Database Report

Impact assessment of past climate change adaptation actions

Sustainable, transformative, and resilient for a Blue Pacific

SPREP PROE

Impacts Assessment of Past Climate Change Adaptation Actions

Database Report

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1 Introduction

This report is the last report of a serious of reports and concentrates on spatial and tabular data available in the project.

This report shows (i) spatial layers or tables which can be used for the GIS data of the countries. (ii) The report also lists all image data purchased through the project. Image data downloaded from Google Earth are documented in the reports before, the image capture details the day of image recording. (iii) The report documents all tabular data which are elements of Access databases. (iv) Finally the report provides the structure of a rainwater harvest database.

All tabular and spatial data will be delivered to the corresponding countries. It is possible that the GIS and database consultant of the project sends on DVDs posted to the relevant project contact persons or SPREP sends the data, where the file names are listed in chapter 6.

The report is structured in relation to the project countries and explains for each country the spatial and the tabular data.

1.1 Spatial Layers and Image Data

The impact of climate change mitigation actions is in most cases not visible yet. There is the exception of detached breakwaters in Tonga where impact is measurable as explained in the report. Other impacts will be visible and quantifiable at a later stage. However, any comparison in a quantitative way requires a mapping to the standards of 1:10,000 scale which is sub five metre accuracy. Google Earth screen dumps are not accurate enough. Ortho-corrected WorldView image data or similar satellites with high geo-accuracy are one solution. The best solution is a mapping with GNSS (GPS) units allowing to store the coordinates and the recording satellites with subsequent differential correction of the position data.

Such GIS layers were in many cases not ready by end of the project, however, in discussion forums and workshops it was discussed that this is an essential requirement as the basis of a monitoring of (i) the climate change mitigation elements itself and (ii) the impact the elements will provide.

1.2 Tabular Data

The project countries performed surveys especially in the technical area of water supply. These surveys have been stored in Excel spreadsheets. Here a relational database has significant advantages as the data is structured and can be easily linked to the corresponding spatial layers to create thematic maps. This was demonstrated in an online Access database training and explained in a training during a final workshop in Fiji. The report explains database elements in detail to allow database developments or copy and paste into their own databases.

With the examples of rainwater harvest databases including the example database it is demonstrated that the elements (i) catchment area (roof), (ii) gutter, (iii) downpipe and (iv) tank can be linked. This allows to calculate the available rainwater for individual households, complete villages or islands in case of an upcoming drought. This is difficult to perform with spreadsheets.

1.3 Climate Change Mitigation Infrastructure Database

From available spreadsheets and other information a database was formed which contains the information available about initiatives to establish climate change mitigation infrastructure. The

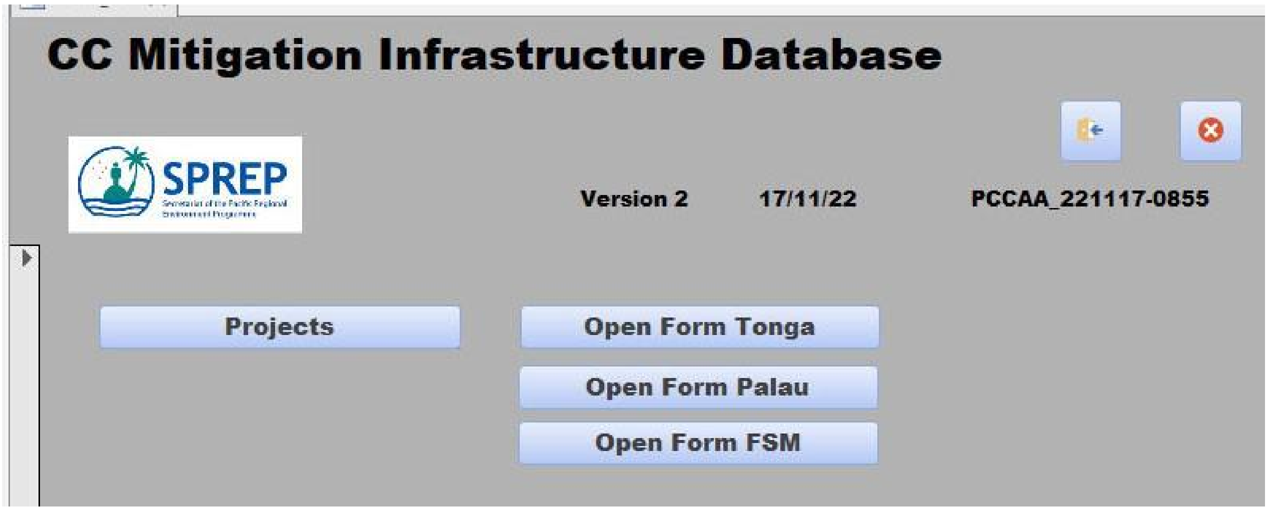


Figure 1.3-01: *Main form of the database allowing to call the country databases.*

database to list the elements established in the countries Tonga, Palau and Federated states of Micronesia. The database provides a structure but has to be updated in regular intervals.

2 Tabular and Spatial Database Tonga

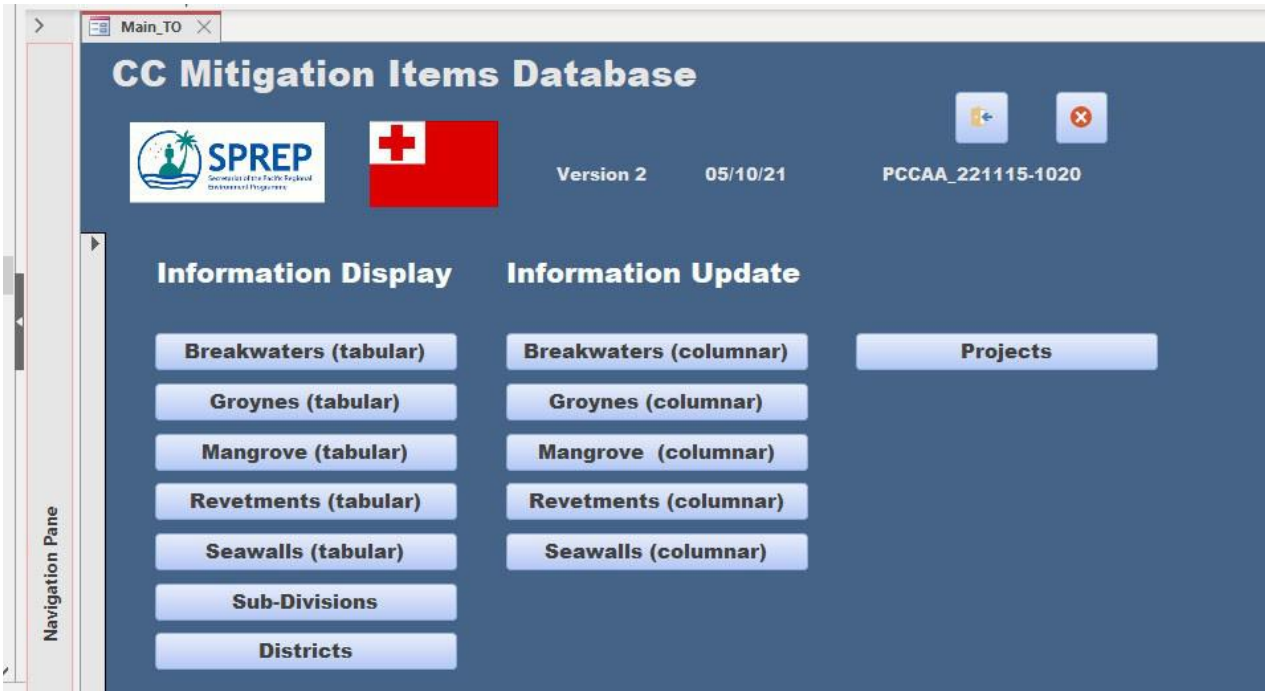


Figure 2-01*: The main form of the Tonga part of the database*

Currently the tabular database shows the situation of 2022. Conducting a new survey in the near future the annotation data can be added to the same database table by giving a time stamp to new measurements.

2.1 Breakwaters in Tonga

Breakwaters are artificial elements which help to establish a stable beach line. A detail description see Tonga Status Report.

2.1.1 Unique IDs

Breakwaters have been established in four different areas closed to the four villages: (i) Kolonga, (ii) Manuka, (iii) Seisa and (iv) Sopu to Nuku'lofa. The unique ID of the breakwaters reflects a) the element ID “Breakwater” through the prefix “BW” the next village through two digits such as “MA” for Manuka and a running number.

2.1.2 Spatial Elements

The polygons of the Tonga Lands Department GNSS survey were imported to GIS environment.

Figure 2.1.2-01: *Breakwaters near Manuka imported as polygons of the Tonga Lands Department GNSS survey.*

The breakwaters of the other three areas are not documented yet.

2.1.3 Tabular Database Table Breakwater Tonga

For details of the different breakwaters a database table was established with the name “Breakwater-TO”. The table contains following fields:

Breakwater_ID

The field Breakwater ID is a primary key allowing to link the table to the graphical element in GIS environment. The content is explained above.

Field Name	Data Type	Description (Optional)
Breakwater_ID	Short Text	BRW - Village Short Cut - Number
Breakwater_ID_Survey	Short Text	Breakwater survey ID
Breakwater_ID_old	Short Text	BRW - Coastal-Unit - Number
Village	Short Text	Next village
Length	Number	Length of breakwater (ruler calculation)
Area	Number	Calculated area in metres
Centroid_X	Number	GIS calculation
Centroid_Y	Number	GIS calculation
Origin	Short Text	Origin of spatial data
DateEstablish	Date/Time	Date the element was established
Comments	Long Text	general comments
Project_ID	Short Text	Country_PRJ-Shortcut possible link to Project table

***Figure 2.1.3-01:** Overview table structure Breakwater-TO*

Breakwater_ID_Survey

This field contains the polygon ID of the Tonga Lands Department GNSS survey.

Breakwater_ID_old

The field contains the unique IDs of the first GIS layers showing breakwaters.

Village

The field “Village” contains the full name of the next village to the breakwater where the village shortcut is part of the unique ID of the table Breakwater-TO.

Length

The field “Length” contains the length of the breakwater in full metres. For the breakwaters elements near Manuka the length was measured with the GIS ruler tool, not measured in the field.

Area

The field “Area” contains the area size in square metres. This calculated by GIS tools using the polygons of the Tonga Lands Department GNSS survey.

Centroid_X and Centroid_Y

The fields “Centroid_X and Centroid_Y” contain the Tonga Map coordinates of the centroid of the breakwater in Tonga Map Grid coordinates.

Origin

The field “Origin” contains a description how the GIS element was established.

DateEstablish

The field “DateEstablish” should contain the date the construction of breakwater element was finalised. These figures are still missing.

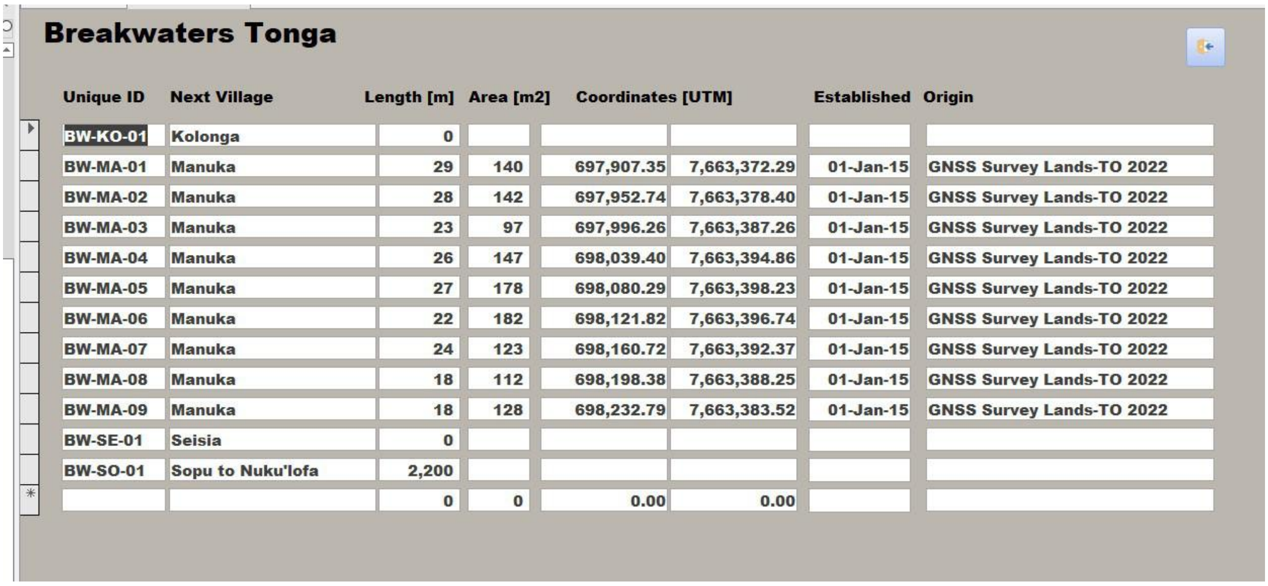
Comments

The field “Comments” is left for descriptions.

Project_ID

The field “ Project_ID” contains the unique ID of the project table. This allows to link both tables.

2.1.4 The two Forms Breakwaters

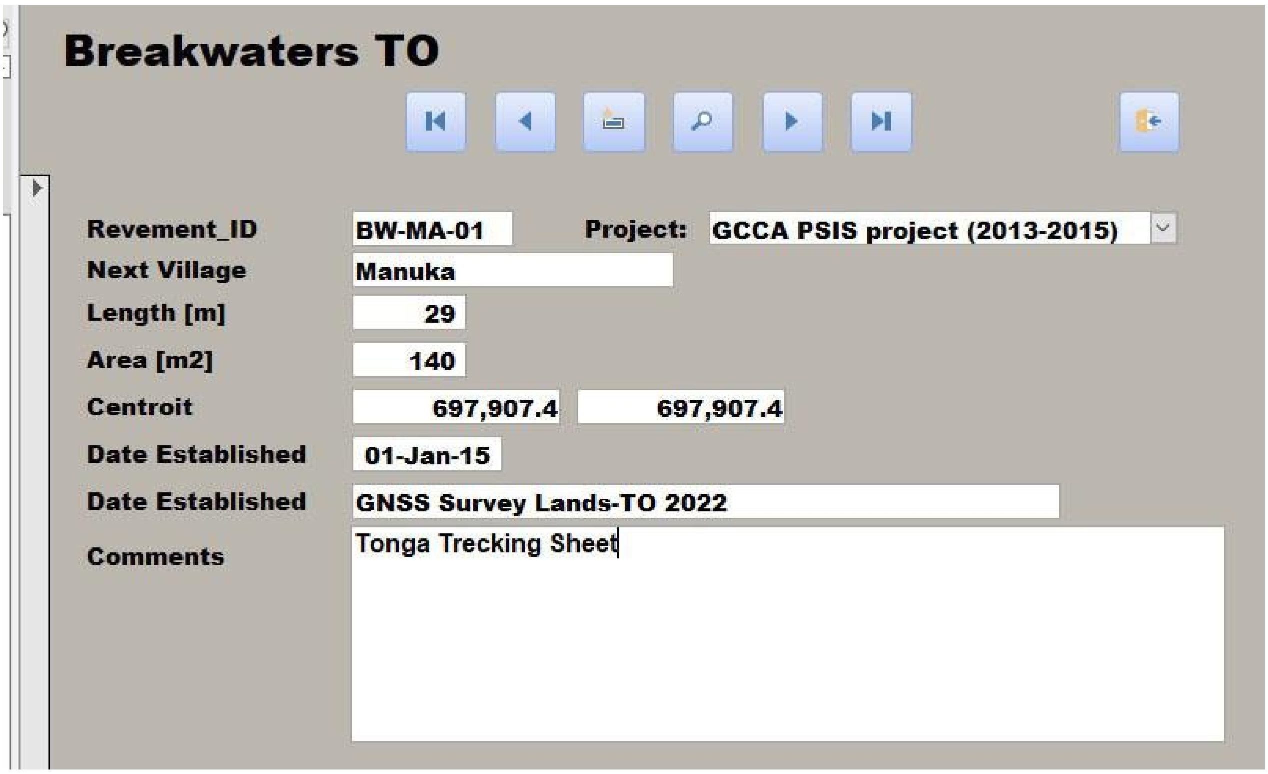


Breakwaters Tonga

Unique ID	Next Village	Length [m]	Area [m2]	Coordinates [UTM]		Established	Origin
BW-KO-01	Kolonga	0					
BW-MA-01	Manuka	29	140	697,907.35	7,663,372.29	01-Jan-15	GNSS Survey Lands-TO 2022
BW-MA-02	Manuka	28	142	697,952.74	7,663,378.40	01-Jan-15	GNSS Survey Lands-TO 2022
BW-MA-03	Manuka	23	97	697,996.26	7,663,387.26	01-Jan-15	GNSS Survey Lands-TO 2022
BW-MA-04	Manuka	26	147	698,039.40	7,663,394.86	01-Jan-15	GNSS Survey Lands-TO 2022
BW-MA-05	Manuka	27	178	698,080.29	7,663,398.23	01-Jan-15	GNSS Survey Lands-TO 2022
BW-MA-06	Manuka	22	182	698,121.82	7,663,396.74	01-Jan-15	GNSS Survey Lands-TO 2022
BW-MA-07	Manuka	24	123	698,160.72	7,663,392.37	01-Jan-15	GNSS Survey Lands-TO 2022
BW-MA-08	Manuka	18	112	698,198.38	7,663,388.25	01-Jan-15	GNSS Survey Lands-TO 2022
BW-MA-09	Manuka	18	128	698,232.79	7,663,383.52	01-Jan-15	GNSS Survey Lands-TO 2022
BW-SE-01	Seisia	0					
BW-SO-01	Sopu to Nuku'lofa	2,200					
		0	0	0.00	0.00		

Figure 2.1.4-01: *The form "Breakwaters Tonga Tabular" allows viewing and cut and past but does not allow to change the data.*

The form "Breakwaters_TAB_TO" allows to view the important data stored in table "Breakwaters_TO" in tabular form. Cut and paste into another document is possible. However, to input or edit data the corresponding record of the table has to be opened in a different form, the form "Breakwaters_COL_TO".



Breakwaters TO

Revement_ID: BW-MA-01 Project: GCCA PSIS project (2013-2015)
Next Village: Manuka
Length [m]: 29
Area [m2]: 140
Centroit: 697,907.4 697,907.4
Date Established: 01-Jan-15
Date Established: GNSS Survey Lands-TO 2022
Comments: Tonga Trecking Sheet

Figure 2.1.4-02: *Form breakwaters Tonga columnar, which allows input and edit of information about breakwaters.*

2.2 Groynes in Tonga

The function of groynes is described in the last situation report for Tonga. Also the visibility of potential impact is explained, which is, however, not noticeable yet. The inclusion of groynes in a database supports the monitoring also of these climate change mitigation elements.

2.2.1 Unique IDs of Groynes

To link tabular and spatial data of groynes these elements must have a unique ID. This was performed by a prefix GR for Groyne and a running number. The village ID of the village most close to the groyne like for the breakwater ID was not included in the unique ID for groynes.

2.2.2 Spatial Elements of Groynes in Tonga

A number of 18 groynes are available as spatial elements all located close to the villages Talafo'ou and Makaunga. These were mapped with: (i) 15 cm resolution satellite image data and are available as polygons and in addition the length was measured and (ii) through a GNSS survey of the Tonga Lands Department available as centroid and as polygon.

Figure 2.2.2-01: *Spatial element groynes digitised with 15 cm resolution space borne image data enhanced from WorldView-3 image data of 30 cm.*

2.2.3 Tabular Database Table of Groynes in Tonga

The table "Groynes_TO" keeps annotation data for every groyne and can be linked to the corresponding spatial element through the unique ID.

The content of the table shows the calculations based on the enhanced WorldView-3 image data not the GNSS mapping of the Tonga Lands Department. However, a GNSS based analysis can be added to the table.

Groynes_TO

Field Name	Data Type	Description (Optional)
Groyne_ID	Short Text	Two digit element type plus two digit running number
Groyne_ID_GNSS	Short Text	Unique ID of GNSS survey elements
Groyne_ID_old	Short Text	GR-AreaNo-Number
Village	Short Text	Next village
Area	Number	Area of of element in square metres
Length	Number	Length of element in metres
DateEstablish	Date/Time	Date the construction was finished
Origin	Short Text	Source of delineation
Comments	Long Text	Comments
Project_ID	Short Text	Country_PRJ-Shortcut
Centroid_X	Number	X-Coordinates of element centre
Centroid_Y	Number	Y-Coordinates of element centre
Area_GNSS	Number	Area of of element in square metres
Length_GNSS	Number	Length of element in metres

Figure 2.2.3-01: *Structure of the table "Groynes_TO"*

Groyne_ID

The field "Goyne_ID" is the primary key of the table with the format two digits indicating the climate change mitigation element "GR" for groyne and a two digit running number.

Groyne_ID_GNSS

This field contains the polygon ID of the Tonga Lands Department GNSS survey.

Groyne_ID_old

The field contains the unique IDs of the first GIS layers showing groynes.

Village

The field "Village" contains the full name of the next village to the breakwater where the village shortcut is part of the unique ID of the table Breakwater-TO.

Length

The field "Length" contains the length of the groyne in full metres. This was measured from spatially enhanced WorldView-3 image data. Not yet with the GNSS survey data.

Area

The field "Area" contains the area size in square metres. This was calculated with WorldView-3 enhanced image data not through GIS tools using the polygons of the Tonga Lands Department GNSS survey.

Centroid_X and Centroid_Y

The fields "Centroid_X and Centroid_Y" currently contain the UTM WGS84 coordinates of the WorldView-3 image data..

Origin

The field “Origin” contains a description how the GIS element was established.

DateEstablish

The field “DateEstablish” should contain the date the construction of breakwater element was finalised. These figures are still missing.

Comments

The field “Comments” is left for descriptions.

Project_ID

The field “Project_ID” contains the unique ID of the project table. This allows to link both tables.

Area_GNSS

The field “Area” contains the area size in square metres. This was calculated through GIS tools using the polygons of the Tonga Lands Department GNSS survey.

Length_GNSS

The field “Length” contains the length of the groyne in full metres. This was measured with the GNSS survey data.

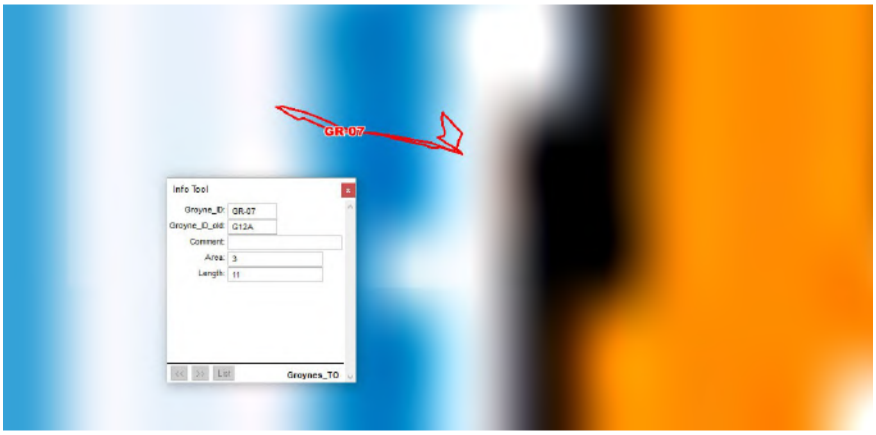
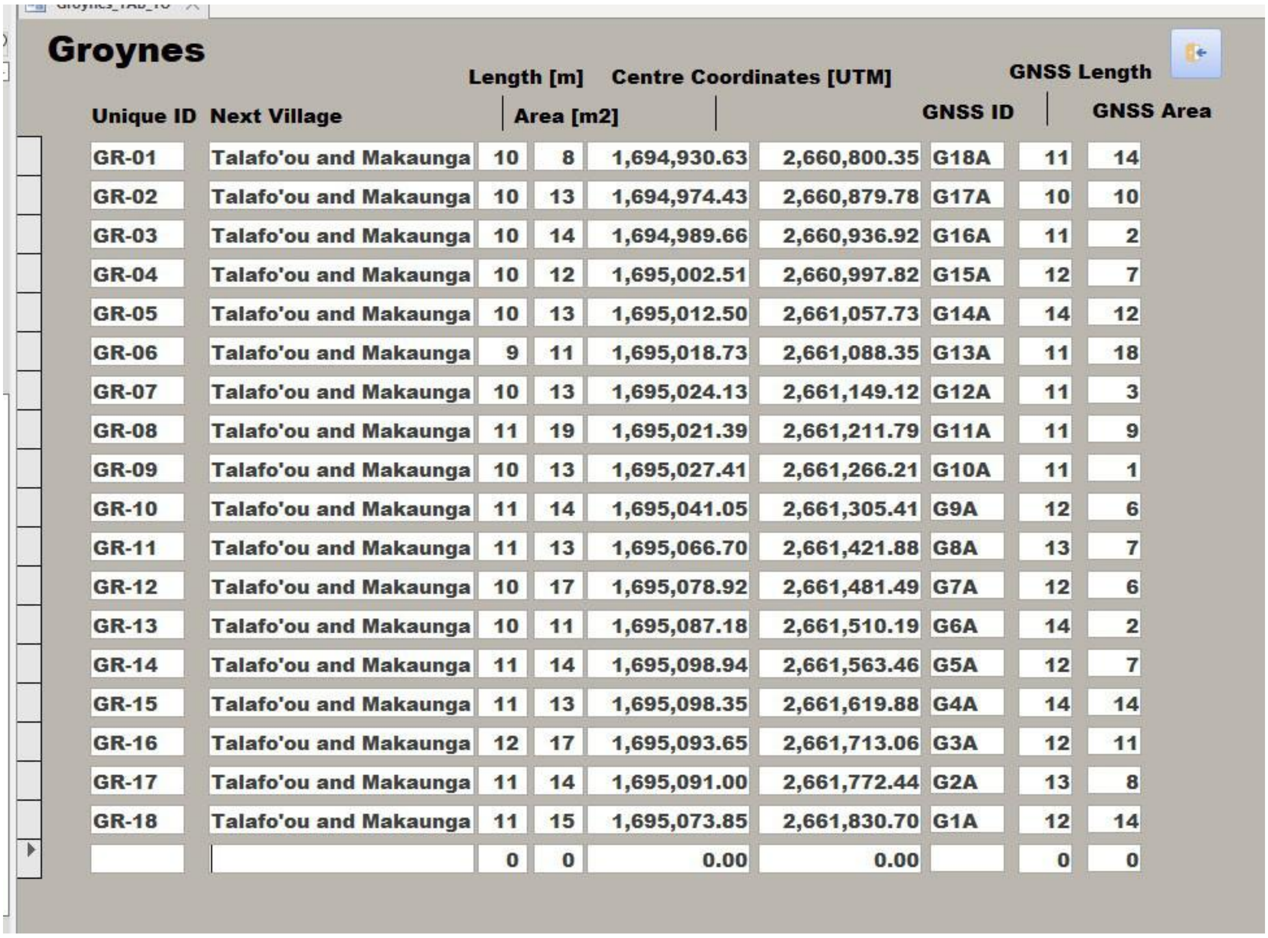


***Figure 2.2.3-02:** Length measurement of polygons created with Lands Department GNSS groyne survey. Polygon display on 1:50,000 map.*

The figure on the left shows the display of polygons superimposed on the 1:50,000 Lands Department map. It seems that the polygon did not have a differential correction yet.

The polygons drawn with satellite image data seem to be more in shape.

2.2.4 The two Forms Groynes



Groynes

Unique ID	Next Village	Length [m]	Area [m2]	Centre Coordinates [UTM]		GNSS ID	GNSS Length	GNSS Area
GR-01	Talafo'ou and Makaunga	10	8	1,694,930.63	2,660,800.35	G18A	11	14
GR-02	Talafo'ou and Makaunga	10	13	1,694,974.43	2,660,879.78	G17A	10	10
GR-03	Talafo'ou and Makaunga	10	14	1,694,989.66	2,660,936.92	G16A	11	2
GR-04	Talafo'ou and Makaunga	10	12	1,695,002.51	2,660,997.82	G15A	12	7
GR-05	Talafo'ou and Makaunga	10	13	1,695,012.50	2,661,057.73	G14A	14	12
GR-06	Talafo'ou and Makaunga	9	11	1,695,018.73	2,661,088.35	G13A	11	18
GR-07	Talafo'ou and Makaunga	10	13	1,695,024.13	2,661,149.12	G12A	11	3
GR-08	Talafo'ou and Makaunga	11	19	1,695,021.39	2,661,211.79	G11A	11	9
GR-09	Talafo'ou and Makaunga	10	13	1,695,027.41	2,661,266.21	G10A	11	1
GR-10	Talafo'ou and Makaunga	11	14	1,695,041.05	2,661,305.41	G9A	12	6
GR-11	Talafo'ou and Makaunga	11	13	1,695,066.70	2,661,421.88	G8A	13	7
GR-12	Talafo'ou and Makaunga	10	17	1,695,078.92	2,661,481.49	G7A	12	6
GR-13	Talafo'ou and Makaunga	10	11	1,695,087.18	2,661,510.19	G6A	14	2
GR-14	Talafo'ou and Makaunga	11	14	1,695,098.94	2,661,563.46	G5A	12	7
GR-15	Talafo'ou and Makaunga	11	13	1,695,098.35	2,661,619.88	G4A	14	14
GR-16	Talafo'ou and Makaunga	12	17	1,695,093.65	2,661,713.06	G3A	12	11
GR-17	Talafo'ou and Makaunga	11	14	1,695,091.00	2,661,772.44	G2A	13	8
GR-18	Talafo'ou and Makaunga	11	15	1,695,073.85	2,661,830.70	G1A	12	14
		0	0	0.00	0.00		0	0

Figure 2.2.4-01: *Form Tonga Groynes tabular display.*

The form shows both measurement of length and groyne area a) based on satellite image data (enhanced WorldView-3) and b) based on GNSS survey of Tonga Lands Department. As explained above, the polygons seem not to have a differential correction[1], therefore the mapping based on satellite image data is more reliable for the time being.

The tabular form allows display and read access, copy and past is possible. However, to edit the data the columnar display should be utilised as the tabular display blocks any change.

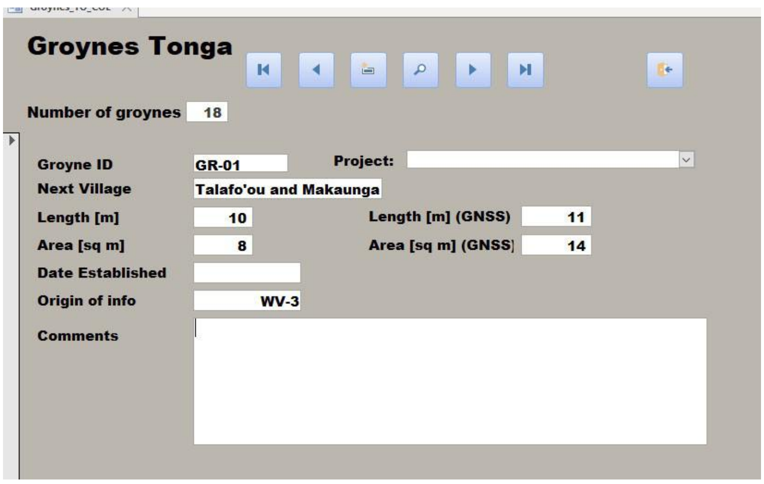


Figure 2.2.4-02: *Form columnar display of Tongan groynes*

1 Differential correction of the GNSS survey data with the base station position which eliminates most disturbance of position signals.

2.3 Revetments in Tonga

There are several revetments. Partly the revetments are difficult to recognise on satellite image data, however, the GNSS survey of Tonga Lands Department clearly indicates the location. The elements were imported to GIS and are available as line elements.

Figure 2.3-01: *The display of the spatial table "Revetments_TO"*

The length of the revetments were re-calculated in GIS environment and rounded to full metres and then exported to the tabular database.

2.3.1 The Unique ID

There are three different ID: a) the primary key field "Revetment_ID" storing the ID with which the spatial and tabular table can be linked, b) old revetment ID and c) the ID stored in the data of the GNSS survey, the field "GNSS_ID".

2.3.2 The Tabular Database Table Revetments_TO

Field Name	Data Type	Description (Optional)
Revement_ID	Short Text	Unique_ID in tabular database and GIS
Revement_ID_old	Short Text	REV-AreaNo-Number
GNSS_ID	Short Text	Village used as GNSS ID
Village	Short Text	Next village
Length	Number	Length of revetment calculated from satellite image
GNSS_Length	Number	Length GNSS survey
GNSS_GIS_Length	Number	Length GIS calculation in full metres
DateEstablish	Date/Time	Date revetment was completed
Comments	Long Text	
Project_ID	Short Text	Country_PRJ-Shortcut

Figure 2.3.2-01: *Structure of the revetments table in the tabular database*

Revetment_ID

The field "Revetment_ID" is the key field of the tabular database table.

Revetment_ID_old

The field "Revetment_ID_old" was the key field before and will be removed soon.

GNSS_ID

The field "GNSS_ID" is the field used as indicator field in the GNSS survey.

Village

The field "Village" stored the next village before the survey.

Length

The field "Length" contains the length of the lements calculated from satellite image data downloaded from Google Earth.

GNSS_Length

The field "GNSS_Length" contains length information of the survey.

GNSS_GIS_Length

The field "GNSS_GIS_Length" contains the length in full metres calculated from the GIS revetment elements. This is the figure to be utilised.

DateEstablish

The field "DateEstablish" will keep the date the revetments were established.

Comments

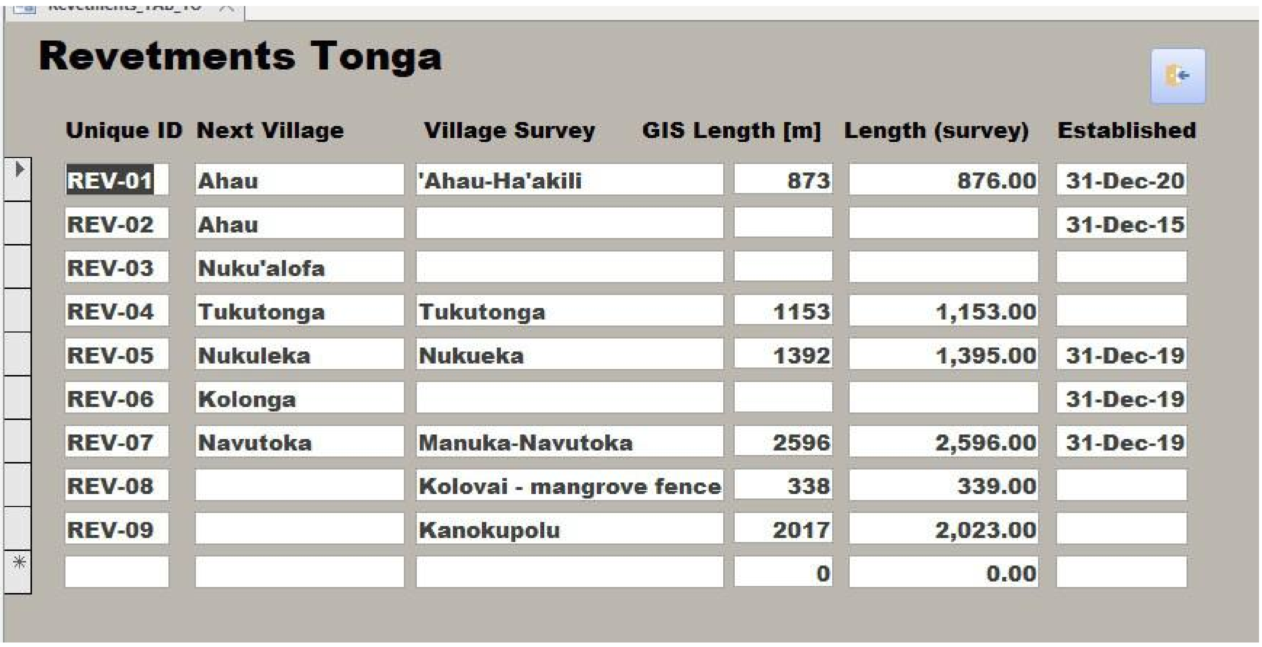
The field "Comments" keeps descriptive information about the revetments.

Project_ID

The field "Project_ID" keeps the unique ID of the project table.

2.3.3 The two Forms Revetments in Tonga

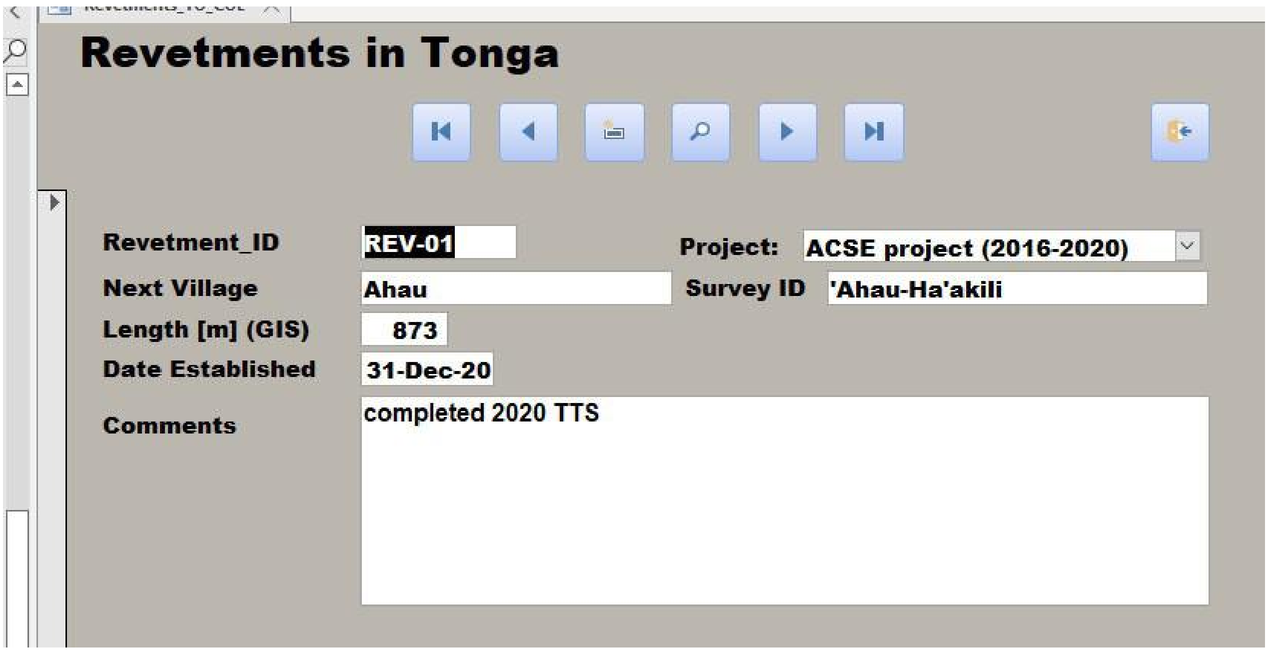
The database has a form of tabular data display of revetments where the fields are blocked for editing. The database also has a columnar display where editing is possible.



Revetments Tonga

Unique ID	Next Village	Village Survey	GIS Length [m]	Length (survey)	Established
REV-01	Ahau	'Ahau-Ha'akili	873	876.00	31-Dec-20
REV-02	Ahau				31-Dec-15
REV-03	Nuku'alofa				
REV-04	Tukutonga	Tukutonga	1153	1,153.00	
REV-05	Nukuleka	Nukueka	1392	1,395.00	31-Dec-19
REV-06	Kolonga				31-Dec-19
REV-07	Navutoka	Manuka-Navutoka	2596	2,596.00	31-Dec-19
REV-08		Kolovai - mangrove fence	338	339.00	
REV-09		Kanokupolu	2017	2,023.00	
			0	0.00	

Figure 2.3.3-01: *Tabular display of revetments in Tonga. The fields are do not allow editing.*



Revetments in Tonga

Revetment_ID	REV-01	Project:	ACSE project (2016-2020)
Next Village	Ahau	Survey ID	'Ahau-Ha'akili
Length [m] (GIS)	873		
Date Established	31-Dec-20		
Comments	completed 2020 TTS		

Figure 2.3.3-02: *Columnar display of revetments in Tonga. This form allows to add new records and to edit the content of new and existing records.*

2.4 Seawalls in Tonga

Seawalls were reported as established in Tonga. However, seawalls are difficult to see on space borne image data and they were not included in the last GNSS survey of the Tonga Lands Department. However, the tabular database included these climate change mitigation elements in Tonga.

2.4.1 The Table Seawalls in Tonga

Seawalls_TO

Field Name	Data Type	Description (Optional)
Seawall_ID	Short Text	Element indicator plus r
Seawall_ID_old	Short Text	REV-AreaNo-Number
Village	Short Text	next village
Length	Number	Length of seaall
DateEstablish	Date/Time	Date seawall finalised
Comments	Long Text	Descriptive comments
Project_ID	Short Text	Country_PRJ-Shortcut

Figure 2.4.1-01: *Structure of the table “Seawalls_TO”*

Seawall_ID

The field “Seawall_ID” is the key field of the tabular database table.

Village

The field “Village” stored the next village before the survey.

Length

The field “Length” contains the length of the elements reported.

DateEstablish

The field “DateEstablish” will keep the date the seawalls were established.

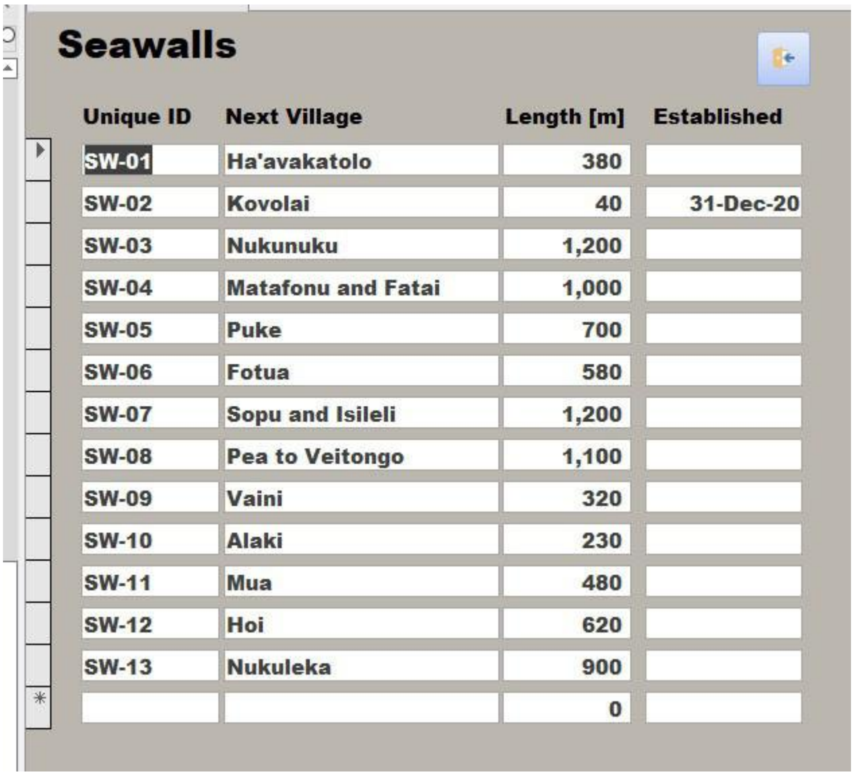
Comments

The field “Comments” keeps descriptive information about the revetments.

Project_ID

The field “Project_ID” keeps the unique ID of the project table.

2.4.2 The two Forms Seawalls



Seawalls

Unique ID	Next Village	Length [m]	Established
SW-01	Ha'avakatolo	380	
SW-02	Kovolai	40	31-Dec-20
SW-03	Nukunuku	1,200	
SW-04	Matafonu and Fatai	1,000	
SW-05	Puke	700	
SW-06	Fotua	580	
SW-07	Sopu and Isileli	1,200	
SW-08	Pea to Veitongo	1,100	
SW-09	Vaini	320	
SW-10	Alaki	230	
SW-11	Mua	480	
SW-12	Hoi	620	
SW-13	Nukuleka	900	
		0	

Figure 2.4.2-01: *Form Seawalls displaying available seawalls in tbula form.*

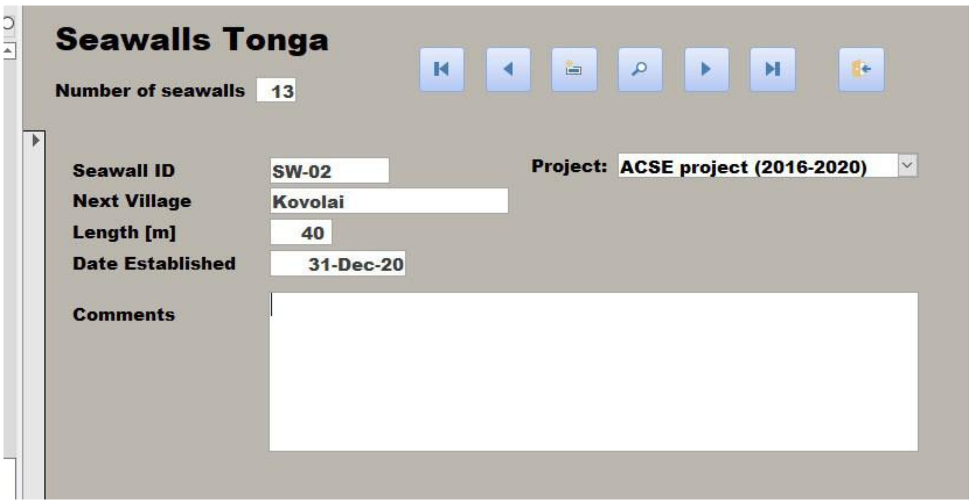


Figure 2.4.2-02: *Form Seawalls displaying the seawall records in columnar way and allowing edits.*

2.5 Roofs Kolovai

The roofs of Kolovai settlement are only one part of a database, which has to be established with the corresponding agency in Tonga.

2.5.1 Unique ID

The unique ID contains a three digit prefix "KOL" as village indicator a "R" to indacate the roof and a running number such as KOL-R074. It is expected that a tank survey will follow where the same number KOL-T074 can be used.

2.5.2 Database Table Tonga Roofs

Field Name	Data Type
ROOF_ID	Short Text
AREA	Number
CENTROID_X	Number
CENTROID_Y	Number
RoofType	Short Text

Figure 2.5.2-01: *Structure of table Roofs_TO*

The field of the table:

ROOF_ID

The field "ROOF_ID" is the key field the content is explained above.

AREA

The field "AREA" contains the area of the complete roof calculated from the digitised polygon in GIS environment and transferred to the tabular database. The values are stored as integer in full square metres.

CENTROID_X and CENTROID_Y

The fields "CENTROID_X" and "CENTROID_Y" contain the coordinates of the roof polygon in UTM coordinates.

RoofType

The field "RoofType" is currently empty. It will be filled with the corresponding roof type such as corrugated iron, timber, pantanas, etc. after the field work is finished.

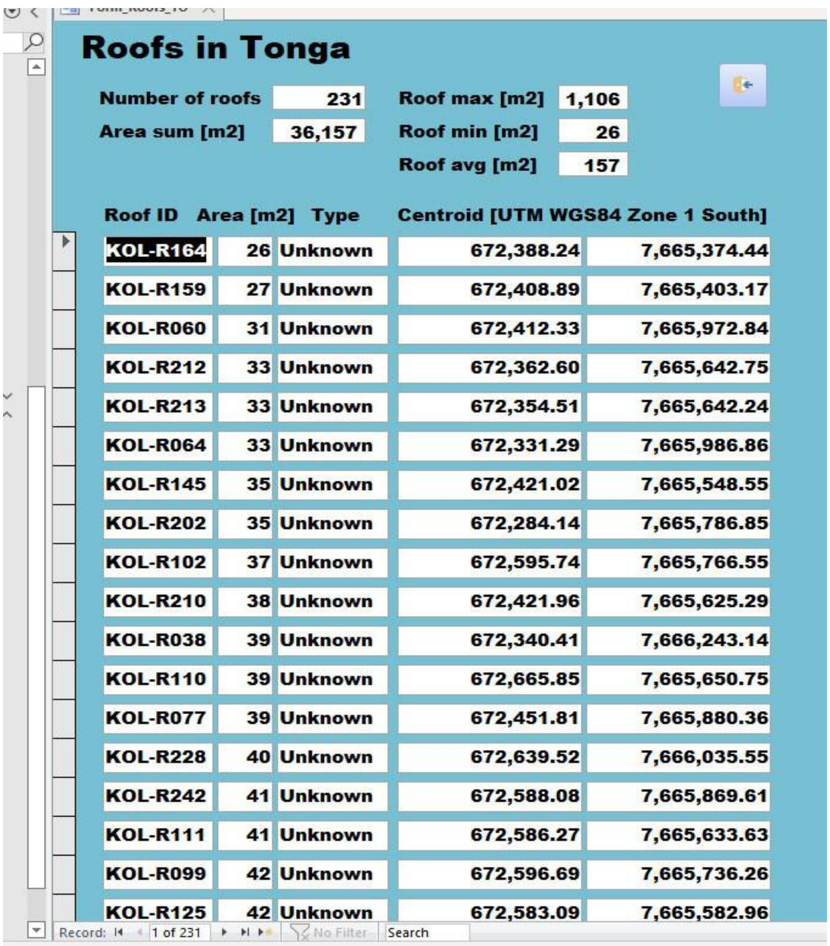
2.5.3 The Form Roofs_TO

The form "Roofs_TO" does not sit on the table "Roofs_TO". It is based on the query "Roofs_TO_Type" which connects the roof with the roof type.

The form displays the records of 231 roofs. However, the form does not allow any edits. The form only display.

The header of the form automatically performs analysis, the form:

- Counts the number of digitised roofs,
- Sums the area of all roofs to a total area,
- Provide the figures (i) smallest, (ii) largest and (iii) roof of average area.



Roofs in Tonga

Number of roofs	231	Roof max [m2]	1,106
Area sum [m2]	36,157	Roof min [m2]	26
		Roof avg [m2]	157

Roof ID	Area [m2]	Type	Centroid [UTM WGS84 Zone 1 South]	
KOL-R164	26	Unknown	672,388.24	7,665,374.44
KOL-R159	27	Unknown	672,408.89	7,665,403.17
KOL-R060	31	Unknown	672,412.33	7,665,972.84
KOL-R212	33	Unknown	672,362.60	7,665,642.75
KOL-R213	33	Unknown	672,354.51	7,665,642.24
KOL-R064	33	Unknown	672,331.29	7,665,986.86
KOL-R145	35	Unknown	672,421.02	7,665,548.55
KOL-R202	35	Unknown	672,284.14	7,665,786.85
KOL-R102	37	Unknown	672,595.74	7,665,766.55
KOL-R210	38	Unknown	672,421.96	7,665,625.29
KOL-R038	39	Unknown	672,340.41	7,666,243.14
KOL-R110	39	Unknown	672,665.85	7,665,650.75
KOL-R077	39	Unknown	672,451.81	7,665,880.36
KOL-R228	40	Unknown	672,639.52	7,666,035.55
KOL-R242	41	Unknown	672,588.08	7,665,869.61
KOL-R111	41	Unknown	672,586.27	7,665,633.63
KOL-R099	42	Unknown	672,596.69	7,665,736.26
KOL-R125	42	Unknown	672,583.09	7,665,582.96

Record: 1 of 231 No Filter Search

Figure 2.5.3-01: *Tabular display of table Roofs_TO.*

Figure 2.5.3-02: *Form for roof type input and edit of roof information*

The form "Roof_TO_COL" is designed for editing roof information. The roof type input is handled through a drop down menu where the operator selects the type. The field is linked to the library table "LT_RoofType".

The input of the roof area for houses is normally performed through update queries which replace the roof area with calculations performed in GIS environment.

2.5.4 The Spatial Data of Rainwater Harvest in Tonga

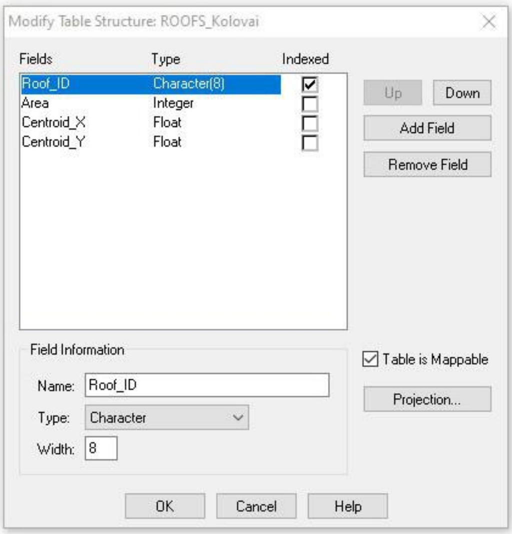
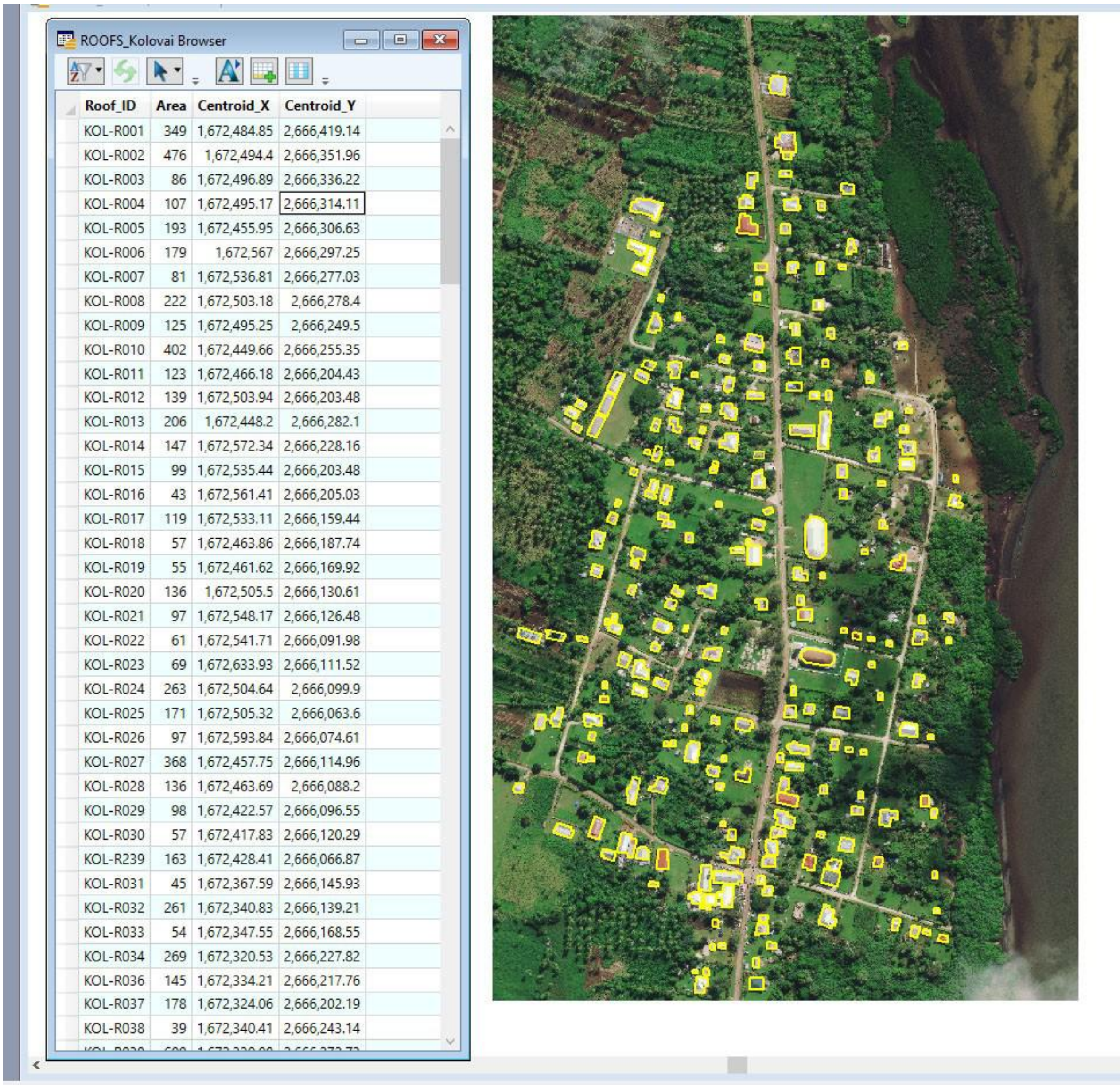


Figure 2.5.4-01: *GIS table "Roofs_Kolovai"*

The project purchased emhanced WorldView 3 image data.

Image data was purchased for complete Hihifo. These image data were converted to a GIS backdrop covering Kolovai allowing digitising of the roofs in GIS environment. So far only roofs for this village were captured through digitising to provide an example. GIS backdrops for other areas of the corresponding peninsula can be produced any time.

The GIS table "Roofs_Kolovai" does not have the field roof type as this can beadded "on-the-fly" when linking tabular and spatial table. This is necessary for the input of the roof material as this influences the water quality for rainwater harvest.



Roof_ID	Area	Centroid_X	Centroid_Y
KOL-R001	349	1,672,484.85	2,666,419.14
KOL-R002	476	1,672,494.4	2,666,351.96
KOL-R003	86	1,672,496.89	2,666,336.22
KOL-R004	107	1,672,495.17	2,666,314.11
KOL-R005	193	1,672,455.95	2,666,306.63
KOL-R006	179	1,672,567	2,666,297.25
KOL-R007	81	1,672,536.81	2,666,277.03
KOL-R008	222	1,672,503.18	2,666,278.4
KOL-R009	125	1,672,495.25	2,666,249.5
KOL-R010	402	1,672,449.66	2,666,255.35
KOL-R011	123	1,672,466.18	2,666,204.43
KOL-R012	139	1,672,503.94	2,666,203.48
KOL-R013	206	1,672,448.2	2,666,282.1
KOL-R014	147	1,672,572.34	2,666,228.16
KOL-R015	99	1,672,535.44	2,666,203.48
KOL-R016	43	1,672,561.41	2,666,205.03
KOL-R017	119	1,672,533.11	2,666,159.44
KOL-R018	57	1,672,463.86	2,666,187.74
KOL-R019	55	1,672,461.62	2,666,169.92
KOL-R020	136	1,672,505.5	2,666,130.61
KOL-R021	97	1,672,548.17	2,666,126.48
KOL-R022	61	1,672,541.71	2,666,091.98
KOL-R023	69	1,672,633.93	2,666,111.52
KOL-R024	263	1,672,504.64	2,666,099.9
KOL-R025	171	1,672,505.32	2,666,063.6
KOL-R026	97	1,672,593.84	2,666,074.61
KOL-R027	368	1,672,457.75	2,666,114.96
KOL-R028	136	1,672,463.69	2,666,088.2
KOL-R029	98	1,672,422.57	2,666,096.55
KOL-R030	57	1,672,417.83	2,666,120.29
KOL-R239	163	1,672,428.41	2,666,066.87
KOL-R031	45	1,672,367.59	2,666,145.93
KOL-R032	261	1,672,340.83	2,666,139.21
KOL-R033	54	1,672,347.55	2,666,168.55
KOL-R034	269	1,672,320.53	2,666,227.82
KOL-R036	145	1,672,334.21	2,666,217.76
KOL-R037	178	1,672,324.06	2,666,202.19
KOL-R038	39	1,672,340.41	2,666,243.14

Figure 2.5.4-02: *Backdrop Kolovai with roof polygons and open GIS table*

Figure 2.5.4-03:*Image coverage Hihifo, image data see chapter 6*

3 Rainwater Harvest Database Palau

The procedure of monitoring and predicting rainwater harvest in Palau was described in Situation Report Palau Version 2 from 22 March 2022. This report will detail the available spatial and tabular data.

There are several steps to estimate rainwater harvest potential for a village:

(i) the roof areas total can be set into relation to the tank capacity as total. This allows a very rough estimation between villages which have no potential and villages which have the potential to capture rainwater. This requires a) a digitising of roof area and b) a survey detailing the tank capacity as estimated sum.

(ii) The tanks and estimated tank capacity can be related to the roofs and roofs not connected to tanks are taken out of the equation. This requires a) digitising of roofs and b) a survey detailing which tank is connected to which roof.

(iii) The roofs are divided into catchment areas as the rainwater is not always captured by all parts of the roof. The 15 cm resolution image data allow the area estimation for each catchment area separately. In the field it is difficult to measure roof areas and catchment areas subdividing the roofs. However, it is possible to estimate the area percentage of each catchment from the total roof area. New is that the 15 cm resolution image data enable the digitising of the roof catchment area directly as explained in the next pages.

3.1 Spatial Data Angaur Rainwater Harvest

The project purchased WorldView 3 image data captured on 20th May 2021 providing 50 cm spatial resolution. The resolution was downsampled to 15 cm resolution by company BLUECHAM. Original Image Data

Figure 3.1.1-01: *The original image data as TIFF converted to ERDAS IMG format files displayed with ERDAS software. There are four separate files.*

The image files have a size of about 500 MB far too large to be handled smoothly with GIS software. Out of the four image files one file was produced covering the village with the name "Subset_03". This file has a size of 19 MB.

3.1.1 GIS Image Backdrops

The image file Subset-03 was converted into a GIS backdrop visible with figure 3.1.2-01. The file still has a size of 180 MB, too large as backdrop for digitising.

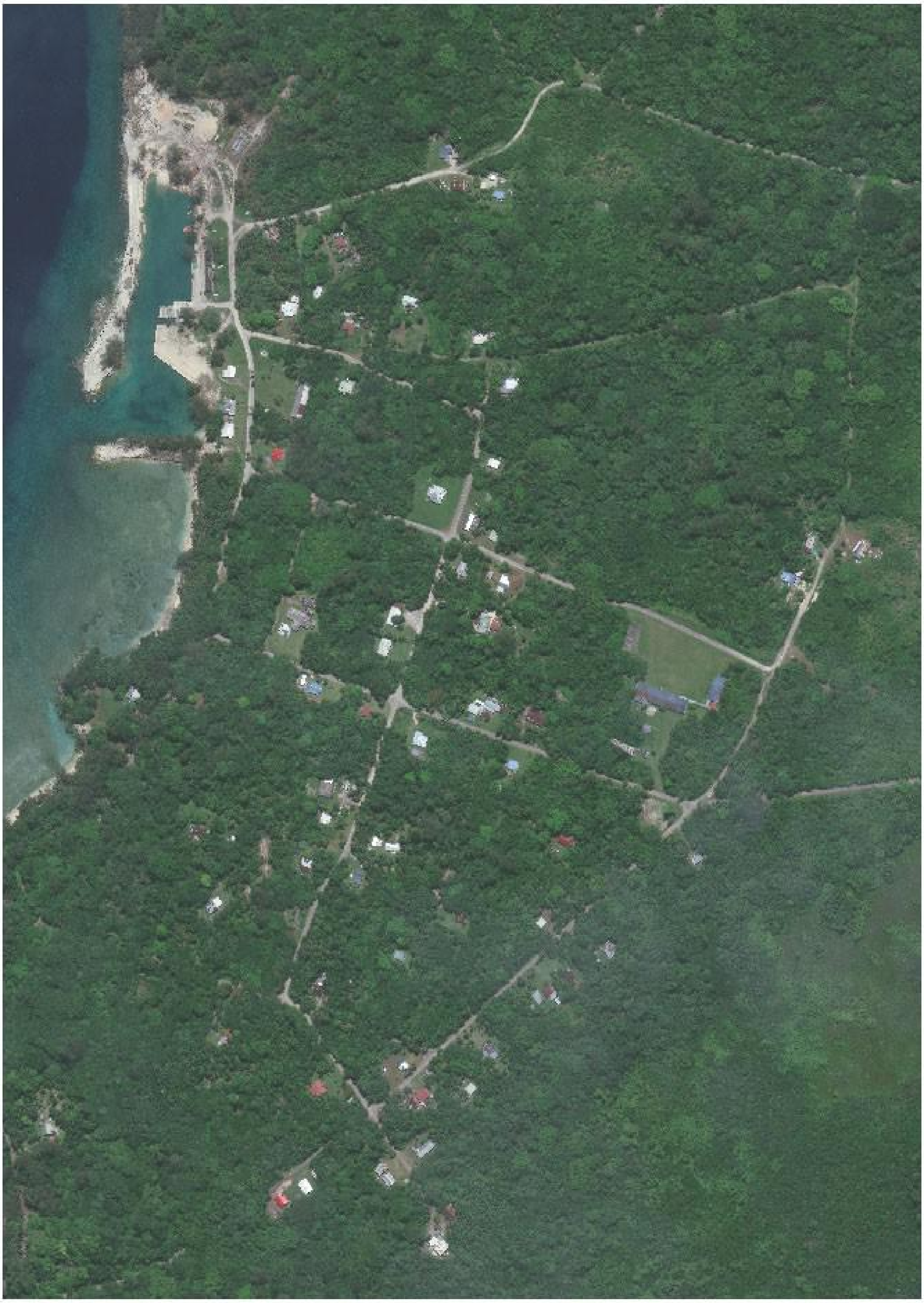


Figure 3.1.1-01: *Image backdrop Subset-03. Coverage of all houses*

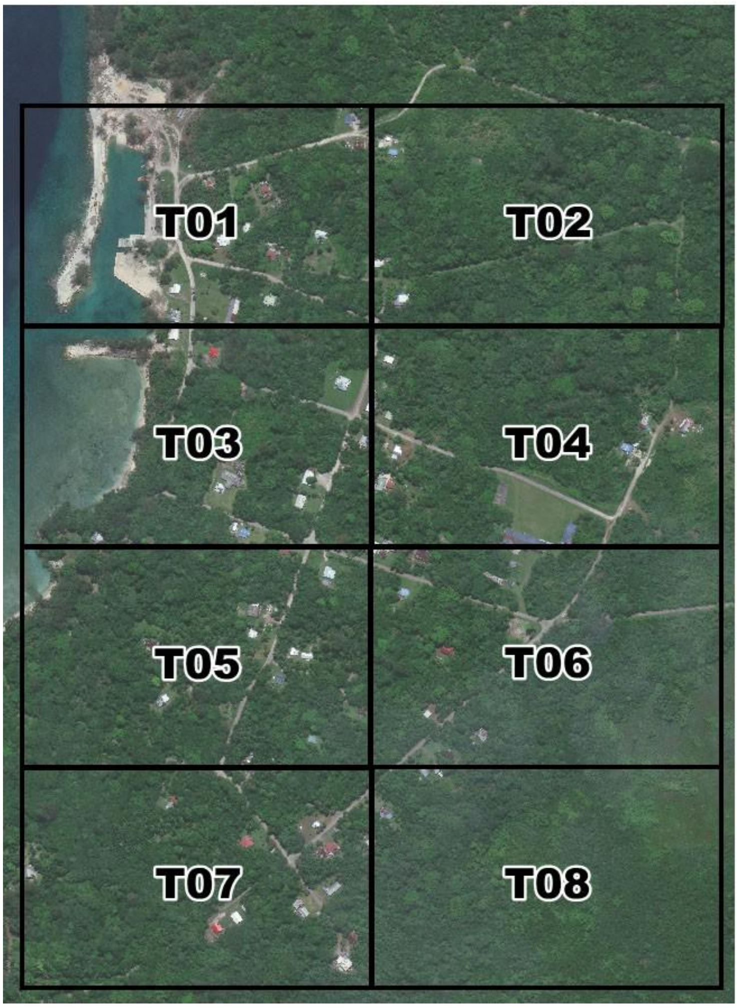


Figure 3.1.1-02: *Image backdrop Subset-03 with grid overlay,*

Figure 3.1.1-02 shows the grid superimposed over the Subset-03 backdrop.

For each of the grid cells an own GIS backdrop was produced where figure 3.1.1-03 shows the backdrop covering the grid cell of tile 01.

The file size of the backdrops covering a tile was then reduced to about 19 MB and digitising allowed a fast zooming in and out.

Figure 3.1.1-04 shows the full potential of 15 cm resolution data which allow a precise digitising of the roofs.

3.1.1-03: *Image backdrop Subset-03 Tile 01.*

Figure 3.1.1-04: *When zoom in to a backdrop the full potential of the 15 cm resolution image data is visible.*

3.1.2 Roof and Tank Position Vector Data

Figure 3.1.2-01: *Roofs and water tanks of image tile "T05". The roof IDs are in red letters and the tank IDs in blue ones.*

There are two GIS tables keeping vector data important for rainwater harvest:

a) “Roofs_Angaur” which stores the polygons of the roof digitising and

b) “TankPosition_02” which stores the position of water tanks

MapInfo Table Roofs_Angaur

The field “**Roof_ID**” keeps the Access key field content Tile ID prefix “R” for roof element and running number such as T05-R009

The field **“RoofArea”** stores the roof area in full square metres.

The field **“Material”** keeps the three digit indicator of the roof material. This field is added to allow to store the interpretation result in the screen display without linking the Access and MapInfo table.

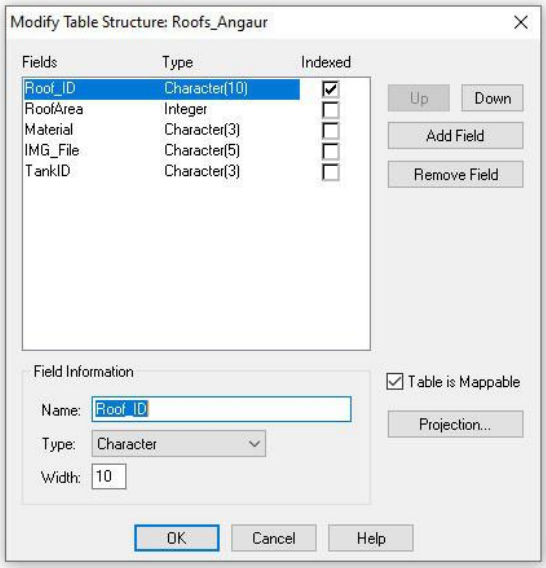


Figure 3.1.2-02: *Structure of MapInfo table “Roofs_Angaur”*

The field **“IMG-File”** stores the name of an image backdrop used for roof display on small image files before working in eight tiles.

The field **“TankID”** is used to store on the screen display the next tank to the roof assuming that the tank belongs to the corresponding roof.

MapInfo Table TankPosition_02

The field **“Tank_ID”** stores the Access primary key field content of the tank indicator which a running number.

The fields **“LAT”** and **“LONG”** keep the latitude and longitude position of the tank survey.

The tank positions were created from the Lat and Long position delivered by the Palau field team.

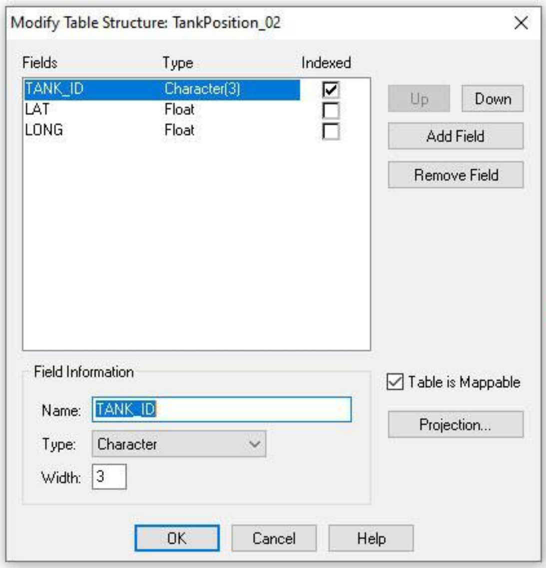


Figure 3.1.2-02: *Structure of MapInfo table “TankPosition_02”*

3.1.3 Potential of Roof Subdivision to Catchment Areas

Figures 3.1.3-01 and 3.1.3-02 show that the image data provide the potential to digitise the separate water catchment areas of a roof in the office of Palaris. The field team can be equipped with images having the roof and catchment IDs superimposed.

Figure 3.1.3-01: *Roof WorldView-3 data 50 cm resolution*

Figure 3.1.3-02: *Roof WorldView-3 data 15 cm resolution. Also the tank seems to be visible.*

3.2 The Tabular Data for Angaur Rainwater Harvest

The database is a proposal to estimate the rainwater harvest with the details of roof catchments, subdividing the roofs into sub-areas draining into different tanks as explained at the beginning of chapter three.

The database “RainwaterCatchment_PW” has tables for all elements necessary to monitor and predict rainwater harvest:

- Roofs,
- Roof Catchments,
- Gutter,
- Downpipes,
- Tanks.

In addition, the database has library tables to ensure normed categories describing type or condition. These tables are:

- LT_DonpipeType
- LT_DownpipeCondition
- LT_GutterCondition
- LT_GutterType
- LT_RoofType
- LT_RoofType02
- LT_TankCondition
- LT_TankFoundation
- LT_TankType

3.2.1 Palau Database Table Roofs

Field Name	Data Type	Description (Optional)
ROOF_ID	Short Text	Unique ID: IMG-TileID, "R" + running number
ROOFAREA	Number	Roof ara in sq m
MATERIAL	Short Text	Roof material se LT RoofType02
IMG_FILE	Short Text	Image file of a GIS backdrop of sub-image showing the roof
TANKID	Short Text	Unique ID of the tank the roof is connected with
VillageName	Short Text	Village name the house is located in
IslandName	Short Text	Island name the village is located in
RoofYN	Short Text	Roof as catchment or roof without harvest faclities

Figure 3.2.1-01: *Structure of table Roofs*

The table Roofs currently contains the roofs of Angaur only. Every record has a corresponding record in the GIS table “Angaur_Roofs”.

Field ROOF_ID

The field “ROOF_ID” keeps the unique ID of the database and GIS object Roof. It has following format: **T01-R003** (i) Three digits are reserved for the tile ID such as T05 where it is expected that the image files and subsequently the roof ID will be handled separately for every village. In case a table will be established for complete Palau the village name and the island name will be added.

They are stored in the same table and can be linked into the unique ID. (ii) "R" as roof indicator and a three digit running number. ***The numbering starts with 001 for every tile!***

Field ROOFAREA

The field "ROOFAREA" keeps the area figure in square metres calculated by the GIS software.

Field MATERIAL

The field "MATERIAL" is a three digit text field keeping the unique ID of the library table "LT_RoofType" indicating the type of roof such as corrugated iron, cement, pandanas, etc. This has influence on the quality of the harvested water.

Field IMG_File

The field "IMG_File" stores the file name of the image file of a GIS backdrop sub-image showing the roof.

Field VillageName

The field "VillageName" keeps the village name the house is located in.

Field IslandName

The field "IslandName" keeps the island name the village and house is located in.

Field RoofYN

The field "Roof_YN" is a one digit field with allowed content either "Y"or "N" indicating a roof as catchment or roof without harvest facilities. Currently all roofs have a "N" as indicator until the database is filled with content.

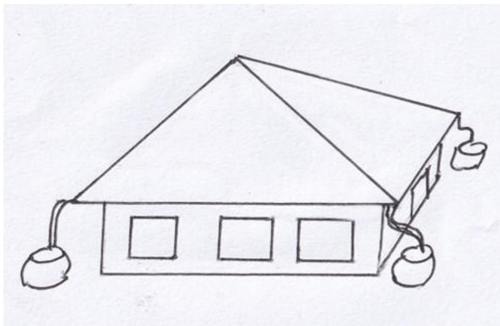


Figure 3.2.1-02: *Roof with several rainwater catchments.*

3.2.2 Palau Database Table RoofCatchment

Field Name	Data Type	Description (Optional)
Catchment_ID	Short Text	1 Digit "C" + 2 digitis catchment
Roof_ID	Short Text	6 digits roof-ID
PercentRoof	Number	% of roof area
CatchmentArea	Number	Calculated area of catchment
RoofType	Short Text	Linked to table roof type
Active	Short Text	Either UNC = unclear or YES = actively connected to tank Or "NO" not connected to a tank

Figure 3.2.2-01: *Structure of table RoofCatchment*

One roof can have several catchments and they might be only partly connected to water tanks see figure 3.2.2-02. This is the reason for the establishment of the table "RoofCatchment". The table is not populated with real data yet.

Field Catchment_ID

The field Catchment_ID is a three digit field with "C" as catchment indicator with a two digit running number. The field creates together with the field "RoofID"an unique ID.

Field Roof_ID

The field "Roof_ID" keeps the roof ID of the table roof.

Field PercentRoof

The field "PercentRoof" keeps the estimated percentage of of the catchment are from the complete roof area. For field teams it will be difficult to measure the area, however, it will be possible to estimate the area percentage of the total roof area. For the example shown in figure 3.2.2-02 it will be 25 % for every of the four roof catchment areas.

Field CatchmentArea

The field "CatchmentArea" stores the database calculation in square metres of the calculated catchment area. The area stored in table "Roofs" will be reduced to the actual catchment area.

Field RoofType

The field "RoofType" redefines the roof type of the catchment. Normally there will be only one roof type, however, it is possible that different catchments have different roof materials.

Field Active

The field "Active" indicates if the catchment is actively connected to tank not connected. It contains "UNC" if the situation is unclear to avoid Null values in the table.

3.2.3 Palau Database Table WaterTanks

Field Name	Data Type	Desc
Tank_ID	Short Text	Three digit running number
TankVol	Number	Tank volume in gallon
Material	Short Text	Tank material linked to library table TankType
lat	Short Text	
long	Short Text	
Roof_ID	Short Text	Roof_ID of table Roofs

Figure 3.2.3-01: *Structure of table Tanks*

The table Tanks was converted from a spreadsheet to an Access database table. It has to be changed as the functionality needs to address the GIS requirements.

Field Tank_ID

The field "Tank_ID" is currently a three digit text field keeping the number of assigned to more than 40 water tanks. This is without any problems being in a tabular database only, however, this table needs a link to the spatial table and sub-areas are very helpful to keep an overview. Sub-areas are map sheets or with the example of the table "Roofs" image tiles.

Field TankVol

The field “TankVol” stores the volume of the water tank in an integer field which does not allow digits behind the point, which is actually not neded.

Field Material

The field material stores the characteristics of the tank regarding the material in a three digit text field. The field is linked to the library table “LT_TankType”.

Fields Lat and Long

The fields “Lat” and “Long” store the geographical coordinates in decimal format.

3.2.4 Palau Database Table Downpipe

The table “Downpipe” keeps the details of the downpipe. Downpipes are parts of the rainwater harvest facilities and equally important as gutter, catchments and water tanks. If the downpipe is missing of not functioning the harvest of rainwater is interrupted.

Field Name	Data Type	Description (Optional)
Downpipe_ID	Short Text	1 Digit "D" + 2 digitis downpipe number
Roof_ID	Short Text	8 digit number 3 digits tile ID + "-" + "R" + 3 digit number
ConnectedGutter1	Short Text	Gutter_ID
ConnectedGutter2	Short Text	Gutter_ID
DownPipeType	Short Text	Linked to table DownPipeType
DownPipeCondition	Short Text	Linked to table DownPipeCondition
Connected_G	Short Text	Either "UN" = unclear or "YES" = connected to gutter Or "NO" not connected to gutter
Connected_T	Short Text	Either "UN" = unclear or "YES" = connected to tank Or "NO" not connected to tank
Tank	Short Text	Tank ID (unique together with Roof_ID) the tank the downpipe is supposed to be connected to

Figure 3.2.4-01: *The structure of table “Downpipe”*

Field Downpipe_ID

The field Downpipe_ID is a three digit field assigned to the downpipe of a house.

Field DownPipeCondition

The field “DownPipeCondition”is linked to the library table with the same name. It is a 4 digit text field and can only contain text of the library’s key field.

Field Connected_G

The field “Connected_G” is a three digit text field containing either “UN” = unclear or “YES” = connected to the gutter or "NO" not connected to the gutter. Other content is not possible through the fields validation rule.

Field Connected_T

The field “Connected_T” is a three digit text field containing either “UN” = unclear or “YES” = connected to the tank or "NO" not connected to the tank. Other content is not possible through the fields validation rule.

Field Tank

The field “Tank” is currently a three digit text field containing the tank number the downpipe is connected to. The field tank should change when the key field of the tank table changes. Currently the tanks have numbers from 001 to 043. A better overview would be if the tank numbers changing accordingly to the roofs which contains the ID of the image tiles.

3.2.5 Palau Database Table Gutter

The table "Gutter" keeps the details of the gutter type and condition. If the gutter is missing or leaking the functioning the harvest of rainwater is affected.

Field Name	Data Type	Description (Optional)
Gutter_ID	Short Text	
Roof_ID	Short Text	
Catchment_ID	Short Text	The catchment the gutter is linked to
GutterType	Short Text	Linked to table GutterType
OpenClosed	Short Text	Either UNC = unclear or YES = open Or "NO" closed
Condition	Short Text	Linked to table GutterCondition

Figure 3.2.5-01: *The structure of table "Gutter"*

Field Gutter_ID

The field Gutter_ID was a three digit field assigned to the gutter of one catchment area and linked to the catchment ID. This has been changed to the new structured key field explained in chapter 4 which is describing the example database.

Field Condition

The field "Condition" is linked to the library table "LT_GutterCondition". It is a 4 digit text field and can only contain text of the library's key field. The field "Condition" can also contain "NOCO" which means no connection which replaces the field "OpenClose".

Field Catchment_ID

The field "Catchment_ID" stores the catchment ID the gutter is linked to. The table gutter does not contain the downpipe ID it is linked to as a gutter can be linked to several downpipes. The gutter ID therefore is stored in the table downpipe.

Field GutterType

The field "GutterType" is a three digit text field containing the key-field of the library table ."LT_GutterType".

3.2.6 Library Tables Introduction

So called "library tables" have the purpose to allow the operator of a main table to choose an input rather than to type the content. This is (i) faster, (ii) ensures to avoid spelling mistakes which creates wrong answers when selecting records and (iii) allows to shorten the stored content to the key field of the library table.

Field Name	Data Type
DownPipeType_ID	Short Text
DownPipeType	Short Text

Figure 3.2.6-01: *Structure of a library table*

The structure for all listed library tables is the same as for the example table "LT_DownpipeType". The ID is shortened to three digits only and the explanation (here downpipe type) contains the explanation of the content. The operator filling the main table sees the explanation but the key field content is stored. Spelling mistakes are avoided and the input is fast.

3.2.7 Library Table LT_DownpipeType

DownPipeTy	DownPipeType	Click to Add
MET	Metal	
PVC	PVC	
UNK	Unknown	

Figure 3.2.7-01: *Content of a library table DownpipeType*

The library table "LT_DownpipeType" only contains three records. However, it can be added if other material than metal or PVC is found.

3.2.8 Library Table LT_DownpipeCondition

Condi	Condition	NoID
DAMA	Damaged	3
GOOD	Good	5
LEAK	Leaking	4
MISS	Missing	1
NCON	Not connected to tank	2
NOAP	Not applicable	0
UNKN	Unknown	6

Figure 3.2.8-01: *Content of a library table DownpipeCondition*

The library table "LT_DownpipeCondition" also keeps the ID of the spreadsheet the team was using during the first survey.

In general it has proven to be more practical to use shortcuts indicating the condition rather than numbers.

3.2.9 Library Table LT_GutterCondition

Condition_ID	Condition	Click to
DAMA	Damaged	
GOOD	Good	
LEAK	Leaking	
MISS	Missing	
NOAP	Not applicable	
NOCO	Not connected to downpipe	
UNKN	Unknown	

Figure 3.2.9-01: *Content of library table LT_GutterCondition*

3.2.10 Library Table LT_GutterType

The different gutter types were copied from the spreadsheets of the rainwater harvest survey carried out in Angaur.

LT_GutterType

GutterType_	GutterType	Click to Add
ALU	Aluminium	
GAL	Galvanised Steel	
UNK	Unknown	
VIN	Vinyl	
ZIN	Zinc	

Figure 3.2.10-01: *Content of library table LT_GutterType*

3.2.11 Library Table LT_RoofType

RoofType_II	RoofType	Click
CON	Concrete	
CUR	Currugated Iron	
MET	Metal	
PAN	Pandanas	
UNK	Unknown	
WOO	Wooden roof	

Figure 3.2.11-01: *Content of library table LT_RoofType*

3.2.12 Library Table LT_TankCondition

Condition_ID	Condition
CORR	Corroded
GOOD	Good
LEAK	Leaking
NOAP	Not applicable
UNKN	Unknown

Figure 3.2.12-01: *Content of library table LT_TankCondition*

3.2.13 Library Table LT_TankFoundation

LT_TankFoundation

Foundation_ID	TankFoundation
CON	Concrete
SOI	Soil
TIM	Timber
UNC	Unclear

Figure 3.2.13-01: *Content of library table LT_TankFoundation*

3.2.14 Library Table LT_TankType

TankType_ID	TankType
CON	Concrete
FIB	Fiberglass
MET	Metal
PLA	Plastics
PVC	PVC
STE	Stainless Steel
UNK	Unknown

Figure 3.2.14-01: *Content of library table LT_TankType*

3.3 Important Forms

There are about 10 different forms available in the database where only the important ones will be explained.

3.3.1 The MainForm

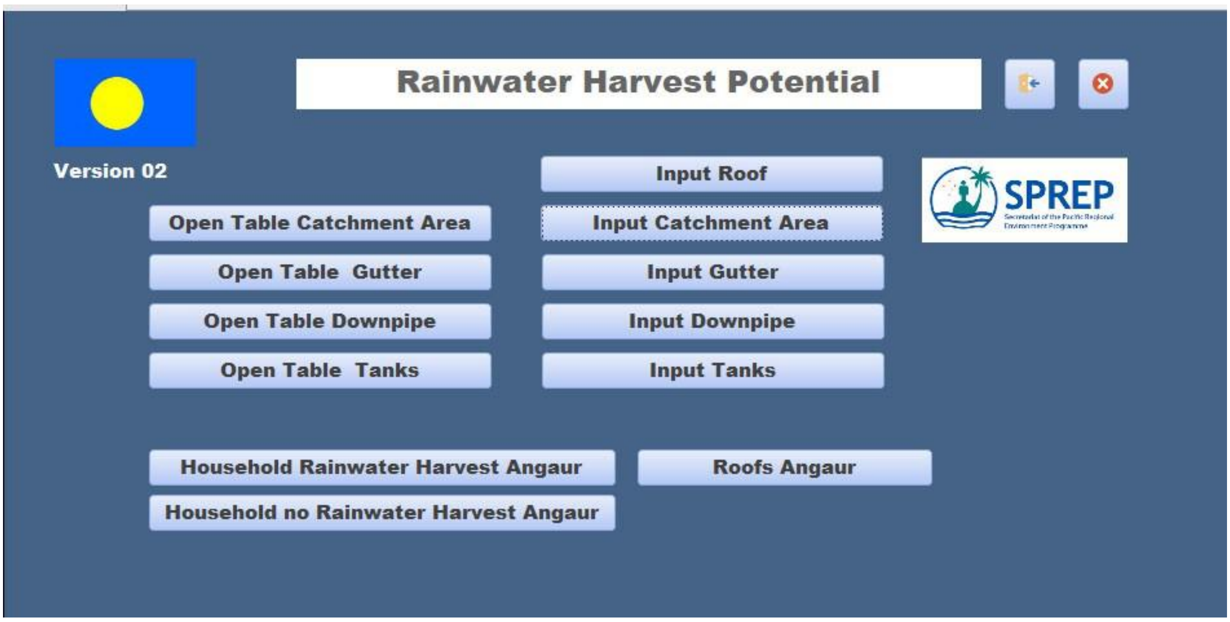


Figure 3.3.1-01: *The main form which automatically appears when opening the database.*

The left buttons of the main form displayed in figure 3.3.1-01 opens the different tables while the right buttons open another form. This form allows to select a roof and concentrating input to catchment areas, gutter, downpipes or tanks connected to the roof. The three buttons on the bottom open analysis forms.

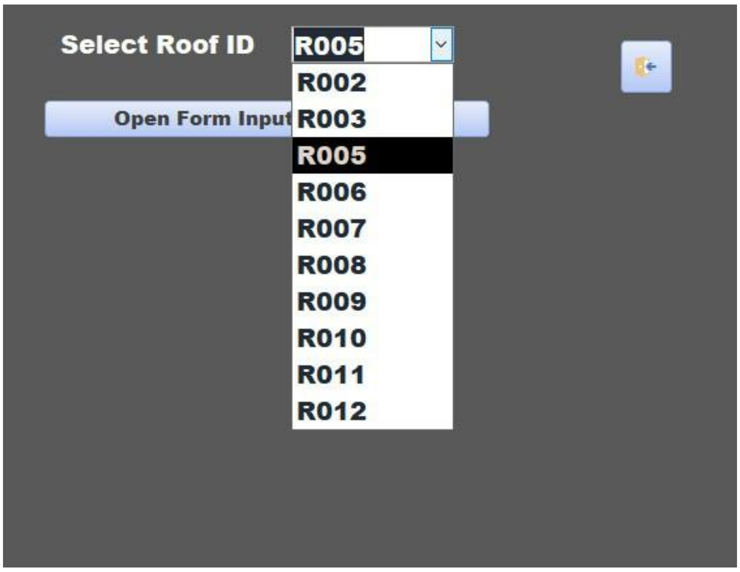


Figure 3.3.2-01: *Form allows to select a roof ID*

3.3.2 Selecting Rainwater Harvest Elements

The form "SelectRoof_ID" provides a drop down menu to select a roof ID. When clicking the button "Input Catchment Area" a selection of the table "RoofCatchment" is extracted for the input of details regarding this particular catchment. This performed through a small code embedded into the form linked to the button. The lines of code are:

```
Private Sub OpenFormGutter_Click()
  Dim VRoof_ID As String
  VRoof_ID = [Forms]![SelectRoof_ID]![Combo4]
  DoCmd.OpenForm "RoofCatchment", acNormal, , "[RoofCatchment].[Roof_ID] = '" + VRoof_ID + "'"
End Sub
```

The little program copies the content of the field "Combo4" of form "SelectRoof_ID" containing the selected roof. Then it opens the form "RoofCatchment" which sits on the table "RoofCatchment" and displays all records with a field content equal to the selected roof ID.

3.3.3 Editing and Input of Information

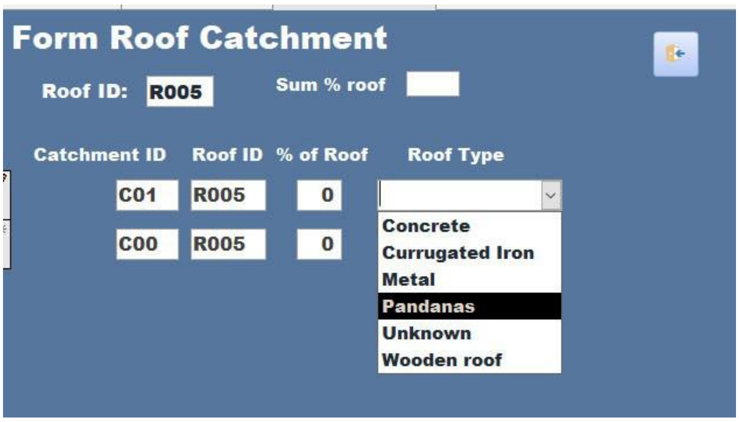


Figure 3.3.3-01: *Input of catchment information*

The form "RoofCatchment" currently displays records having the selected roof ID "R005" (see figure 3.3.2-01) as roof ID in the corresponding field.

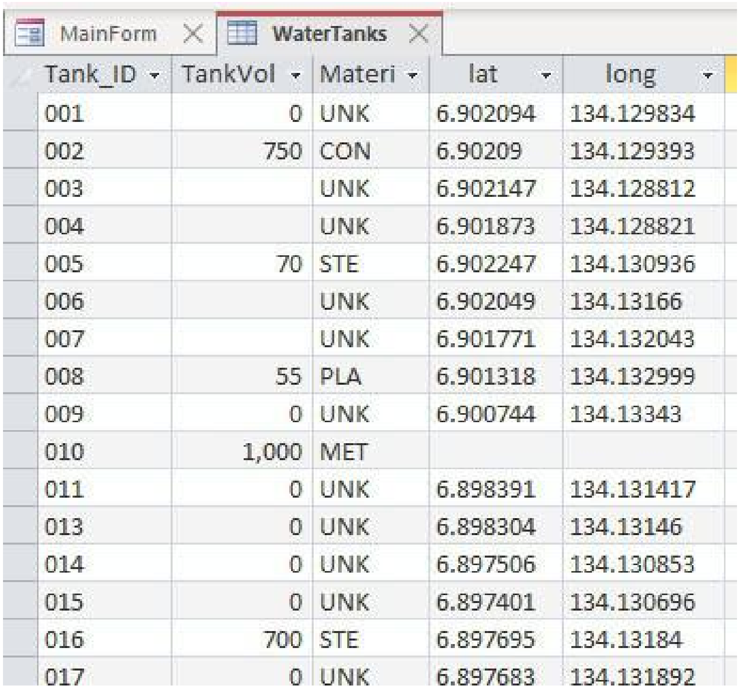
Now the user can perform the input of the (i) catchment ID which creates together with the roof ID the key field[2], (ii) the percentage of the complete roof the catchment covers with its area and (iii) the roof type.

The form does not ask for the connected downpipe as this information is stored in he table "DownPipe".

The information input for gutters, downpipes and tanks follows the same structure.

By clicking the button "Open Table Tanks" the table "WaterTanks" will be opened for display of all records, see figure 3.3.3-02. Content can be changed in the table. Th field Roof_ID is not displayed as this is still empty in this table.

The structure in the example database has changed. There the field "Tank_ID" also contains the roof ID.



Tank_ID	TankVol	Materi	lat	long
001	0	UNK	6.902094	134.129834
002	750	CON	6.90209	134.129393
003		UNK	6.902147	134.128812
004		UNK	6.901873	134.128821
005	70	STE	6.902247	134.130936
006		UNK	6.902049	134.13166
007		UNK	6.901771	134.132043
008	55	PLA	6.901318	134.132999
009	0	UNK	6.900744	134.13343
010	1,000	MET		
011	0	UNK	6.898391	134.131417
013	0	UNK	6.898304	134.13146
014	0	UNK	6.897506	134.130853
015	0	UNK	6.897401	134.130696
016	700	STE	6.897695	134.13184
017	0	UNK	6.897683	134.131892

Figure 3.3.3-02: *Opening the table "WaterTanks"*

2 This structure has changed in the example database

3.3.4 Analysis Form “Form_AngaurRoofs”

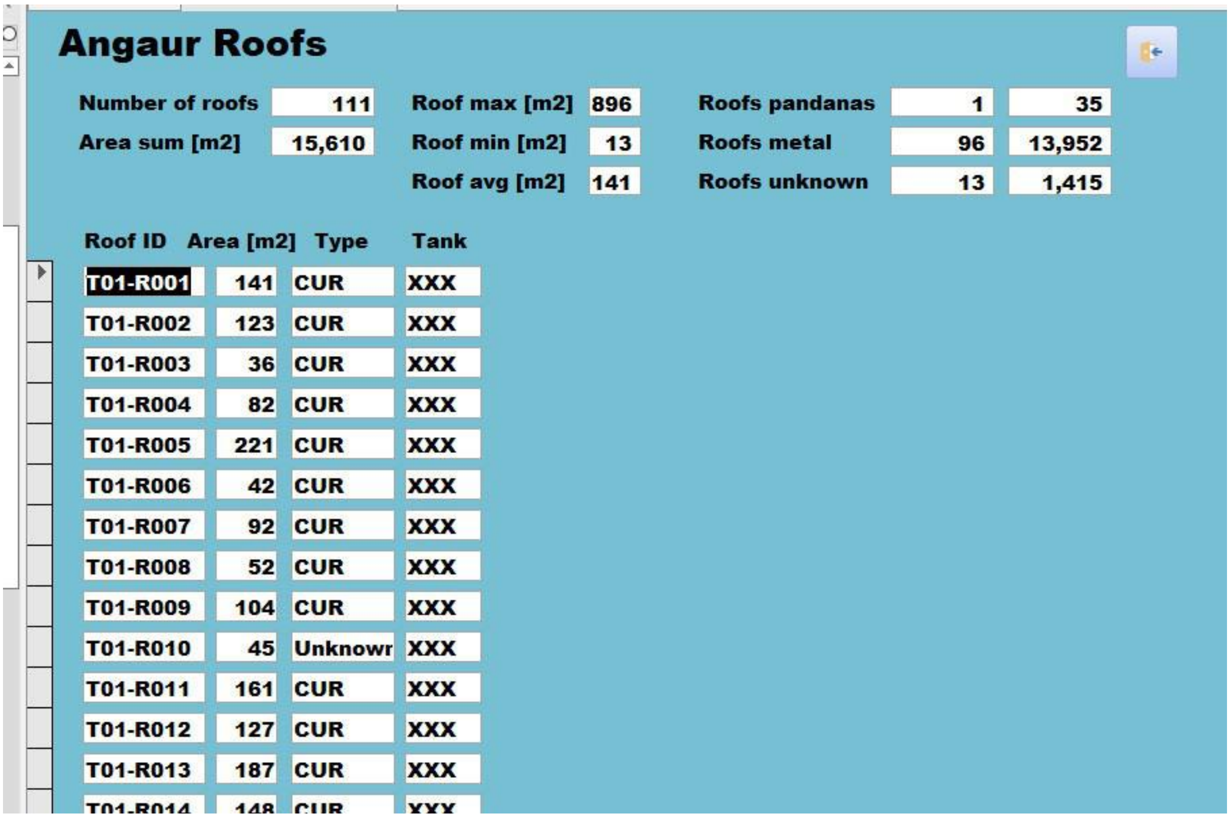


Figure 3.3.4-01: *Display and analysis of digitised roofs in Angaur. The tanks are not linked yet and the link is structured slightly different in the example database shown in chapter 4.*

The forms displayed in figure 3.3.4-01 shows all roof records in tabular format. The form also analysis the roofs through functions placed in fields of the form header. See below two examples:

1) To calculate the total roof area of al roofs the function DSum is used which goes the table “Roofs” and sammrises the m^2 values stored in the field “ROOFAREA”. The code is: **=DSum("[ROOFAREA]","Roofs")**

2) The average roof size is calculated by function “DAvg” which also goes to the table “Roofs”. The code is: **=Davg("[ROOFAREA]","Roofs").**

3.3.5 Analysis Form “AngaurWaterTankSurvey”

The form is sitting on the table “AngaurWaterTankSurvey_02” which derived from a converted spreadsheet created in Palau after a tank survey looking at water tanks as part of a rainwater harvest survey providing data for 41 tanks and rainwater harvest setup.

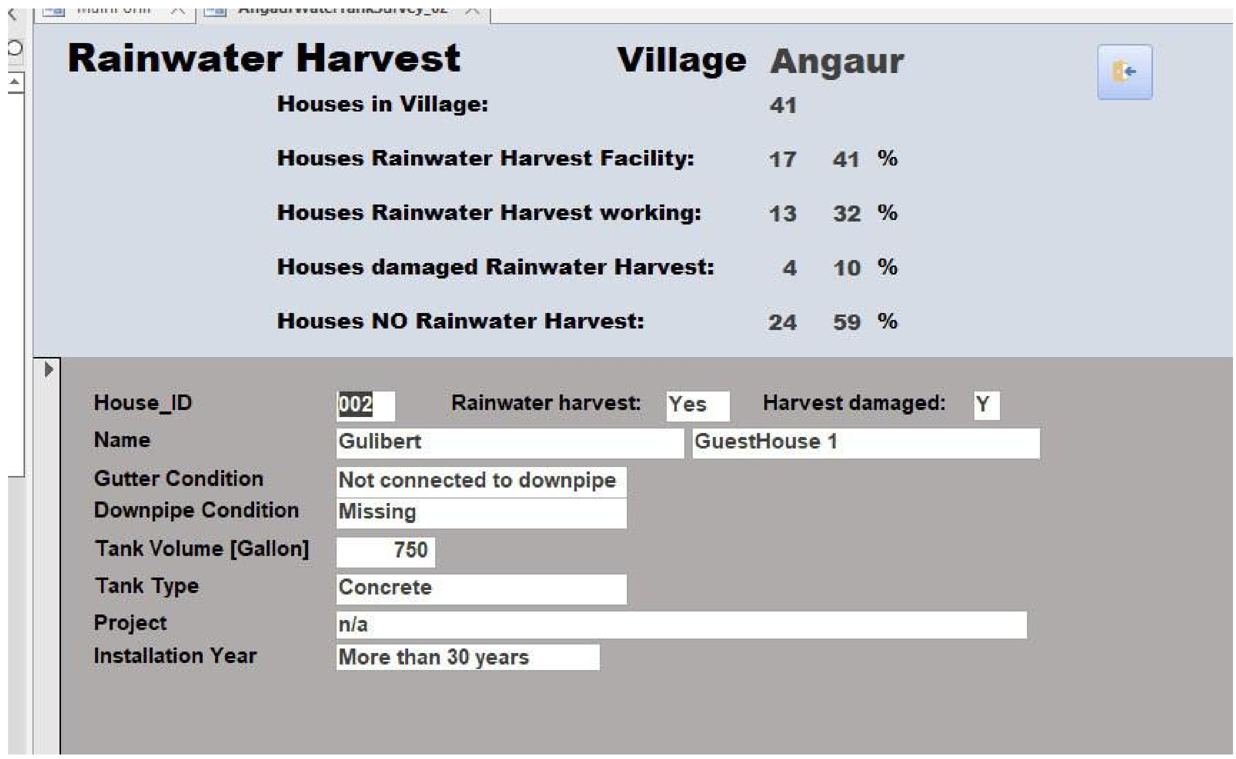


Figure 3.3.5-01: *Display of rainwater harvest report records in columnar form and analysis figures in the header of the form.*

4 Rainwater Harvest Database Elements Nukuoro FSM

The rainwater harvest database for Nukuoro was established end of 2021 as first database structuring rainwater catchment from available roofs. A description was documented in report “Situation Report Federated States of Micronesia (Version2) from 26/04/22.

4.1 Available Spatial Data

The project purchased WorldView 3 image data of 15 cm spatial resolution[3]. The image data was recorded 27 January 2022 and arrived rectified to UTM Zone 56 North, WGS84 EPSG Code 32656. The cost covering the complete island was only US$ 104.

The image data were stitched together and then divided into sub-areas with image analysis software. Afterwards the sub-area images were imported to GIS software. The sub-area images covered all houses in Nukuoro.

4.1.1 GIS Backdrops

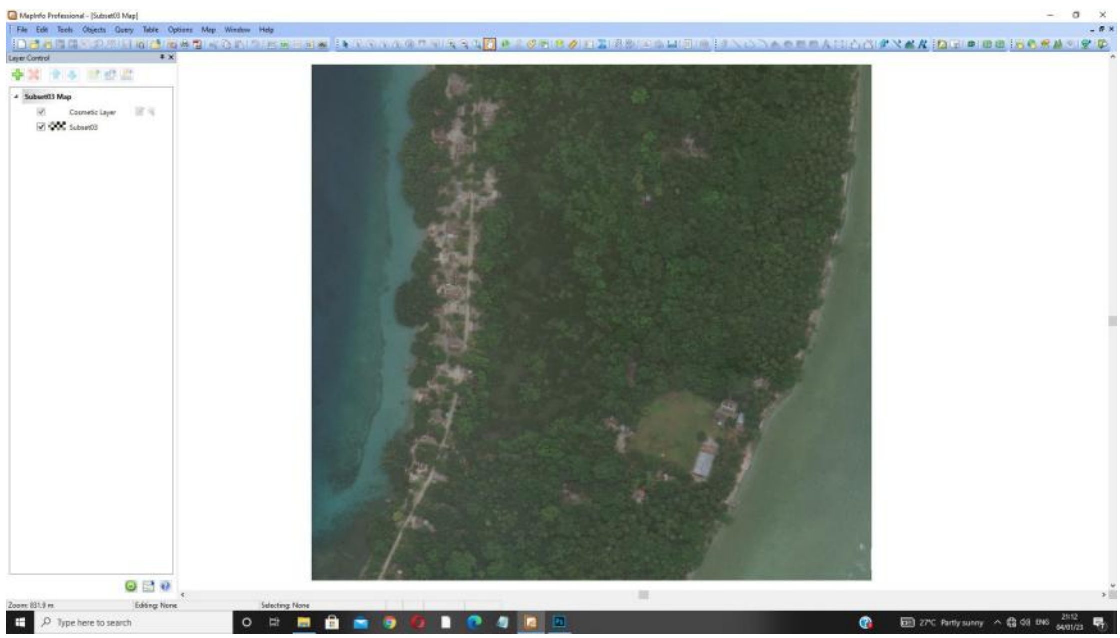


Figure 4.1.1-01: *GIS backdrop “Subset03”*

GIS backdrops are georeferenced files which can be opened like a table. If image data are too large the GIS handling gets slow. Subsets handled as backdrops reduce the interpretation time. Four backdrops “Subset01” to “Subset04” are available as subsets of the much larger original image file.

The image data allow a delineation of the roof area in 1:5,000 scale accuracy see figures 4.1-01 and 4.1-02. The mapping can be improved at a later stage by zooming in, delineating and zooming out.

3 The normal 30 cm spatial resolution was increased to 15 cm by artificial intelligence algorithms

4.1.2 Nukuoro GIS Table NukuoroRoofs

Figure 4.1.2-01: *Example of metallic and pandanas covered roofs visible in the image data*

Figure 4.1.2-02: *Polygons superimposed over the roofs visible.*

Each roof area has to have a unique ID to be able to be entered into a relational database. Here it approved to separate the total area into 11 so called “settlement areas”[4] as also demonstrated for Palau. These settlement areas are artificial sub-areas which have nothing to do with political boundaries.

The table “NukuoroRoofs” contains the polygons created by digitising the roof from the image data.

The table has following structure:

Field Name	***Field Type***
RoofID	Character (10)
RoofArea	Integer
Material	Character (3)

Field “RoofID”

The table currently has 179 records. The field “RoofID” indicates with “S” and a two digit number the settlement and with “R” and a three digit number the roof number within the settlement. The RoofID is the field allowing to link the tabular database.

Field “RoofArea”

The field “RoofArea” keeps the GIS calculation of the roof size in full square metres.

Field “Material”

The field “Material” keeps a three digit ID for the roof material. This can be linked to a library table of the tabular database to see the full expression such as Corrugated Iron instead of “CUR”. The field was left in the spatial database table as it is easier to store the interpretation.

4.1.3 GIS Table “NukuoroSettlements”

Like in Palau, it was easier to create a unique ID and to keep the overview by dividing the complete area into 11 “Settlement Areas”.

Field Name	***Field Type***
Settlement_ID	Character (10)
SettlementArea	Integer

Field “Settlement_ID”

The field “Settlement_ID” keeps the unique ID of the settlement area polygon from Area_01 to Area_11.

Field “SettlementArea”

4 Please see: Impacts Assessment of Past Climate Change Adaptation Actions, Situation Report Federated States of Micronesia

The field “SettlementArea” keeps the GIS calculation of the area.

4.1.4 GIS Table “TANKS_NU”

The table “THANKS_NU” was converted from a spread sheet in which the tank survey was stored. The X and Y coordinates captured by GPS allowed an automatic establishment of this spatial layer. The table contains 35 records.

Field Name	***Field Type***
Tank_owner	Character (254)
Site_	Decimal (19,5)
X_Coordina	Decimal (19,5)
Y_Coordina	Decimal (19,5)
Site_id	Character (254)
RoofID	Character (8)

Field “Tank_owner”

The field “Tank_owner” contains the tank owner stored in an excel spread sheet after the tank survey.

Fields “X_Coordina” and “Y_Coordina”

The fields “X_Coordina” and “Y_Coordina” keep the GPS position coordinates from the survey.

Field “Site_id”

The field “Site_id” keeps the unique ID of the tank. The unique ID also indicates with the two digits (i) “PT” if the tank is a private tank, or with (ii) “CT” community tank or (iii) a “CW” community well.

Field “RoofID”

The field “RoofID” keeps the ID of the next roof assuming that this roof is liked to the tank. The field was kept in the spatial **database** table to store the GIS interpretation. From there it was copied to the tabular database.

4.2 Available Tabular Data for FSM

The tabular database contains data for Nukuoro, Satawan and Kapingamarangi which have been converted from available spreadsheets containing survey data of surveys conducted by the team in the Federated States of Micronesia.

The library table such as “LT_RoofType”, “LT_GutterCondition”, etc. have been copied from the Palau database and have to be adapted to the situation in the different islands or to a general

5 Appendix 01 Example Database “Rainwater Harvest”

This example database does not contain real data. It is supposed to demonstrate a structure allowing to analyse the potential rainwater harvest taking the roof area into account, but detailing it to different catchment areas of the same roof. The other information processed is the condition of the elements (i) gutter, (ii) downpipe and (iii) tank.

The database objects (i) catchment area, (ii) gutter, (iii) downpipe and (iv) tank are linked which cannot be performed with an excel spreadsheet.

The database can simulate the situation of a detailed rainwater harvest estimation showing the actual harvest capacity detailing the roof area and the possibility to actual calculate the water which theoretically reaches the water tanks.

The database consist of artificial data for 10 roofs to simulate the analysis potential of a relational database. The database structure can be copied to other applications.

The example database also shows the importance of storing data in a relational database rather than in spreadsheets which would not allow such a detailed harvest estimation.

5.1 Analysis Forms

There are three analysis forms showing the rainwater harvest catchment area with gutter, downpipe and water tank in good condition, the situation with leaking elements and the catchment area where elements are not connected or broken.

5.1.1 Gutter, Downpipe and Tank in good Condition

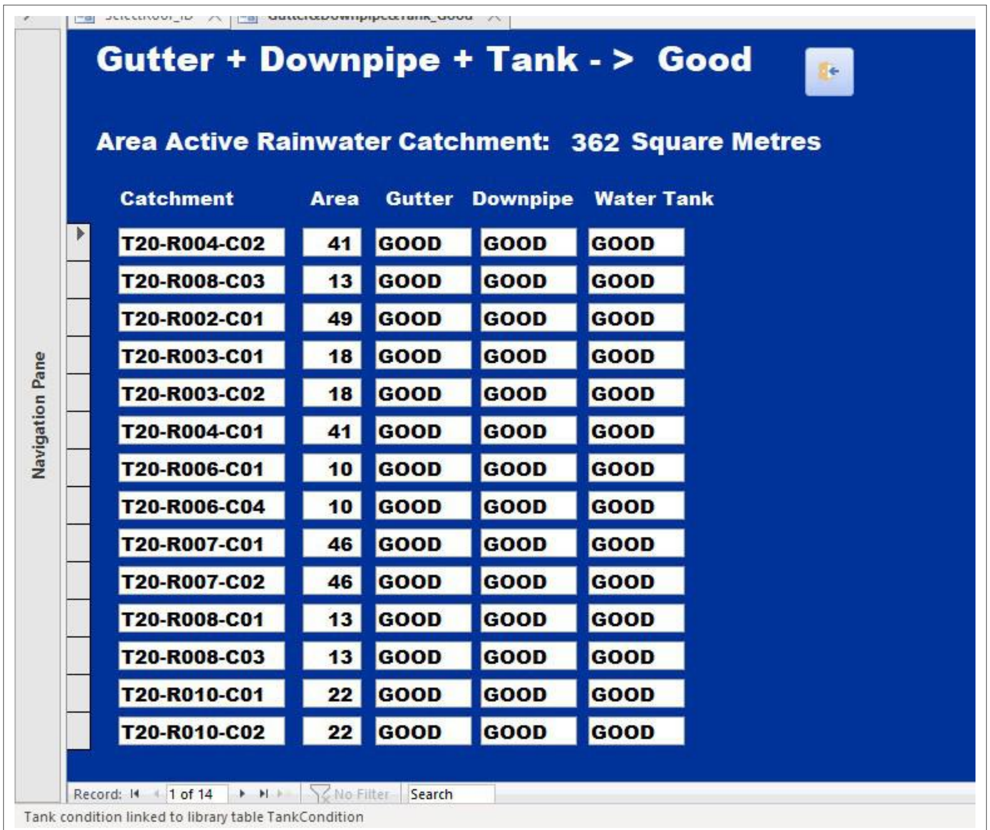


Figure 5.1.1-01: *Gutter, downpipe and water tank in good condition.*

A query behind the form connects the element gutter, downpipe and water tank and only selects records where all three elements are in good condition. If the tanks have sufficient capacity all rainwater will be stored. If tanks are too small they will have an overflow, which also could be calculated, however, this would be an additional analysis the database offers.

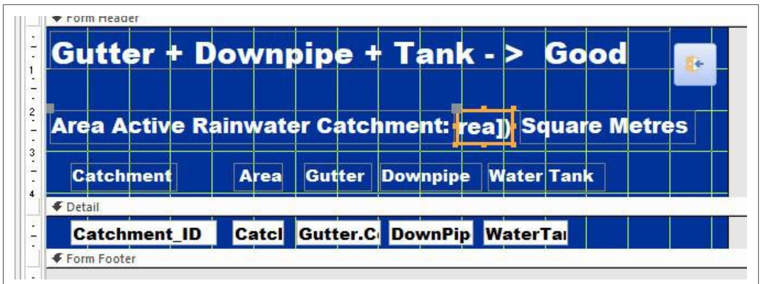


Figure 5.1.1-02: *The form in design view. The field CatchmentSum framed in yellow contains a code.*

The calculation of the total area is performed by a small code within a field of the form see figure to the left.

The field contains a code using the function “Sum”, which summarises all catchment areas displayed by the form.

The code is: **=Sum([CatchmentArea]).** The “CatchmentArea” is a field of the table “RoofCatchment” from which 14 records are displayed.

5.1.2 Leaking Elements

Figure 5.1.2-01: *Situation where either gutter, downpipe and water tank are leaking. The area of 486 m^2 would only provide reduced water collection as not all water can be harvested.*

How much water leaking system element still can provide has to be calibrated and is currently not part of the database analysis.

5.1.3 Not Connected Systems

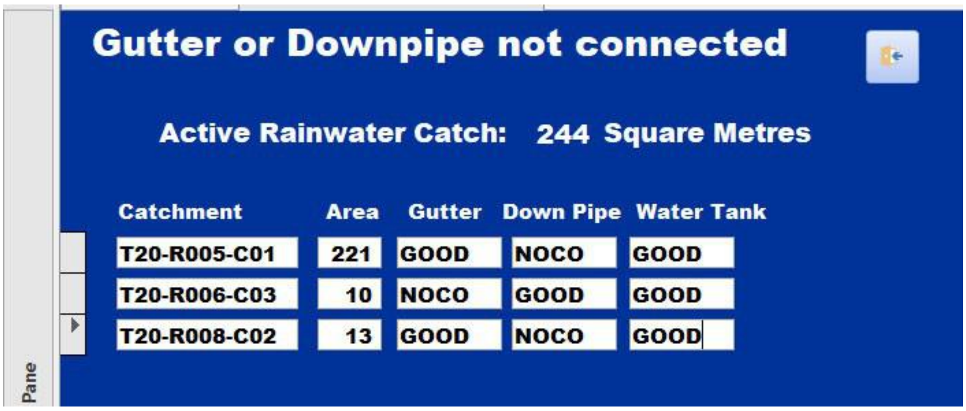


Figure 4.1.3-01: *Situation where either gutter, downpipe and water tank is not connected. The area of 244 m^2 will not provide water which can be stored for dry periods.*

Also this sits on a query connecting the five different tables (i) “Roof”, (ii) “RoofCatchments”, (iii) “Gutter” (iv) “Downpipe” and (v) “WaterTank” like the two other analysis forms above.

5.2 Queries behind the Forms

The essential advantage of a relational database is the technical possibility to links different tables. This can be performed through queries. Queries are an access database object allowing the user to handle SQL code in graphical form without any code writing. The code, however, is running in the background.

5.2.1 The Query Selecting good Rainwater Harvest Elements

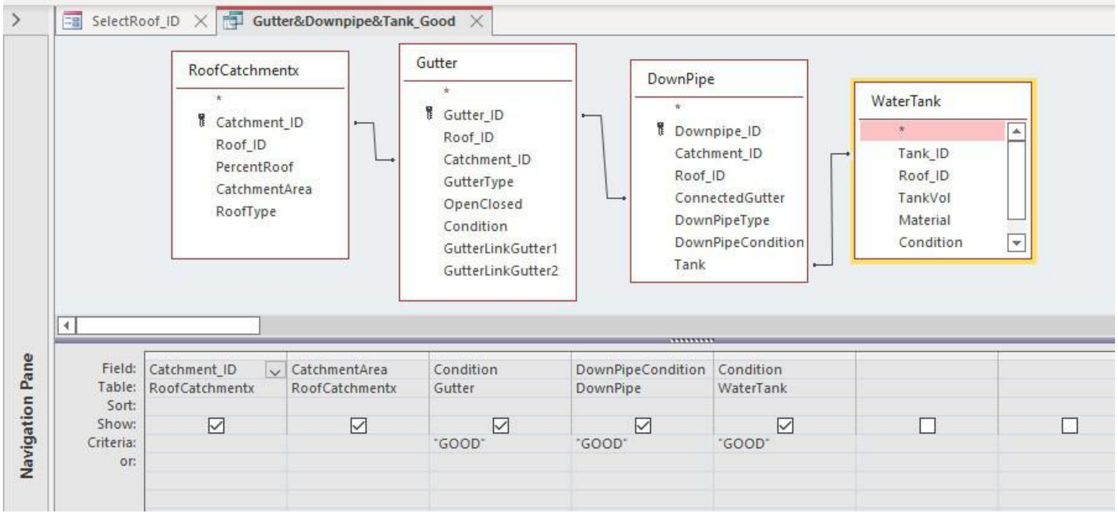


Figure 5.2.1-01: *The Access surface “Query” allows to combine table and select records without SQL writing*

The Access surface “Query” allows to combine table and select records without SQL writing. Important is the link between the tables through the instruction INNER JOIN and the selection of records through conditions combined with “AND” which instructs that the condition “GOOD” has to be fulfilled in all three rainwater harvesting elements (i) gutter, (ii) downpipe and water tank.

```
SELECT RoofCatchmentx.Catchment_ID, RoofCatchmentx.CatchmentArea, Gutter.Condition,
DownPipe.DownPipeCondition, WaterTank.Condition
FROM ((DownPipe INNER JOIN Gutter ON DownPipe.ConnectedGutter = Gutter.Gutter_ID)
INNER JOIN WaterTank ON DownPipe.Tank = WaterTank.Tank_ID)
INNER JOIN RoofCatchmentx ON Gutter.Catchment_ID = RoofCatchmentx.Catchment_ID
WHERE (((Gutter.Condition)="GOOD")
AND ((DownPipe.DownPipeCondition)="GOOD")
AND ((WaterTank.Condition)="GOOD"));
```

Figure 5.2.1-02: *The Access “Query” as SQL code*

5.2.2 The Query Selecting leaking Rainwater Harvest Elements

The Access query searching for leaking gutter, downpipes or tanks (see figure 4.2.2-01 combines the elements and setting the OR condition as it is sufficient if one of the elements is leaking.

The query also gets the field “CatchmentArea” from the table “RoofCatchment” as the form needs it to summarise the total area.

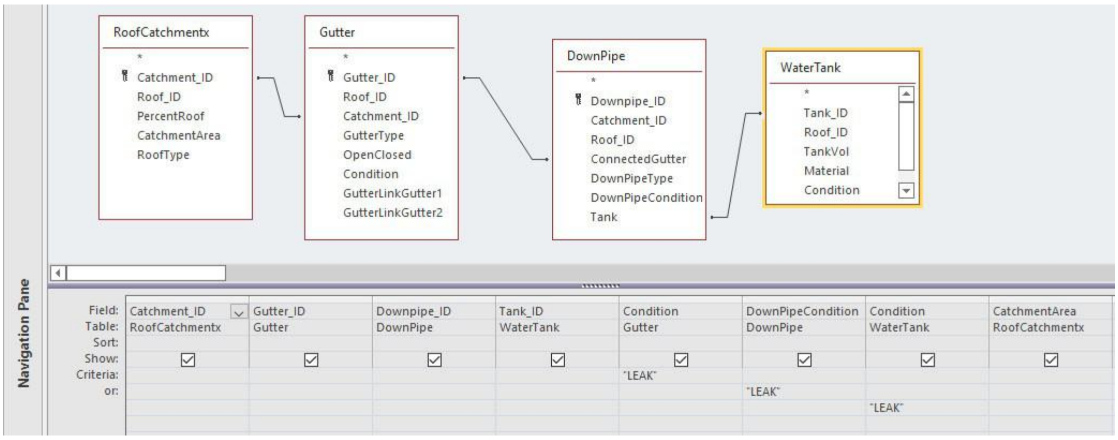


Figure 5.2.2-01: *The Access query searching for leaking elements.*

For the form showing records of not connected elements the corresponding query has a similar OR condition like the query searching for leaking elements. The difference is that the condition field is set to NOCO = not connected.

5.3 Other Forms

The database has other important forms which can be copied into a new rainwater harvest survey and analysis databbase.

5.3.1 Main Form "SelectRoof_ID"

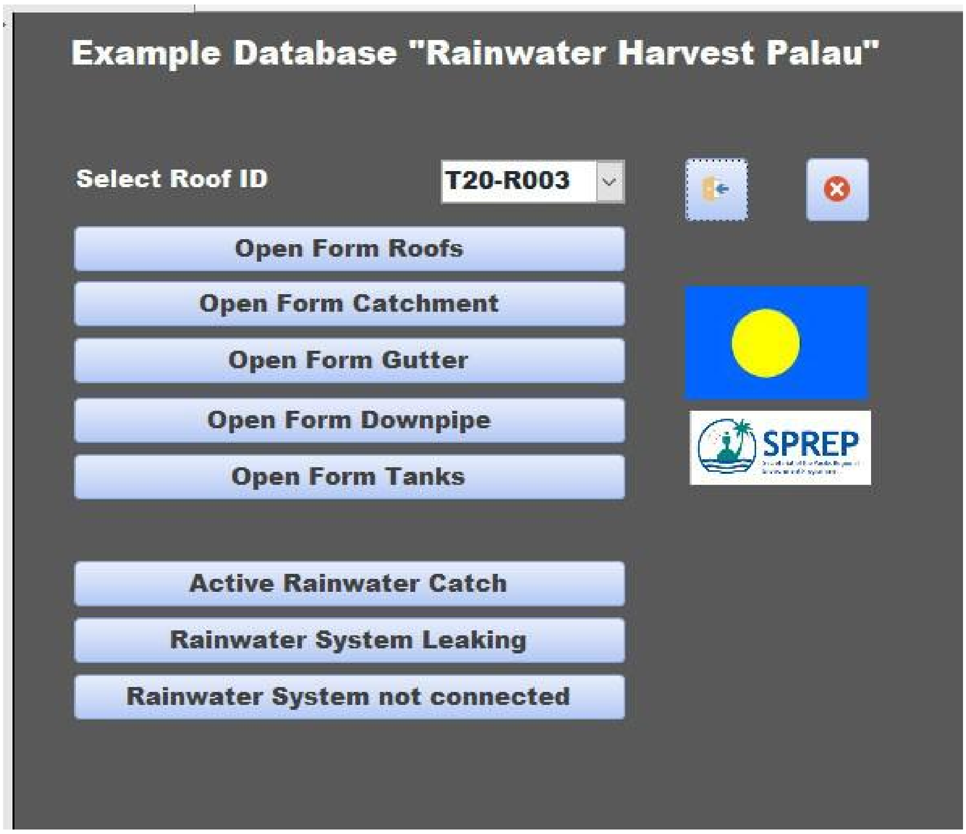


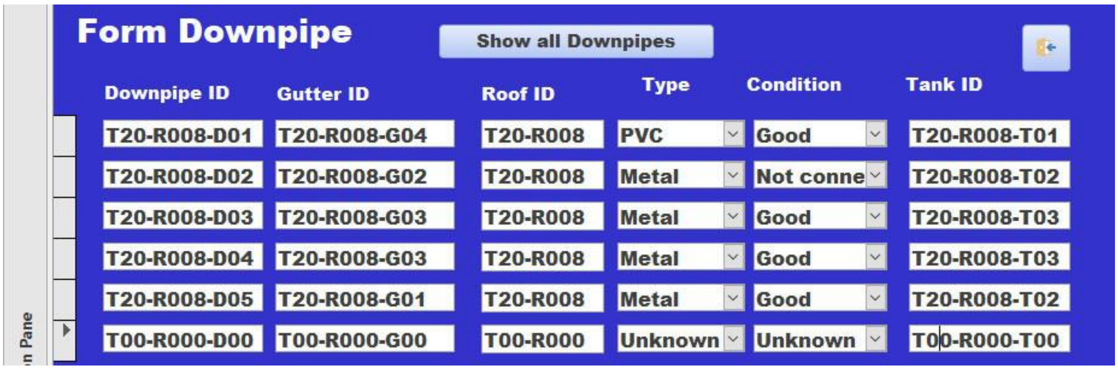
Figure 5.3.1-01: *The main form of the database allowing to select a house (roof) for data entry and to launch the analysis forms.*

The main form shown in figure 4.3.1-01 will be opened automatically when launching the Access example database through the Access Macro “AutoExec”.

The forms displaying the content of the corresponding tables (i) “Roof”, (ii) “RoofCtchment”, (iii) “Gutter”, (iv) “Downpipe” and (v) “WaterTank” can be opened by clicking the corresponding button. They will show all available records related to the selected roof catchment.

By clicking the lower buttons the analysis forms will be opened explained in chapter 4.1 Analysis Forms.

5.3.2 The Structure of Input and Edit Forms


Form Downpipe

Show all Downpipes

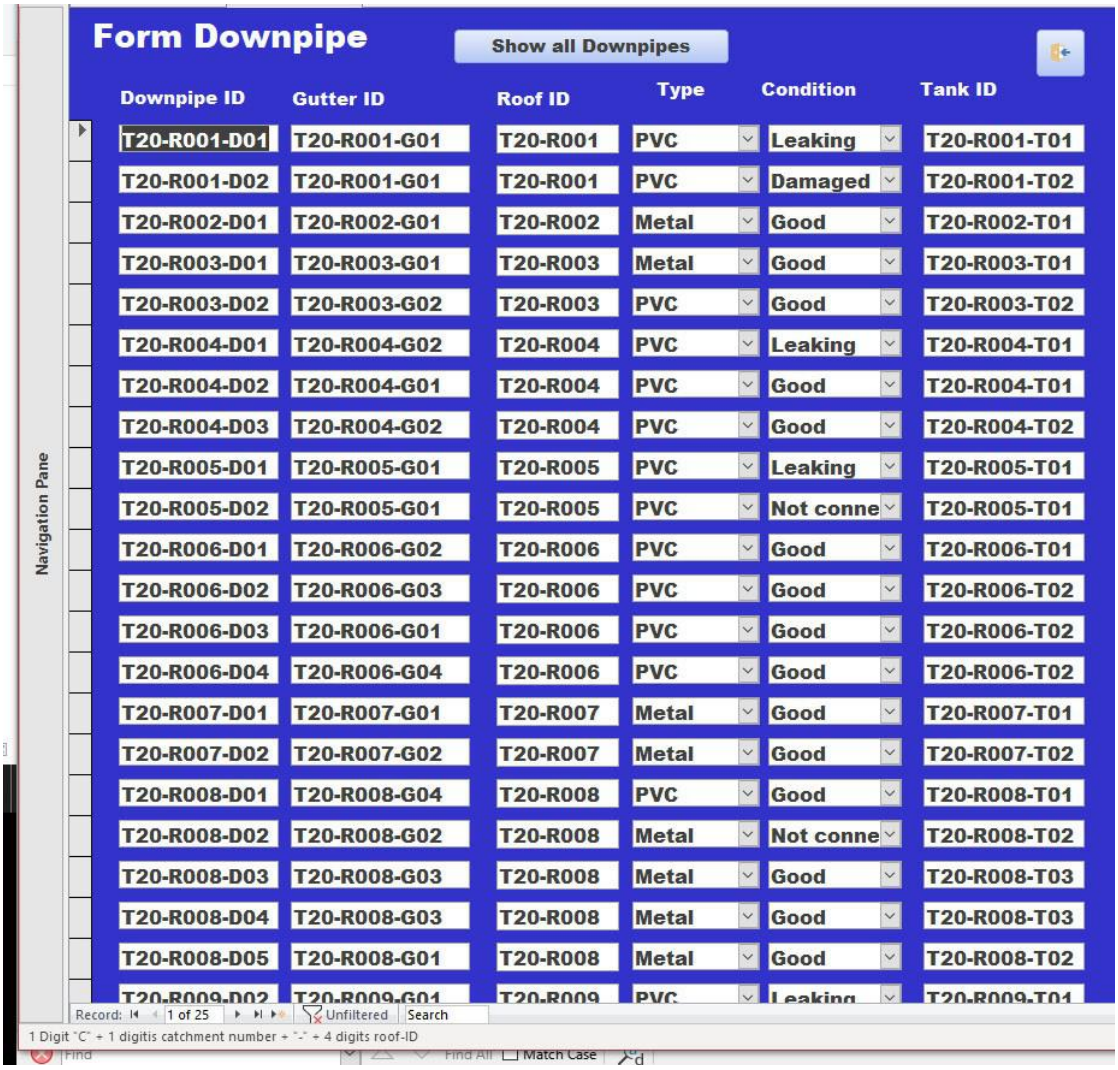
Downpipe ID	Gutter ID	Roof ID	Type	Condition	Tank ID
T20-R008-D01	T20-R008-G04	T20-R008	PVC	Good	T20-R008-T01
T20-R008-D02	T20-R008-G02	T20-R008	Metal	Not conne	T20-R008-T02
T20-R008-D03	T20-R008-G03	T20-R008	Metal	Good	T20-R008-T03
T20-R008-D04	T20-R008-G03	T20-R008	Metal	Good	T20-R008-T03
T20-R008-D05	T20-R008-G01	T20-R008	Metal	Good	T20-R008-T02
T00-R000-D00	T00-R000-G00	T00-R000	Unknown	Unknown	T00-R000-T00

Figure 5.3.2-01: *Form “Downpipe” showing all five records for roof T20-R008*

Figure 4.3.2-01 shows the form for downpipe input. The main form (figure 4.3.1-01) allows to select a roof (or house) and a field team can input all items of this house, in this case all five downpipes. A downpipe is connected to one gutter and one tank[5]. The field team has to fill these information into forms or a database display on a tablet when doing the field work. It is essential that every downpipe has a unit ID keeping the ID of the roof and that the unit ID of gutter and tank is filled for every downpipe..

By clicking the button “Show all Downpipes” all captured downpipes for all houses will be displayed, see figure 4.3.2-02.

5 A gutter can be connected to two other gutters and these might not have downpipes, however, these special cases can be handled later. Also a tank can be connected to another tank; again these special cases can be handled at a later stage.



Form Downpipe

Show all Downpipes

Downpipe ID	Gutter ID	Roof ID	Type	Condition	Tank ID
T20-R001-D01	T20-R001-G01	T20-R001	PVC	Leaking	T20-R001-T01
T20-R001-D02	T20-R001-G01	T20-R001	PVC	Damaged	T20-R001-T02
T20-R002-D01	T20-R002-G01	T20-R002	Metal	Good	T20-R002-T01
T20-R003-D01	T20-R003-G01	T20-R003	Metal	Good	T20-R003-T01
T20-R003-D02	T20-R003-G02	T20-R003	PVC	Good	T20-R003-T02
T20-R004-D01	T20-R004-G02	T20-R004	PVC	Leaking	T20-R004-T01
T20-R004-D02	T20-R004-G01	T20-R004	PVC	Good	T20-R004-T01
T20-R004-D03	T20-R004-G02	T20-R004	PVC	Good	T20-R004-T02
T20-R005-D01	T20-R005-G01	T20-R005	PVC	Leaking	T20-R005-T01
T20-R005-D02	T20-R005-G01	T20-R005	PVC	Not conne	T20-R005-T01
T20-R006-D01	T20-R006-G02	T20-R006	PVC	Good	T20-R006-T01
T20-R006-D02	T20-R006-G03	T20-R006	PVC	Good	T20-R006-T02
T20-R006-D03	T20-R006-G01	T20-R006	PVC	Good	T20-R006-T02
T20-R006-D04	T20-R006-G04	T20-R006	PVC	Good	T20-R006-T02
T20-R007-D01	T20-R007-G01	T20-R007	Metal	Good	T20-R007-T01
T20-R007-D02	T20-R007-G02	T20-R007	Metal	Good	T20-R007-T02
T20-R008-D01	T20-R008-G04	T20-R008	PVC	Good	T20-R008-T01
T20-R008-D02	T20-R008-G02	T20-R008	Metal	Not conne	T20-R008-T02
T20-R008-D03	T20-R008-G03	T20-R008	Metal	Good	T20-R008-T03
T20-R008-D04	T20-R008-G03	T20-R008	Metal	Good	T20-R008-T03
T20-R008-D05	T20-R008-G01	T20-R008	Metal	Good	T20-R008-T02
T20-R009-D02	T20-R009-G01	T20-R009	PVC	Leaking	T20-R009-T01

Figure 5.3.2-02: *Display of all downpipes of a village.*

The structure of the forms for roof catchments, gutters, and tanks is the same as shown for the downpipe input. However, for the tank input the linked downpipe does not have to be typed, the link is handled in the downpipe table. The same applies to the gutter, the link is stated in the downpipe table. The reason is that a downpipe can only be linked to one gutter but a gutter can have several downpipes. Also a tank can be linked to several downpipes while a downpipe normally is only linked to one tank. Between gutter and catchment normally is a one to one link. However, there are exceptions where gutters without downpipes are just linked to other gutters. These can be handled if cases arrive.

5.4 Main Tables

The main tables are:

- Roof
- RoofCatchment
- Gutter
- Downpipe
- WaterTank

The structure is described in chapter “3.2 The Tabular Data for Angaur Rainwater Harvest”. Some annotations fields are cut for this example database. In the Angaur database the spreadsheet information was kept as far as possible.

5.5 Library Tables

The library tables of the example database are nearly identical with the Angaur Rainwater Harvest database. These library tables are available:

- LT_DownpipeCondition
- LT_DownpipeType
- LT_GutterCondition
- LT_GutterType
- LT_RoofType
- LT_TankCondition
- LT_TankFoundation
- LT_TankType

The library tables need an agreed calibration, e.g. it has to be clearly defined what is “damaged” and “leaking” or the difference “not connected to tank” or “missing”.

5.6 Update Query “UD_CatchmentArea”

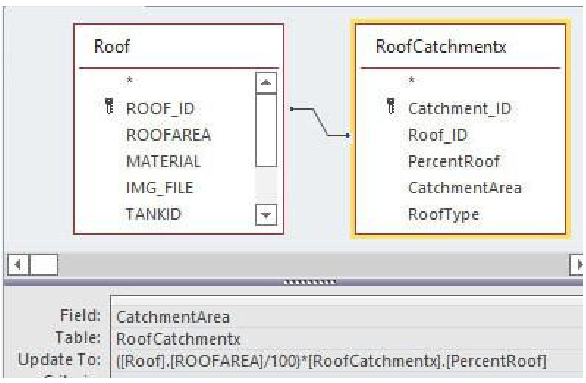


Figure 5.6-01: *Catchment area update query*

The query “UD_CatchmentArea” links the the table “Roof” with the table “RoofCatchments”. The roof area was calculated with GIS tools from very high resolution image data. In case the catchment area is not digitised it can be estimated in the field as percentage of the total roof area.

Having the percentage of the total roof the roof catchment area can be calculated by this update query.

6 Appendix 02 List of Data to be Handed Over

Most country tabular data is included in the general database: PCCAA_221117-0855.accdb

Data which are already in the countries are not listed in this appendix.

6.1 Palau

6.1.1 Palau Image Data and Spatial Data

Satellite Image Data

- 21MAY20012802-S2AS_R1C1-014840501020_01_P001.TIF
- 21MAY20012802-S2AS_R1C2-014840501020_01_P001.TIF
- 21MAY20012802-S2AS_R2C1-014840501020_01_P001.TIF
- 21MAY20012802-S2AS_R2C2-014840501020_01_P001.TIF

Backdrops Palau (Angaur)

- Subset-03-01.TAB, to Subset-03-08.TAB
- Subset-03-01.img, to Subset-03-08.img
- Subset-03-01.rrd to Subset-03-08.rrd

GIS Map Layer

- Roofs_Angaur.TAB, Roofs_Angaur.MAP, Roofs_Angaur.ID, Roofs_Angaur.dbf, Roofs_Angaur.DAT
- TankPosition.TAB, TankPosition.MAP, TankPosition.ID, TankPosition.DAT

6.1.2 Palau Tabular Data

RainwaterCatchment_PW_02.accdb

6.2 Tonga

6.2.1 Tonga Image Data and Spatial Data

Tonga IMG Data

- 014938699010_01.zip
- 014916474020_01.zip
- 20MAY11215238-S2AS-014916474020_01_P002.TIF
- 20MAY11215238-S2AS-014916474020_01_P002.RRD
- 20MAY11215238-S2AS-014916474020_01_P002.IMG

Image Data Hihifo

- 21jun24215302-s2as_r1c1-014938699010_01_p001.img, 21jun24215302-s2as_r1c1-014938699010_01_p001.rrd
- 21jun24215302-s2as_r1c2-014938699010_01_p001.img, 21jun24215302-s2as_r1c2-014938699010_01_p001.rrd
- 21jun24215302-s2as_r2c1-014938699010_01_p001.img, 21jun24215302-s2as_r2c1-014938699010_01_p001.rrd

- 21jun24215302-s2as_r2c2-014938699010_01_p001.img, 21jun24215302-s2as_r2c2-014938699010_01_p001.rrd
- 21jun24215302-s2as_r3c1-014938699010_01_p001.img, 21jun24215302-s2as_r3c1-014938699010_01_p001.rrd
- 21jun24215302-s2as_r3c2-014938699010_01_p001.img, 21jun24215302-s2as_r3c2-014938699010_01_p001.rrd
- 21sep14215737-s2as-014916474020_01_p001.img, 21sep14215737-s2as-014916474020_01_p001.rrd

Tonga Backdrops Hihifo

- Ahau.img, Ahau.rrd
- ha'atafu.img, ha'atafu.rrd
- Ha'atafuBeach.img, Ha'atafuBeach.rrd
- Ha'avakatolo.img, Ha'avakatolo.rrd
- Hihifo01.TAB, Hihifo01.rrd, Hihifo01.img, Hihifo01.ige
- Kolovai.TAB, Kolovai.rrd, Kolovai.img, Kolovai.ige

Backdrops Talafoou

- Area01-01.TAB, Area01-01.img, Area01-01.rrd
- Area01-02.TAB, Area01-02.img, Area01-02.rrd
- Area01-03.TAB, Area01-03.img, Area01-03.rrd

Tonga Spatial Layers Hihifo

ROOFS-Kolovai.DAT, ROOFS-Kolovai.dbf, ROOFS-Kolovai.ID, ROOFS-Kolovai.IND, ROOFS-Kolovai.MAP, ROOFS-Kolovai.TAB

Tonga Spatial Layers Tokutonga

- Channels_TO.DAT, Channels_TO.ID, Channels_TO, Channels_TO.TAB
- CHA-03-02.DAT, CHA-03-02.ID, CHA-03-02, CHA-03-02.TAB
- CHA-03-03.DAT, CHA-03-03.ID, CHA-03-03, CHA-03-03.TAB
- CHA-03-04.DAT, CHA-03-04.ID, CHA-03-04, CHA-03-04.TAB
- CHA-03-05.DAT, CHA-03-05.ID, CHA-03-05, CHA-03-05.TAB
- REV-03-02.DAT, REV-03-02.ID, REV-03-02, REV-03-02.TAB

Tonga Spatial Layers Manuka

- Breakwaters_MA.DAT, Breakwaters_MA.dbf, Breakwaters_MA.ID, Breakwaters_MA.MAP, Breakwaters_MA/TAB
- BeachArea-2014.DAT, BeachArea-2014.DBF, BeachArea-2014.ID, BeachArea-2014.MAP, BeachArea-2014.TAB
- BeachArea-2016.DAT, BeachArea-2016.DBF, BeachArea-2016.ID, BeachArea-2016.MAP, BeachArea-2016.TAB
- BeachArea-2021.DAT, BeachArea-2021.DBF, BeachArea-2021.ID, BeachArea-2021.MAP, BeachArea-2021.TAB
- BreakwaterManuka.DAT, BreakwaterManuka.DBF, BreakwaterManuka.ID, BreakwaterManuka.MAP, BreakwaterManuka.TAB

- BreakwaterManukaLength.DAT, BreakwaterManukaLength.DBF, BreakwaterManukaLength.ID, BreakwaterManukaLength.MAP, BreakwaterManukaLength.TAB
- ReferencePoints.DAT, ReferencePoints.DBF, ReferencePoints.ID, ReferencePoints.MAP, ReferencePoints.TAB
- RoadManuka.DAT, RoadManuka.DBF, RoadManuka.ID, RoadManuka.MAP, RoadManuka.TAB
- StreetBoundary.DAT, StreetBoundary.DBF, StreetBoundary.ID, StreetBoundary.MAP, StreetBoundary.TAB
- VegetationManuka.DAT, VegetationManuka. VegetationManuka.ID, VegetationManuka.MAP, VegetationManuka.TAB

6.2.2 Tonga Tabular Data

All Tonga climate change mitigation infrastructure elements with tabular reference are stored in the database PCCAA_221117-0855.accdb. There is no extra database.

6.3 Federated States of Micronesia

6.3.1 FSM Image Data and Spatial Data

Satellite Image Data

- FSM-NUKUORO-20210521.zip
- 21MAY21000657-S2AS_R1C1-014840501010_01_P001.TIF
- 21MAY21000657-S2AS_R2C1-014840501010_01_P001.TIF

Backdrops Kaipamarangi:

- Tile_01.TAB, Tile_01.tif
- Tile_02.TAB, Tile_02.tif
- Tile_03.TAB, Tile_03.tif
- Tile_04.TAB, Tile_04.tif
- Tile_05.TAB, Tile_05.tif

Spatial Layers Kaipamarangi:

- KAPINGAM_Tanks.TAB, KAPINGAM_Tanks.MAP, KAPINGAM_Tanks.ID, KAPINGAM_Tanks.DBF

Spatial Layers Nukuoro:

- NU_TankType.TAB, NU_TankType.MAP, NU_TankType.ID, NU_TankType.DBF
- NukuoroRoofs.TAB, NukuoroRoofs.MAP, NukuoroRoofs.ID, NukuoroRoofs.DBF, NukuoroRoofs.DAT
- NukuoroSettlementAreas.TAB, NukuoroSettlementAreas.MAP, NukuoroSettlementAreas.ID, NukuoroSettlementAreas.DBF, NukuoroSettlementAreas.DAT

6.3.2 FSM Tabular Data

- RainwaterHarvest-FM.accdb