Integrating Climate Change Risk in the Agriculture and Health Sectors in Samoa (ICCRAHS)

STRENGTHENING CLIMATE SERVICES IN SAMOA

Recommendations for the next development phase of integrating climate change mitigation and adaptation services into the agriculture and health sectors in Samoa [2013–2018]

Compiled for the
Ministry of Natural Resources and Environment
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&
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EXECUTIVE SUMMARY

The current phase of the implementation of the GEF- funded project, 'Integrating climate change risk in the Agriculture and Health Sectors in Samoa' (ICCRAHS), managed by the Samoan Ministry of Natural Resources and Environment (MNRE), ends in 2013.

Planning is under way to build on the outcomes from this project to further develop climate services in Samoa.

This document, requested by MNRE and UNDP, draws on two sources of guidance to evaluate the progress of climate services so far in Samoa, and to point to planning and implementation priorities:

- needs and gaps in current climate services expressed by state sector workers and other stakeholders at a Sector Engagement Workshop in Apia in October 2012;
- the Global Framework for Climate Services (GFCS) Implementation Plan endorsed at the Extraordinary Session of the WMO Congress (Cg-Ext (2012)) in November 2012,

Significant progress has been achieved during the implementation of ICCRAHS to enhance the capacity of the Samoa Meteorological Division (SMD) to observe, capture and manage weather and climate data.

Several joint workshops of SMD climate staff, agriculture and health professionals, and other agency and community leaders, have been held to help to clarify basic climate information, services and early warning advisories that could regularly and routinely assist these agencies with climate risk management. These workshops, and guidelines provided by the GFCS, have helped to clarify the future priorities for development of climate services in Samoa.

The table below lists 11 priority actions that will build on the activities conducted to date to help deliver the outcomes expected under the ICCRAHS project. The priority actions are grouped under three themes:

- Provide regular sector briefings using currently available information
- Continued improvement of access to data and development and uptake of baseline and tailored sector-specific climate products and services.
- Provide further capacity development as needed

More detail on these (and other) recommendations is identified in Sections 4 and 5 of this report. Draft costings of the recommended tasks listed in Section 4 are included in Appendix 1. These costs are indicative only and should be subjected to on-going review. At the time of writing, this report suggests an additional 1.85 full time equivalent staff time per year would be required to build climate services over two years to the point of routine and regular implementation. The cost of the recommendations including additional staff time would be approaximately WST1.3M.

1.	**Climate briefings**
1.	Conduct a monthly climate briefing to MAF staff (selected from administration and field officers) covering: • Climate developments over the past few weeks including severe events if any and their impacts on agricultural production and food security • Climate outlook for the next three months • Actions needed to improve climate information for the agricultural sector.
2.	Conduct a monthly climate briefing to MOH and NHS staff and health workers covering: • Climate developments over the past few weeks and any significant impacts on health • Climate outlook for the next three months • Actions needed to improve climate information for the health sector.
3.	Use the information from the above briefings to improve sector focus and quality of climate information provided by Samoa Met Division to these sectors.
4.	Provide regular climate bulletins to established communication networks, such as Samoa Farmers Association and Women in Business, and meet with them to provide training and improve understanding of what information would best suit the needs of these networks.
2.	**Access to Data and Products**
5.	Provide fit-for-purpose and affordable inter-departmental, sector-specific and public access to climate data, products and information produced at Samoa Met Division (while respecting institutional responsibilities and their different needs and requirements).
6.	Develop and improve institutional and technical arrangements within Samoa to enable all observed climate data, and climate related data, to be used in the production and delivery of climate services in Samoa.
7.	Improve data systems and data exchange collaborations to enable Samoa to gain increased access to global and regional climate resources and services (e.g. global telecommunications system (GTS) data, web tools, seasonal forecasts, satellite data).
3.	**Capacity building**
8.	Continue to build and (critically) maintain a robust climate observation network across all climatic zones of Samoa to underpin data needs for sector decision-making.
9.	Ensure high quality climate data records and management are sustained through continued professional development of staff capabilities and responsibilities.
10.	Through technical support and staff training as needed, maintain and extend the development and use of open source tools (including CLIDE, R, QGIS, and selected web based services) for the regular production of climate products designed to inform decision making.
11.	Improve in-house capabilities for analysing and interpreting climate patterns and trends to inform risk planning on all time scales

Key Processes and Outcomes

The key objectives, processes, outcomes, and benefits to Samoa through building climate services can be summarized as follows:

1. Help secure and sustain Samoa against weather and climate risks, by improving resilience in agriculture, health, forestry, water supply, recreation and communities.
2. Build and operate a robust climate observation network that is capable of observing the main climate variables across all climatic zones of Samoa, and that is manageable and sustainable into the future.
3. Preserve, archive and analyse past and current climate records of Samoa to enable improved understanding of weather and climate risks through better characterisation of past and current events and trends, and how these may change in future with climate change, and to inform risk planning on all time scales.
4. Provide easy and affordable public access to climate data and information, including observational data, and value added products and services that are relevant to public needs.
5. Continue to build partnerships with climate-sensitive sector agencies, based on sector priorities and needs, to enable integration of climate information with user information, thereby improving timeliness, ease of interpretation and applicability of sector-focussed climate services.
6. Enable Samoa to gain increased access to global and regional climate resources and services, through improved data systems and data exchange collaborations.
7. Through public and sector engagement, consultations, and appropriate expert as well as peer to peer training, increase common understanding and familiarization with climate information, risks, applications and planning opportunities.

Institutional and Strategic Linkages

The focus of the recommendations and technical objectives set out in this document are consistent with the objectives of Samoa's National Adaptation Programme of Action, and build on the work already achieved under the ICCRAHS project.

This report's recommendations are also consistent with Global Framework for Climate Services Implementation Strategy of the World Meteorological Organisation (WMO).

Finally, context for the preparation of this document was provided by the Pacific Islands Meteorological Strategy 2012-2019[1](PIMS), which sets out a strategic framework for the development and support of national and regional meteorological services in the Pacific. Recommendations here are particularly relevant to the PIMS Pacific Key Outcomes 5, 6, 7, 8, 10, 11 and 13.

[1] Pacific Islands meteorological strategy 2012-2019: sustaining weather and climate services in Pacific Island countries and territories. Apia, Samoa. *Secretariat of the Pacific Regional Environment Programme (SPREP), 2012.*

CONTENTS

1 BACKGROUND

Integrating Climate Change Risks in the Agriculture and Health Sectors in Samoa (ICCRAHS) is a project funded by the Global Environment Fund (GEF) and implemented by UNDP. The project arose from Samoa's National Adaptation Programme of Action (recorded in the 'NAPA document'), which was the outcome of extensive government, national and community consultations over a period of two years prior to 2004.

The ICCRAHS project aims to increase resilience and adaptive capacity of Samoa's meteorological, agricultural and health sectors to adverse climate impacts, under both current and possible future climates. A major component of ICCRAHS is the development of a Climate Early Warning System (CLEWS), and information services to agriculture and health, to inform planning and operations, assist in disaster risk reduction initiatives, and increase resilience in these sectors.

The ICCRAHS project is being led by the Ministry of Natural Resources and Environment (MNRE), mainly through its Meteorology Division, and is supported by several agencies within Government, including the Ministry of Agriculture and Fisheries, National Health Service, and Ministry of Health.

The ICCRAHS project's goal is for Samoa to be able to provide good quality scientific data, and deliver effective and efficient climate services to its people to enable them to better manage agriculture and health-related risks and opportunities of climate variability and change, through the development and incorporation of science based climate information and prediction into planning, policy and practices at national and community levels.

1.1 ICCRAHS PROGRESS AND OUTCOMES

The current phase of the ICCRAHS project, commenced in 2009, ends in 2013. Significant progress has been made in achieving the objectives of ICCRAHS, particularly in strengthening the capability of the Samoa Meteorological Division to systematically monitor, observe, manage and deliver meteorological data and services.

The significant achievements under the ICCRAHS project framework so far, particularly those planned under the Meteorological Component, have resulted from the timely concurrence and parallel implementation of several projects—the ICCRAHS project led by MNRE , the design and implementation of the climate database management system CLIDE by the Australia Bureau of Meteorology, the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) programme (formerly the Pacific Climate Change Science Programme), funded by Australian Aid, the strengthening of the SMD weather observations and forecasting systems funded by Japan International Cooperation Agency (JICA) and United States' National Oceanographic and Atmospheric Administration (NOAA), the continued development of the Island Climate Update seasonal forecasting programme, funded by New Zealand Aid and coordinated by New Zealand's National Institute of Water and Atmospheric Research (NIWA) and the Secretariat of the Pacific Regional Environment Programme (SPREP), upgrading of the Faleolo automatic weather station by the Meteorological Service of New Zealand Ltd (MetService), and various initiatives by the Samoa Ministry of Natural Resources and Environment (MNRE), such as the strengthening of the Disaster Management Office.

In collaboration with SMD, these agencies have supported infrastructure development and training for forecasting and technical staff, and have assisted with end-user workshops. Thus Samoa has been the focus of the work of many organisations, including those working in partnerships with other Pacific Islands through planning, administration and science programmes, in the development of climate services and related environmental management in the country.

1.2 GLOBAL FRAMEWORK FOR CLIMATE SERVICES

Concurrently with the implementation of ICCRAHS, the Global Framework for Climate Services (GFCS), endorsed by the World Climate Conference–3 in 2009, has been developed to improve international collaboration and support for climate services. The main goal of the GFCS is to "enable better management of the risks of climate variability and change and adaptation to climate change, the development and incorporation of science-based climate information and prediction into planning, policy and practice on the global, regional and national scale*". [World Climate Conference–3]*

The GFCS draws together the collective experience so far of the global climate services community, which has been further shaped into a systematic strategy for action by the World Meteorological Organization (WMO). The GFCS thus provides a useful framework against which to compare progress in ICCRAHS core objectives, thereby enabling a quasi-independent assessment of ICCRAHS core outcomes so far.

1.3 PURPOSE OF THIS REPORT

This report, requested by UNDP on behalf of MNRE, follows a two-day 'Sector Engagement Workshop' for MNRE and other Ministry staff, conducted under the ICCRAHS project implementation and facilitated by UNDP, MNRE and NIWA. The report:

- summarises key ideas and responses from workshop participants which point to developments in climate services that are needed to fully engage users and enable improved decision making in Samoa;
- uses core themes or *pillars* developed independently by the GFCS consultation as a landscape against which to assess the progress of ICCRAHS so far;
- outlines and recommends priority actions, and associated draft costs, to further strengthen the outcomes from ICCRAHS and build future climate services

A report of the Sector Engagement Workshops, sponsored by MNRE and facilitated by UNDP and NIWA, is available separately[2].

[2] Integrating climate change risk in the agriculture and health sectors in Samoa: Report from the Sector Engagement Workshop, Apia, 10-11 October, 2012. Edited by NIWA.

2 KEY FINDINGS FROM THE SECTOR ENGAGEMENT WORKSHOPS

Workshop discussion on the management of climate variability, impacts and change was organised around three broad themes—impacts and related data, user needs for data and services, and knowledge about climate and weather risks. Findings from the workshop are summarized below.

2.1 CLIMATE HAZARDS AND SECTOR IMPACT DATA

The most common hazards that participants were concerned about were:

- tropical cyclones and severe storms
- drought and low soil moisture
- heavy rainfall and flooding

Other conditions and hazards discussed were:

- good (favourable) climatic conditions
- risk of high temperatures (hot days)
- above normal rainfall
- coastal risks such as erosion and inundation due to climate change and sea level rise
- coastal damage from storm surges

Many potentially relevant sector-based sources of information and data were identified (e.g. forestry site survey data after a tropical cyclone event, or information on volume and price of food imports during a drought) which could be used to assess the impacts of meteorological events. Participants recommended that the relationships between sector impacts and weather and climate events, essential to the building of climate services, should be developed through collaborative partnerships involving relevant ministries and the Samoa Meteorological Division.

2.2 USER NEEDS

Much of the workshop discussion around the use of desired products and services focussed on the provision of accurate and timely forecasts and warnings. Another common theme was the presentation of information in plain English or preferably in Samoan so that it could be easily interpreted and communicated. Regarding dissemination, participants discussed multiple methods of getting messages out to those people at risk, including a text messaging warning service and using existing networks such as that of the Ministry of Women Community and Social Development (MWCSD). Timely and reasonably priced (if possible, free) access to raw and "homogenised" meteorological data and derived products like GIS data sets was also regarded as being essential to the work of other departments, such as for forestry and hydrological applications.

The participants reported on many potential uses of data and products, indicating that for the most part the capacity to apply the information is already established in the sectors, but that more could be done regarding training and education. One well-supported suggestion was to have regular (such as monthly) climate briefings presented by the SMD and open to Ministry staff to enable and encourage familiarization with climate and weather information, and facilitate inter-agency consideration of any risk issues that might be raised in the upcoming seasonal climate outlook. This would lead to the development of a more regular process of sharing and co-generation of climate knowledge, through routine exchanges between community knowledge holders, decision makers and climate scientists and service providers. An outcome of such sharing of knowledge would be better design of user-focussed climate services that would in turn lead to improved planning and decision making.

2.3 Risk knowledge and early warning systems

At the workshop there was a general consensus that significant knowledge of sectoral risks and impacts does exist, particularly with respect to tropical cyclones, but there is less knowledge regarding flooding, and much less regarding drought. There was a mixed response regarding the state of monitoring and warning systems in Samoa, with participants acknowledging that there is still room for improvement. Warnings of tropical cyclones are generally very well disseminated and communicated, but there is work to be done to provide both background and advance warning on other hazards. Also, simple messages (in English and Samoan) were identified as being critical for effective communication of risk. Lastly, response capability is quite high for tropical cyclones (people generally know what to do when they receive a warning, eg baton down houses and check emergency supplies), but the workshop participants agreed that it is generally not well known what to do if warned about, or following the onset of, a drought.

3 USING GFCS OBJECTIVES AS BENCHMARKS FOR STRENGTHENING ICCRAHS OUTCOMES

The implementation structure of the GFCS includes five components across which activities will be coordinated and integrated. These components are shown in the figure below.

Sections 3.1 to 3.4 of this report demonstrate how recent developments in climate services in Samoa accord closely with this international framework. This accord provides the opportunity to further compare the GFCS pillars with the outcomes so far of ICCRAHS, as an aid to identifying gaps or opportunities to strengthen ICCRAHS objectives. The comparison is developed in Section 4 of this report.

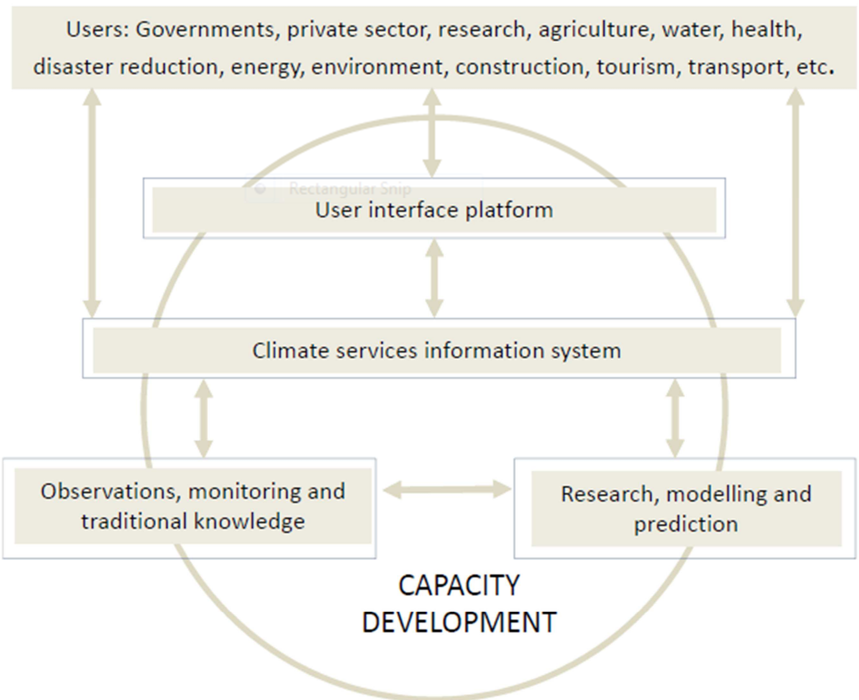


Figure 3.1: Adapted from *Global Framework for Climate Services: Draft implementation plan.* WMO. In this adaptation we have added 'traditional knowledge' to the 'Observations and monitoring' pillar, to give this aspect added emphasis.

The Pillars of the GFCS are reflected strongly in the Meteorological Component of the ICCRAHS project, as illustrated in Figure 3.2 below. The figure illustrates the complexity of the climate services infrastructure in Samoa, which requires the management of data from diverse observations systems, through connected telemetric and database operations, in order to successfully support both weather and climate services.

Some of the desired data connections have not yet been made. In particular, the data collected for weather forecasting purposes are not yet seamlessly available 'on-line' for climate services. Ultimately the SMD climate group needs and aims to use data from all available sources to develop and deliver the range of climate data and information services that are needed to engage in a variety of ways with the very diverse user community.

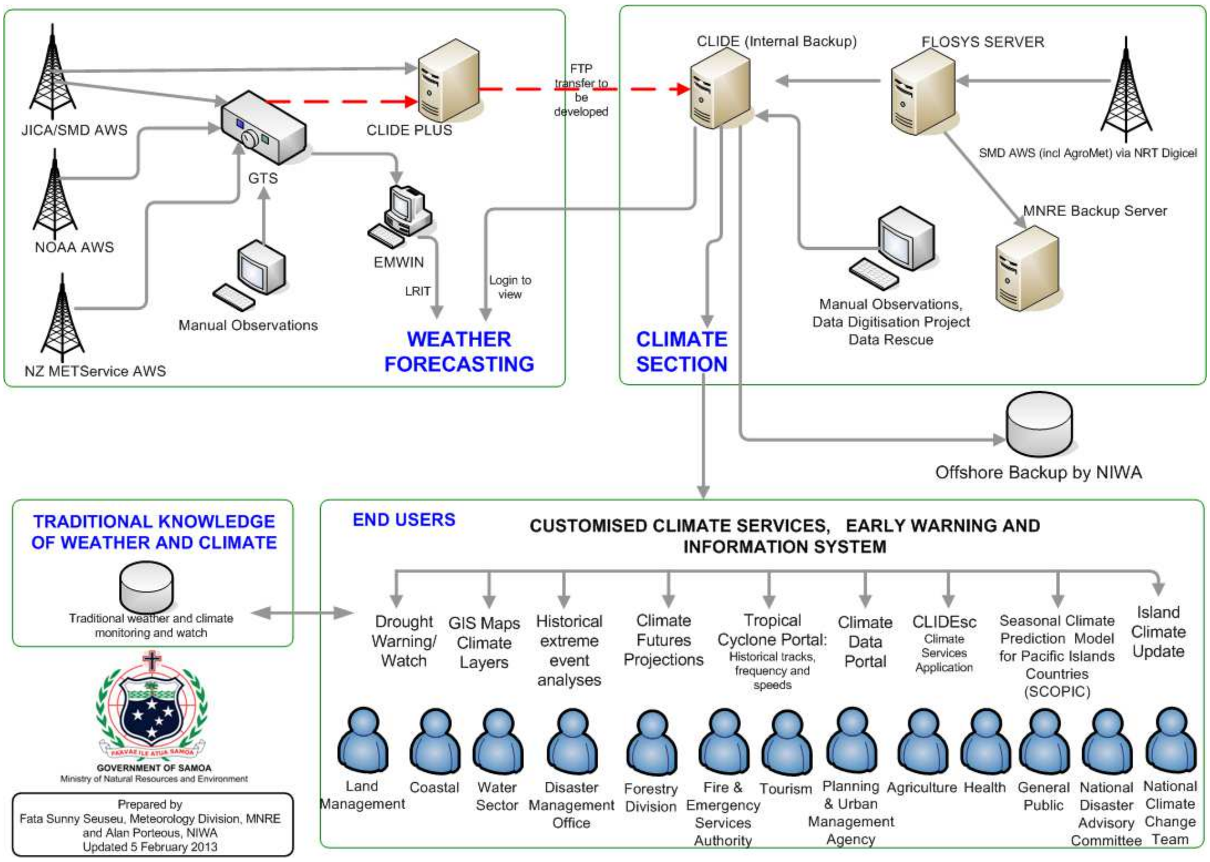


Figure 3.2: A schematic view of the structure and pathways of data services, weather forecasting and climate services accessed from, or centred at, Samoa Met Division, Apia. The blue 'end user' icons indicate the need and scope to build climate services in Samoa. *Source: Sunny Seuseu, Samoa Met Division.*

3.1 OBSERVATIONS, MONITORING AND TRADITIONAL KNOWLEDGE

Samoa has one of the longest standing archives of meteorological observations in the South Pacific region. The observing network has been further strengthened over the past five to six years with new observing and telemetry equipment, and with data feeding in real time both the Global Telecommunications System (GTS)[3] and a newly-developed, world leading database system (CLIDE)[4] at Samoa Met Division. Work is well advanced to fully integrate and standardise data quality assurance and archiving, including local and off-shore secure and duplicated data storage. A significant effort has been put in to data rescue, funded by Australian Aid and others (including ACRE Pacific[5]), with a programme of recovering paper records and key entry of historical data into CliDE.

[3] The GTS is a global telecommunications network for the transmission of meteorological data from weather stations, satellites and numerical weather prediction centres.
[4] CLIDE – Climate Data for the Environment, an open source, PostGres relational database management system developed by the Australian Bureau of Meteorology.
[5] Funded from the French Economic, Social and Cultural Co-Operation Fund for the Pacific.

Samoan communities have traditional insights into climate and weather that can assist scientific understanding of the climate system and how it affects the country[6]. This knowledge was recognised in the consultation process that lead to the development of the NAPA and ultimately the ICCRAHS project. During ICCRAHS, consultations have continued between community leaders and agency professionals in Samoa to improve knowledge sharing and build collaborative response arrangements.

3.2 RESEARCH, MODELLING AND PREDICTION

Samoan meteorological data have been scrutinized for discontinuities in homogeneity (e.g. caused by relocations of climate stations), and gross errors, benefitting from extensive collaboration with the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) programme. The corrected or *homogenised* data series are being used to determine key trends and changes in past climate, and to improve models of future climate change in Samoa[7].

These homogenised data, combined with real-time observations, form the basis for on-going development and applications of seasonal forecasting for Samoa under the Seasonal Climate Outlook for Pacific Island Countries (SCOPIC) and Island Climate Update (ICU) programmes.

Homogenised data are currently stored externally to the database and are therefore not yet available for routine, near real-time analyses such as the daily production of climate maps or data time series visualizations sourced from data on CliDE.

SMD help to generate and then make use of international products and services (particularly the Seasonal Climate Outlook for Pacific Island Countries (SCOPIC), and the Island Climate Update (ICU)), and staff members regularly attend training workshops held throughout the Pacific. However, more needs to be done to train and regularly update SMD staff members on the latest research and developments in climate science, particularly with respect to the use of models for seasonal and long-term climate prediction, and their interpretation to sector users and the public.

3.3 CLIMATE SERVICES INFORMATION SYSTEM

Samoa Met Division has a small but fully functional Climate Section, whose staff manage the observing network, climate database, and also develop and deliver climate services. However the capacity to engage with and deliver services to end users is limited by the small number of staff, the manual nature of much of the delivery of climate products and services, and the multitude of duties that are required of staff in order to maintain a national climate service.

In spite of these constraints, climate staff currently routinely produce a number of reports and services. A climate summary report for the past month reviews recent variability in a range of climate parameters. Rainfall outlook reports, including updates on the El-Niño Southern

[6] See *Ua 'afa le Aso* Stormy weather today: traditional ecological knowledge of weather and climate – the Samoan experience. Penehuro Lefale. In *Climate Change* Vol 100(2), May 2010, p317-335. Publ Springer.
[7] See for example http://www.cawcr.gov.au/projects/PCCSP/pdf/posters2011/10._Samoa_GH_Poster.pdf

Oscillation, are distributed each month, mostly by email. Drought reports are issued as needed, particularly during the dry season. Requests for raw and analysed (Excel based) data are also serviced.

3.4 USER INTERFACE PLATFORM

Key personnel in Samoan government agencies routinely receive climate forecasts and other advisories such as drought reports. Capacity development under ICCRAHS has improved the availability of data to generate these reports. Government departments such as the Disaster Management Office are vital links in the User Interface. However the use of this information in routine decision making is often limited by a lack of familiarity with the content and its applicability.

In Samoa there is a strong awareness of climate change issues amongst government planners and administrators, which is being strengthened through workshops and the media. For example, Samoan communities have participated in a project using videos to show damage attributed to climate change. Examples of this video series can be found at: http://content.undp.org/go/newsroom/2010/may/les-habitants-de-samoa-documentent-le-changement-climatique-en-vido.en

MNRE is also building a climate change web portal which contains information generated through ICCRAHS. The web portal will contain summaries and statistics of observations, rainfall and tropical cyclone outlooks, media releases, and related information such as tides.

4 GAPS AND PRIORITIES – THE WAY FORWARD

In this section, we compare key objectives from the pillars of the GFCS with the outcomes of ICCRAHS. The comparison is a valuable opportunity, provided by the recent ratification and launching of the GFCS programme, to independently evaluate progress in the development of climate services in Samoa so far under ICCRAHS.

The table below is set out as follows:

- GFCS objectives are listed respectively by row (Column 1)
- the relevance of the objectives to ICCRAHS outputs for the agriculture and health sectors in Samoa (Column 2)
- the current status of the services in Samoa to meet this objective (Column 3)
- the further capacity development that is needed to meet the project's outcomes (Column 4)

Clickable text in the 5th column provides links to additional discussion of priority actions in Section 5 of this report.

TABLE 4a	1. Observations and monitoring (including traditional knowledge)				
GFCS objectives *The GFCS objectives listed in the first column of this table are adapted from* 'The Global Framework for Climate Services – Innovation and Adaptation.' *WMO Bulletin Vol. 61(2) 2012, pp4-8.*	**Relevance to ICCRAHS outputs for agriculture and health**	**Current status in Samoa**	**Capacity building needed for agriculture and health services**	**Responsible agency**	Link to more detail
Observations of the right type of meteorological parameters, adequate quality and quantity are made.	Directly relevant	A wide range of observations are made, from ground conditions including soil moisture and temperature, to upper air (SODAR).	1. Develop a fully costed maintenance plan and budget for the next 5 years. 2. Implement a routine site maintenance schedule 3. Ensure equipment and capability is in place for instrument calibration and replacement 4. Provide an annual professional development course for key technical staff 5. Design, build, document and implement a data quality assurance process and user interface for the climate database. 6. Collect and collate meteorological and physical observations based on traditional knowledge.	MNRE SMD, BOM, NIWA	O1
Observations should be available at the right place and time.	Directly relevant	Network coverage is comprehensive, with a few remaining gaps. Not all AWS data are exchangeable between weather and climate services. Near real time observations are not available in some key coastal, upper catchment, and remote forest locations.	7. Fill key gaps in observation network: coastal locations; upland river catchments; 8. Arrange transfer of JICA and NOAA data from the respective observing networks to Climate Section database for climate services (CLIDE). 9. Develop data exchange agreement between Met and Hydrology divisions	MNRE JICA NOAA WRD	O2
Both surface-based and space-based observations are required of physical and chemical variables of the atmosphere, land and oceans, including the hydrologic and carbon cycles.	Physical variables of atmosphere and land are most relevant to agriculture and health; hydrologic cycle and chemical variables, directly relevant. Dust is a key issue for health.	Space based observations of Samoa are available but not routinely used due to lack of data processing systems and capabilities. Samoa Water Authority has a systematic programme to measure salinity in coastal ground water.	10. Evaluate need for remotely sensed data and/or special data observations to build climate services 11. Evaluate availability and use of satellite data (eg NDVI, TRMM) for capturing agriculture, forest and other environmental variables; 12. Develop routines for processing and using relevant and applicable remotely sensed data where relevant to climate service outputs.	SMD and NOAA MAF MOF	O3

For national use in particular, socio-economic, biological and environmental data should be available.	All are directly relevant and prerequisite for effective services.	Some sources of data are available (see Section 2.1 above).	13. Match sector impacts data with meteorological events and anomalies, to enable risk profiles to be better understood and where possible included in short term and seasonal forecasts.	MAF, NHS, MOH, SMD	O4
All key regions and climate zones should be covered by observations.	National coverage is important – eg for extreme rainfall analyses.	Integration of the data from Samoa's various climate networks is constrained.	14. Improve data archiving systems to ensure all climate data — NOAA, JICA, SMD, NZ MetService, Water Resources — is available for climate services (while respecting institutional priorities and arrangements).	MNRE JICA NOAA WRD NZ MetService	O5
Gaps in data time series should be minimal. Historical data should be rescued.	Directly relevant	Data rescue programme is on-going. Large gaps in data series remain at some sites.	15. Data rescue: From assessments of the paper based climate data archive in Samoa, provide resources to complete the key entry of paper based data.	SMD BOM NIWA ACRE	O6
All data should be quality assured and made available in standard formats.	Essential	Climate database (CliDE) provides procedures for data editing, and for extracting data in standard data formats.	16. Document and implement QA procedures for daily data on CliDE 17. Develop QA procedures for sub-daily data. 18. Develop accessibility to homogenised data for producing climate service products such as anomaly maps.	SMD BOM NIWA	O7
Data should be freely exchanged where possible, while national and international data policies are respected.	Free and unrestricted exchange of data between Met Division and agriculture and health agencies is needed	Exchange of data between departments is restricted.	19. Data sharing: Establish agreements and arrangements to match agriculture and health data with weather and climate events, to enable SMD to improve the sector focus of weather and climate advice.	MAF MOF MOH NHS	O8
A formal process in place for consultation with users to assess the need for and role of climate observations for adaptation to climate change.	Directly relevant	Limited or no arrangements are in place for strategic collaboration between meteorologists and sector professionals. However there is a strong awareness of climate change risks, and sector planning for climate change, in public agencies in Samoa, as was identified by the recent sector engagement workshops.	20. Improve analyses of past climate records for specific hazard and impact data, to enable scenarios of changing risk to be developed for future climate changes. 21. Apply these results to determine future potential agriculture and health risks, as a key component of the Climate Early Warning System.	SMD BOM NIWA	O9

Other observational networks should be engaged where possible – non-governmental organisations, universities and the private sector.	Directly relevant	Several observational networks exist – NOAA, JICA, SMD/NIWA, SMD manual, MetService, Water Resources Division - data sharing and integration between networks has institutional constraints.	22. Fully implement data exchange between existing meteorological observational networks. 23. Implement data exchange between hydrometric network and meteorological networks (while respecting institutional arrangements), to enable climate services such as flood forecasting and water resource management.	MNRE JICA NOAA WRD NIWA	O10

TABLE 4b		**2. Research, modelling and prediction**			
GFCS objectives *The GFCS objectives listed in the first column of this table are adapted from* 'The Global Framework for Climate Services – Innovation and Adaptation.' *WMO Bulletin Vol. 61(2) 2012, pp4-8.*	**Relevance to ICCRAHS outputs for agriculture and health**	**Current status in Samoa**	**Capacity building needed for agriculture and health services**	**Responsible agency**	Link to more detail
Proactively target research towards developing and improving practical applications and information products so that the initial requirements of climate information users can be satisfied at the current science and technology level.	Most important	Significant research is going on in seasonal outlooks and climate change scenarios and impacts. There is a lot of information already available or that can be generated easily to meet user requirements, but this information is unfamiliar or not fully understood and is therefore underutilized.	24. Test currently available climate information through sector targeted climate briefings (see linked example). 25. Use feedback from these briefings to improve the focus of sector-applicable climate science where needed 26. Improve availability of science effort to developing sector-focussed advice. 27. Develop a **Seasonal Calendar based on Traditional Knowledge** 28. Revise the Climate of Samoa booklet and publish on the MNRE climate webpage.	SMD NHS MOH MAF	R1

Significantly enhance the interaction and cooperation of the corresponding research communities with climate information users and operators through the User Interface Platform.	Indirectly relevant. Not a core objective of ICCRAHS but would certainly benefit from such interactions.	At present there is little interaction.	29. Develop collaboration with corresponding research communities, eg Crop Research Division, Forestry Division enable joint development of climate services such as GIS data layers, user-focussed analyses, tools and pathways for dissemination. 30. Develop collaborative research partnerships between sector experts and climatologists. 31. Continue research into traditional ecological knowledge (insights) of climate and weather in Samoa, building on the work already completed. For example, expanding on the Samoa Seasonal Calendar.	MNRE MAF Crop Divn NHS MOH MOF Communities Community networks	R2
Enhance the science-readiness level for the production of improved climate projections, predictions and user-tailored climate information products.	Directly relevant	A sufficient level of science-readiness exists to develop and deliver a range of services.	32. Continue professional development of climate staff in production and communicating of science-based climate services. 33. Develop collaborative research partnerships between sector experts and climate staff.	MNRE SMD MAF NHS MOH MOF	R3
Continue to improve the understanding of the Earth's climate in the aspects that determine the impacts of its variability and change on people, ecosystems and infrastructure.	Not a core objective of ICCRAHS, but contributes to understanding climate change impacts in Samoa.	Senior officials from Samoa participate in international climate change fora and negotiations.	34. No ICCRAHS action required.		R4
In the context of climate information, users and decision makers need to know the limits of current scientific understanding of climate, how to take into account the inherent uncertainty of provided information, and how to effectively and accurately communicate their needs to scientists.	Directly relevant	Users generally have limited knowledge of limitations and uncertainties of climate science and services.	35. Address limitations and uncertainties at the monthly climate briefings.	MNRE SMD MAF NHS MOH MOF	R5

On-going investment in climate science (research, modelling and prediction) to assess and meet future users' needs for climate information.	Relevant.	On-going programmes under COSPac and ICU are providing science development and consolidation.	36. Use the outcomes and results from monthly climate briefings to determine levels of investment needed to apply climate science and related technologies to improve user-focussed services for decision making.	MNRE SMD MAF MOH	R6

TABLE 4c	3. Climate services information system				
GFCS objectives *The GFCS objectives listed in the first column of this table are adapted from* 'The Global Framework for Climate Services – Innovation and Adaptation.' *WMO Bulletin Vol. 61(2) 2012, pp4-8.*	**Relevance to ICCRAHS outputs for agriculture and health**	**Current status in Samoa**	**Capacity building needed for agriculture and health services**	**Responsible agency**	Link to more detail
A core system to routinely collate, store, process data, and generate products and services that help to inform decision-making processes across a wide range of climate sensitive activities and enterprises.	Essential to have operational systems and tools	A core system (CLIDE) is now in place, including systematic observations, data management, web-based data delivery, but with limited capacity to routinely generate basic analyses, products and services. A companion application suite, CliDEsc Lite is installed and capable of producing basic data visualizations. GIS climate maps have been produced but required software is not available yet for routine climate services.	37. Prepare and conduct monthly climate briefings for the agriculture and health sectors, including describing recent past climate and seasonal climate outlooks, and work with these sectors to relate climate to sector risk awareness and management. 38. Develop routines to extract, process and summarize data from CLiDE in response to user needs and enquiries 39. Provide regular feedback to Bureau of Meteorology on development needs for CliDE database. 40. Evaluate and install software relevant to the development of climate services 41. Evaluate and improve access to relevant web-based services that would enhance climate knowledge and applications in Samoa.	MNRE SMD MAF NHS MOH MOF SMD BOM	S1

A physical structure, together with professional human resources, to develop, generate, and distribute a wide range of climate information products and services.	Essential	Climate outlooks and drought advisories are routinely disseminated by email. Some use is made of internet publication of climate information. The climate team is under-resourced.	42. Conduct regular climate briefings (see above). 43. Use the briefings to tailor and improve climate services (see above). 44. Engage with user community to improve user-understanding of climate information and potential hazards and risk. 45. User public channels to disseminate routine and easy to understand climate bulletins: eg. radio, newspapers, NGO briefings. 46. Develop a ***Guide to climate services for Agriculture and Forestry*** booklet in English and Samoan 47. Develop a ***Guide to climate services for Health*** booklet in English and Samoan. 48. Develop (or enhance) a Samoan climate service web portal. 49. Investigate and if possible implement a 10-day forecasting system for Samoa.	MNRE SMD MAF NHS MOH MOF	S2
Complying with the implementation strategy of the GFCS, the provision of climate services in Samoa is based on a three-tiered structure of collaborating institutions that will ensure climate information and products are generated, exchanged and disseminated: • Globally through a range of advanced centres; • Regionally through a network of entities with regional mandates; • Nationally and locally by SMD through national institutional arrangements.	Directly relevant.	Samoa provides selected data to the GTS, and participates frequently in international climate meetings. The Pacific Climate Desk, hosted in Samoa, provides a focus for regional climate activity. Regional climate outlook data are exchanged through the Seasonal Outlook fora SCOPIC and ICU.	50. Continue to contribute to and access climate science and services at all levels – global, regional and national – where they directly contribute to improving climate risk decision making in Samoa.	MNRE NOAA SPREP	S3

Priority functions of the Climate Services Information System (CSIS): • Climate data rescue, management and mining • Climate analysis and monitoring; • Climate prediction and climate projection These will encompass processes of data retrieval, analysis and assessment, re-analysis, diagnostics, interpretation, attribution, verification and communication over a global-regional-national system of inter-linked producers and providers.	Essential	The enhancement of climate services under ICCRAHS will meet all priority functions of the GFCS.	51. Develop and implement guidelines for public and institutional data accessibility at Samoa Met Division. 52. Improve protocols and agreements for data exchange via the GTS.	MNRE SMD MAF NHS MOH MOF	S4
Formalized structures and procedures will be essential for standardization, sustainability, and reliability.	Directly relevant	Some current structures and procedures are not standardised. Long-term sustainability of systems such as instrument and network maintenance, database upkeep, and data services, are at risk if funding sources cease and in the absence of formal agreements.	53. Implement a financial and administrative programme to secure and maintain the infrastructure for delivering climate services. 54. Agree and implement with sector groups routine and regular climate briefings and methods to evaluate social and economic benefits.	MNRE SMD MAF NHS MOH MOF	S5
The CSIS engages with the User Interface Platform (UIP) to gain a clear understanding of user requirements and how users apply climate information.	Directly relevant	At least four user-focussed workshops have been conducted with this objective.	55. Conduct monthly briefings to provide information addressing user needs using content that is readily understood 56. Develop and improve sector-specific advisories that can be disseminated at current levels of demand and understanding (these should be in Samoan and English). The content and application focus of the advisories can be enhanced over time as user requirements and applications are better understood.	SMD MAF NHS MOH MOF	S6
Regional climate fora stimulate collaborative assessment to assist users to identify robust climate signals, in understanding inherent uncertainties and in developing consensus.	Relevant	Regional climate mechanisms for participation by Samoan climate staff include seasonal outlook link-ups (ICU, SCOPIC), Pacific Climate Change Roundtable, science programmes such as COSPac, and regional GFCS meetings.	57. Ensure opportunities are maintained for Samoan climate staff to participate in regional climate exchanges and professional development	SMD	S7

TABLE 4d	4. User interface platform				
GFCS objectives *The GFCS objectives listed in the first column of this table are adapted from* 'The Global Framework for Climate Services – Innovation and Adaptation.' *WMO Bulletin Vol. 61(2) 2012, pp4-8.*	**Relevance to ICCRAHS outputs for agriculture and health**	**Current status in Samoa**	**Capacity building needed for agriculture and health services**	**Responsible agency**	Link to more detail
The UIP provides a structured means for users, climate researchers and climate service providers to interact at the global, regional and national levels to ensure that the needs of users are met. The UIP aims at four outcomes:					
• Feedback – identify the optimal methods for obtaining feedback from user communities.	Essential	No formal reporting structure at present	57. Document feedback: Feedback could be verbal through community representatives, village councils, Women's Committees, and churches, via field meetings and surveys, or through online data gathering.	SMD MAF NHS MOH MOF	U1
• Dialogue – build dialogue between climate service users and those responsible for the observation, research and information systems.	Essential	Good dialogue with key users such as the Samoa Electric Power Company EPC, health authorities, Urban Planning and others; dialogue with individuals such as farmers and community leaders is intermittent.	58. Increase climate dialogues with institutionalised groups, such as Samoa Farmers Association, Women in Business, Red Cross, etc. 59. To address this need, Samoan language products and services will need to be developed. 60. Issue basic climate stories and bulletins using radio and television.	SMD MAF NHS MOH MOF	U2
• Outreach - improve climate literacy in the user community through a range of public education initiatives and online training programmes.	Essential	Limited documentation of climate literacy is available.	61. Use of the climate web portal as a means of disseminating and learning about climate information. 62. Use of public seminars and print media to promote and explain climate in terms that are easily understood.	SMD MAF NHS MOH MOF	U3

• Evaluation – develop monitoring and evaluation measures for the services in agreement between users and providers.	Essential	No systematic evaluation exists.	63. Routine monitoring such as annual surveys could be done through direct community approaches or through representative groups such as the Samoa Farmers Association. This would help evaluate progress from year to year and enable improvement of evaluation processes, and of sector focus in the development of services.	MAF NHS MOH MOF	U4

5 ADDITIONAL DETAIL ON PRIORITY ACTIONS FOR CAPACITY BUILDING

This section provides some additional detail to the priority actions that are recommended in the section above. No attempt is made here to order these actions; they are listed in the same order as in Tables 4a–4d in Section 4 above.

<table>
<tr><th>Link</th><th></th></tr>
<tr><td>Obs1</td><td>Historically in Samoa there have been frequent failures of instruments, stations and network systems due to lack of resources and scheduling for planned maintenance. It is essential that specifically funded and scheduled maintenance programmes (eg a fully costed 5-year plan) are implemented for

instrument calibration and replacement
telemetry periodic costs (eg monthly service charges)
telemetry upgrades and enhancements as systems evolve and improve
periodic upgrades of system servers and associated hardware
one FTE equivalent trained technicians for maintenance work
dedicated maintenance fund or similar mechanism to provide on-going finance (For example, $2M deposited at 5% would provide 100k per year.)
</td></tr>
<tr><td>Obs2</td><td>An automatic rain gauge network has been proposed and approved under NAPA 4 and will be installed during 2013.

Two (three?) climate stations will be installed in key remote forest locations under ICCRIFS.

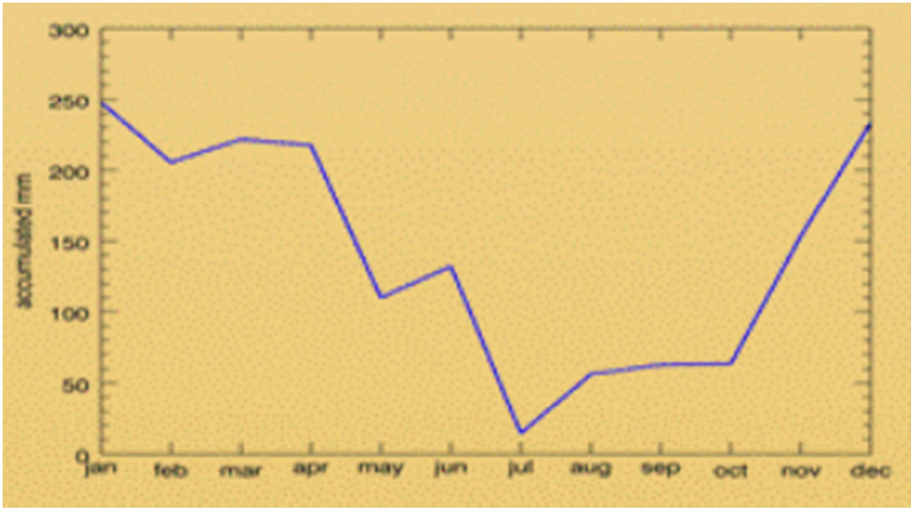
Currently data from the hydrometric network are downloaded manually during periodic site visits. These sites could be upgraded and automated. The data need to be archived on CliDE with data sharing arrangements agreed between Met and Hydrology divisions.

Data from NOAA automatic weather stations operating in Samoa are not routinely accessed by climate staff and therefore are not available for climate services. Routinely downloading and locally archiving NOAA AWS data needs to be implemented. This could be achieved by accessing the data from the GTS.

Climate services need improved access to JICA AWS data. An ftp link needs to be developed to copy JICA data from the CliDE Plus database to CliDE.</td></tr>
<tr><td>Obs3</td><td>In the context of developing climate services, it would be useful to test whether extreme or anomalous weather and climate events in Samoa, such as droughts, can be detected, for example, in the variability of NDVI (normalized difference vegetation index) or other remotely sensed vegetation indices. If there is a signal, particularly if that signal can be confirmed by ground-truthing, then the data can be used to help assess impacts, highlight trends over time, provide near real time indications of changes that may not be easily detected by sparse ground measurements, and possibly validate seasonal forecasts. In essence, correlating the satellite derived vegetation indices with ground measurements of vegetative health would prove to be a worthwhile effort towards implementing future related satellite products. The NASA MODIS sensor provides adequate resolution (250 metres) for derived vegetation data to meet the needs of small island states like Samoa.

Free access to other monitoring services, such as the NASA Tropical Rainfall Monitoring Mission (TRMM) shown in the example below, would enable Samoa to better monitor the intensity and spatial variability of weather and climate. See also Appendix 1: Regional Tools and Services

Note that these services do not remove the need for ground-based observations. The latter remain essential for the development and continuation of climate services, as well as to enable calibration and verification of the remotely sensed data.</td></tr>
</table>

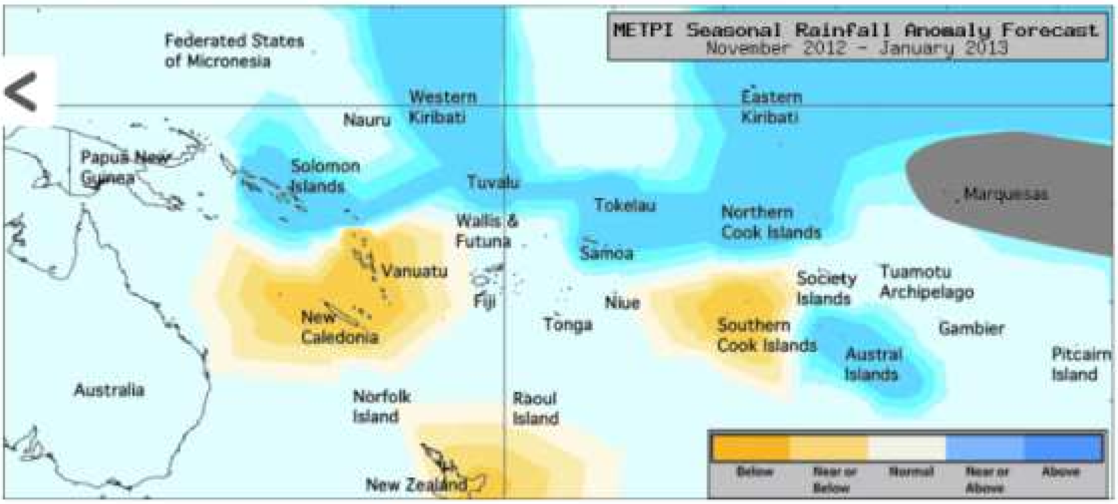
	 **NDVI values derived from the NASA terra-MODIS sensor illustrating vegetative vigour for the month of December 2009. Dark areas represent less active vegetation. *Courtesy NASA and IEDRO***  **Precipitation estimates derived from NASA TRMM capturing the 2009 seasonal cycle of rainfall for a satellite grid box within Savaii. A dry season is visible throughout the mid-summer month of July. Interannual comparison of these data would help determine the relative severity of annual dry period rainfall deficits.** Some questions that would need addressing are: • What preparatory development would be needed? • What procedures and agreements would need to be put in place for periodic access to the data? • How would the data/outputs be assimilated and distributed through routine and sustainable climate services? • What would be the on-going costs to maintain access? • What agencies are producing images and how could these images be accessed?
Obs4	Matching meteorological data with impacts enables better characterisation of meteorological variables and conditions in weather and climate services. Eg instead of forecasting 'heavy rainfall', the forecast could suggest that rainfalls in excess of some critical threshold would be likely. Examples of matching the scale of physical parameters of meteorological phenomena with social, economic and environmental data: 1. Air temperatures and hospital admissions on extreme hot days. 2. Extreme wind thresholds and damage to traditional houses. 3. Drought parameters (eg deciles of total rainfall) and food shortages, market prices, import costs. 4. Extreme rainfall rates and occurrences (rainfall depths per unit of time), matched with some known flooding events. 5. Dry/wet period changes in hospital admission caseloads for diarrhoea. 6. Matching of hourly rainfall, humidity and air temperature with recorded taro leaf blight infection

	periods.
Obs5	See Figure 3.2. The key missing links in data exchange at Samoa Met Division are shown as red dashed lines. All Samoan data that are available to the GTS should be archived in the CliDE plus database. At present, data from the JICA AWS network used in weather forecasts are not transferred to the climate database and are therefore not available for climate work. Hence a link from CliDE-plus to CliDE (the database for climate services) needs to be built. There are currently no protocols to archive NOAA AWS data or the Faleolo Airport AWS data to CliDE. Data from all these sources are needed to provide national coverage of climate services. An alternative solution for this problem may be to access the GTS directly.
Obs6	Samoa holds a significant paper archive. Rescuing and key-entering these data will enable a more robust historical climate record to be built for Samoa, as a foundation for current and future climate analyses and climate change projections. Australian Aid, ACRE Pacific, and NIWA are providing support for data rescue in Samoa. Students funded by Australian Aid are currently (during 2012 and 2013) entering data from field books into CliDE and are rapidly filling data gaps in key climate records. Much of the residual historical paper archive has been catalogued and stored in acid-free boxes.
Obs7	Currently data checking on CliDE by climate staff is limited to daily data values. NIWA has developed software for range checking and flagging of sub-daily AWS data, and this software has been implemented in Samoa. Further testing and development of this system is required. The CliDE development team at the Bureau of Meteorology is continuing to develop the native data QA procedures on the database. Homogenised historical data sets have been developed under the PCCSP programme. Arrangements need to be made to enable these data to be used in the routine production of climate services products.
Obs8	If climate staff know the thresholds and relevance of climate parameters that cause varying levels of impact risk for agriculture and health they may be able to develop more information-rich services. For example, warning of drought at various specified thresholds of dryness (and therefore response initiation), rather than just a blanket advisory.
Obs9	The historical climate data record needs to be fully explored for the frequency and severity of the occurrence of key climate risks, as a basis for determining what changes in frequency and severity may occur in the future. This will improve knowledge of potential changes to sector hazards and risks, and hence economic consequences, in the future. This will be a key element of the climate early warning system.
Obs10	See also figure 3.2 above. In order to correctly spatially interpolate climate data in Samoa, data from all observing networks need to be incorporated in the climate database CliDE.

Res1

Example of advisory that could incrementally developed to improve user focus and specific applications:

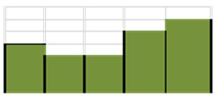
Seasonal outlook for November to January



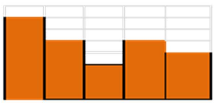
Rainfall anomaly map for Nov 2012 to Jan 2013

Recent rainfall

Recent soil moisture



Recent air temperature



Recent rainfall has been lower than average, with water shortages reported in some north-western parts of the country. Normal or above normal rainfall is likely over the next three months.

Soil moisture levels have been low in the north and west, and near normal elsewhere. Normal soil moisture availability is likely.

Air temperatures are expected to be near normal, with the average number of hot days for the season expected.

Climate and monitoring risk of unusual or severe conditions

LOW | NORMAL | HIGH

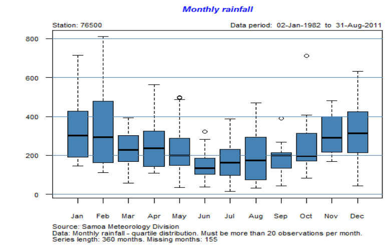
Recent monitored risk ↔ Future risk

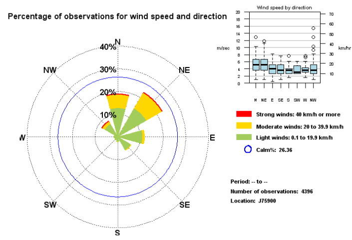
	AUG	SEP	OCT	NOV–JAN
Heavy rainfall				
Urban flooding				
River flooding				
Drought				
Low water supply				
High daytime temperatures				

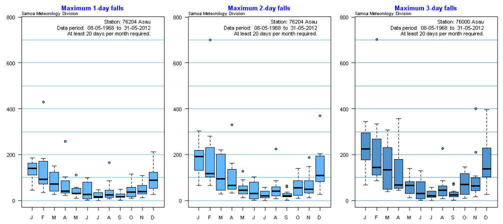
The previous climatology of Samoa was published about 1984, (*The Climate and Weather of Western Samoa. New Zealand Meteorological Service publication 188(8)*) and needs updating. This summary would provide an update of the main features of the climate of Samoa and would be helpful as a general introduction and guide to Samoa's climate.

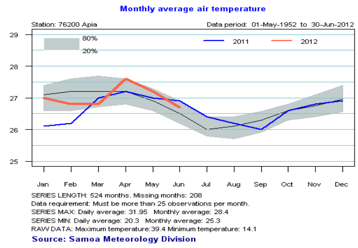
Res2	There is potential and need for the user community to drive the demand for and design of climate services. This would benefit from the engagement of the research institutions in the agriculture and health sectors in developing well researched links between weather and climate phenomena and consequent impacts on their sectors. Many of these needs were identified in the recent Sector Engagement Workshops (see Section 2.2). There is a need to enhance the recording, understanding and applications of traditional knowledge in the application of climate services, particularly in Samoan communities. More research into traditional ecological knowledge (insights) of climate and weather in Samoa would on the work already completed. For example, expanding on the Samoa Seasonal Calendar. Samoan communities could help with further documenting of observed physical changes eg. Coastal erosion, and provide insights into meteorological and oceanographic phenomena.
Res3	Eg. Simple but robust models to determine correlations between climate and other environmental variables and reported incidences of dengue can be used to predict where recent conditions favouring the disease may have occurred, or where suitable conditions might occur over the next few weeks or months. Event maps could be produced to highlight at-risk areas. Such information if shared between countries can alert authorities to the risk of transmission by international travellers. Analyses of past infection periods from historical data would help to determine temporal and spatial changes in future associated with climate change.
Res4	No ICCRAHS-relevant action required.
Res5	It is important that users understand and are continually reminded that there are limitations on the accuracy of climate data, forecasts and projections. Clear understandings of responsibility and liability need to be developed, including appropriate documentation and caveats on all products and services. This is essential in order to protect climate service providers from liability. While acknowledging the uncertainties, but not being unnecessarily constrained by them, steps can be taken to mitigate potential risks – a no regrets approach that is founded in the principles of information sharing and national benefits.
Res6	Research relationships between meteorologist and user agencies are needed to incorporate addressing of user-identified needs into science-based products and services. In some cases users may need to consider funding support. University engagement in climate science and applications would be helpful. An important example research project would be to examine infection periods for taro leaf blight, using disease data from historical leaf blight outbreaks. These data can be matched with weather observations to determine the contributing meteorological factors. From historical climate data, the historical or 'climatological' frequency and severity of infection periods can be determined, and an assessment can be made of whether there will be increased risk in the future under climate change scenarios. If the meteorological contributing factors to taro leaf blight (or other diseases) are well understood, they can be used by weather forecasters to predict potential infection periods in the days ahead as part of routine weather forecasting services.
Sys1	**CliDE** The CliDE relational database management system, developed at the Australian Bureau of Meteorology has been running successfully at Samoa Met Division since 2010. Subsequent upgrades have been successfully implemented to improve database operation. CliDE's open source technology and lack of expensive licencing fee makes it an appropriate and ideal system for data management in Samoa. CliDE is being successfully used in archive data in both real time and by key entry from paper records. The operation and maintenance of this database is vital to the future of climate services in Samoa. Keeping the database up to date is central to providing routine monthly climate updates and seasonal forecasts. A web services interface to CliDE enables easy download of data and assists preparation of basic reports such as monthly rainfall tables. These reports are easy to understand and are suitable for presentation to user groups, enabling for example easy comparison of recent rainfall with the long term average, or the same month of the previous year. **CLIDEsc** CliDEsc is a companion applications suite to CliDE, and is designed to aid quick and easy data analyses and visualizations of recent climate data. It can for example provide simple graphics comparing the current daily rainfall accumulation with the previous year and with long term averages. Such simple visualizations will add value to climate update presentations, and are designed for easy recognition and familiarity in the user community.

A range of data visualization tools are available with CliDEsc Lite (a demonstration version of CliDEsc), which has been installed at Samoa Met Division. The full version of CliDEsc will include web services. A selection of CliDEsc Lite products are shown below. (see enlargements appended to this document).









Quantum GIS

Climate services in Samoa need an easy-to-use desktop GIS application to routinely provide spatially resolved climate data. An ideal package for this is Quantum GIS (QGIS). QGIS is a user friendly Open Source Geographic Information System (GIS) licensed under the GNU General Public License. QGIS is an official project of the Open Source Geospatial Foundation (OSGeo). It runs on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster, and database formats and functionalities. Quantum GIS provides a continuously growing number of capabilities provided by core functions and plugins. Users can visualize, manage, edit, analyse data, and compose printable maps. For more information see: http://www.qgis.org/

To implement Quantum GIS in Samoa, the software can be downloaded from a suitable source. Customisation for Samoa would require setting up files of geographical and cadastral data, and in-house template methods to routinely access these and operational (climate) data to create useful products for advisories and publication.

Quantum GIS can ingest or export a large range of file formats used by other systems, such as MapInfo, this enabling the possibility of close data collaboration by Samoa Met Division with other departments using GIS systems in Samoa (eg Solutions for Open Land Administration (SOLA), Forestry, Urban Planning Unit).

See Appendix 2 for an example base map for Samoa produced in Quantum GIS.

Quantum GIS is supported in the Pacific by SOPAC and NIWA.

Sys2	See also **Sys1** above. Example services that can be generated from **current data services and science capacity** at Samoa Met Division (noting that technical capacity developments, such as CliDEsc and other data processing procedures, are yet to be enhanced to enable routine production of these products): • Data time series and maps of recent precipitation, combined with weather forecasts, to indicate recent and current risk of low (high) water supply, diarrhoea, and water borne diseases such as cholera and diarrhoea. • Data time series and anomaly maps of temperature and relative humidity to indicate risk of mosquito borne diseases such as dengue. • Time series graphics showing hourly infection risk of crop fungal diseases • Time series and extreme (low and high) values of rainfall data, combined with weather forecasts, to indicate risk of aquatic breeding sites for mosquitos. **10-day forecasts** SMD currently issue 4-day weather forecasts and alerts based on analysis and interpretation of global numerical weather prediction models. Extended-range (e.g. 10-day) forecasts could also be developed for Samoa based on statistical relationships between large-scale climate variables such as atmospheric pressure, temperature and humidity and climate station data such as daily precipitation, maximum and minimum temperature, and wind speed.
Sys3	WMO is presently evaluating the feasibility of Regional Climate Centres (RCCs) around the world. One such centre could be established for the Pacific region. The centre would facilitate the generation and transfer of climate science and information (including, but not limited to weather forecasts, seasonal climate outlooks and climate change information) to WMO member countries within the region. The RCCs would build on the many Regional Climate Outlook Forums (RCOFs) which are already established.
Sys4	International data sharing was discussed at the Pacific Regional Meteorological Services Directors Workshop in Support of Climate Adaptation Planning in the Pacific Islands, Majuro, Marshall Islands, August 8, 2011. NMS directors at the Workshop particularly noted the need for re-investment locally to support infrastructure and data management systems. They also noted that MOU/MOAs represent a practical mechanism for data exchange, yet these mechanisms are not necessarily the most effective tools. It was resolved that further investigation is required to address the above concerns and risks of data sharing. Internally in Samoa, further work is needed to help clarify conditions and methods for public access to data, including institutional and commercial arrangements.
Sys5	Given the limited resources of Samoa and other small Pacific Island states, long term sustainability of national and regional climate services needs to have a regional solution eg perhaps jointly managed by the Pacific Climate Desk at SPREP. Instrument calibration, routine maintenance including the supply of spare parts, and technical training could all be managed regionally. In addition, specialist technicians will be required from time to time.
Sys6	During the implementation of ICCRAHS there have been several workshops where sector leaders, administrators and community leaders have been presented with and discussed climate information. These have provided valuable insights into the climate services that are needed, and form a useful basis for developing tailored services. However further clarification of user needs is likely to come only after improved understanding by users of what is possible in terms of the delivery and application of climate information. This is likely to be achieved most effectively by implementing routine climate briefings and thereby instituting an iterative process to improve sector-focussed climate information over time.
Sys7	The following topics for training could be followed up on, based on end-user needs identified in the sector engagement workshops: • Accessing climate data • Understanding weather forecasts and seasonal outlooks • Interpreting climate change projections and impacts • Climate early warning: Using climate information for risk planning
Use1	A wikispaces forum could be established for feedback from agricultural and health professionals in Samoa. An example from New Zealand can be found at http://climate-smartfarmers.wikispaces.com/About+Climate-Smart. Whether this or some other mechanism is used, the need is for a systematic collation of user feedback as a basis for further tailoring of products and services based on user understanding and capacity to use the information for decision making.

Use2	Samoan language bulletins and advisories will be essential in getting the climate information to Samoan communities, such as the weather forecasts currently issued by SMD, for example. Translations to Samoan of extracts from English language documents are a key opportunity.
Use3	This requires the preparation of key literature, posters and other easily understood climate information. The PACCSAP poster "Climate, climate variability and change in Samoa" (see link in Section 3.2) is a good example. Information modules for community and school use could be developed.
Use4	There is a need to engage with specific groups, eg Samoa Farmers Association, MWCSD etc, to determine a mechanism for regular enhanced engagement with farmers, health workers and communities on working with climate information. This will maximise the opportunity to use existing and customary communications channels.

Appendix 1: Budget estimates for priority tasks identified in Tables 4a–4d

Notes

1. Listed local staff time is additional to current staff capacity at SMD, and is given in full time equivalents (FTE). Participation of current SMD staff in operations developments and training, where this is done in Apia, is not costed in this budget estimate.
2. All costs are provided in WST.
3. Budgeted items are estimates and should be interpreted as a guide only. Actual costs must be subject to further planning and eventual verification.

Priority objectives from Table 4	Observations and monitoring (including traditional knowledge)	Notes	Local staff salary / year (Full time equivalent/ year)	Local staff salary (WST/year)	International service contract, incl travel & per diem	Materials, internal travel	Total 2-year cost (WST)
1	Develop a fully costed maintenance plan and budget for the next 5 years.	Science staff	0.05	2,750	2,000	n/a	9,500
2	Implement a routine site maintenance schedule including on the job training	Technical staff	0.1	4,000	18,000	2,000	48,000
3	Ensure equipment and capability is in place for instrument calibration and replacement	Maintenance and calibration kit	n/a	n/a	n/a	3,000	3,000
4	Provide an annual professional development course for key technical staff	Annual training programme, including training materials	n/a	n/a	18,000	3,000	42,000
5	Design, build, document and implement a data quality assurance process and interface for the climate database.	Requires system development expertise and collaboration with Bureau of Meteorology, and training for SMD staff. Total approximately 3 weeks work.	0.05	2,000	53,190	n/a	55,190

6	Collect and collate meteorological and physical observations based on traditional knowledge.	SMD staff to conduct survey and collate information. Develop seasonal calendar of traditional knowledge.	0.05	2,000	18,000	5,000	50,000
7	Fill key gaps in observation network: coastal locations; upland river catchments;	Includes equipment upgrades, telemetry, database enhancement to manage hydrometric data.	n/a	n/a	50,000	400,000	450,000
8	Arrange transfer of JICA and NOAA data from the respective observing networks to Climate Section database for climate services (CLIDE).	May be best done by taking data directly from GTS and transfer to CliDE. NIWA has the technology to do this.	n/a	n/a	18,000	n/a	18,000
9	Develop data exchange agreement between Met and Hydrology divisions	Inter-departmental agreement required.	n/a	n/a	n/a	n/a	
10	Evaluate need for remotely sensed data and/or special data observations to build climate services	Requires liaison with sector users of climate information.	0.05	2,000	18,000	n/a	20,000
11	Evaluate availability and use of satellite data (eg NDVI, TRMM) for capturing agriculture, forest and other environmental variables;	May include trainer from international agency eg IEDRO	0.05	2,000	20,000	n/a	22,000
12	Develop routines for processing and using relevant and applicable remotely sensed data where relevant to climate service outputs.	Requires systems development expertise and some training of SMD staff.	0.05	2,000	18,000	n/a	40,000
13	Match sector impacts data with meteorological events and anomalies, to enable risk profiles to be better understood and where possible included in short term and seasonal forecasts.	Joint project with sector managers and scientists	0.1	5,500	18,000	4000	55,000

14	Improve data archiving systems to ensure all climate data — NOAA, JICA, SMD, NZ MetService, Water Resources — is available for climate services (while respecting institutional priorities and arrangements).	See 8 and 9 above.	n/a	n/a	n/a	n/a	
15	Data rescue: From assessments of the paper based climate data archive in Samoa, provide resources to complete the key entry of paper based data.	Could be done by students, with technical support and supervision. If electronic scanning of documents is required, additional material costs for scanner and associated hardware should be considered (40,000)?	0.2	8,000	n/a	n/a	16,000
16	Document and implement QA procedures for daily data on CliDE	To be done by Bureau of Meteorology; some liaison needed.	n/a	n/a	5,000	n/a	10,000
17	Develop QA procedures for sub-daily data.	See 5 above.	n/a	n/a	n/a	n/a	
18	Develop accessibility to homogenised data for producing climate service products such as anomaly maps.	Requires liaison with Bureau of Meteorology. Extra table to be added to CliDE data model.	n/a	n/a	5,000	n/a	10,000
19	Data sharing: Establish agreements and arrangements to match agriculture and health data with weather and climate events, to enable SMD to improve the sector focus of weather and climate advice.	See 13 above.	n/a	n/a	n/a	n/a	

20	Improve analyses of past climate records for specific hazard and impact data, to enable scenarios of changing risk to be developed for future climate changes.	To be done by Samoan climate scientist. Would be an ideal project to involve university students.	0.1	5,500	n/a	n/a	11,000
21	Apply these results to determine future potential agriculture and health risks, as a key component of the Climate Early Warning System.	See 20 above.	n/a	n/a	n/a	n/a	
22	Fully implement data exchange between existing meteorological observational networks.	See 8,9, and 14	n/a	n/a	n/a	n/a	
23	Implement data exchange between hydrometric network and meteorological networks (while respecting institutional arrangements), to enable climate services such as flood forecasting and water resource management.	See 8,9, and 14. Develop forecasting system and products for flood forecasting jointly with weather forecasting section.	0.1	5,500	18,000	n/a	47,000
	Research, modelling and prediction						
24	Test currently available climate information through sector targeted climate briefings.	Conduct monthly climate briefings and dialogues with agriculture and health sectors.	0.1	5,500	18,000	n/a	47,000
25	Use feedback from these briefings to improve the focus of sector-applicable climate science where needed	Explore questions of information design and content, and understanding of risk, and design information that meets user needs.	0.1	5,500	18,000	n/a	47,000
26	Improve availability of science effort to developing sector-focussed advice.	See 25 above.	n/a	n/a	n/a	n/a	

27	Develop a **Seasonal Calendar based on Traditional Knowledge**	See 6 above.	n/a	n/a	n/a	n/a	
28	Revise the Climate of Samoa booklet and publish on the MNRE climate webpage.	Climatology of Samoa could be developed by a team of students guided by a Samoan climate scientist. Use the 1980s climatology as a starting point to develop a English/Samoan version.	0.1	5,500	18,000	5,000	57,000
29	Develop collaboration with corresponding research communities, eg Crop Research Division, Forestry Division enable joint development of climate services such as GIS data layers, user-focussed analyses, tools and pathways for dissemination.	See also 26 above.	0.1	5,500	n/a	n/a	11,000
30	Develop collaborative research partnerships between sector experts and climatologists.		n/a	n/a	n/a	n/a	
31	Continue research into traditional ecological knowledge (insights) of climate and weather in Samoa, building on the work already completed. For example, expanding on the Samoa Seasonal Calendar.	See 6 above.	n/a	n/a	n/a	n/a	
32	Continue professional development of climate staff in production and communicating of science-based climate services.	See 4,5, and 12 above. Some specific communication training would be required.	0.05	2,750	18,000	n/a	41,500
33	Develop collaborative research partnerships between sector experts and climate staff.	See 29 above.	n/a	n/a	n/a	n/a	

34	*No ICCRAHS action required.*		n/a	n/a	n/a	n/a	
35	Address limitations and uncertainties at the monthly climate briefings.	See 24 above.	n/a	n/a	n/a	n/a	
36	Use the outcomes and results from monthly climate briefings to determine levels of investment needed to apply climate science and related technologies to improve user-focussed services for decision making.	See 25 above.	n/a	n/a	n/a	n/a	
	Climate services information system						
37	Prepare and conduct monthly climate briefings for the agriculture and health sectors, including describing recent past climate and seasonal climate outlooks, and work with these sectors to relate climate to sector risk awareness and management.	See 24 above.	n/a	n/a	n/a	n/a	
38	Develop routines to extract, process and summarize data from CLiDE in response to user needs and enquiries	See 25 above.	n/a	n/a	n/a	n/a	
39	Provide regular feedback to Bureau of Meteorology on development needs for CliDE database.	No additional cost: can be done by current climate staff.	n/a	n/a	n/a	n/a	

40	Evaluate and install software relevant to the development of climate services	Consult WMO for developments in other countries. Evaluate appropriate software packages, particularly open source tools, that may be useful in Samoa.	0.05	2,750	8,000	n/a	21,500
41	Evaluate and improve access to relevant web-based services that would enhance climate knowledge and applications in Samoa.	eg. Investigate collaboration with PaCIS, IEDRO, etc.	0.05	2,750	8,000	n/a	21,500
42	Conduct regular climate briefings.	See above.	n/a	n/a	n/a	n/a	
43	Use the briefings to tailor and improve climate services.	See above.	n/a	n/a	n/a	n/a	
44	Engage with user community to improve user-understanding of climate information and potential hazards and risk.	See above.	n/a	n/a	n/a	n/a	
45	User public channels to disseminate routine and easy to understand climate bulletins: eg. radio, newspapers, NGO briefings.		0.05	2,750	n/a	n/a	5,500
46	Develop a ***Guide to climate services for Agriculture and Forestry*** booklet in English and Samoan	Work collaboratively with project Agriculture coordinator.	0.05	2,750	14,000	n/a	33,500
47	Develop a ***Guide to climate services for Health*** booklet in English and Samoan.	Work collaboratively with project Health coordinator.	0.05	2,750	14,000	n/a	33,500
48	Develop (or enhance) a Samoan climate service web portal.	Can be developed with current MNRE resources.	n/a	n/a	n/a	n/a	
49	Investigate and if possible implement a 10-day forecasting system for Samoa.	This may be more of a weather forecasting activity.	0.05	2,750	27,000	n/a	59,500

50	Continue to contribute to and access climate science and services at all levels – global, regional and national – where they directly contribute to improving climate risk decision making in Samoa.	Covered in above tasks.	n/a	n/a	n/a	n/a	
51	Develop and implement guidelines for public and institutional data accessibility at Samoa Met Division.	Policies and access rules to be developed by MNRE.	n/a	n/a	n/a	n/a	
52	Improve protocols, agreements and procedures for data exchange via the GTS (Global Telecommunications System).	Some development needed to extract data from the GTS. See also 8 above.	n/a	n/a	n/a	n/a	
53	Implement a financial and administrative programme to secure and maintain the infrastructure for delivering climate services.		0.05	2,750	n/a	n/a	5,500
54	Agree and implement with sector groups routine and regular climate briefings and methods to evaluate social and economic benefits.	See 42–44 and elsewhere above.	n/a	n/a	n/a	n/a	
55	Conduct monthly briefings to provide information addressing user needs using content that is readily understood	See above.	n/a	n/a	n/a	n/a	

56	Develop and improve sector-specific advisories that can be disseminated at current levels of demand and understanding (these should be in Samoan and English). The content and application focus of the advisories can be enhanced over time as user requirements and applications are better understood.	See above.	n/a	n/a	n/a	n/a	
57	Ensure opportunities are maintained for Samoan climate staff to participate in regional climate exchanges and professional development	This can often be best done in conjuction with regional meetings. Travel to these meetings is usually supported by the sponsoring agencies.	n/a	n/a	n/a	n/a	
	User interface platform						
58	Document feedback: Feedback could be verbal through community representatives, village councils, Women's Committees, and churches, via field meetings and surveys, or through online data gathering.	See above.	n/a	n/a	n/a	n/a	
59	Increase climate dialogues with institutionalised groups, such as Samoa Farmers Association, Women in Business, Red Cross, etc.		0.05	2,750	n/a	n/a	5,500
60	To address this need, Samoan language products and services will need to be developed.		0.05	2,750	n/a	n/a	5,500
61	Issue basic climate stories and bulletins using radio and television.	See 45 above.	n/a	n/a	n/a	n/a	

62	Use of the climate web portal as a means of disseminating and learning about climate information.	See 48 above.	n/a	n/a	n/a	n/a	
63	Use of public seminars and print media to promote and explain climate in terms that are easily understood.	See above.	n/a	n/a	n/a	n/a	
64	Routine monitoring such as annual surveys could be done through direct community approaches or through representative groups such as the Samoa Farmers Association. This would help evaluate progress from year to year and enable improvement of evaluation processes, and of sector focus in the development of services.	Additional work required to design and collate survey material to ensure evaluation of progress on developing climate services.	0.05	2,750	n/a	n/a	5,500
		Subtotals	1.85	93,500	422,190	422,000	
		Grand total WST					**1,307,190**

APPENDIX 2: NOTES ON REGIONAL TOOLS AND SERVICES

Regional tools and services can be used by climate services staff who have the appropriate access and interpretive skills, as a means to add analytical depth where this may be needed in the preparation of climate services in Samoa. These tools are not essential but would add value to selected climate services in Samoa.

Online support for environmental data (analysis and user applications) is robust and offers every needed element to support climate services. The availability is comprehensive and includes items that aid in data access, analysis, download, and visualization without concurring any costs, subscriptions, or complicated programming.

All regional tools and services can be conducted through access to free and unrestricted data portals that provide complete diagnosis from data selection to graphical output. Precipitation, winds, vegetation, soil moisture, sea surface temperatures, and other parameters that are all related to the regional services can all be easily accessed through the online web portal service.

NASA GIOVANNI

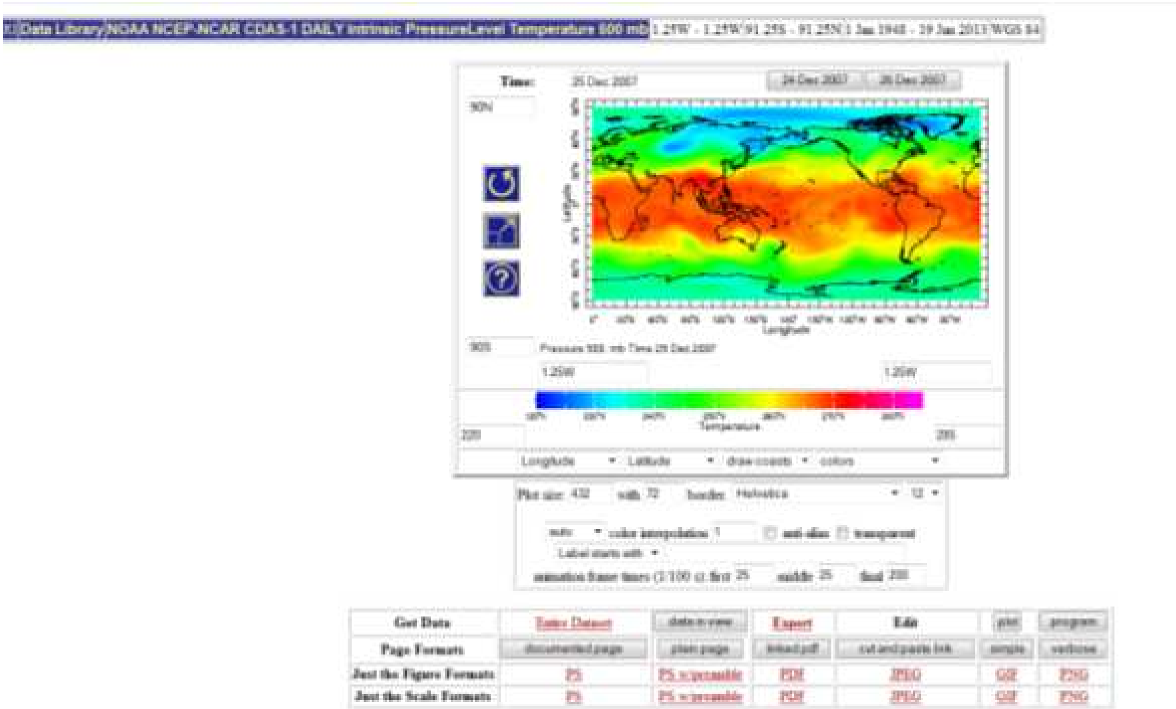
Direct access to NASA satellite derived vegetation and land products along with rainfall estimates can be located through the NASA Giovanni data explorer:
http://disc.sci.gsfc.nasa.gov/giovanni/overview/index.html

Giovanni provides a GUI style web based point and click method to access and subset data. In addition, various plots and graphs can be produced as output along with the raw data.

ENVIRONMENTAL DATA ANALYSIS

Complete data analysis can be conducted on most data sets of choice through the International Research Institute's (IRI) Climate Library System: http://iridl.ldeo.columbia.edu/

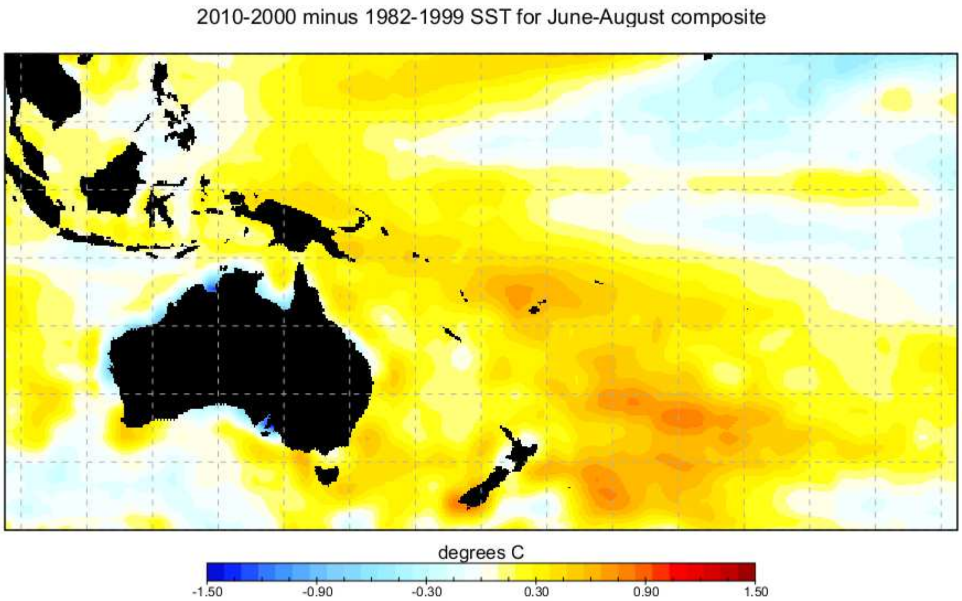
A comprehensive listing of analysis functions ranging from complex time series filtering to simple averaging is easily managed using the Climate Library; a complete listing of analysis options is found via the function documentation link. In addition, multiple tutorial options exist to aid in user familiarity. Data analysis and visualization can be done directly through the portal or data can be subset and output through various formats for further external analysis or plotting. Some examples of formatted output using the Climate Library are GIS shapefiles, Excel spreadsheet formats, ASCII output, and GeoTiff. Observations, reanalysis products, satellite measurements, and model output are all available through the Climate Library system.



Screen capture for the IRI Climate Library web portal.

SITE SPECIFIC ANALYSIS USING ONLINE TOOLS:

The NOAA Physical Sciences Division Web Products and Tools (NOAA PSD) offers a unique ability for users to ingest their own time series data into their portal to produce spatial correlation maps, monthly / seasonal mean composite maps, and other statistical time series decompositions. In addition, like the Climate Library, the NOAA PSD site allows the user to select and subset various types of environmental data, which can be analysed independently or ingested into the NOAA PSD web portal for further analysis. For example, users can easily produce correlation maps of observed rainfall in Samoa and global sea surface temperatures at lead times sufficient enough to support early warning research. Additional information can be found at http://www.esrl.noaa.gov/psd/products/analysis/ . The example below uses the NOAA PSD web portal to produce a difference map between June, July, August composite sea surface temperatures from the period 1982-1999 and 2000-2010.



Composite difference between June, July, and August sea surface temperature from 1982-1999 and 2000-2010. Positive values indicate warming. Dataset: NOAA OI SST.

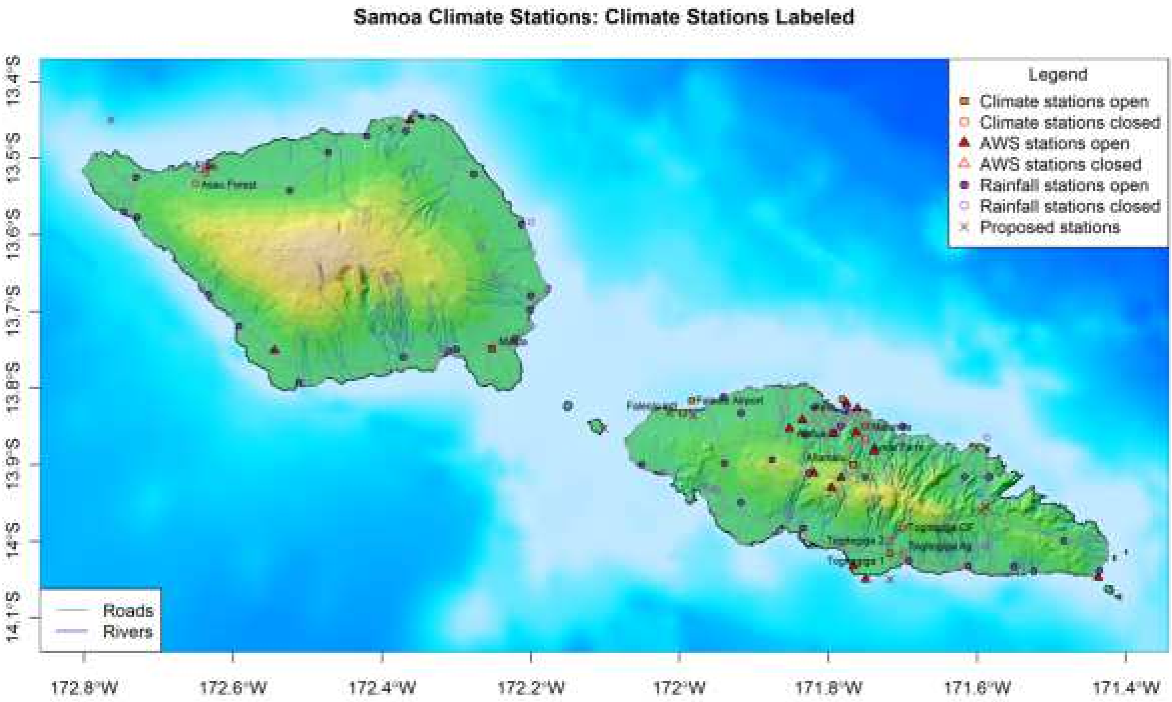
Other non-web portal open source tools include:
IRI Climate Predictability Tool
Python Data Analysis software
Grid Analysis and Display System (GrADS) http://www.iges.org/grads/
NCAR Command Language (NCL) http://www.ncl.ucar.edu/
NASA Panoply Data Viewer

APPENDIX 3: NOTES ON LOCAL TOOLS AND SERVICES

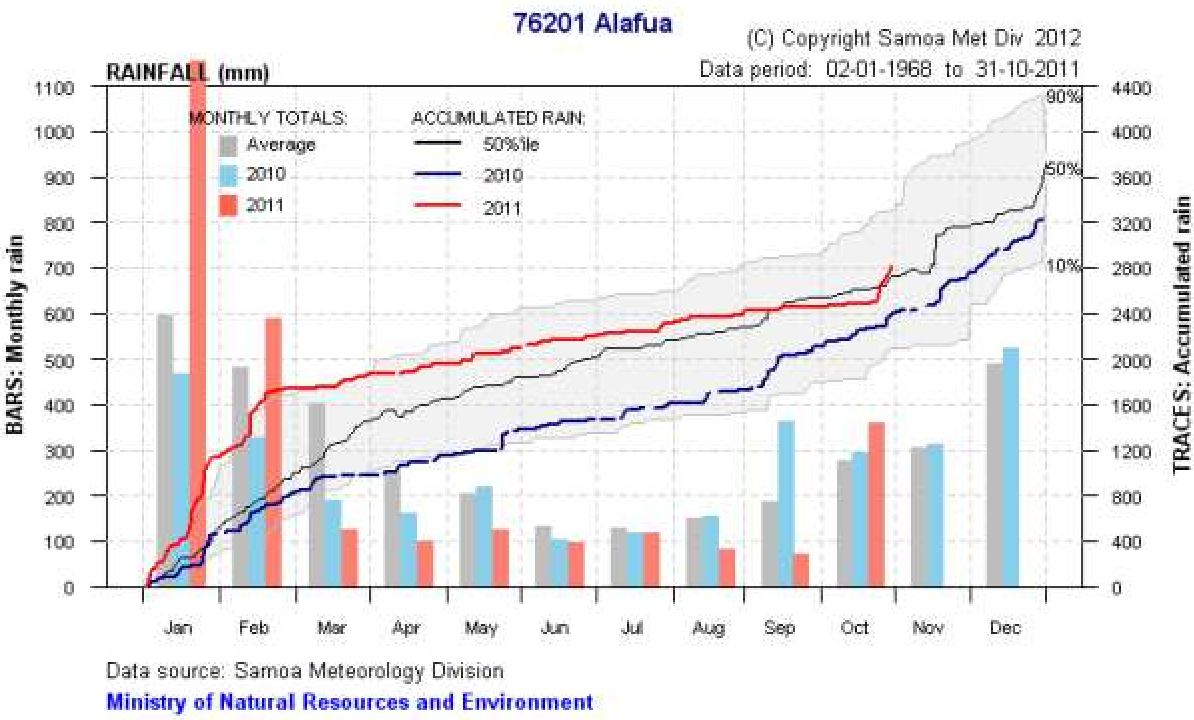
CLIDESC AND QUANTUM GIS

Some examples of a larger range of products that can be delivered easily or automated from CliDEsc are shown on the following pages. CliDEsc is a companion software suite to CliDE. Currently the demonstration version of this software (CliDEsc Lite) is implemented as a file based package requiring the user to submit queries and then run designated processes picked from a menu. Eventually CliDEsc will be fully web-based.

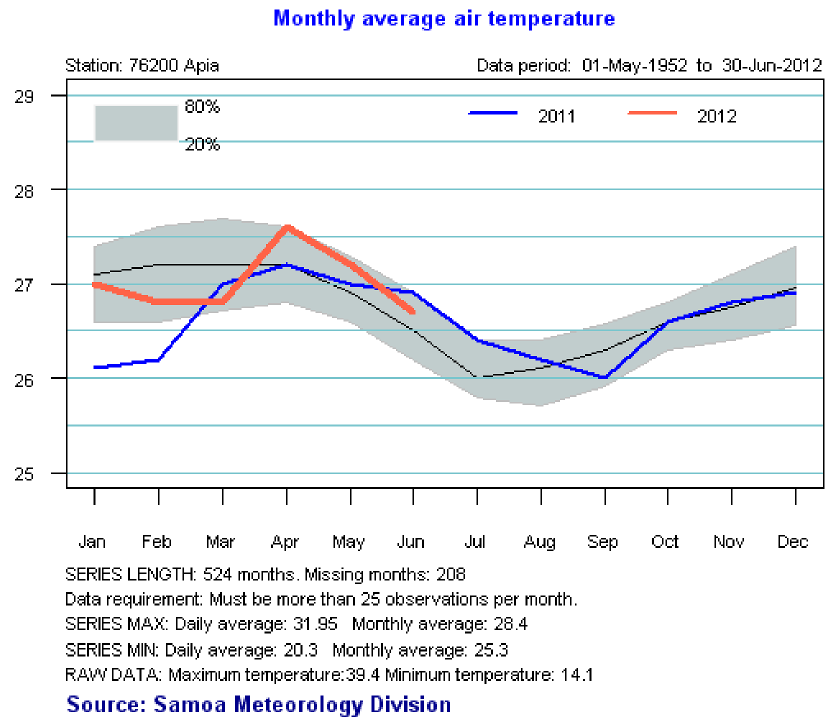
Examples of CliDEsc products are followed below by basic geo-referenced map of Samoa using Quantum GIS.



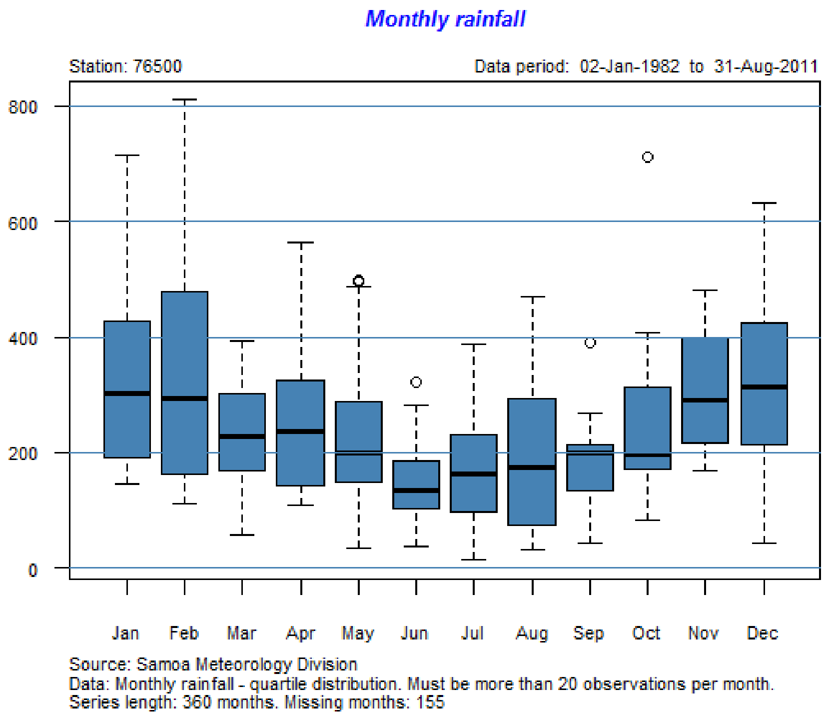
Example CliDEsc product: Location of climate stations in Samoa. The map also shows terrain elevation data, roads, rivers and bathymetry.



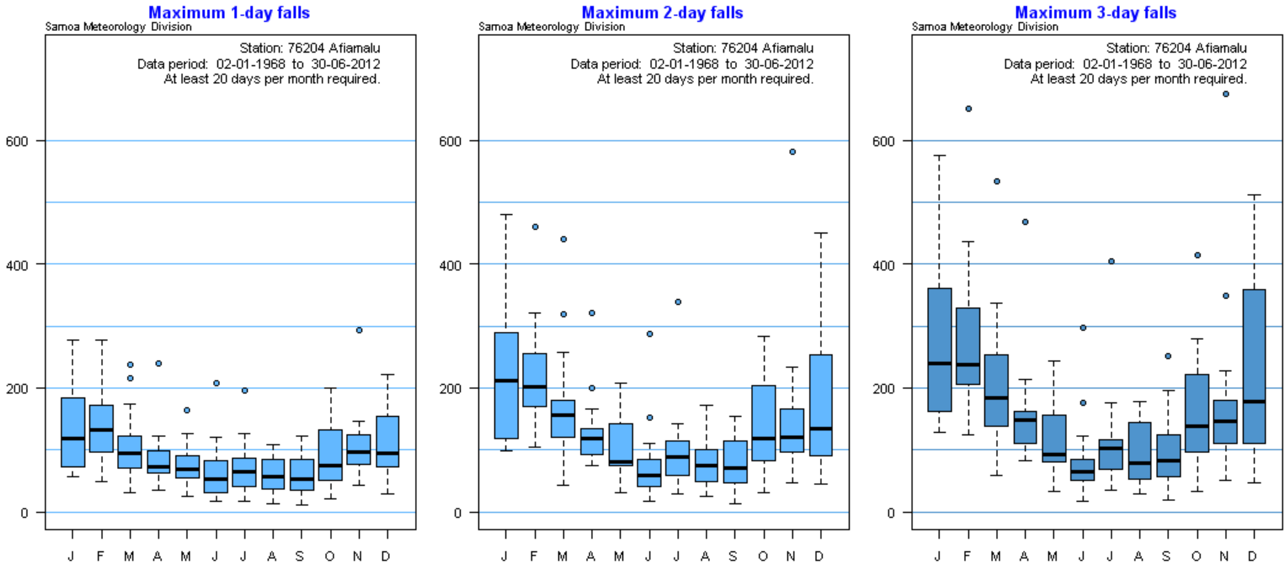
Example CliDEsc product: Rainfall observations from Alafua weather station. Monthly rainfall totals are shown as vertical bars; traces show the annual accumulation of daily totals.



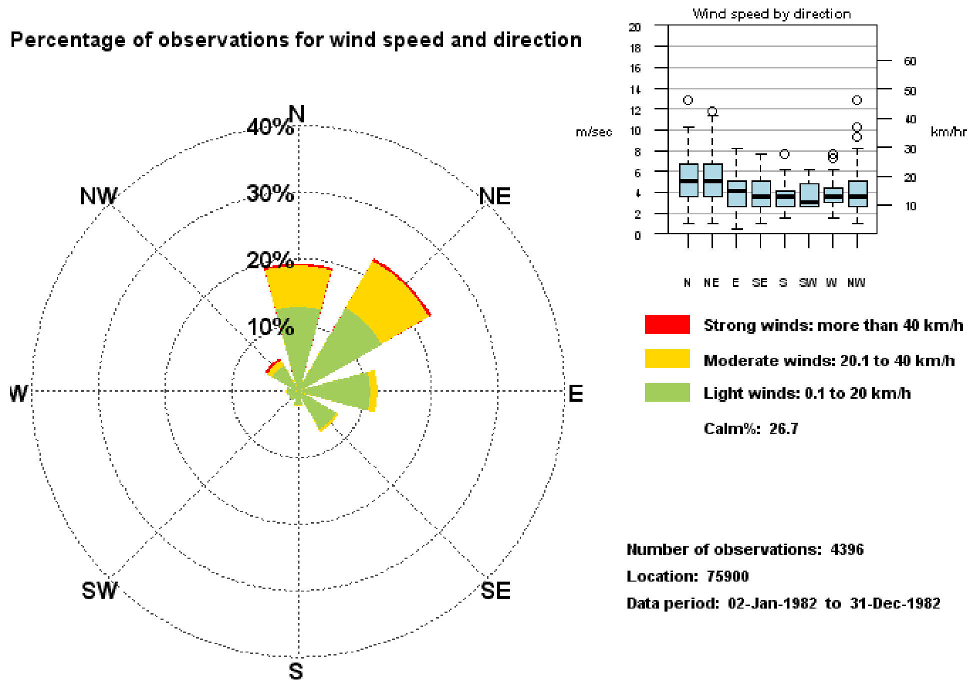
Example CliDEsc product: Monthly average air temperatures at Apia. The grey band shows the 20th and 80th percentile values, and the black curve is the median.



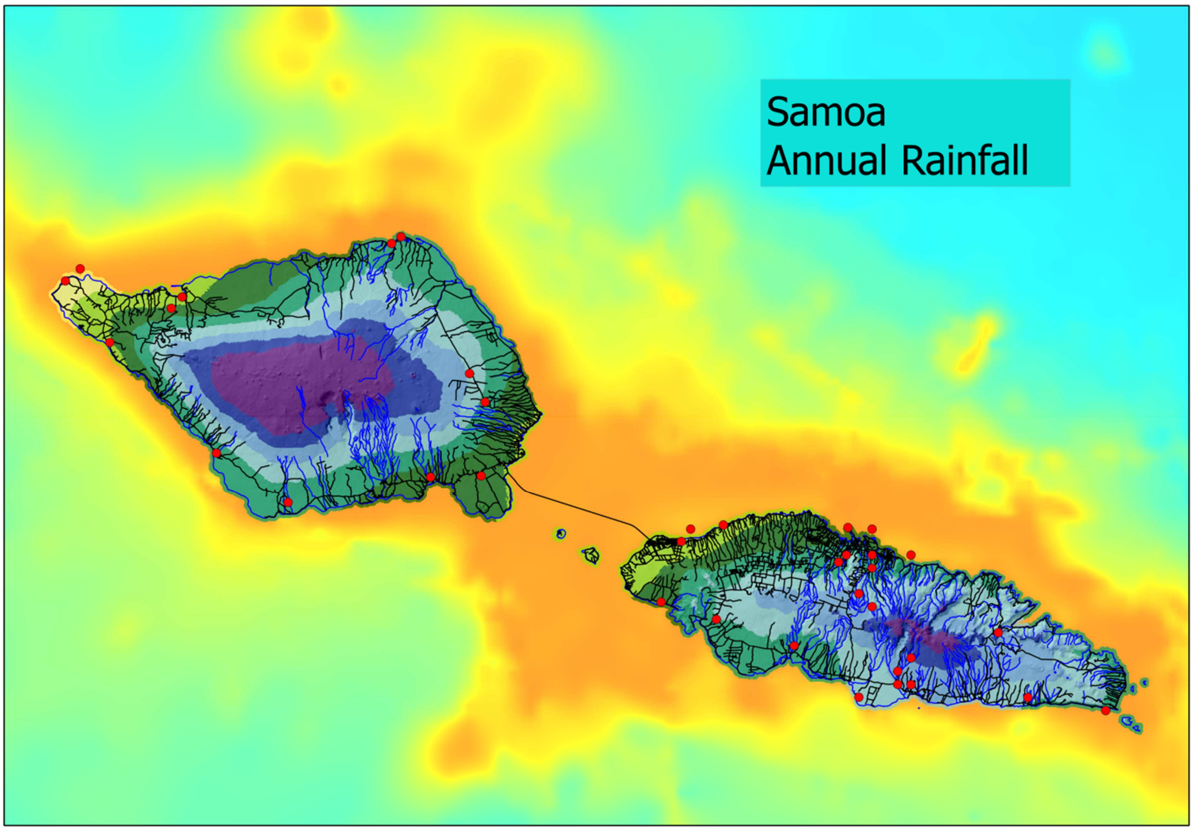
Example CliDEsc product: Monthly rainfall quartile distribution and extreme values for Station 76500.



Example CliDEsc product: Maximum one-, two- , and three-day rainfalls for Afiamalu, Samoa. These data are useful for engineering design, particularly for high rainfall events.



Example CLIDEsc product: Number of wind speed observations recorded for eight directions, shown as percentages of all observations, for calendar year 1982, at station 75900. The distribution of wind speed ranges by direction is also shown (right hand figure).



A base map of Samoa produced in Quantum GIS, showing topography, bathymetry, station locations, rivers, roads, coastline and annual rainfall. Climate data surfaces, such as rainfall anomaly maps, produced in Quantum GIS can be exported for use on other GIS platforms. The software is designed for easy importing of geo-referenced data, such as agricultural or health risk data sets.