Training materials: Step by step GIS Training for Ecosystem Accounting – focusing on blue carbon ecosystems

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Purpose

This guide and the data contained therein is for **training purposes only**.

This guide will enable practitioners that are new to Ocean Accounts to compile extent accounts from data extracted and manipulated from open access sources. The step-by-step exercise focuses on mangroves and aligns with the System of Environmental Economic Accounting - Ecosystem Accounts (SEEA EA). It does not, however, cover land classification or condition and ecosystem service accounts.

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Required Materials:

- QGIS software installed on participants' laptops.
- Access to sample datasets for practical exercises.

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Background

This step-by-step guide enables practitioners to calculate statistics for ecosystems at different administrative levels for a country, using blue carbon ecosystems within the Maldives as an example.

- Activity 1 – provides methods for **rapid statistics** to calculate the stocks of seagrass across multiple years.
- Activity 2 – Works step by step to get data from the QGIS programme into excel, which makes it a more shareable format.

For further reading and conceptual support, practitioners are encouraged to refer to the SEEA website and Ocean Accounting Technical Guidance.

Case study: Maldives

The Maldives is an archipelagic state located in the Indian Ocean, renowned for its clear waters, coral reefs, and abundant marine biodiversity. It contains over 1,200 islands, grouped into 26 atolls, which are organized into 19 administrative regions and an additional region encompassing the capital city, Malé. Each atoll administration is responsible for managing resources, implementing environmental conservation efforts, and overseeing development activities within its jurisdiction.

The country's geography and climate make it an ideal habitat for a variety of marine ecosystems, including extensive seagrass meadows and coral reefs, which support a myriad of fish, crustacean, and mollusc species. These ecosystems play a vital role in the Maldivian economy, including the sectors of tourism and fisheries. Balancing conservation and development require an understanding of ecosystems and their services, to carefully weigh trade-offs in the context of changing environments due to climate change.

Mangroves

Mangroves are complex intertidal ecosystems comprised of salt-tolerant trees and shrubs that flourish in sheltered coastal areas. These ecosystems serve as breeding grounds and nurseries for commercially important species (e.g., fish, crustaceans, and shellfish). They act as natural barriers, protecting shorelines from erosion and storm surges, while simultaneously filtering pollutants and sediments from land-based runoff, ensuring the health of adjacent seagrass and coral reefs. Furthermore, mangroves contribute significantly to the local economy by providing resources such as timber, and traditional medicinal plants.

Seagrass

Seagrass Meadows within the Maldives are underwater ecosystems characterized by flowering plants that form dense underwater beds in shallow, clear waters. These habitats support a diverse array of marine life, including endangered species like sea turtles, by providing food and shelter. At least 6 distinct species of seagrass can be found in the Maldives. Seagrass beds play a critical role in coastal protection, mitigating erosion by stabilizing sediments with their root systems. They also act as carbon sinks, absorbing carbon dioxide from the atmosphere and ocean, thus helping to mitigate climate change. In addition, these meadows enhance water quality by filtering pollutants and provide significant economic benefits to local communities as another nursery for fisheries and attract species that positively impact tourism.

Data inventory

Table 1. Data inventory for the exercise

Data type	Data name	Description	Source
Activity 1: Rapid seagrass statistics for Laamu Atoll			
Administrative areas	Laamu_adm3_43N	Administrative boundaries at the sub-atoll level, projected to UTM zone 43N	Maldives - Subnational Administrative Boundaries: https://data.humdata.org/dataset/cod-ab-mdv Collected by UNICEF, provided by Government of the Maldives
Seagrass extent shapefiles	Sg_17, SG_20	Seagrass extent generated using satellite data (SPOT 6/7)	Generated using GIS by GOAP Secretariat
Satellite data	All_2020	Satellite data of Laamu Atoll	Generated from SPOT (1.5 m) data. Related open access data could be downloaded from Copernicus Open Access Hub (Sentinel 2, 10 m).

Getting started

Please get acquainted with QGIS before proceeding. There are materials on the website, which can be accessed using [this link](). We will be working off **QGIS version 3.34.**

Launch QGIS

Open GIS using the desktop symbol or menu bar. You should be presented with the following:

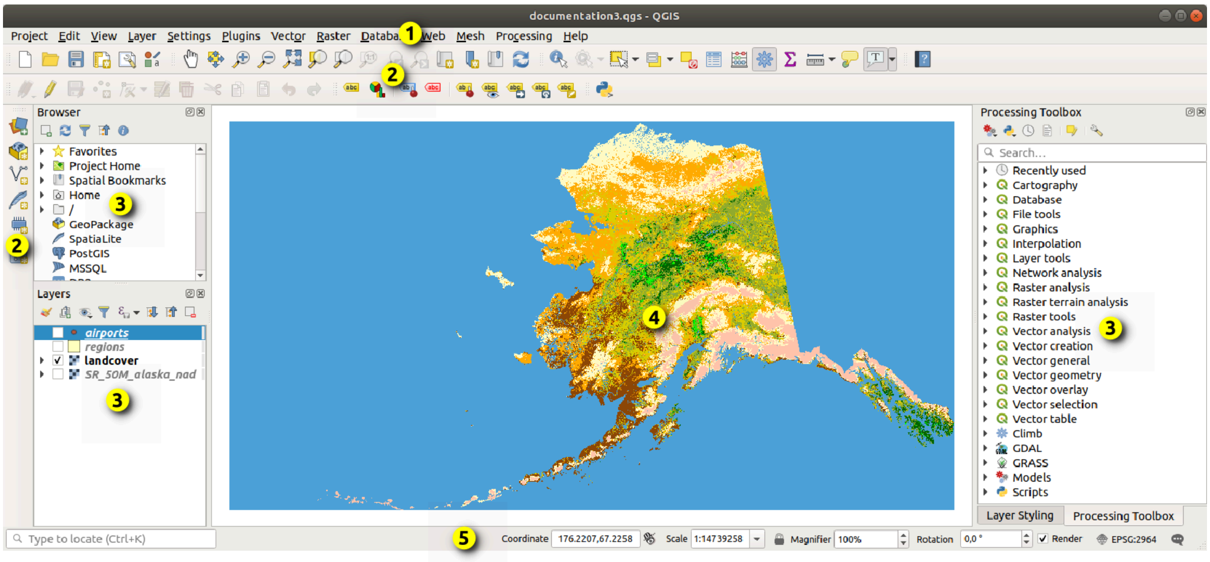


Figure 1. QGIS Graphical User Interface, showing (1) menu bar, (2) toolbars, (3) panels, (4) map view and (5) status bar. Adapted from the QGIS manual (3.28).

Make sure you save the QGIS file, named after the activity (e.g., “MDV_blue_carbon”)

Practical data for activities

All the sample data for the activities will be stored in a folder, with the link to access below:

[Activity Data Download]()

Please create a new folder for the activities (e.g., “Maldives Blue Carbon”).

1. Ensure that the data has been unzipped and placed in the folder together with the QGIS project file (.qgs)
2. Ensure that the file names match those in this guide.

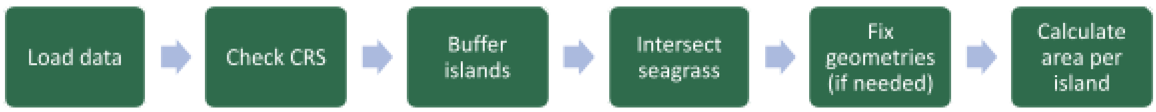
Activity 1: Seagrass statistics for Laamu Atoll

Objective: Calculate the area of seagrass for a hypothetical area, using Laamu Atoll as a case study.

Context: Imagine you have been requested to compile an inventory (in km^2) of the seagrass within 200 m of each island on Laamu Atoll. You must create an area and analyze the seagrass near each island.

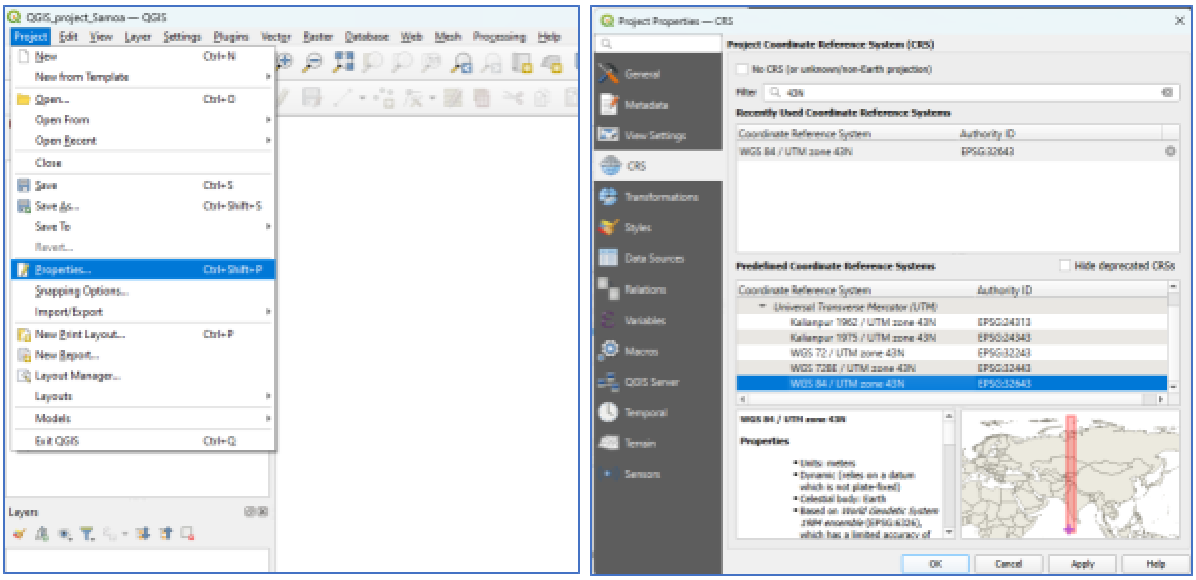
Note that you only need to analyse the year 2020.

Workflow



Before starting: Set map Coordinate Reference System (**CRS**).

- Click on the "Project" menu and select "Properties."
- In the Project Properties dialog box, select the "CRS" tab.
- In the "Filter" section, find the correct CRS (for us it is WGS 84 / UTM Zone 43N). Use the filter function to find the correct CRS and click “OK”.



Step 1: Add data (Shapefiles) to the Map

You can either drag or drop the shapefile file (extension .shp) into QGIS from the Browser to the map section **or** do the following:

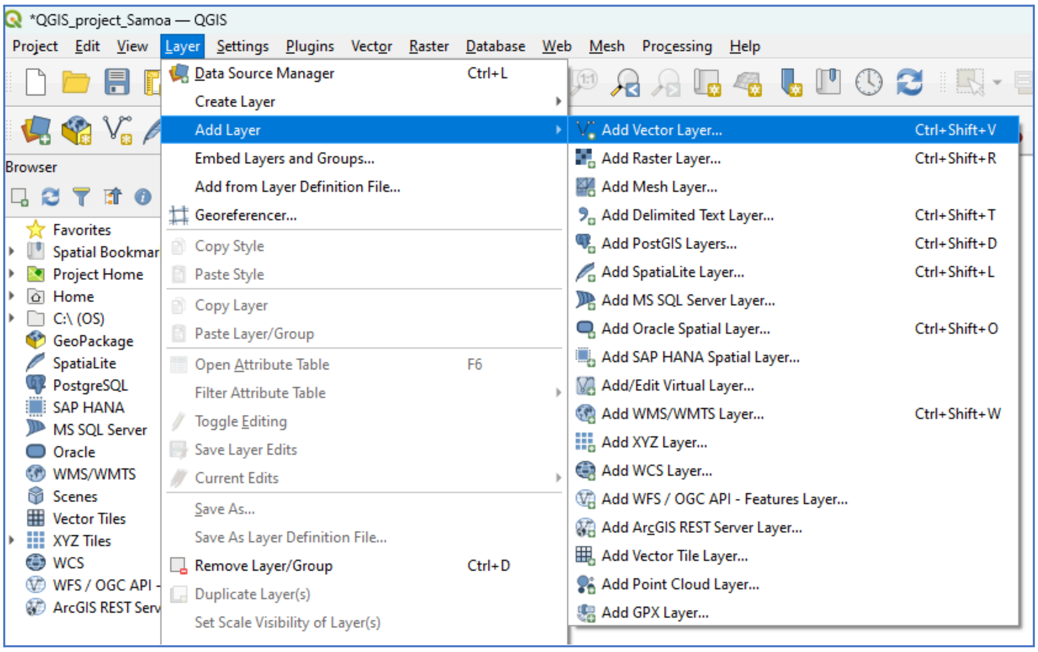
1. Click on the "Layer" menu and select "Add Layer" > "Add Vector Layer."
2. Navigate to the folder containing the shapefiles you want to add.
3. Select the shapefile(s) you want to add and click "Open."

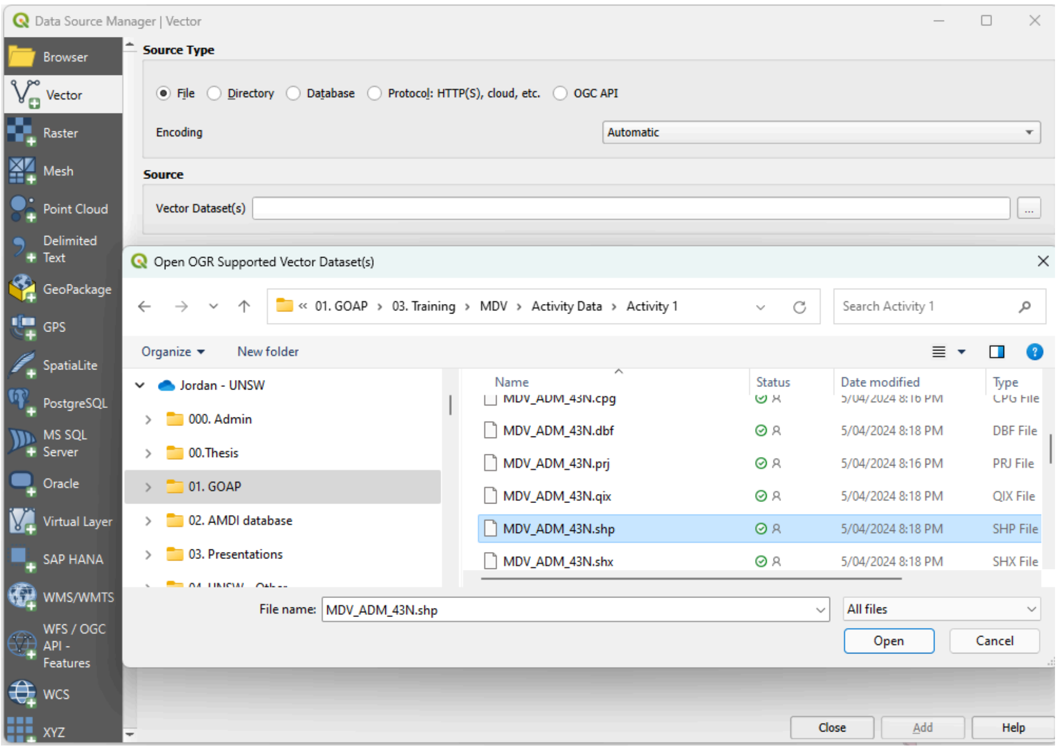
4. The shapefile(s) will be added to the map and displayed in the Layers panel.

Add the following shapefiles and ensure they are in the table of contents:

- MDV_ADM_43N (Administrative boundary),
- SG_17_43N – estimated seagrass cover for 2017,
- SG_20 – estimated seagrass cover for 2020.

*When loading shapefile data, please select the file with extension ".shp". When prompted on options – just use defaults.



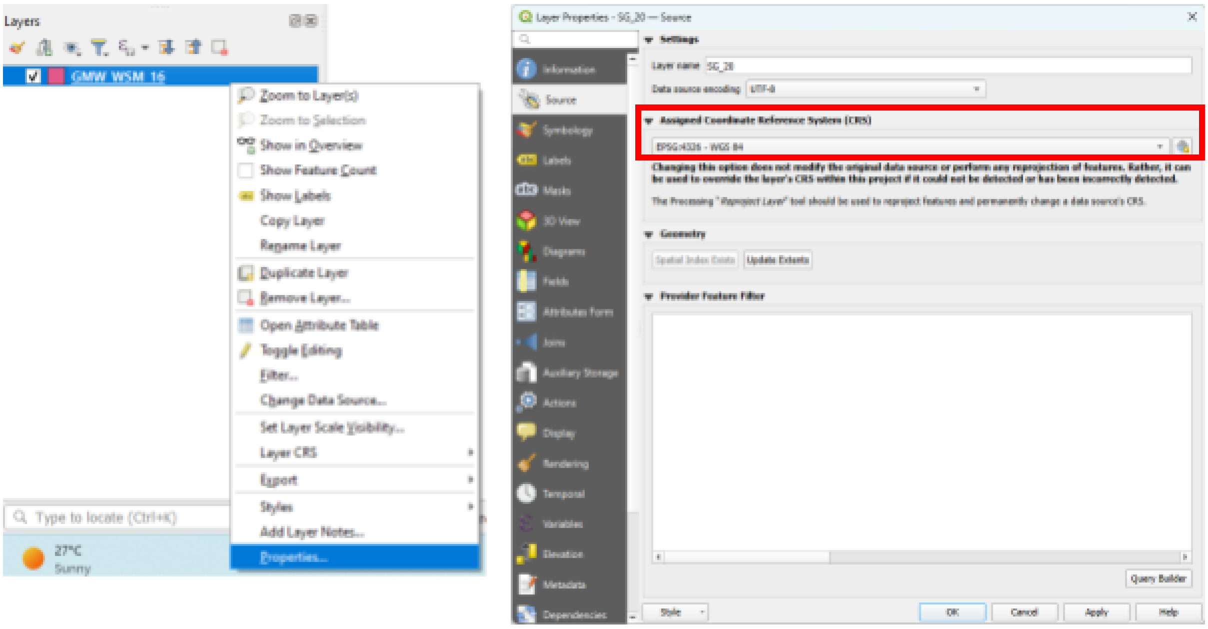


Step 2: Check the Coordinate System, project (if needed)

All shapefiles must have the same coordinate reference system (CRS) for analysis. To calculate area in m^2, a projected CRS must be used. For Maldives, we are using WGS84 / UTM 43N.

Double-click on the layer to open Properties > Select "Source" tab. The CRS of the layer will be displayed in the "CRS" field.

Using an example of GMW_WSM_20_WGS – we can see that CRS is WGS 84, **not** WGS 84 / UTM zone 43N! **Do not change the CRS in properties. We need to reproject this layer.**



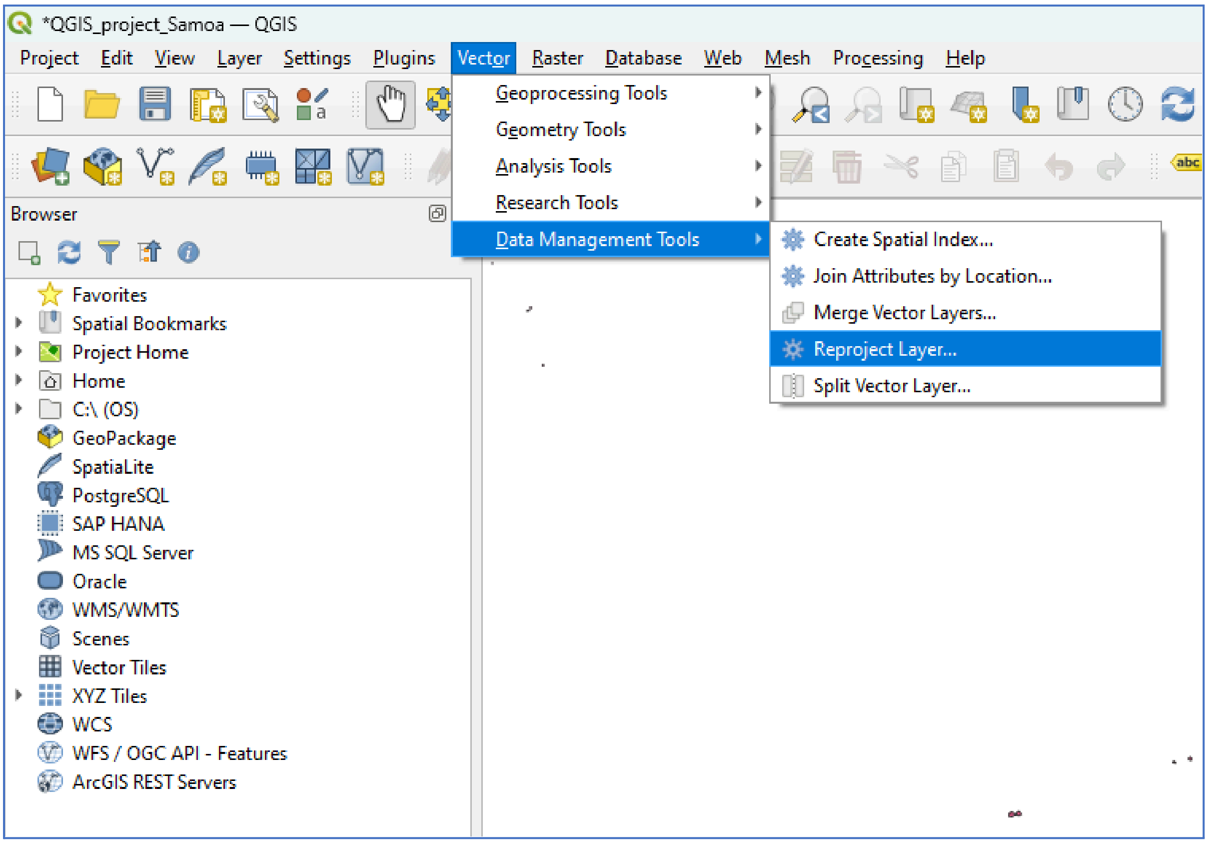
If not the desired CRS, save a projected version of the file. Be careful not to overwrite your original data.

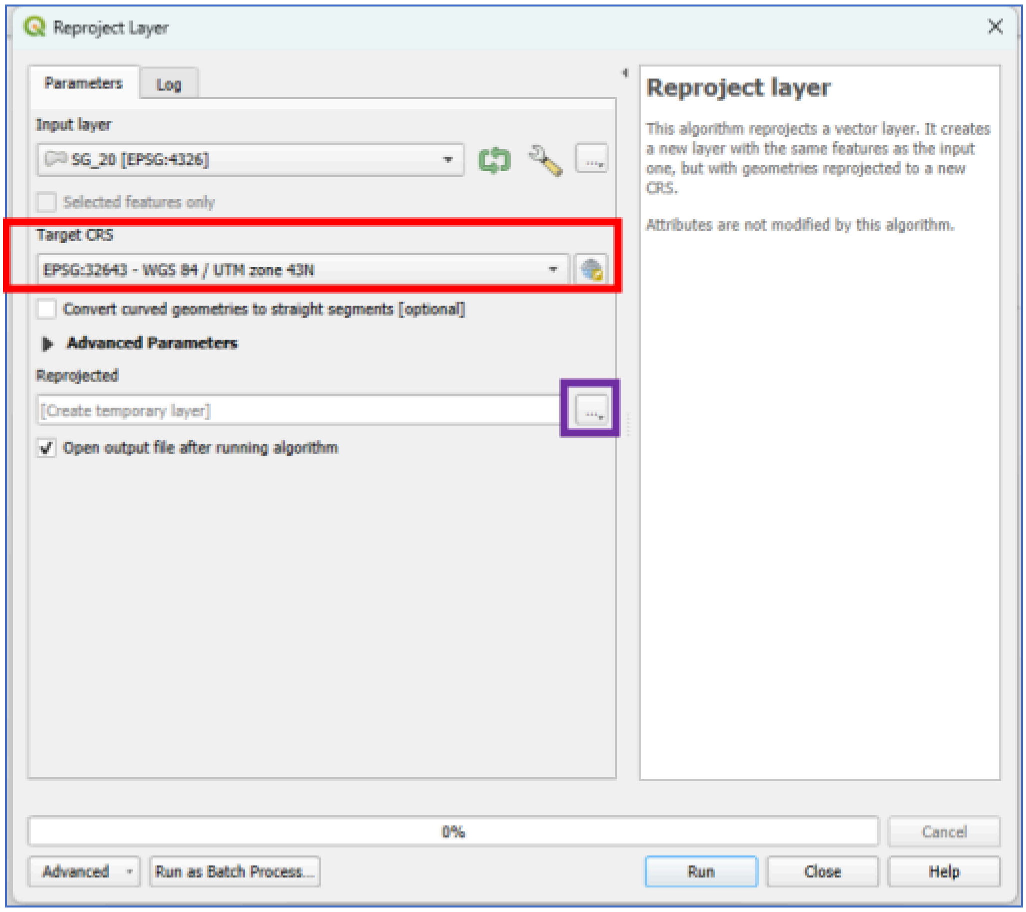
Close dialogue box.

Basic steps below, see following page for more detailed instructions.

1. Click on your layer and select "Vector" > "Data Management Tools" > "**Reproject layer**."
2. The input layer is the target to reproject.
3. Select the "Target CRS" from the list of CRSs.
4. Please save your file (using the 3 dots, purple rectangle). Make sure that the layer is clearly renamed (e.g., Output for "SG_20" could be named "SG_20_43N") and are saved as **shapefiles** (.shp).
5. Click on "Run".

Check if this is needed for all layers in Activity 1.


*QGIS_project_Samoa — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Geoprocessing Tools
Geometry Tools
Analysis Tools
Research Tools
Data Management Tools
Create Spatial Index...
Join Attributes by Location...
Merge Vector Layers...
Reproject Layer...
Split Vector Layer...
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (OS)
GeoPackage
SpatiaLite
PostgreSQL
SAP HANA
MS SQL Server
Oracle
WMS/WMTS
Scenes
Vector Tiles
XYZ Tiles
WCS
WFS / OGC API - Features
ArcGIS REST Servers


Reproject Layer
Parameters
Log
Input layer
SG_20 [EPSG:4326]
Selected features only
Target CRS
EPSG:32643 - WGS 84 / UTM zone 43N
Convert curved geometries to straight segments [optional]
Advanced Parameters
Reprojected
[Create temporary layer]
Open output file after running algorithm
Reproject layer
This algorithm reprojects a vector layer. It creates a new layer with the same features as the input one, but with geometries reprojected to a new CRS.
Attributes are not modified by this algorithm.
0%
Cancel
Advanced
Run as Batch Process...
Run
Close
Help

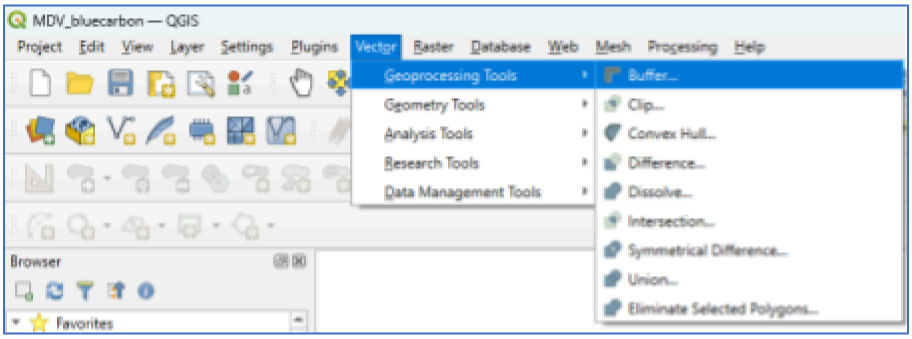
Step 3: Buffer islands

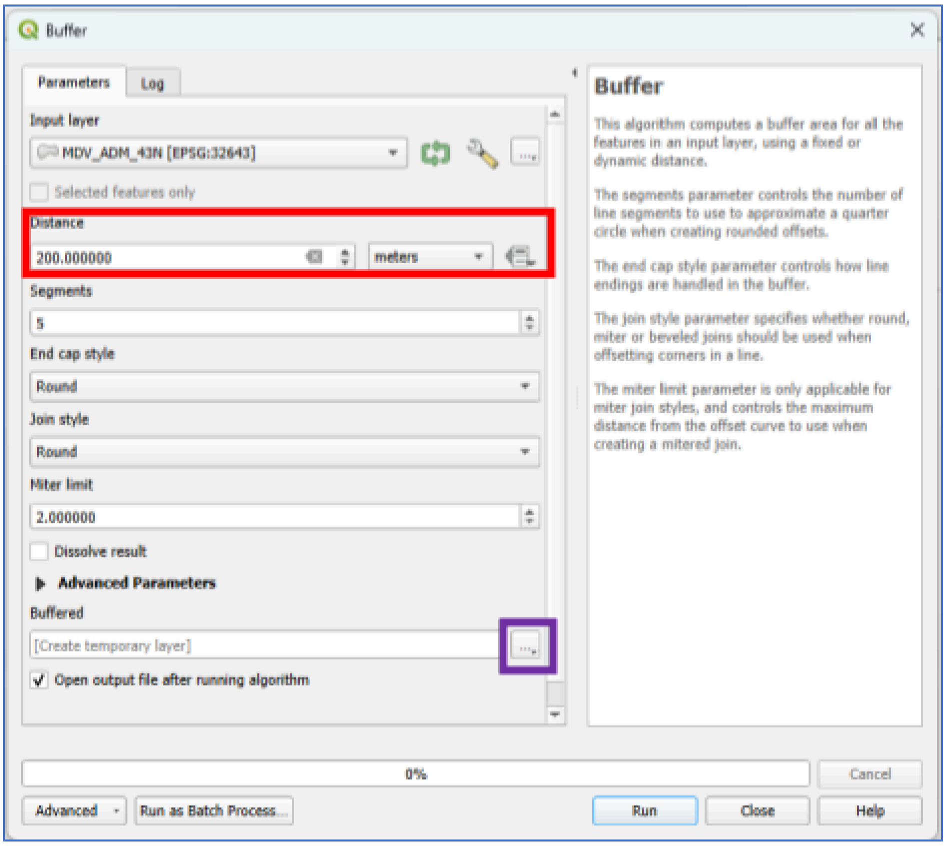
We need to produce a polygon that measures all the seagrass within 200 m of each island. Using MDV_ADM_43N (all islands in Laamu), we will "**buffer**" each polygon, extending each shape by 200 m.

The steps to buffer are below.

1. Click "Vector" > "Geoprocessing Tools" > "**Buffer…**"
2. The input layer is the target to buffer.
3. Set "Distance" to 200 m
4. Save your layer, (using the 3 dots, purple rectangle)
5. Click on "Run".

Make sure that the layer is clearly renamed (e.g., Output could be named "Laamu_Buffer_200") and saved as **shapefiles** (.shp).





Step 4: Calculate Intersected Areas

We will now calculate the area of seagrass by comparing (i) the 200 m, with (ii) the seagrass vector (e.g., SG_17_43N)

Open the "Intersection" tool ("Vector" > "Geoprocessing Tools"). This tool will create a new shapefile with polygons that represent the intersection of the two input shapefiles.

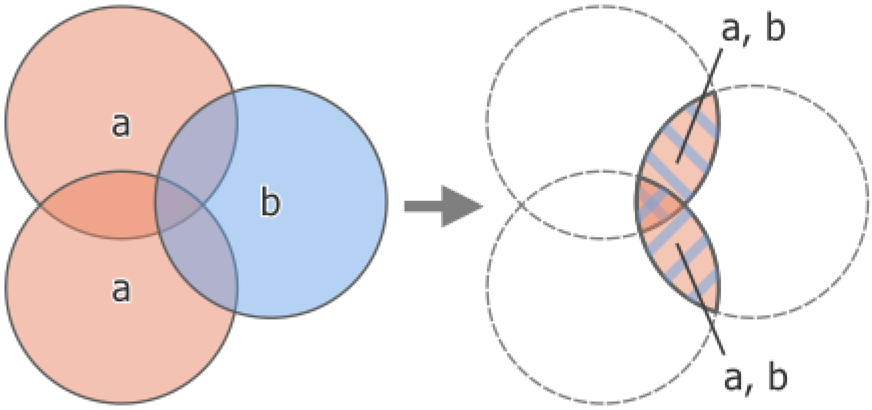
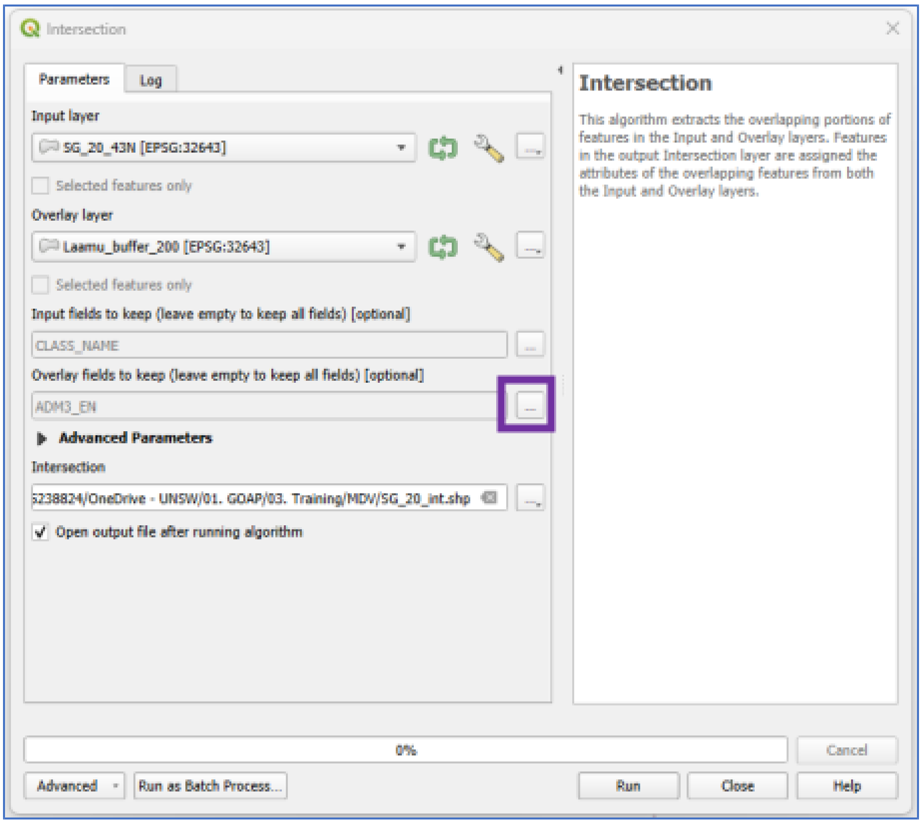


Figure 2. Example of an intersection under the vector overlay tools. Adapted from QGIS guide (27.1.19.5)

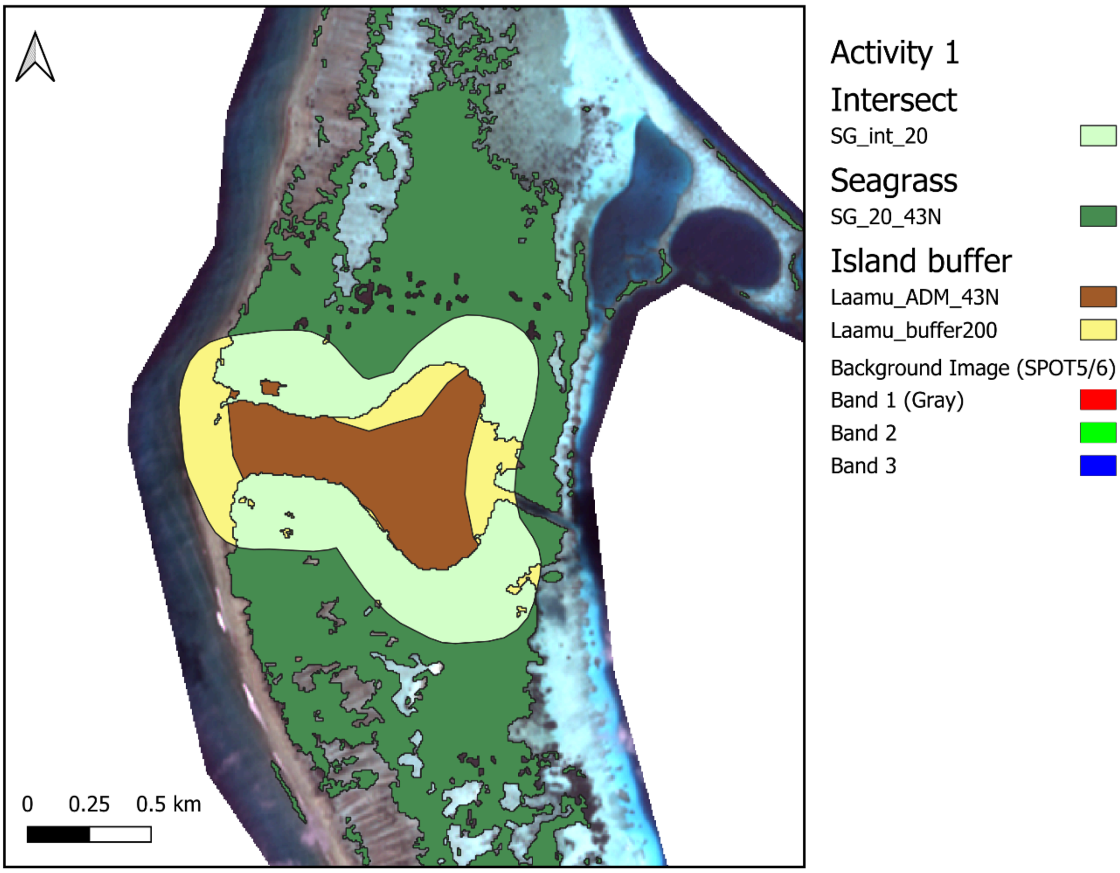
Enter the following into the dialogue box:

- Input Features: Select the **projected** layer representing the buffered zones per island (Laamu_buffer_200).
- Overlay Features: Select the layer representing the areas of interest (seagrass – SG_20_43N).
- Under "intersection", save to file (purple box - suggested name "SG_20_int")
- Click "Run" when ready.



Output of Step 3, using Maavah as an example.

Light green areas show what is measured by the intersected area, while dark green show areas outside the buffer zone.


0
0.25
0.5 km
Activity 1
Intersect
SG_int_20
Seagrass
SG_20_43N
Island buffer
Laamu_ADM_43N
Laamu_buffer200
Background Image (SPOT5/6)
Band 1 (Gray)
Band 2
Band 3

Step 4.5: Fix geometries

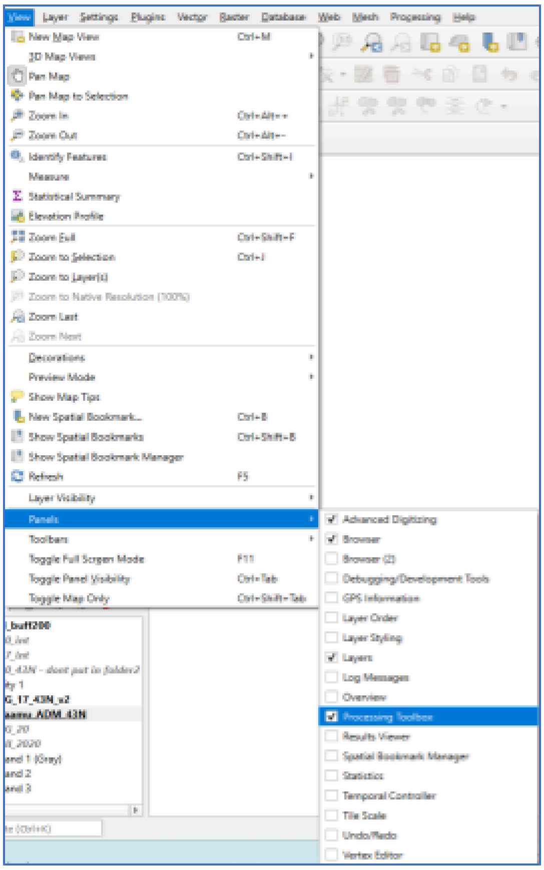
For QGIS, geometries of your files need to comply with Open GIS, specifically:

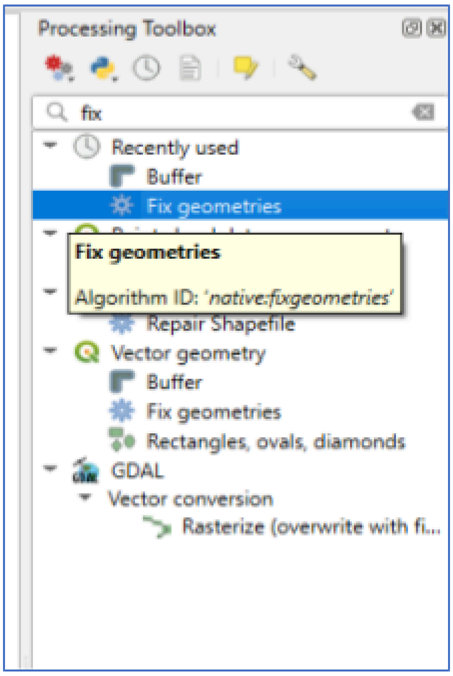
- Lines are valid if they don't pass an inner vertex twice.
- Polygons are valid if their linear components are simple and none of their rings cross.

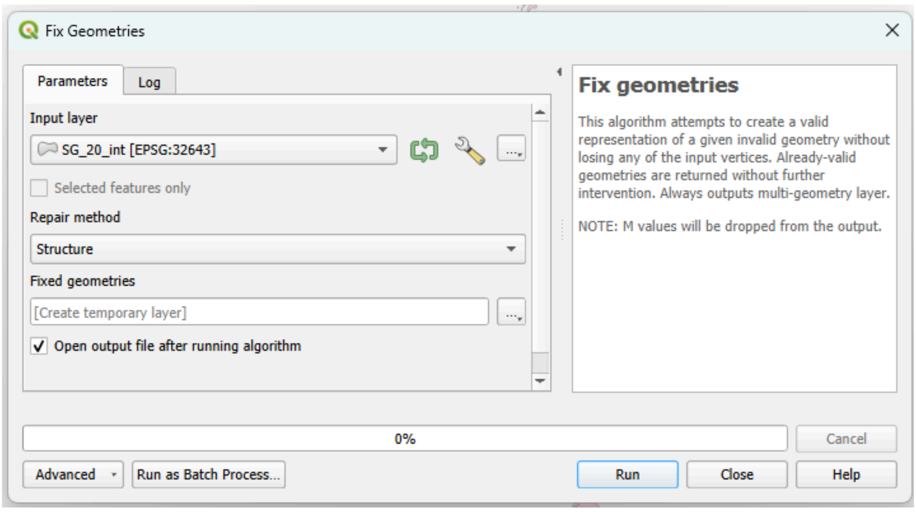
When using QGIS, sometimes your files will require their geometries to be fixed, especially if they have been created in ArcGIS (.shp) or Google Earth (.kmz files), which do not always comply with the QGIS standards for valid geometries.

We will need to fix your new intersected file, SG_20_int, using fix geometries. Search and locate fix geometries in your processing toolbox. If you cannot see your toolbox, follow the below steps:

- View > Panels> Processing Toolbox.



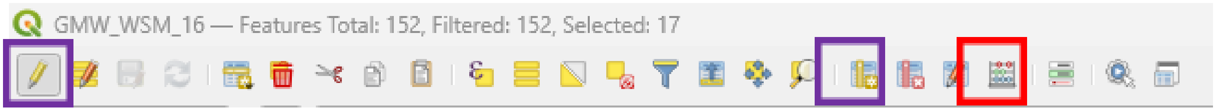




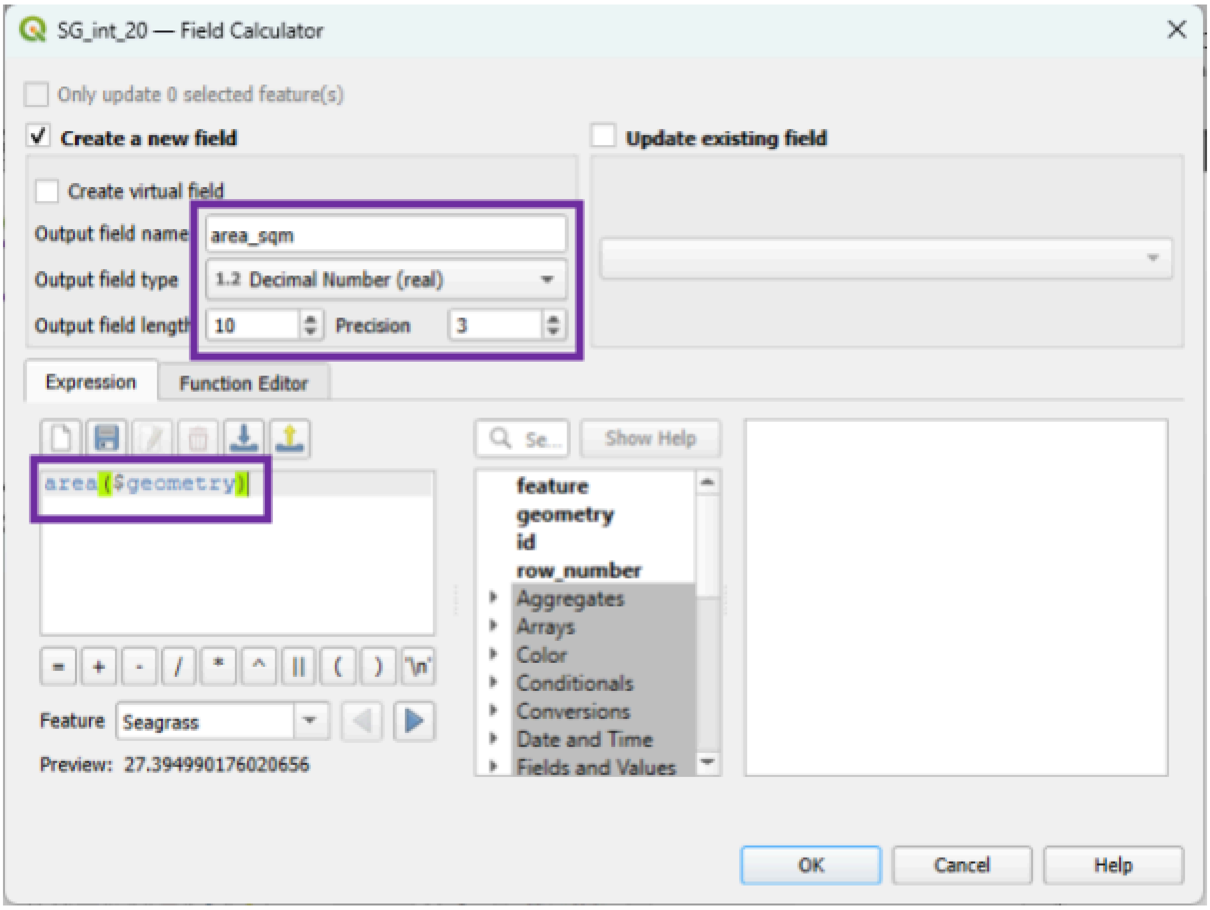
Step 5: Calculate Area

Right click on the layer from Step 3 > "Open Attribute Table" of the new shapefile.

- Toggle "Edit mode" and "Add field" named "Area_sqm". Set type to Decimal.



- Turn off "Edit mode" and open the "Field Calculator" (Red).
- Options:
  - o Update existing field – Area_sqm,
  - o Expression - area($geometry)



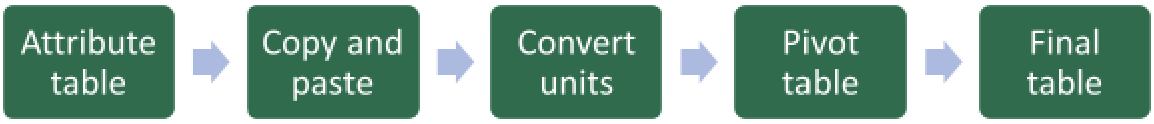
Make sure that there are no features selected or uncheck the box for selected features.

You should now have a table that has area in square meters.

Activity 2: QGIS to Excel

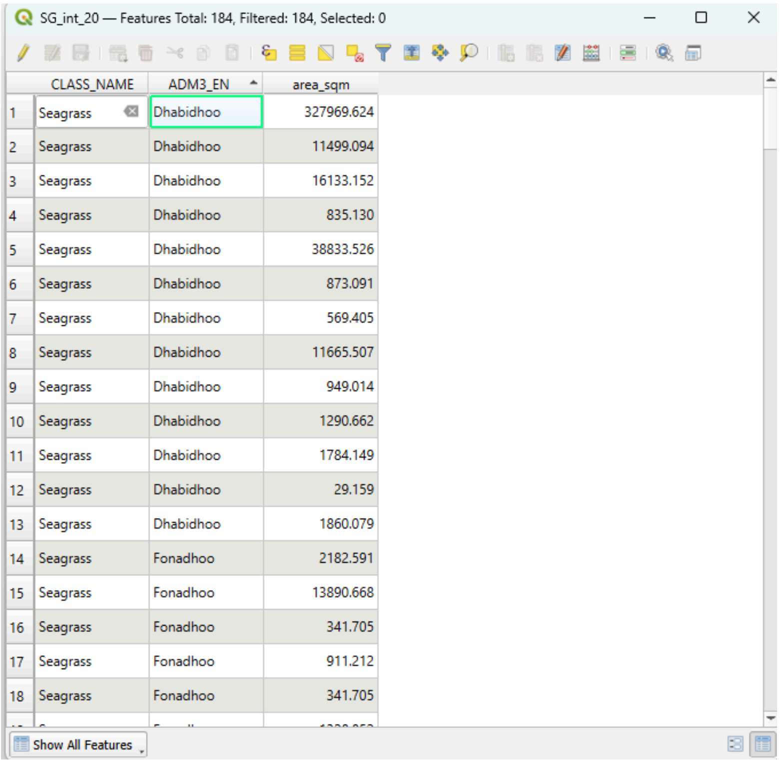
Converting data from QGIS attribute table to **Excel** formats allows a wide range of stakeholders with access to spatial data. Excel allows users who may not have GIS expertise but require access to the data for tasks such as statistical analysis, or reporting.

Workflow



Step 1: Copy and paste the table into Excel

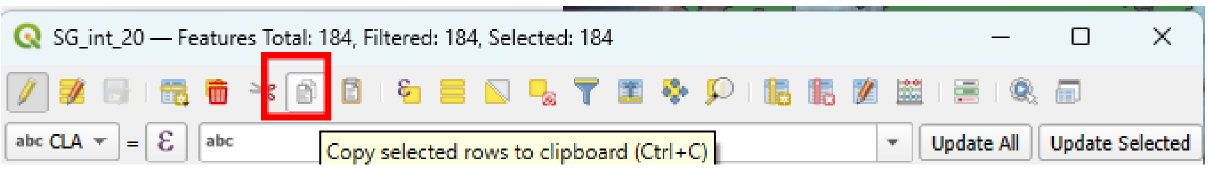
To open attribute table (Right click > "Open attribute table") and ensure it's in table view.



	CLASS_NAME	ADM3_EN	area_sqm
1	Seagrass	Dhabidhoo	327969.624
2	Seagrass	Dhabidhoo	11499.094
3	Seagrass	Dhabidhoo	16133.152
4	Seagrass	Dhabidhoo	835.130
5	Seagrass	Dhabidhoo	38833.526
6	Seagrass	Dhabidhoo	873.091
7	Seagrass	Dhabidhoo	569.405
8	Seagrass	Dhabidhoo	11665.507
9	Seagrass	Dhabidhoo	949.014
10	Seagrass	Dhabidhoo	1290.662
11	Seagrass	Dhabidhoo	1784.149
12	Seagrass	Dhabidhoo	29.159
13	Seagrass	Dhabidhoo	1860.079
14	Seagrass	Fonadhoo	2182.591
15	Seagrass	Fonadhoo	13890.668
16	Seagrass	Fonadhoo	341.705
17	Seagrass	Fonadhoo	911.212
18	Seagrass	Fonadhoo	341.705

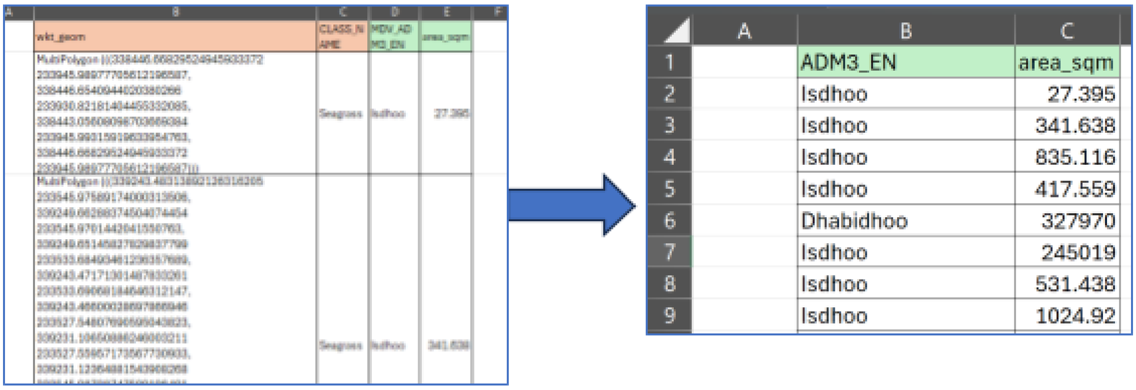
The intersect tool will (1) remove areas that are not found within each island buffer boundary and (2) assign each section to a specific buffer. Note the field of view shows **Dhabidhoo**.

Select all rows (Ctrl + A) and right click to copy. Paste into excel.



Delete columns (wkt_geom and CLASS_Name - marked in red). Keep ADM3_EN and area_sqm (in green)

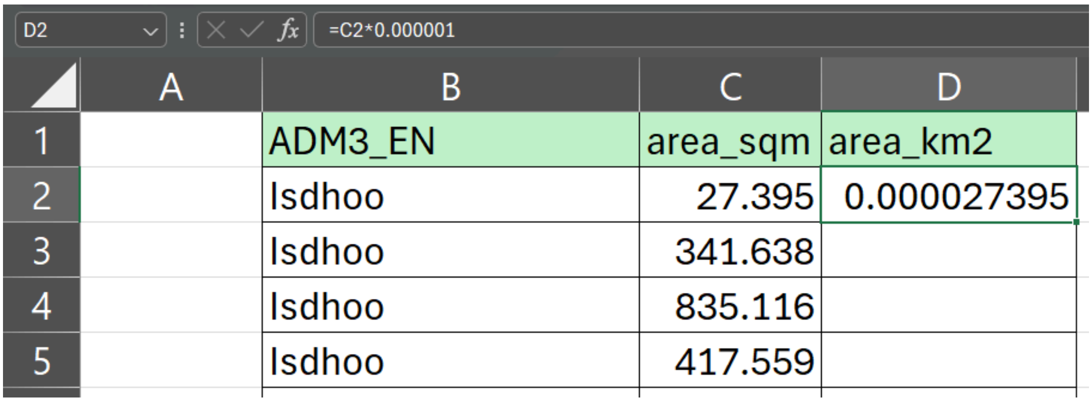
- ADM3_EN- Field with name per island
- Area_sqm - Area of seagrass in square meters



	A	B	C
1		ADM3_EN	area_sqm
2		Isdhoo	27.395
3		Isdhoo	341.638
4		Isdhoo	835.116
5		Isdhoo	417.559
6		Dhabidhoo	327970
7		Isdhoo	245019
8		Isdhoo	531.438
9		Isdhoo	1024.92

Step 2: Convert units

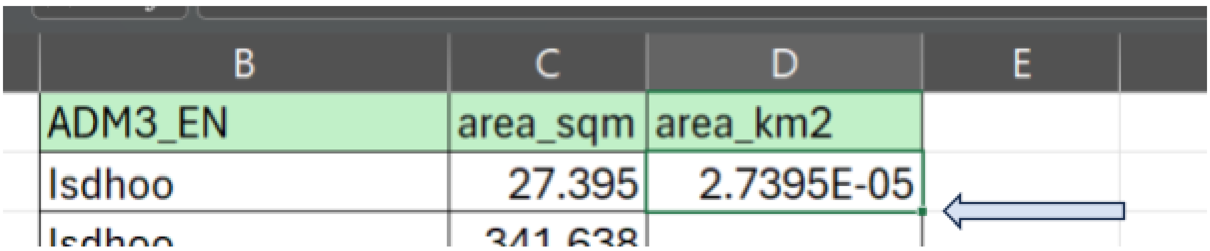
Create a new column called “area_km2”. We will convert the area to square kilometres (km^2) using the following relationship (1 m^2 = 0.000001 km^2). **Use the equation = [cell with area_sqm] * 0.000001.**



D2 | =C2*0.000001

	A	B	C	D
1		ADM3_EN	area_sqm	area_km2
2		Isdhoo	27.395	0.000027395
3		Isdhoo	341.638	
4		Isdhoo	835.116	
5		Isdhoo	417.559	

Then, you can drag the equation to all the relevant cells in the column by **double clicking** the green square of the cell. Alternatively, you can copy and paste the equation, highlighting all the relevant cells in the column.

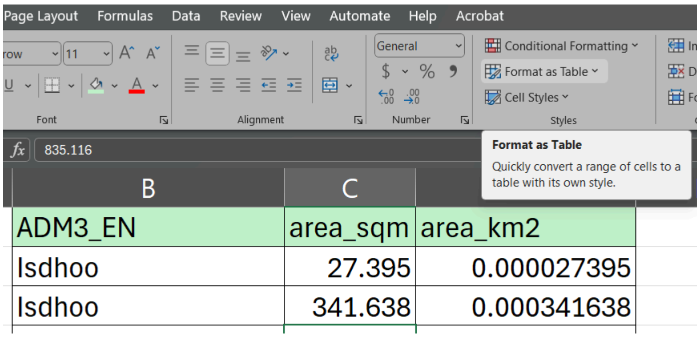


B	C	D	E
ADM3_EN	area_sqm	area_km2	
Isdhoo	27.395	2.7395E-05	
Isdhoo	341.638		

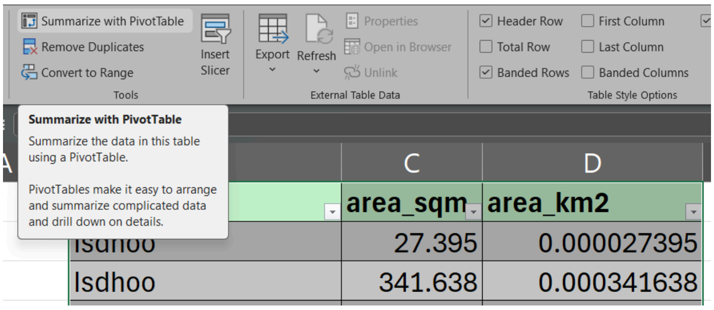
Step 3: Set up your pivot table

A pivot table is a tool to summarize data, enabling users to automatically sort, count, and total or average the data stored in **one table** and present it in a **second table**. This interactive process allows users to rearrange (or "pivot") the columns and rows of data to view it from different perspectives, offering a customizable report from a larger data set. We will drag and drop fields into different axes of the pivot table, to explore the data without altering the original data.

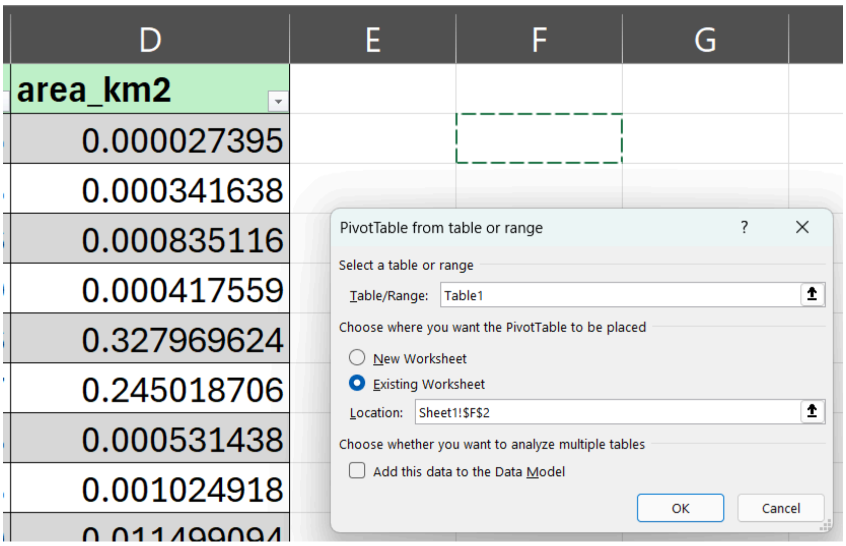
1. Click anywhere in your data and format the rows as a table.



2. Produce a pivot table next to your data.

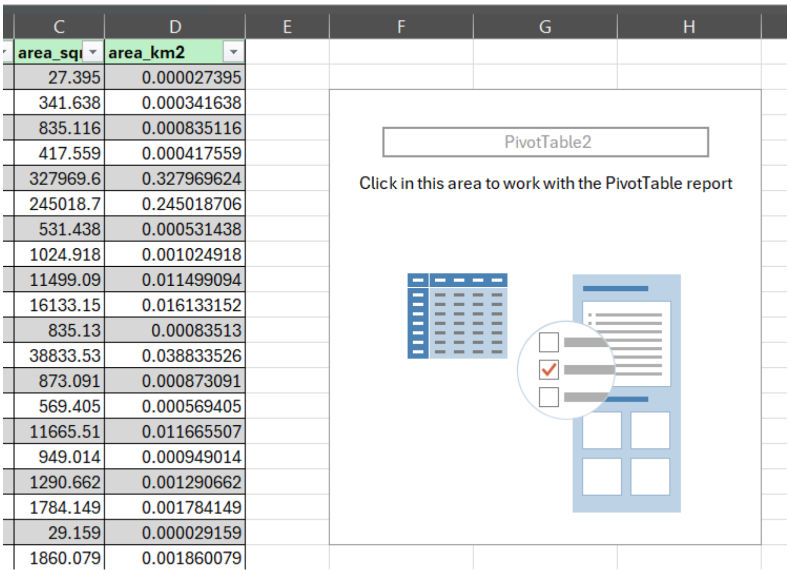


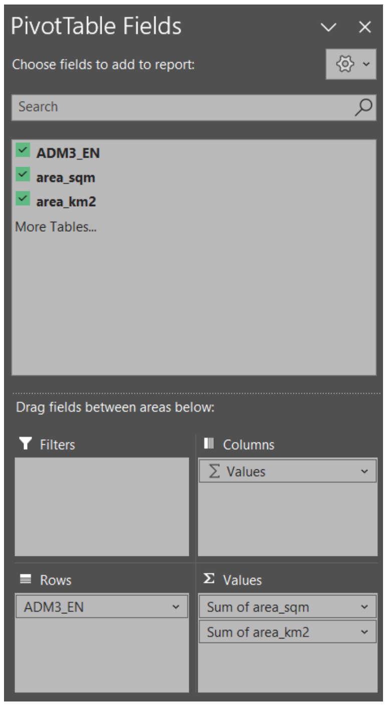
3. Select existing worksheet and click a cell near your data.



Step 4: Adding values to the pivot table

You will now have an empty pivot table, like below. Add the following data to the rows and columns of the pivot table. Experiment with the combinations – how do they change the data that is presented?





Step 5: Calculate statistics

You will have a table that shows the area (in m^2 and km^2) for all islands. Fill in the table on the following page.

ADM3_EN	area_sqm	area_km2
Isdhoo	27.395	0.000027395
Isdhoo	341.638	0.000341638
Isdhoo	835.116	0.000835116
Isdhoo	417.559	0.000417559
Dhabidhoo	327969.6	0.327969624
Isdhoo	245018.7	0.245018706
Isdhoo	531.438	0.000531438
Isdhoo	1024.918	0.001024918
Dhabidhoo	11499.09	0.011499094
Dhabidhoo	16133.15	0.016133152

Row Labels	Sum of area_sqm	Sum of area_km2
Dhabidhoo	414291.592	0.414291592
Fonadhoo	1131469.176	1.131469176
Gaadhoo	848499.915	0.848499915
Gan	465502.408	0.465502408
Hithadhoo	348696.751	0.348696751
Isdhoo	920875.822	0.920875822
Kalhaidhoo	93639.725	0.093639725
Kunahandhoo	535552.126	0.535552126

Fill the table below:

Table 2. Estimated mangrove extent per island area, buffered by 200 m

Island	Area (m^2)		Area (km^2)		Percentage change (includes cloud / error)
	2017	2020	2017	2020	
Dhabidhoo	571202.77		0.57		
Fonadhoo	1210572.69		1.21		
Gaadhoo	890431.17		0.89		
Gan	518784.74		0.52		
Hithadhoo	524001.71		0.52		
Isdhoo	434165.26		0.43		
Kalhaidhoo	124660.88		0.12		
Kunahandhoo	232868.21		0.23		
Maabaidhoo	317731.38		0.32		
Maamendhoo	26656.43		0.03		
Maavah	681691.35		0.68		
Mundhoo	351278.25		0.35		
Grand Total	12826743.35		12.82		

General guidance

Data sources

Data for ocean accounts (mangroves and beyond) may come from a variety of sources. Accounting activities should carefully consider whether national or international datasets should be used to achieve robust and accurate accounts.

National and international datasets both offer valuable resources for compiling ecosystem accounts, but the choice between them depends on several factors. National datasets could provide detailed information specific to a particular country's ecosystems and economic activities. This granularity can be crucial for understanding local environmental challenges and informing policy decisions. However, national data may not be standardized or comparable across different areas (and adjacent countries) and may not contain sufficient timeseries.

International datasets, on the other hand, offer consistent methodologies and formats that may be maintained over time (e.g., Landsat satellite imagery). This can be helpful for identifying trends and informing sustainable development goals, especially if national data is limited. The data, however, may not be at an appropriate resolution to resolve important local variations. It is also important to note that there can be inconsistencies in national statistics generated from international datasets. The choice of data sources should be determined through consultation and consensus among key stakeholders and end-users including, but not limited to, the Ministry of Environment, Geographic Information Systems (GIS) practitioners, and national statistical office.

Processing satellite data vs. existing polygons

Note that data from these sources may be unclassified remote sensing images or already classified into discrete categories. If data is the raw remote sensing image, usually a raster, the data must be classified into meaningful categories (e.g., water, forest, mangrove). This step may not be applicable if it has already been conducted. These classified datasets might originate from previous satellite image classifications, field surveys, or other sources. Note, however, that the classifications may differ to your needs and should be carefully assessed before use.

Key considerations for mangroves

- **Data Availability:** The availability and quality of mangrove data vary considerably across the Pacific. Some countries might have detailed mapping, while others might have limited or outdated information.
- **Data Format:** Data formats and accessibility can vary across sources. Carefully note the different file formats. Project and extract relevant information when needed.
- **Ground truthing**: Satellite imagery and remote sensing data are often used for mapping global and international datasets. These datasets, however, may have been trained using different conditions than the local context. Ground truthing is needed to determine the accuracy of these datasets.

Potential sources for mangrove data

The European Space Agency's (ESA) Copernicus program provides unprecedented access to the Sentinel satellite constellation. Among these, Sentinel-2 provides high-resolution optical imagery and processed data on land cover, vegetation, and environmental dynamics. The platform contains 13 sensors, with a spatial resolution varying from 10 m to 60 m. The combination of these sensors provides indices that assist in identifying mangrove extent and health. Data from the satellite could be either the raw raster image or processed into classes.

Time series / Accounting years

Timeseries data is crucial for environmental economic accounting because it enables analyses that link trends to potential drivers. Specifically, timeseries assist in understand change through identifying trends and breakpoints:

- **Trends**: Patterns in the data that could show increase or decrease through time. For example, total and rates of loss in habitat.

- **Breakpoints:** Certain years might signal significant changes in the system. An introduction of a new environmental tax, a major natural disaster, or a shift in government policy can all have noticeable impacts.

There is no single "correct" timeframe or timeseries for environmental economic accounting. Choosing the right years depends on the specific use cases and questions, data availability, and the desired level of detail. By carefully considering these factors and the importance of timeseries data, robust and informative accounts could be compiled, which could inform solutions towards environmental challenges. For example:

- If the question is measuring change over time, the regular production of accounts over fixed time periods (e.g., every two years) would be beneficial,
- If the accounts will investigate immediate changes due to an event, an appoint focusing on breakpoints may be more appropriate.

Trade-offs are often made between “breadth” and “depth” of data. Longer Timeseries offer a wider perspective on environmental trends and changes, while shorter timeseries could assist in understanding specific issues or events. For example, accounts could isolate the effects of specific policies, and capture more nuanced dynamics. Longer timeseries may have data gaps or less granularity, while shorter ones may not capture long-term trends or miss crucial turning points.

Annex: Answers

Activity 1

Island	2017 (km^2)	2020 (km^2)	Percentage change (includes cloud / error)
Dhabidhoo	0.57	0.41	27.47%
Fonadhoo	1.21	1.13	6.53%
Gaadhoo	0.89	0.85	4.71%
Gan	0.52	0.47	10.27%
Hithadhoo	0.52	0.35	33.46%
Isdhoo	0.43	0.92	-112.10%
Kalhaidhoo	0.12	0.09	24.88%
Kunahandhoo	0.23	0.54	-129.98%
Maabaidhoo	0.32	0.19	40.58%
Maamendhoo	0.03	0.03	-27.52%
Maavah	0.68	0.73	-6.68%
Mundhoo	0.35	0.37	-6.33%
Grand Total	12.82	12.39	