

## Module 2: Calculate Area Below Cost Threshold

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This model calculates area (km<sup>2</sup>) where seaweed can be farmed at or below two user-chosen cost thresholds (net cost per ton of seaweed harvested or net cost per ton of CO<sub>2</sub> equivalent). This model identifies and displays areas that can be farmed for costs below each cost threshold.

The input raster should account for the costs associated with farming the seaweed and transporting it to its target destination as well as income received for the seaweed, which may vary depending on the purpose for which it is grown. The target destination may be a port, a sinking location, or a destination further along the supply chain, such as a processing facility. Costs may be framed in units of greenhouse gas reduction (carbon dioxide equivalent) from using the end seaweed products to displace conventional products, carbon sequestration from sinking seaweed, or in terms of dry weight of seaweed harvested. Any currency may be used.

The model creates a polygon of area meeting the two thresholds. The polygon's attribute table records the area meeting each cost threshold (Table 1). Note that cost thresholds below zero (i.e., negative net cost) represent profit. A threshold of zero represents breaking even (i.e., costs equal to income derived from the seaweed).

*Limitations:* This model assumes costs will be the same over entire an grid cell. Coarse input resolutions may omit some nearshore areas. Model maps do not display uncertainty associated with cost thresholds for seaweed farming. Users are recommended to view maps as a visual guide with caution. Sample data that may accompany this tool are for educational purposes only. Users are responsible for verifying the accuracy, timeliness, and relevance of all input data used in this tool.

Requirements:

- R software Version 3.3.0 or later
- Within R, the following packages are required:
  - “raster”
  - “sf”

Notes:

- Working Directory must include folders named “Inputs” and “Outputs”
- Cost Threshold 1 must be larger than Cost Threshold 2 (th1 > th2) for plotting
- Input raster must be *.tif* format

Outputs:

- Map highlighting areas for seaweed farming that match each Cost Threshold
- Table summarizing the total area below each Cost Threshold (exported as a *.csv* file)
- Polygons with area below each cost threshold (exported as *.shp* files)

**Table 1.** Description of inputs and outputs for the Area Below Cost Threshold model.

<b>Parameter</b>	<b>Explanation</b>
Input Net Cost Raster (costras)	Net cost of seaweed farming per ton of carbon dioxide equivalent offset (Mg CO <sub>2</sub> e; includes direct sequestration) or per ton dry weight harvested. Any currency may be used. File must be <i>.tif</i> format.
Cost Threshold 1 (th1)	Cost threshold 1 (number). Any currency may be used.
Cost Threshold 2 (th2)	Cost threshold 2 (number). Any currency may be used.
Units of net cost raster (unit)	Text string noting units of the net cost raster. This string will be incorporated into the column headers of the final output table.
Results Table (results_table)	Table with total area (km <sup>2</sup> ) of where seaweed can be farmed for equal or less than the two cost thresholds using the currency of the input raster.

*Workflow:*

1. **Setting up R**

- Install and load the required packages using *install.packages("raster")* and *install.packages("sf")*, then *library(raster)* and *library(sf)*.

2. **Setting the Working Environment**

- Set your working directory to where your data is stored with *setwd("Your/Directory/Path")*.

3. **Data Input**

- Load your cost raster file with *raster("Path/To/CostRaster.tif")*.
- Ensure the file is *.tif* format.

4. **Analysis**

- Define the cost thresholds (e.g., *th1 = 1400*, *th2 = 0*). For plotting purposes, *th1* should be greater than *th2*.
- Use conditional plotting to visualize areas where seaweed farming meets these thresholds.

5. **Data Conversion**

- Identify cells with values below each cost threshold.
- Convert the identified areas into polygons for further analysis using *raster::rasterToPolygons(costX, na.rm = TRUE, dissolve = TRUE)*.
- Transform these polygons into 'sf' objects for accurate area calculation using *st\_as\_sf(polygonsX)*.
- Set coordinate reference system (CRS) to **WGS84** for area calculation using *st\_transform(polygonsX\_sf, crs = 4326)*

6. **Area Calculation**

- Calculate the area of each polygon in km<sup>2</sup> using *st\_area(polygonsX\_sf) / 10<sup>6</sup>*.

- Note: Division by  $10^6$  is required to get area in  $\text{km}^2$  as the package calculates area in  $\text{m}^2$  by default.

#### **7. Results Compilation**

- Combine the area of each polygon with same cost threshold using `sum(polygonsX_sf$area_km2)`.
- Summarize and display the results, including the total area below each cost threshold using `print(results_table)`.

#### **8. Exporting Results (Optional)**

- Export polygons for each cost threshold as shapefiles.
- Export the summary table as a CSV file to the Outputs folder.