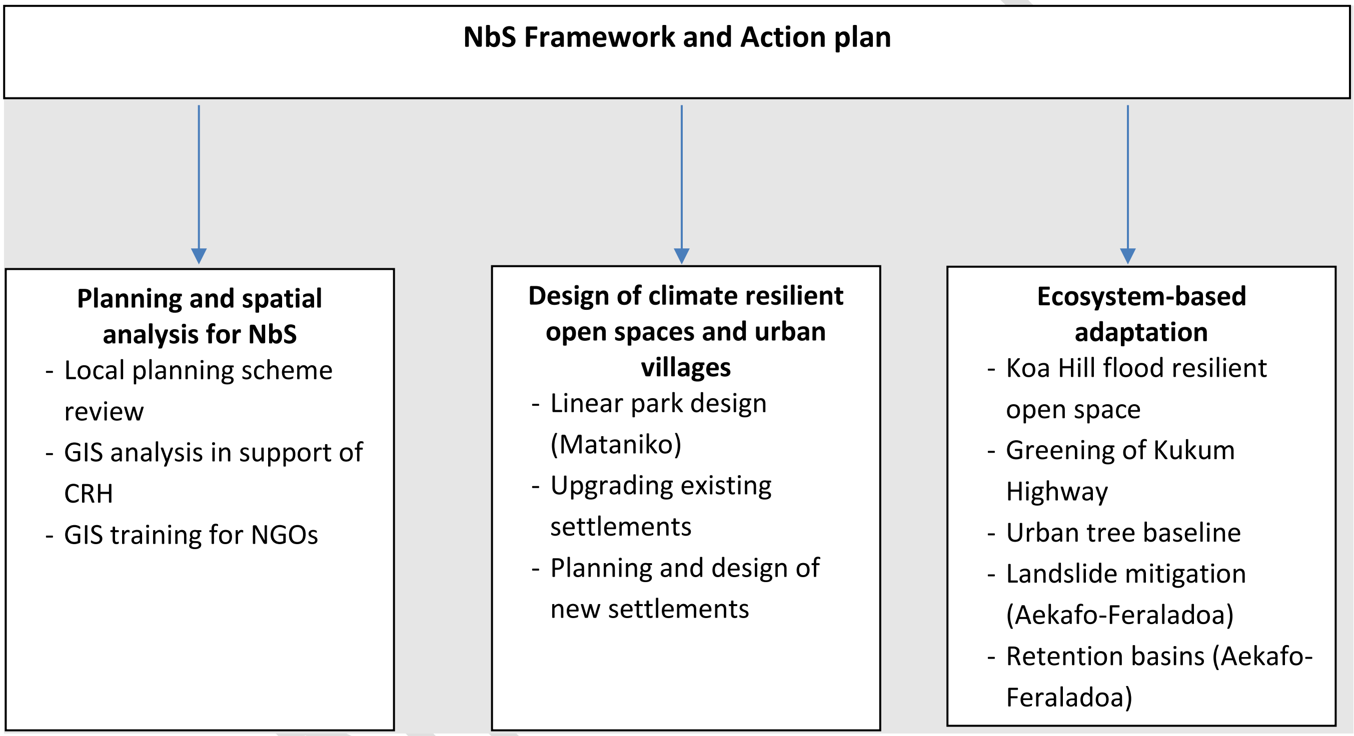
- Step 4: Development of financing strategy (local stakeholders will need to consider funding streams for actions beyond the confines of the project).
- Step 5: Develop detailed ‘place-based’ design of selected NbS interventions (stakeholder consultations, site visits, design studios, and student conceptual designs, have informed the development of a portfolio of potential actions. These are listed in the proposed action plan – see next section – for 2020 / 2021). It important to stress that the proposed solutions require validation by the local stakeholders and communities.
- Step 6: Implement with local partners (suggested local implementation lead organisations have been highlighted in the action plan).
- Step 7: Monitor & inform future actions (led by implementation lead organisations to promote local ‘ownership’).

Figure 42: Working together. Design material generated at RMIT University (top) and co-design workshop with SINU graduates in Honiara (below). (Photo credit: Ninsalam).

9. Proposed action plan for 2020 / 2021

Based on a mixture of stakeholder consultations (in particular HCC and SPREP), site visits, co-design workshops, student conceptual designs, LiDAR analysis and drone mapping; the following portfolio of actions and activities have been identified as the most appropriate options for implementation consideration in the short-term (2020 / 2021).

9.1. Schematic of proposed actions



9.2. Portfolio of short-term actions / activities

Planning and spatial analysis for NbS

1. Formalisation of the NbS framework and action plan (short, medium, and long-term actions) into a policy document; to be co-produced with HCC.

   This will provide the overarching framework for all NbS actions in Honiara, and will provide HCC with the evidence base and policy documentation to sustain actions in the longer-term. Funding streams for subsequent medium and long-term actions would, however, need to be identified.

2. Review of local planning scheme

   MLHS will be reviewing the local planning scheme in 2020 (to be updated every 5 years). The plan will be analysed for improvements and additional material as part of a RMIT graduate course (Vahanvati and Ninsalam). It is intended that a new GIS overlay for landslide risk will also be produced for inclusion in the updated scheme.

3. GIS analysis in support of NbS and other CRH actions

   The GIS team at RMIT (Tara and Ninsalam) will continue to support the spatial analysis of NbS and CRH actions (LiDAR, satellite images, drone mapping) as required.

4. GIS training for NGOs

   To follow up from the GIS training conducted for SI Government officials in December 2019, basic-level GIS training will be replicated for interested local NGOs and CSOs (e.g. this was requested for the Barana nature reserve wardens).

Ecosystem-based adaptation

1. Koa Hill flood resilient community space

   A community open space (to include gardens and sports facilities) will be co-designed in partnership with HCC, SINU, and local community groups. Designs will create a public space that will deter informal settlement, as well as mitigating flood risk. Co-design workshops will be held at RMIT, SINU and HCC, with validation by community groups.

Figure 43: Drone captured orthomosaic imagery of a segment of Koa Hill community open space, documented on 11 February 2020 (Photo Credit: Ninsalam)

2. Greening of Kukum Highway (for the Pacific Games)

   To involve GIS analysis to identify locations and design options for urban greening along the Kukum Highway (as the entrance way for the Pacific Games).

3. Establishing a baseline of urban trees, to provide the foundations for an urban tree strategy (Dias Baptista, Ho, Tara).

   This will involve a mix of geospatial analysis (conducted remotely at RMIT) together with ground-truthing / species identification to provide a baseline for an urban tree strategy (local partner to be identified).

4. Retention basins to reduce flooding (Aekafo-Feraldoa)

   This will further build on the SINU and RMIT student project ideas developed in 2019, to develop a detailed conceptual site design, and to implement this as a pilot site. This will be conducted in collaboration with RMIT engineers.

5. Landslide mitigation (Aekafo-Feraladoa)

   This will further build on the student project ideas developed in 2019, to develop a detailed site design, and to implement this as a pilot site.

Design of climate resilient open spaces and urban villages

1. Co-design of a linear park in the Mataniko River corridor.

   A public park will be co-designed in partnership with HCC, SINU, and local communities. Designs will create a public space that will deter informal settlement, as well as mitigating flood risk. Co-design workshops will be held at RMIT, SINU and HCC, with validation by community groups.

2. Design recommendations for upgrading of existing informal settlements

This will involve a mix of geospatial analysis to inform creation of designs at urban settlement scale (conducted remotely at RMIT). Ground-truthing of proposed design options will only be feasible once current travel restrictions are lifted. Designs will involve drawings as well as recommendations as implementation pathways (e.g. changes in the local planning scheme).

3. Planning of new urban fringe settlements (Noah's Hill)

This will involve a mix of geospatial analysis to inform creation of planning and settlement scale designs (conducted remotely at RMIT).

9.3. Estimated costs

Action	RMIT leads	RMIT costs	Local implementing partners	Local costs
1. Development of NbS framework and action plan				
Desk-top research	Vahanvati	$	-	-
Consultations and validation	Vahanvati (2 x workshops)	$	HCC	$
2. Local planning scheme review				
RMIT postgraduate course (90+ students)	Vahanvati	$	-	
Local consultations	Vahanvati (2 x workshops)	$	MLHS HCC	-
Landslide risk GIS overlay	Tara Ninsalam Maqsood	$	MLHS	-
3. GIS analysis				
GIS support for spatial risk analysis and detailed NbS	Tara Ninsalam	$	-	-
4. GIS training				
Training workshop for NGOs	Tara Ninsalam	$	NGOs / CSOs	$
5. Koa Hill flood resilient community space				
Co-design of community open space	Tara Ninsalam Vahanvati + 1 x workshop	$	SPREP MLHS HCC Local community	$$
6. Greening of Kukum Highway				
GIS analysis to identify locations / options for urban greening	Tara Ninsalam Vahanvati + 1 x workshop	$	HCC	$
7. Urban tree strategy				
Geospatial analysis (city-wide)	Dias Baptista Ho Tara	$$	-	-
Ground-truthing and species identification	Dias Baptista Tara	-	Ministry of Forestry	$$

8. Retention basins (Aekafo-Feraladoa)				
Retention basins to reduce flooding (in collaboration with RMIT engineers)	Tara Ninsalam	$	MLHS HCC SINU Local community	$$
9. Landslide mitigation (Aekafo-Feraladoa)				
Landslide mitigation (Aekafo-Feraladoa)	Tara Ninsalam Maqsood	$	MLHS HCC SINU Local community	$$
10. Linear park				
Co-design of a linear park (Mataniko river catchment)	Tara Ninsalam Vahanvati + 1 x workshop	$$	SPREP MLHS HCC Local community	$
11. Design options for upgrading of existing informal settlements				
	Tara Ninsalam Vahanvati + 1 x workshop	$	MLHS HCC	$$
12. Design of new fringe settlements (Noah Hill)				
	Tara Ninsalam Vahanvati + 1 x workshop	$	MLHS	-

$ - Under US$20,000
$$ - US$20,000 - $50,000
$$$ - Over US$50,000

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