



The Fred Hollows
Foundation NZ

Building Climate-Resilient Healthcare Facilities in the Pacific



Based on research conducted by Edge Impact.

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Protecting healthcare facilities from the impacts of climate change

Health infrastructure in Pacific Island countries is increasingly at risk due to the growing impacts of climate change. These risks are expected to worsen over time.

This report shares important findings and practical recommendations to help ensure that healthcare facilities remain functional, affordable, and resilient in the face of these challenges.

Photo: Patients line up to be screened at a surgical outreach in Kerema, Papua New Guinea.



Photo: Foundation-sponsored Dr Alice Irafa gives eye drops to a patient at Port Moresby General Hospital, Papua New Guinea.

Why strengthening Pacific healthcare centres against climate change matters for eye health.

Community-based healthcare centres are often the first point of contact for individuals with eye problems. Ensuring these facilities remain operational and well-equipped – especially during climate-related disruptions – is essential for timely treatment and appropriate referrals for vision care.

Climate change is expected to increase the burden of eye conditions in the Pacific, including conjunctivitis, pterygium, cataracts, myopia, blepharitis, glaucoma, and retinal vascular disorders.

These are linked to rising exposure to air pollution, extreme heat, fluctuating weather patterns, nutritional deficiencies, and emerging infectious diseases¹.

While further research is needed to fully understand the climate/eye health connection, strengthening the resilience of healthcare centres is a practical and urgent step to provide consistent and reliable healthcare for individuals of all abilities. Caring for our healthcare centres is not only important for general health but also helps safeguard access to vital eye care services as the implications of climate change become more apparent.

¹ https://www.researchgate.net/publication/376761143_Impacts_of_Climate_Change_on_Ocular_Health_A_Scoping_Review

Case study :

Benefits of upgrading energy systems at Foundation-supported healthcare facilities

These outcomes show how sustainable infrastructure reduces climate-related disruptions, improves care access, and redirects savings to patient outcomes.

Total Annual Health Impact

 **30⁺** additional days of operation/year (on average)

 **2,513** additional medical interventions

Enabled by reliable power, resilient infrastructure, improved WASH, and workforce continuity.

Total Financial Impact (\$USD):

 **\$903,498**

in solar savings (Net Present Value across all sites)

Solomon Islands

 **930⁺** interventions

 **\$619,777** saved

Papua New Guinea

 **1,273⁺** interventions

 **\$153,267** saved

Vanuatu

 **310⁺** interventions

 **\$130,454** saved

This report is based on climate and environmental impact assessments conducted at three healthcare facilities – all eye clinics – in Solomon Islands, Vanuatu, and Papua New Guinea.

These assessments were initiated by The Fred Hollows Foundation NZ (The Foundation), in partnership with the Solomon Islands Ministry of Health and Medical Services, the Vanuatu Ministry of Health and Medical Services, and the Papua New Guinea National Department of Health. The Foundation is an organisation focused on building a quality and sustainable Pacific eye care workforce, eliminating avoidable blindness and vision impairment, and helping to strengthen eye healthcare systems across the Pacific.

Pacific governments have a responsibility to ensure that all people have continuous access to safe, reliable health services – even during emergencies. This is a basic human right. Although current needs are pressing, climate change will increasingly impact infrastructure, operations, and service delivery, highlighting that stronger long-term planning and investment are essential. The recommendations in this report focus on building climate-resilient and environmentally sustainable healthcare facilities that can serve communities now and in the future.

Working in partnership with Pacific governments, development partners, and civil society, The Foundation commissioned Edge Impact to carry out Climate and Environmental Impact Assessments at three eye clinics in Solomon Islands, Vanuatu, and Papua New Guinea. *Climate Resilient and Environmentally Sustainable Health Care Facilities* (CRESHCF) guidance², developed by the World Health Organization (WHO), was adapted to provide a contextualised, structured process against which to review health facility **operations, infrastructure, and services** to evaluate how they may be affected by climate change. The assessments helped to identify practical actions to strengthen resilience, ensure service continuity, and protect vulnerable populations from climate-related risks.

Based on the climate and environmental impact assessments, this report provides recommendations to support environmentally responsible, resilience-building efforts that can be applied to a wide range of healthcare facilities, regardless of their specific function. It is being shared to contribute to best practice in the region.

² World Health Organization (2020) *WHO Guidance for Climate-Resilient and Environmentally Sustainable Health Care Facilities*. Geneva: World Health Organization. Available at: <https://www.who.int/publications/i/item/9789240012226>



Photo: Foundation-sponsored Dr Epeli Navela conducts an eye exam at the Mobile Eye Clinic on a surgical outreach to Tavua, Fiji.

Climate Hazards in the Pacific

This overview shows broad climate change impacts across the Pacific region, focusing on Madang (Papua New Guinea), Port Vila (Vanuatu), and Honiara (Solomon Islands). It is representative of the regional acceleration of climate change and its unique local effects. As a highly vulnerable region, the Pacific already faces disproportionate and compounding climate impacts.



Madang, Papua New Guinea

Current Climate Hazards:

-  **Sea Level Rise (SLR):**
Sea level rise & coastal erosion
-  **Storms:**
Increased intensity & frequency
-  **Heat:**
Increased temperatures and humidity
-  **Drought:**
Extended and intensified dry seasons

Compounding Climate Hazards & Impacts:

Sea level rise, flooding, and erosion are altering land use and reducing access to safe freshwater.

More intense and frequent storms are increasing landslips, disrupting water and energy services.

Honiara, Solomon Islands

Current Climate Hazards:

-  **Sea Level Rise (SLR):**
Sea level rise & coastal inundation
-  **Flooding:**
Increased severity & frequency
-  **Storms:**
Increased intensity

Compounding Climate Hazards & Impacts:

Sea level rise, flooding, and storm surges are already impacting low-lying coastal areas, with intensifying storms and cyclones causing repeated inundation of critical infrastructure.

Port Vila, Vanuatu

Current Climate Hazards:

-  **Tropical Cyclones:**
Increased intensity & frequency
-  **Storms:**
Increased intensity
-  **Heat:**
Increased temperatures and humidity

Compounding Climate Hazards & Impacts:

Longer, more intense dry seasons are reducing water availability and affecting agriculture and livelihoods.

Sea level rise, flooding, and storm surges are already impacting low-lying coastal areas, with intensifying storms and cyclones causing repeated inundation of critical infrastructure.

Healthcare centres involved in this study are described here. All healthcare centres are government facilities that The Foundation supports through operational assistance. Summarised findings specific to each healthcare centres are provided on pages 22 to 24.

Madang Provincial Hospital Eye Clinic

Madang, Papua New Guinea

The Madang Provincial Hospital Eye Clinic, in partnership with Divine Word University, is an essential training centre as well as an eye care clinic. In 2022, a solar energy system was installed to overcome frequent power outages and ensure uninterrupted surgeries. This innovation has cemented the Mandang Eye Clinic's status as a leader in eye care and training.

Vanuatu National Eye Centre

Port Vila, Vanuatu

The Vanuatu National Eye Centre provides high-quality eye care to the people of Vanuatu, supported by the country's first trained eye doctor and a state-of-the-art facility, strengthened to withstand earthquakes and cyclones.

Regional Eye Centre

Honiara, Solomon Islands

The Regional Eye Centre (REC) at the National Referral Hospital in Honiara features six consultation rooms, a two-bed operating theatre, a procedure room, and a dedicated teaching centre. Staffed by a skilled local workforce, it delivers high-quality eye care to patients from all corners of Solomon Islands.

The REC was built to be both climate-resilient and environmentally friendly. Solar panels generate the Centre's energy needs, rainwater harvesting ensures a reliable water supply, and an independent sewerage system reduces reliance on local utilities. The Centre has become a vital hub for eye health in the region.

While further research is needed to fully understand the climate/eye health connection, strengthening the resilience of healthcare centres is a practical and urgent step to provide consistent and reliable healthcare for individuals of all abilities. Safeguarding our healthcare centres is not only important for general health but also helps preserve access to vital eye care services as the implications of climate change become more apparent.



Photo: Masi and his cousin play games after a successful cataract surgery at the Pacific Eye Institute in Suva, Fiji.

Alignment with National, Regional and Global Plans

The vision set by Pacific Heads of Health is that, by 2031, countries and communities across the Pacific will have the capacity to anticipate and respond to the health impacts of climate change³.

The priorities laid out in key vision papers and strategies, such as *For the Future: Towards the Healthiest and Safest Region* and the *Pacific Islands Action Plan on Climate Change and Health*, coalesce around four pillars of work:

01

Advocacy to stimulate cross-sectoral action to address the health impacts of climate and environmental change

02

Building resilience into health systems to withstand the impacts of climate change and environmental threats

03

Monitoring the impact of climate change and the environment on health to inform decision-making, guide advocacy and drive action

04

Applying a **climate change and environment lens** to all areas of the health sector's work.⁴

Photo: The waiting area at the Pacific Eye Institute in Suva, Fiji.

³ Pacific Heads of State. (2021). *Putting health at the centre of the climate change discussion*.
⁴ (ibid)

The commitment made by Pacific Heads of State shapes development planning, policymaking, and resource allocation from the national level down to local communities, and this report will further strengthen these efforts. Strengthening healthcare systems to adapt to climate impacts – while also contributing to national emission reduction goals – aligns closely with the priorities of the *Blue Pacific Strategy* and the environmental and climate policies of Solomon Islands, Vanuatu, and Papua New Guinea. These frameworks emphasise the importance of resilient infrastructure, continuous access to health services, and the integration of climate action into national development efforts.

For example:



Vanuatu’s National Environment Policy and Implementation Plan (NEPIP) 2016–2030

highlights climate change adaptation in public service infrastructure, including health, as a national priority.



PNG’s Climate-Compatible Development Strategy and National Adaptation Plan

identify the health sector as vulnerable and call for climate-resilient health infrastructure and services.



Solomon Islands’ National Climate Change Policy and National Environmental Management Strategy (NEMS)

promote the integration of climate resilience across all sectors, including healthcare facilities and service delivery.

There is also a commitment to support nationally adapted plans guided by the WHO and CRESHCF document, used as the basis for the findings in this report. There is already a CRESHCF country-specific guide for Solomon Islands and upcoming documents from the Vanuatu and Papua New Guinean governments, who are working with the WHO on strategy development. Ministries of Health are heeding the call to scale up preparedness and improve resilience against climate impacts. By aligning health adaptation efforts with WHO strategies adapted to the specific needs of the Pacific context, governments can improve the reliability of healthcare services, reduce climate-related risks, and contribute to sustainable development and regional stability.



Creating more resilient healthcare centres also supports the SDGs:



Photo: Siafy can see his wife clearly again after his cataract surgery at a surgical outreach to Kerema, Papua New Guinea.

Predicting Future Risks^{5,6}

Predictions indicate that healthcare facilities in the Pacific will be increasingly at risk from the impacts of climate change. The Pacific region’s vast expanse encompasses diverse climate zones, from the arid islands of the central Pacific to the tropical regions of Melanesia.

This geographical diversity results in varied climate scenarios:

Scenario A:

Increased temperatures with decreased rainfall

Scenario B:

Increased temperatures and humidity with increased rainfall

These scenarios are influenced by complex oceanic and atmospheric interactions, including the El Niño–Southern Oscillation and the South Pacific Convergence Zone. Such variability necessitates tailored adaptation strategies to ensure the resilience of healthcare facilities across the Pacific.

⁵ CSIRO and SPREP, *NextGen Projections for the Western Tropical Pacific: Current and Future Climate for Papua New Guinea, Solomon Islands, and Vanuatu, 2021*.
⁶ *Intergovernmental Panel on Climate Change (2021) Sixth Assessment Report (AR6)*. Geneva: IPCC. Available at: <https://www.ipcc.ch/report/ar6/wg1/>.

Climate Projections for the Pacific

Drought



The dry season is getting longer, making droughts worse across the Pacific. This leads to less rainfall and puts water security at risk during these months.

Heat



Climate projections indicate increasing temperatures, more frequent extreme heat events, and higher heat stress indices across the Pacific region due to climate change.

Flooding



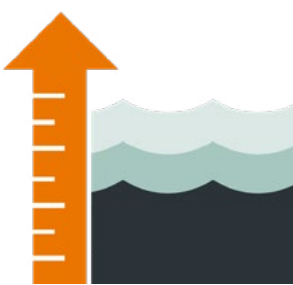
Coastal regions are particularly vulnerable to heavy rainfall, riverine flooding, and coastal inundation, with future projections indicating more frequent and extreme rainfall events and rising sea levels. Tropical cyclones, storm surges and king tides further exacerbate flood risks.

Storms



The Pacific region is subject to increased exposure to projected increases in storm and cyclone frequency and intensity in the short and long term. Extreme winds, lightning strikes and heavy rainfall are likely to have direct impacts on the infrastructure and operational capacity of the facilities.

Sea-Level Rise (SLR)



Sea levels are projected to rise by 0.3 – 1.0 metres by 2100 across the Pacific, depending on global emissions pathways. It is likely SLR coupled with king tides, coastal erosion, and saltwater intrusion will threaten coastal communities, their infrastructure and freshwater resources.



Climate resilient healthcare facilities: seven key insights to guide planning

The WHO Guidance for Climate-Resilient and Environmentally Sustainable Health Care Facilities (CRESHCF) offer valuable direction to health authorities and governments in the Pacific and globally.

Using a contextualised methodology guided by this resource, The Foundation asked Edge Impact and local health authorities to work together to conduct climate and environmental impact assessments in three eye clinics on Solomon Islands, Vanuatu, and Papua New Guinea. This section draws seven key insights from the report findings, presented here as recommendations.

Photo: Popo and his wife celebrate his restored sight after a cataract surgery at a surgical outreach in Kerema, Papua New Guinea.



Seven Key Insights to Guide Planning

01

Prepare for emergencies

Ensure that all staff – not just those in leadership – are familiar with emergency and disaster response plans, as this is essential for improving preparedness, enabling timely anticipatory action before a disaster, and ensuring a coordinated, efficient response afterward. Engagement with relevant authorities, such as Disaster Management Officers, Ministries of Health, and Provincial Health Authorities, should be strengthened to support the coordinated development, documentation, and integration of climate resilience plans. Additionally, implementing business continuity plans will help standardise emergency procedures and ensure institutional knowledge is distributed across teams, reducing reliance on individual staff and improving system-wide resilience.

02

Think ahead to ensure healthcare facilities are resilient to current and future climate predictions, and create a transition plan

Sites designed to withstand current climate risks may not be resilient to future, more severe impacts. Health authorities need to work with climate planners and authorities to anticipate and plan for future predictions, especially related to sea level rise, flooding, droughts, increased cyclonic activity and extreme heat. As they do so, it is important to keep in mind the impact of these things on essentials such as access to safe water and electricity, and to consider this as investments in infrastructure are being made. The installation of climate resilient infrastructure now – or the development of a transition plan to guide planning and budget-setting to upgrade over time – is important to reduce the vulnerability of healthcare facilities to climate risks. Plans might include the integration of climate projection data into enhanced design and construction of buildings; improved cooling capacity of heating, ventilation and air conditioning systems; increasing the volume and protection of secured water storage; and adapting or creating new Standard Operating Procedures (SOPs).

03

Advocate for the integration of climate resilience in healthcare education

Healthcare facilities should seek opportunities to collaborate with universities (both local and international) and health institutions (e.g., WHO) to incorporate climate resilience, adaptation planning, and environmental sustainability into health-related curricula. As climate change increasingly affects healthcare systems – through rising disease burdens, supply chain disruptions, and infrastructure damage – it is essential that healthcare professionals are trained to anticipate, respond to, and manage these challenges effectively.

Partnerships with institutions such as Divine Word University PNG and the University of Technology Sydney, which provide course design support in PNG and Vanuatu respectively, offer valuable opportunities to integrate climate-related content into professional training programs, enhancing capacity-building efforts.



Photo: A nurse conducts an eye screening at the National Eye Centre in Port Vila, Vanuatu.



Case Study:

Vanuatu higher level education programme redesign

Vanuatu's Ministry of Health (MoH) is strengthening its healthcare workforce by embedding public health and climate change into medical and health science education through partnership with the University of Technology Sydney (UTS).

This initiative enhances climate resilience, ensures healthcare professionals are better equipped to manage emerging health risks, and fosters a sustainable, locally led approach to healthcare in the region.

Seven Key Insights to Guide Planning

04

Improve water, sanitation, and hygiene (WASH) and infection control practices

Apply structured WASH training and monitoring programmes across all healthcare centres to improve hygiene and infection control compliance. The study found that staff at surveyed eye clinics had a stronger grasp of WASH protocols than the broader hospital workforce, indicating an opportunity for knowledge transfer. Administrators should leverage this expertise to promote consistent WASH standards facility-wide and support staff in advocating for improved practices among external partners, including in waste management and water sourcing. This will strengthen infection control both within and beyond healthcare facilities.

05

Schedule outreach activities for times when the climate is less likely to disrupt

Schedule outreach activities during periods of lowest climate risk – such as the dry season – to minimise disruptions from heavy rainfall, flooding, or cyclones. Incorporate short-term weather forecasts and climate tools into planning to increase flexibility and responsiveness. Use historical attendance records alongside local climate data to optimise timing, improve resource allocation, and ensure continuity of care.

06

Improve collaboration, integration and coordination for outreach clinics

Partnerships with other healthcare, public health, and climate organisations can improve outreach effectiveness, particularly in remote communities. Collaborative efforts ensure broader community impact by linking health services with climate education and resilience-building initiatives.

07

Standardise and strengthen maintenance and emergency preparedness protocols

Facilities rely on external contractors for maintenance, often leading to inconsistency in service delivery and a lack of knowledge transfer to localised staff. Formalising maintenance schedules in SOPs will promote accountability and operational resilience. Emergency response and disaster management plans should be reviewed and enhanced to ensure actionable, site-specific guidance.



Case Study:

Creating energy and water resilience

All three Foundation-supported eye clinics have installed photovoltaic (PV) systems with battery storage and backup power generation (PNG and Solomon Islands only). Additionally, their resilience to water scarcity has been enhanced through the installation of rainwater capture systems (water tanks). To further bolster energy security, these systems should include surge protection.



Solomon Islands: Battery system at the Regional Eye Centre, Honiara. 48 × 2V 2500Ah batteries, 240 kWh total capacity.



Vanuatu: 10,000 L water storage tank at the National Eye Centre, Port Vila, supporting water security and clinic operations.



Papua New Guinea: Partial view of the 160-panel solar photovoltaic array at Madang Provincial Hospital Eye Clinic, delivering sustainable energy and ensuring reliable power supply.



Conducting a climate risk assessment

A climate risk assessment is a vital tool for building the resilience of healthcare facilities to climate change.

This process typically combines two complementary approaches.

The traditional climate risk assessment evaluates exposure, threats, and vulnerabilities across infrastructure, services, and surrounding communities. It uses future climate scenario modelling – often based on high-emissions pathways such as RCP8.5 – to assess risks like extreme weather, rising temperatures, and sea-level rise over time. This helps prioritise proactive adaptation measures.

In parallel, WHO and CRESHCF⁷ offers material against which to assess the robustness of healthcare facilities.

Other checklists exist, such as the WHO *Checklists to Assess Vulnerabilities in Health Care Facilities in the Context of Climate Change*⁸ and *Operational Framework for Building Climate Resilient and Low Carbon Health Systems*⁹. While referred to, these were seen as too exhaustive for the scope of this study.

The Methodology Used in this Report

The remainder of this report presents the findings from assessments made at the three eye clinics in Vanuatu, Solomon Islands and Papua New Guinea, with observations concerning **risks** and **response guidance measures** grouped under the following sections in this report: **Infrastructure** including technology and products, **Operations**, including energy, water and sanitation, and waste management, and **Service** delivery.

Relevant CRESHCF metrics were identified for each healthcare facility and subsequently assessed by an Edge Impact consultant, collaborating with Ministry of Health Officials, eye clinic personnel, and other key stakeholders. The tailored metrics were scored based on the level of implementation evidenced, as follows:



Low Performance

Activity is unavailable, or the facility is unable to implement it



Medium Performance

Activity is in progress or incomplete



High Performance

Activity is completed, achieved, and tested

Strengths and gaps were then identified across the four domains from the WHO Guidance for CRESHCF⁷, highlighting areas of high, medium, and low climate resilience and environmental sustainability, and reports were produced for each Centre.

This document presents consolidated findings from the three reports.

Photo: Dr Alice Irafa attends class at the University of Papua New Guinea in Port Moresby.

⁷ WHO Climate-Resilient and Environmentally Sustainable Health Care Facilities Guidance
⁸ <https://www.who.int/publications-detail-redirect/9789240022904>
⁹ <https://www.who.int/publications/i/item/9789240081888>



Risk and response guidance findings

Climate Risks to Health Infrastructure

As climate change intensifies, critical infrastructure will face growing pressure from increased exposure to events. This can disrupt the delivery of essential healthcare services.

Key risks to **infrastructure** identified in the eye clinics studied include:

Heat, Humidity & Drought: Rising temperatures, humidity, and prolonged dry periods can impair medical equipment, particularly sensitive ophthalmic instrument, while also increasing the risk of mould growth, moisture damage within buildings, and water scarcity that affects cooling systems, sanitation, and clinical operations.

Extreme Weather Events: Cyclones, heavy rainfall, and strong winds can damage clinic structures, disrupt power and water supply, and compromise medical equipment, leading to costly repairs and service interruptions.

Flooding & Sea Level Rise: Clinics in low-lying coastal areas, such as Honiara and Madang, are at risk of coastal flooding, erosion, and saltwater intrusion, which can weaken structural integrity, damage essential equipment and corrupt fresh water supplies.



Photo: A family adds a roof to their fale near Apia, Samoa.

Health Infrastructure

Response Guidance: Integrating Climate-Resilient Design into Healthcare Facility Infrastructure

To reduce climate-related risks and maintain continuity of care during extreme weather events, healthcare facilities should incorporate climate-resilient design measures.

Recommended best-practice, as modelled by the healthcare centres studied, include:

Cyclone-Resilient Construction:

Use reinforced structural designs with cyclone-rated fixings to reduce damage and ensure buildings remain safe and operational during severe weather events.

Passive Ventilation and Adjustable Flaps: Incorporate louvred walls, cross-ventilating roof structures, and adjustable flaps to enhance natural airflow. These features help maintain comfortable indoor conditions, reduce dependency on air conditioning, and optimise energy use, which is particularly important in areas with high energy costs.

Insulated Roofing and Exterior Shading: Apply light-coloured, insulated roofing materials and install external shading to minimise internal heat gain. This reduces cooling demand, lowers electricity consumption, and improves energy efficiency.

These measures can help ensure that healthcare facilities remain safe, functional, and cost-effective in the face of escalating climate pressures.



Photo: Foundation-sponsored nurse Wilma Tul screens patients before their surgeries at an outreach to Kerema, Papua New Guinea.

Health Operations

Climate Risks to Health Operations

Climate hazards not only threaten healthcare infrastructure but also disrupt essential operations, affecting energy supply, WASH systems, and the availability of critical services and products. These disruptions can compromise patient care and the overall functionality of healthcare facilities. Key risks to **operations** identified in the eye clinics studied include:

Power & Water Reliability: Energy supply disruptions and water shortages impact sterilisation, air conditioning, and overall functionality. These are among the most significant threats to operational continuity for healthcare facilities across the Pacific.

Supply Chain Disruptions: Extreme weather and infrastructure damage can delay shipments of medical supplies, medications, and specialist equipment, reducing treatment availability - particularly for outreach clinics.

Increased Demand for Services: Climate change contributes to rising cases of eye health conditions, including infections linked to poor water quality and UV-related eye diseases, increasing pressure on eye clinics and the broader healthcare system.

Response Guidance: Integrating Climate-Resilient Design into Healthcare Facility Operations

To address operational challenges posed by climate risks, a combination of best practice strategies and additional recommendations have been identified to strengthen resilience across the healthcare facilities.

Energy

Install Integrated Energy Systems including solar photovoltaic (PV) panels, battery storage, and backup generators – to ensure a reliable power supply, reduce energy outages, and lower operational costs. These systems are essential for maintaining critical healthcare services and ensuring continuity of care during climate-related disruptions. *(where applicable).*

Ensure reliable internet connectivity to support remote monitoring of energy systems and enable staff training on solar and battery systems. In areas with limited internet access, explore options like Starlink for improved connection. Strong internet access also helps with emergency response, communication, and the use of digital health technologies. *(where applicable).*

Expand Circuit Isolation: It is recommended to implement advanced circuit isolation at all critical energy points across healthcare facilities to enhance protection against power surges and improve system resilience.

Upgrade Power Supply Systems: Upgrading power supply systems in regions with unstable grids is critical to ensure consistent energy access, even during extreme climate events.

Evaluate Fuel Supply Chains for Backup Generators: Facilities should evaluate local fuel sourcing and logistics for backup generators to guarantee reliable fuel access during power outages caused by climate-related disruptions.



Photo: Teaching Ophthalmologist
Dr Subash Bhatta delivers eye surgery
at the Pacific Eye Institute in Suva, Fiji.

Response Guidance: Integrating Climate-Resilient Design into Healthcare Facility Operations

Photo: A power outage during a surgical outreach to Kerema, Papua New Guinea leaves Lily waiting to have her bandage removed in the dark.

Best Practice:

Climate Resilient and Environmentally Sustainable Energy System Design

Despite financial and infrastructure challenges, especially in rural healthcare, ideal facility design should still prioritise these key considerations:

Integrated Energy System: Install a solar photovoltaic (PV) array sized to meet the facility's average and peak energy demand, with consideration of local solar radiation and usage patterns. Pair the system with battery storage and a backup generator to ensure uninterrupted power during grid outages or periods of low solar generation.

Battery Storage: Size the battery system to provide sufficient autonomy during outages or low sunlight periods, with capacity to support all critical healthcare services and essential infrastructure.

Backup Generator: Select a generator capable of meeting peak load requirements and operating for extended periods. Ensure reliable access to fuel by evaluating local supply chains and storage options.

Smart Energy Management:

Use hybrid inverters and remote monitoring systems to manage energy flow between solar, battery, and generator sources efficiently. Ensure staff are trained in system operation, basic maintenance, and troubleshooting.

Circuit Isolation: Implement advanced circuit isolation at key points to protect sensitive medical equipment and improve resilience during power surges or faults.

Connectivity and Communication:

Ensure stable internet connectivity to support system monitoring, digital health tools, and emergency communication. In remote areas, consider solutions such as Starlink.

Context-Specific Design: Tailor the system design to local climate conditions, available resources, and operational needs. Include energy supply for critical infrastructure such as water filtration and medical equipment to ensure continuity of care during disruptions.

Response Guidance: Integrating Climate-Resilient Design into Healthcare Facility Operations

Water Accessibility

Reliable water infrastructure integrates multi-stage filtration with diversified water sources to enhance sanitation, operational resilience, and climate adaptability.

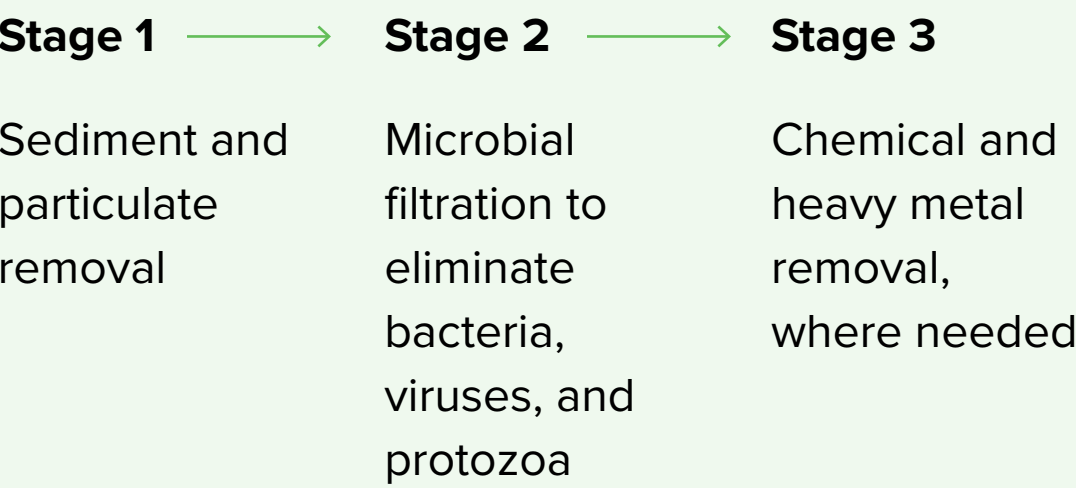
Filtrate and Treat Water: Multi-stage filtration ensures that both rainwater and municipal water meet sanitation standards before use. Routine water quality testing and monitoring should be implemented to maintain high safety standards.

Photo: Louro waits to have his bandage removed after cataract surgery at an outreach to Kerema, Papua New Guinea.

Best Practice: Water Filtration System Design

Contaminant-Specific Filtration: Design water treatment systems based on local water quality assessments, targeting the specific contaminants found in source water. Tailor solutions to address biological, chemical, and physical risks.

Multi-Stage Filtration: Implement a multi-barrier approach to treatment:



Technology Compatibility and Maintenance: Choose filtration technologies that are compatible with local conditions and resources. Prioritise systems that are easy to operate, maintain, and repair using locally available materials and skills.

Backup and Redundancy Measures: Incorporate contingency options to maintain safe water access during primary system failures or contamination events. Examples include:

- Ceramic or bio-sand filters for point-of-use treatment
- Solar water distillers for producing small volumes of clean water
- Chlorine tablets or liquid chlorination for microbial disinfection
- Gravity-fed ultrafiltration units for backup treatment during outages

Monitoring and Maintenance Protocols: Establish routine maintenance schedules and water quality monitoring procedures. Equip staff with training to perform basic troubleshooting and ensure system longevity.

Context-Specific Design: Account for local climate, seasonal water availability, and infrastructure constraints. Ensure systems can supply clean water to all critical healthcare functions, including sterilisation, patient care, and sanitation.

Response Guidance: Integrating Climate-Resilient Design into Healthcare Facility Operations

Water Accessibility

Improve Water Catchment and Storage:

The most effective systems combine rainwater capture with municipal supply, ensuring flexibility during dry seasons while reducing strain on treatment infrastructure. Where multiple tanks are unavailable, at least one tank should be designated for rainwater-only storage, with additional tanks functioning as hybrid systems to enhance water security.

Improve Infrastructure and Maintenance:

Upgrading water treatment infrastructure, improving UV filter maintenance through local technician training, and ensuring a reliable supply chain for spare parts will strengthen long-term system resilience.

By implementing multi-source water systems, upgrading treatment infrastructure, and enhancing local maintenance capabilities, healthcare facilities can ensure a consistent, high-quality water supply, safeguarding essential medical services even under changing climate conditions.

Photo: Foundation-sponsored nurse Julian Sikwaae prepares a patient for surgery at the Regional Eye Centre in Honiara, Solomon Islands.

The Climate Resilience Assessment identified specific water management applications in Solomon Islands, Vanuatu, and Papua New Guinea.

Solomon Islands: A rainwater-only system reduces filtration strain and extends the lifespan of pumps and equipment, as softer water requires less treatment. The assessment noted that captured rainwater should be prioritised for critical services such as operating theatres, where water quality and reliability are paramount.

PNG & Vanuatu: Hybrid systems that combine rainwater and municipal water provide greater resilience during prolonged dry seasons, mitigating shortages as climate patterns shift. The assessment indicated that expanding rainwater capture capacity and ensuring reliable municipal connections in areas with increasingly long dry seasons will improve water security.

At all three sites where the Climate Resilience Assessment was conducted, a technical review recommended fitting outlet taps with non-return valves to prevent contamination and installing water distillers as a backup to UV filters to ensure consistent water quality, particularly in the event of filtration system failure.

Response Guidance: Integrating Climate-Resilient Design into Healthcare Facility Operations

Wastewater Management

Effective wastewater management systems prioritise treatment, containment, and safe discharge to protect public health and the surrounding environment.

Treat and Contain Wastewater: Use a multi-stage treatment system and maintain it regularly. This helps ensure safe processing before disposal and reduces the risk of environmental contamination.

Expand Wastewater Capacity and System Resilience: Increasing storage capacity and reinforcing removal protocols will help prevent system failures and improve long-term reliability.

Discharge & Environmental Impact: Where direct discharge occurs, enhanced treatment measures and structured oversight can improve environmental outcomes.

By reinforcing maintenance protocols, expanding storage capacity, and building local expertise, healthcare facilities can improve wastewater resilience, safeguard environmental health, and ensure sustainable, locally managed solutions.



Photo: Underground wastewater treatment tanks in a compact onsite system – including access points and ventilation – providing decentralised sanitation support for the REC in Honiara, Solomon Islands.



Case study:
A best practice example from the Foundation-supported eye clinic in Solomon Islands

A multi-stage treatment process within an isolated system ensures wastewater is processed through multiple underground tanks. While proactive emptying is already in place, building local capacity for sewer inspections and system maintenance will enhance long-term functionality. Training facility staff and local workers to conduct routine maintenance and inspections – rather than relying solely on external contractors – will improve system resilience and reduce long-term costs.

Waste Management

Robust waste management systems integrate secure storage, structured disposal, and sustainable reduction strategies to improve hygiene, operational resilience, and environmental responsibility.

Ensure Compliance with WHO Guidelines for Internal Waste Management: Stringent waste management procedures minimise exposure to medical and general waste. Ongoing training equips healthcare staff with best practices for safe handling and disposal.

Ensure Coordination when Managing External Waste: Effective coordination with government authorities, waste contractors, and medical stores is essential for waste removal, treatment, and disposal. Partnerships with local waste management providers strengthen external waste treatment capacity.

Practice On-Site Incineration: Where feasible, on-site incineration improves containment and reduces transportation challenges, as demonstrated at Vila Central Hospital in Vanuatu.

Create Secure Storage: Designated, elevated, and secure storage areas ensure safe handling before disposal. Facilities should incorporate waste segregation to prevent cross-contamination.

Establish Reliable Transport logistics for Off-Site Treatment: Offsite disposal provides a viable alternative where in-house incineration is not an option, as seen in Solomon Islands.

Practice Sustainable Waste Reduction: Minimise single-use materials, improve segregation beyond general and clinical categories (e.g., biological, chemical), and optimise recycling initiatives to reduce environmental impact while maintaining operational efficiency and lowering costs.

Integrating structured waste management strategies strengthens healthcare facility resilience, supports compliance with national health standards, and promotes sustainable waste solutions.

Climate Risks to Healthcare Services

Climate hazards not only impact healthcare infrastructure and operations but also disrupt patient access and place additional strain on the health workforce.

These disruptions reduce healthcare availability, delay treatments, and disproportionately affect vulnerable populations. Key risks to **healthcare services** identified in the eye clinics studied include:

Transport Disruptions: Intense rainfall, flooding, landslides, and storm surges damage infrastructure, preventing patients from reaching clinics. This is particularly challenging for those in outer islands reliant on sea travel or remote areas with geographical barriers such as mountains, dense vegetation, and limited road access.

Healthcare System Strain: During disaster events, healthcare resources, including government-contracted staff, are redirected to emergency response efforts, delaying non-urgent but essential specialist treatment.

Vulnerability of At-Risk Groups: The elderly, people with disabilities, and those in rural or coastal communities face greater challenges accessing eye care and speciality healthcare services, exacerbating existing health inequities.

Response Guidance: Integrating Climate-Resilient Design into Healthcare Services

To mitigate these risks, climate-resilient strategies have been integrated into the three assessed eye clinics. Best-practice measures include:

Supply Chain Contingency Planning: Pre-positioned stockpiles of essential medications and medical supplies reduce reliance on delayed shipments. Strengthened procurement agreements with local and regional suppliers enhance supply chain resilience, while collaboration with government agencies helps expedite customs clearance for critical healthcare items.

Weather-Resilient Transport Solutions: Transport contingency plans, including designated safe docking points and alignment with shipping schedules, improve maritime access for outer island communities, ensuring more reliable patient transport.

Disaster-Resilient Healthcare System Planning: Standardised emergency response protocols ensure the continuity of eye care services during climate-related disruptions. Designated healthcare facilities serve as regional hubs during disasters, with adaptable spaces to accommodate

increased patient loads. Cross-training healthcare staff at the university and professional levels enhances workforce flexibility, ensuring service delivery continues when personnel are reallocated to emergency response efforts.

Decentralised & Community-Based Healthcare: Strengthened community health programs by training local health workers to provide basic eye care, improving local access in remote areas. Coordinated outreach clinics, integrating other medical service lines, enhance early diagnosis and intervention for both specialised eye conditions and broader health needs.

Inclusive & Accessible Healthcare: Targeted transport assistance programmes support vulnerable groups, including the elderly and people with disabilities, ensuring equitable access to essential treatments. Integrated referral systems between local health posts and central eye clinics improve patient coordination and reduce treatment delays – an approach consistently implemented across all The Foundation-supported eye clinics in the Pacific.



Photo: A patient undergoes eye screening on a busy day at the Regional Eye Centre in Honiara, Solomons Islands.

Individual results from the three healthcare centres studied

Regional Eye Centre

Honiara, Solomon Islands



Key Infrastructure & Climate Risks

Critical Facility in a High-Risk Area

Located in a region prone to tropical cyclones, storm surges, and river flooding (Mataniko River). Infrastructure must withstand extreme weather.

High Flood Exposure

The clinic is vulnerable to storm surge and heavy rainfall-driven flash flooding, particularly during the wet season.

Energy Resilience Under Cloud Cover

Solar power is a key asset, but increased wet-season cloud cover reduces solar generation, leading to energy reliability concerns.

Outreach Barriers

Rough seas and strong winds in the wet season limit outreach clinics to remote provinces like Kirakira and Tulagi.

What They Do Well & Adaptation Recommendations

Healthcare Workforce

- ✓ Strong emergency response knowledge among key staff.
- ✓ Operates under Ministry of Health governance as part of the national health system, with support from The Foundation.
- 💡 Expand emergency response training to all staff to ensure knowledge is widespread, not concentrated among a few.
- 💡 Integrate climate resilience into professional development programmes to strengthen disaster preparedness.

Water, Sanitation & Healthcare Waste

- ✓ Clinic has strong waste management practices within the healthcare facility.
- ✓ Well-maintained and advanced wastewater system.
- ✓ Rainwater is captured and stored in a 70,000 litre bladder tank and two 5,000 litre plastic tanks, providing a reliable and secure primary water supply.
- 💡 Regular water quality testing and verification of sanitation systems (e.g., confirm non-return valves are in place).

Energy

- ✓ Solar power and energy system reduces dependence on the unstable grid.
- ✓ Backup generator prevents major disruptions and increases resilience.
- 💡 Upgrade battery storage for improved efficiency and storage to improve resilience during extended cloudy periods.
- 💡 Improve monitoring and training on energy system maintenance to reduce reliance on a few key staff members.

Infrastructure, Technology & Products

- ✓ Clinic is highly adaptive, including the ability to relocate the facility, despite extreme climate conditions.
- ✓ Strong facility maintenance culture.
- 💡 Enhance flood mitigation measures (e.g., drainage improvements, raised equipment storage).
- 💡 Improve digital record-keeping and contingency documentation to strengthen long-term planning.

Individual results from the three healthcare centres studied

National Eye Centre

Port Vila, Vanuatu



Key Infrastructure & Climate Risks

Frequent Exposure to Severe Cyclones

The clinic has faced multiple Category 4-5 cyclones (Pam, Harold, Lola, Judy, Kevin), requiring strong disaster preparedness.

More Reliable Municipal Infrastructure

Unlike other locations, Port Vila benefits from relatively stable power and water services, but disruptions still occur during cyclones.

Transport Disruptions

Heavy storms and rough seas often limit outreach clinic access to more remote areas.

Wind & Storm Damage Risks

Despite strong resilience, further reinforcement of infrastructure could improve long-term durability.

What They Do Well & Adaptation Recommendations

Healthcare Workforce

- ✓ Highly skilled team, experienced in disaster response.
- ✓ Effective integration with the national health system and Ministry of Health governance.
- Expand public health and climate adaptation training to support a broader resilience-building approach.

Water, Sanitation & Healthcare Waste

- ✓ Relatively strong municipal water supply compared to other locations.
- ✓ Clinic maintains high internal sanitation standards.
- Improve hospital-wide waste segregation and disposal to address broader system inefficiencies.
- Expand use of water filtration systems and storage tanks to strengthen water security.

Energy

- ✓ Resilient municipal power grid reduces reliance on backup systems.
- ✓ Solar integration enhances sustainability and energy security.
- Increase solar PV battery storage to reduce dependence on the municipal grid during storms.
- Improve staff training on backup power systems to ensure rapid response during outages.

Infrastructure, Technology & Products

- ✓ One of the most resilient clinics in the region.
- ✓ Strong coordination with local emergency response systems.
- Upgrade infrastructure to be more wind-resistant (e.g., roof reinforcements, improved drainage).
- Improve access to digital patient records and disaster contingency planning.

Individual results from the three healthcare centres studied

Madang Provincial Hospital Eye Clinic

Madang, Papua New Guinea

What They Do Well & Adaptation Recommendations



Key Infrastructure & Climate Risks

High Heat, Humidity & Drought

The region experiences high heat index values and prolonged dry periods, increasing the risk of thermal stress for patients and staff while placing additional pressure on water resources.

Coastal Flooding & Storm Surges

While less exposed to cyclones, extreme rainfall, monsoonal storms, and rising sea levels pose long-term risks.

Water Security Challenges

Groundwater reliance increases vulnerability to saltwater intrusion and supply issues during dry seasons throughout the community.

Frequent Power Outages & Grid Instability

The clinic faces recurring electricity disruptions, impacting operational efficiency.

Healthcare Workforce

- ✓ Resilient team skilled in working under extreme conditions.
- ✓ Efficient patient management despite environmental challenges.
- Enhance training in energy and water conservation strategies to adapt to infrastructure limitations.

Water, Sanitation & Healthcare Waste

- ✓ Proactive water conservation strategies in place.
- ✓ Hybrid system utilising rainwater harvesting.
- Expand rainwater collection and storage capacity to increase water security.
- Improve wastewater backflow prevention systems to prevent contamination issues.
- Establish a proper waste management system to improve safe disposal and reduce health and environmental risks.

Energy

- ✓ Solar power system offsets most energy reliability issues experienced by the broader hospital.
- ✓ Staff manage power disruptions effectively.
- Expand solar PV and battery capacity, as well as surge protection to improve energy security.
- Enhance staff training in energy system monitoring and maintenance.

Infrastructure, Technology & Products

- ✓ Staff are highly adaptable to climate and operational challenges.
- ✓ Effective local knowledge applied to problem-solving.
- Improve infrastructure resilience against extreme rainfall and potential coastal inundation threat.
- Enhance contingency planning for prolonged power and water outages.

Next steps

The successful execution of these recommendations hinges on a concerted effort and clear commitment across multiple sectors. There is urgent need for:

Promotion of Pacific-wide adoption and rollout of climate and environmental impact assessments for healthcare centres across all community locations. These assessments should use locally adapted tools aligned with the CRESHCF framework.

Implementation strategies should follow, enabling coordinated interventions and procurement that generate economies of scale. Multi-lateral and bi-lateral donor funding should be aligned and leveraged alongside government investment to support SMART (Specific, Measurable, Achievable, Relevant, Time-bound) actions and drive sustainable change.

Regular assessment and dynamic adaptation of strategies, ensuring that climate change interventions remain flexible and relevant in the face of evolving risks. Continuous evaluation will guarantee that healthcare systems remain adaptable and robust.

Strong and sustained government leadership is essential to advancing climate-resilient healthcare. This includes a long-term commitment prior to funding, policy support, and capacity building that

extends beyond election cycles. Strategic planning and investment must be future focused to enable an effective transition toward resilient healthcare systems. A multi-layered approach is required, anchored in Pacific regional leadership and supported by coordinated action across national, provincial, and local levels, to ensure healthcare centres are prepared for both current climate impacts and the anticipated rise in extreme weather events.

Collaboration across sectors with ongoing dialogue between health agencies, climate organisations, education institutions, national disaster risk management authorities, community leaders – and other duty bearers. Only through shared knowledge and resources can we create truly resilient healthcare systems that are fit for the challenges ahead.

Community engagement and empowerment: Promoting individual healthcare management and encouraging citizens to engage in the care and maintenance of the facilities within their community, requires that they understand the issues related to the impacts of climate

change, and why investments are being made. Information campaigns linking their engagement to an urgent response to climate change and environmental impacts will be necessary to highlight the importance of ‘why this’ and ‘why now’. Decisions should involve local communities, including those often excluded from decision-making processes such as children and youth, women and people living with disabilities. Processes should support this engagement.

Formation of targeted partnerships, such as with The Foundation, who focus specifically on preventable blindness, can offer support such as specialised training for healthcare workers on climate risks, equipping them with the tools to manage and mitigate future challenges.

Monitoring the impact of climate change and the environment on health to inform decision-making, guide advocacy and drive action. This is one of the calls to action promoted by Pacific Heads of Health in their 2021 paper, *‘placing health at the centre of the climate change discussion’*.



The **Fred Hollows**
Foundation NZ

The time for action is now.

We urge all stakeholders – governments, organisations, and communities – to join forces and commit to driving these vital changes. The future of healthcare delivery in the Pacific depends on the actions we take today.

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to join the effort:

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