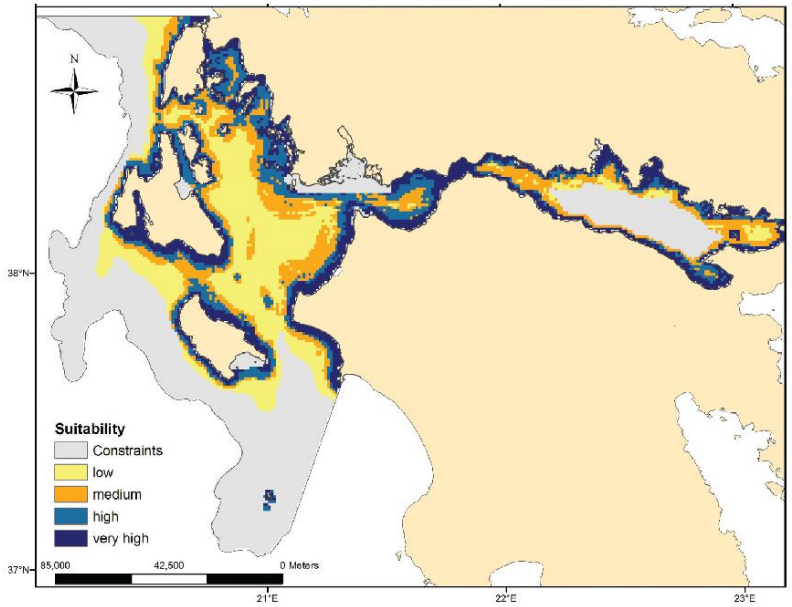
Fishing footprint of Small Scale Coastal Fisheries: the ***fprmcda*** R package



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AIM: Develop a geospatial tool for visualizing fisheries spatial footprint of Small and Medium Scale Fisheries based on a Multi-Criteria Decision Analysis (MCDA)

Main Tasks (T1.11, T1.12):

- Develop two R libraries that will implement the Multi-Criteria Decision Analysis
- Link R library outputs with a Geoportal

Kavadas, S., I. Maina, D. Damalas, I. Dokos, M. Pantazi, and V. Vassilopoulou (2015). Multi-Criteria Decision Analysis as a tool to extract fishing footprints and estimate fishing pressure: application to small scale coastal fisheries and implications for management in the context of the Maritime Spatial Planning Directive. Mediterranean Marine Science 16:294-304. http://dx.doi.org/10.12681/mms.1087

Flowchart of steps and methods of MCDA

Part A

Part B

Table 2. Ranking* of the criteria taken into account in MCDA.

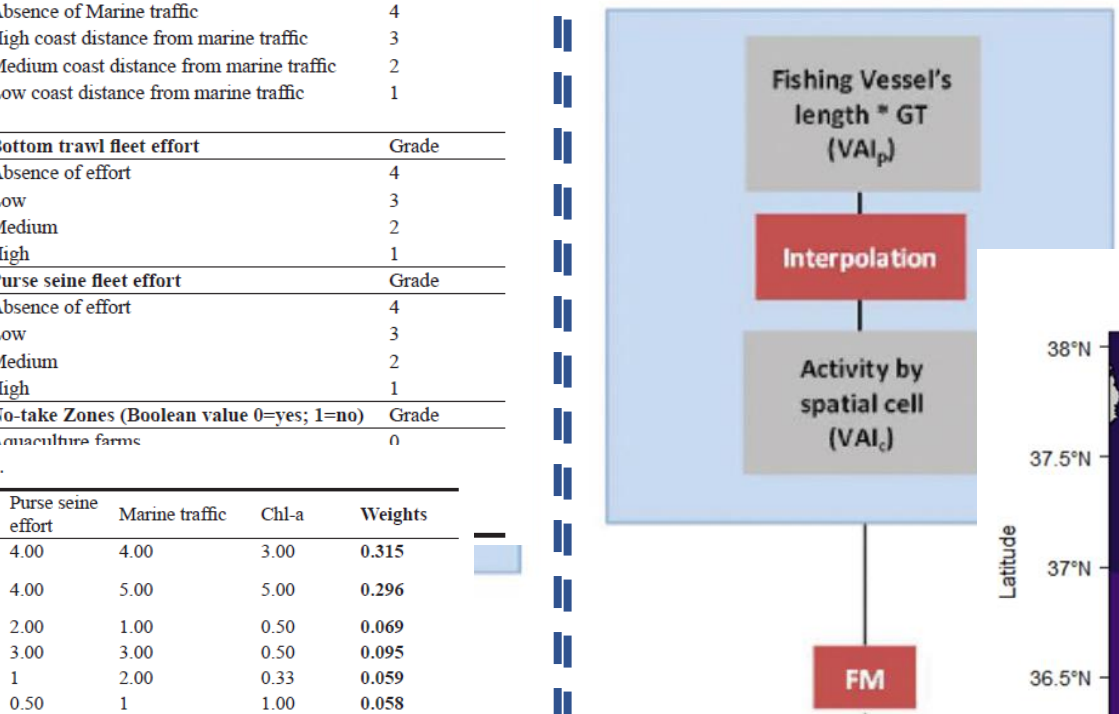
Bathymetry (meters)	Grade
0 - 50 m	4
50 m - 100 m	3
100 m - 200 m	2
200 m - 500 m	1
>500 m	0
Distance from coast (nautical miles)	**Grade**
< 1.5 nm	4
1.5 nm - 3 nm	3
3 nm - 6 nm	2
>6 nm	1
Sea Surface Chlorophyll (Chl-a) (mg/m³)	**Grade**
Eutrophic waters: >0.793mg/m3	4
Upper mesotrophic waters : 0.46mg/m3 - 0.793mg/m3	3
Medium mesotrophic waters: 0.23mg/m3 - 0.46mg/m3	2
Lower mesotrophic waters: 0.1mg/m3 - 0.23mg/m3	1
Legislation	**Grade**
available areas	4

Marine traffic activity	Grade
Absence of Marine traffic	4
High coast distance from marine traffic	3
Medium coast distance from marine traffic	2
Low coast distance from marine traffic	1
Bottom trawl fleet effort	**Grade**
Absence of effort	4
Low	3
Medium	2
High	1
Purse seine fleet effort	**Grade**
Absence of effort	4
Low	3
Medium	2
High	1
No-take Zones (Boolean value 0=yes; 1=no)	**Grade**
Aquaculture farms	0

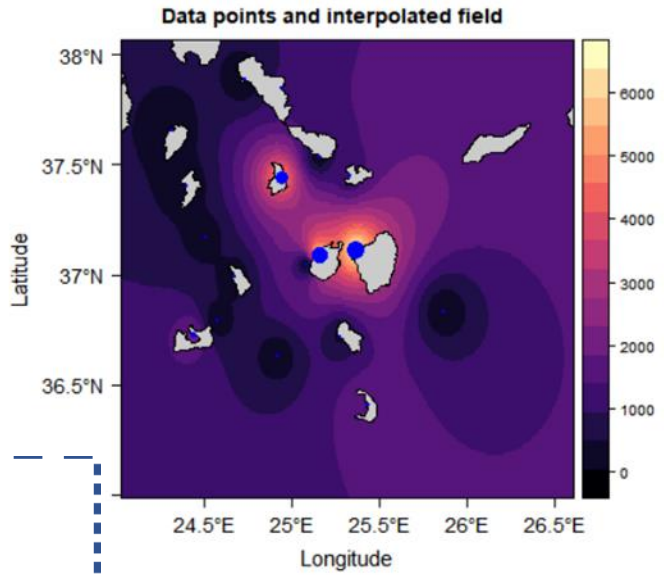
Table 3. Pair-wise comparison matrix and relative importance of weights.

	Bathymetry	Distance from coast	Legislation	Trawl effort	Purse seine effort	Marine traffic	Chl-a	Weights
Bathymetry	1	2.00	4.00	5.00	4.00	4.00	3.00	**0.315**
Distance from coast	0.50	1	6.00	4.00	4.00	5.00	5.00	**0.296**
Legislation	0.25	0.17	1	1.00	2.00	1.00	0.50	**0.069**
Trawl effort	0.20	0.25	1.00	1	3.00	3.00	0.50	**0.095**
Purse seine	0.25	0.25	0.50	0.33	1	2.00	0.33	**0.059**
Marine traffic	0.25	0.20	1.00	0.33	0.50	1	1.00	**0.058**
Chl-a	0.33	0.20	2.00	2.00	3.00	1.00	1	**0.109**

A4. Application of the Weighted Linear Combination method (WLC)

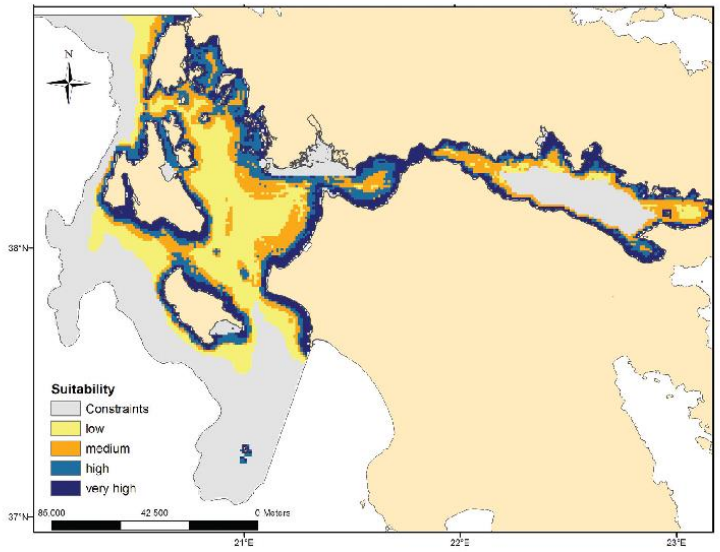


B1. Apply interpolation method to Fishing Fleet data

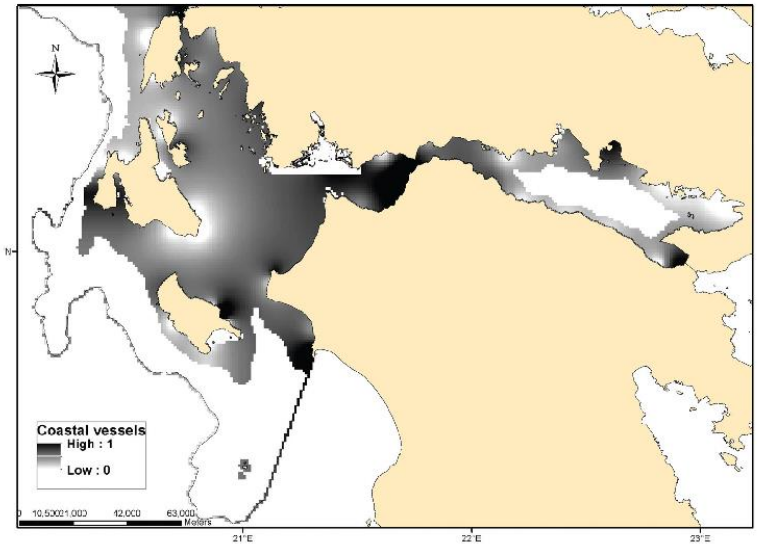


Part C

Spatial representation of the Coastal fishery suitability index (Sc)

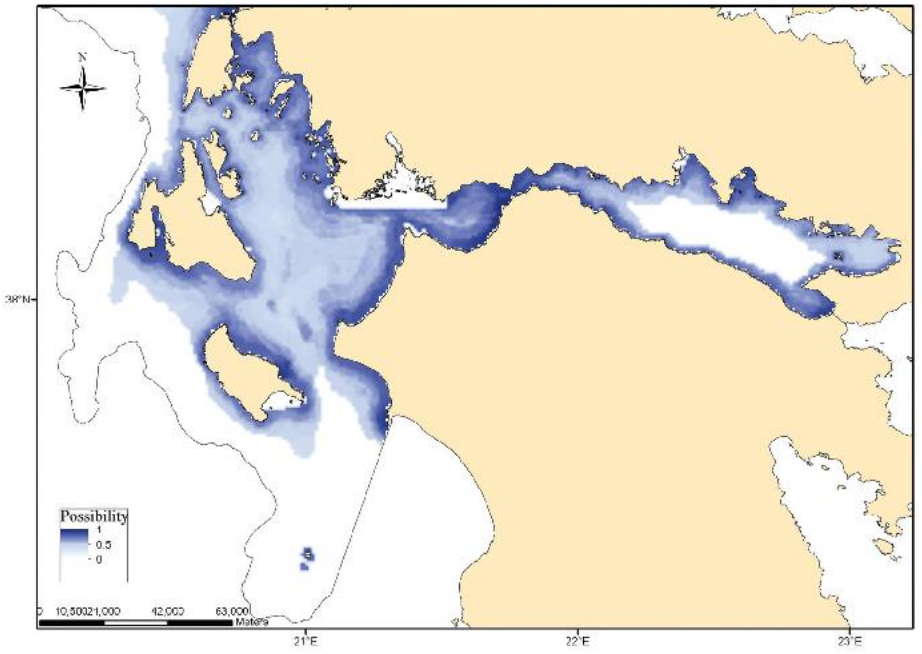


Spatial representation of Coastal vessels activity index (Ac)



FINAL RESULT

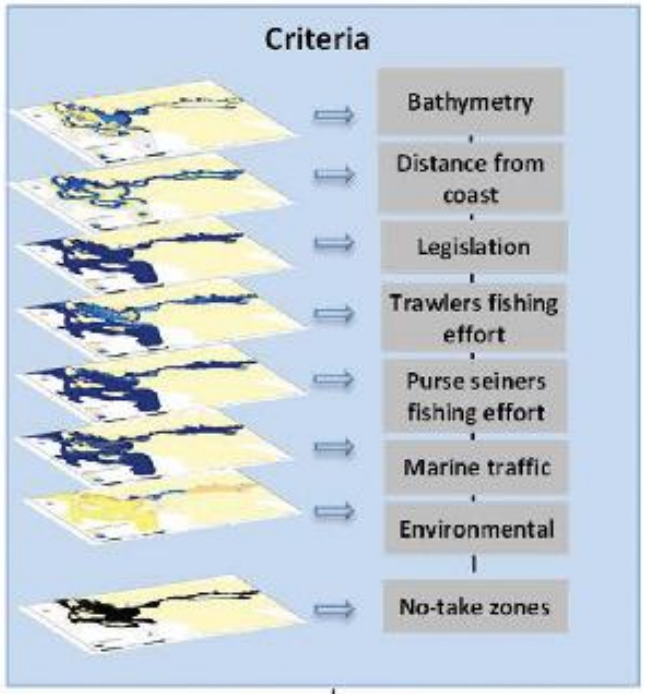
Spatial representation of the Fishing pressure index (FPc)



Workflow

1 Load Spatial Data (raster, shapefiles, or csv)

# 1a Score the Criteria
Scored_Data = **fgrade**(Data, cuts, scores)



Input: Pair-wise comparison matrix between criteria

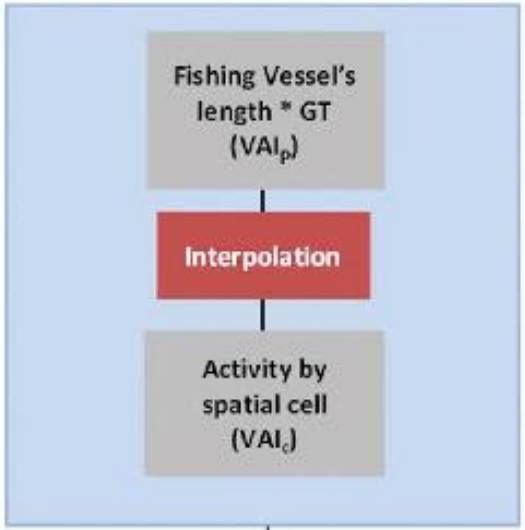
# 1b. Apply Analytic Hierarchy Process
AhpOut = OptAhp(PairwiseMatrix)

Outputs: Weights, RMSE

# 1c. Weighted Linear Combination method (WLC)
Sc = sum(AhpOut$Weights*Scored_Data)

# 1d. Normalise Sc
Sc <- FuzzyMember(Sc)

2 Load Fishing Fleet (FishG) data (lon, lat, GTL)



Inputs: FishG data and spatial mask

# 2a. Apply IDW interpolation
IFg<- **idwfg**(FishG, mask.raster)

Outputs: Ac, Error

3 Synthesis

AHP

FM

Coastal fishery suitability index (S_c)

# 3a Combine Sc, Ac
FPc=Sc* IFg$Ac

Fuzzy Product

FM

2b Normalise Ac
IFg$Ac<- **FuzzyMember**(IFg$Ac)

Coastal fishery activity index (A_c)

Fishing Pressure from coastal fisheries (FP_c)

# 3b Normalise FPc
FPc <- **FuzzyMember**(FPc)

R-fprmcda Cheat Sheet

R Studio

R-fprmcda Cheat Sheet

Studio

Getting help

- **Overview of the package**

help(“fprmcda”)

- **Tutorial**

path <- system.file("doc", "fprmcdaTutorial.pdf", package = "fprmcda")
system(paste0('open "', path, ‘”’))

- **Demos**

demo(package="fprmcda") : list the demos

- **fprmcda Shiny apps**

dir1 <- system.file("shiny-examples", "shiny1", package = "fprmcda")
runApp(dir1)

Functions

fgrade(Data, cuts, scores)
Add scores to a dataset based on criteria

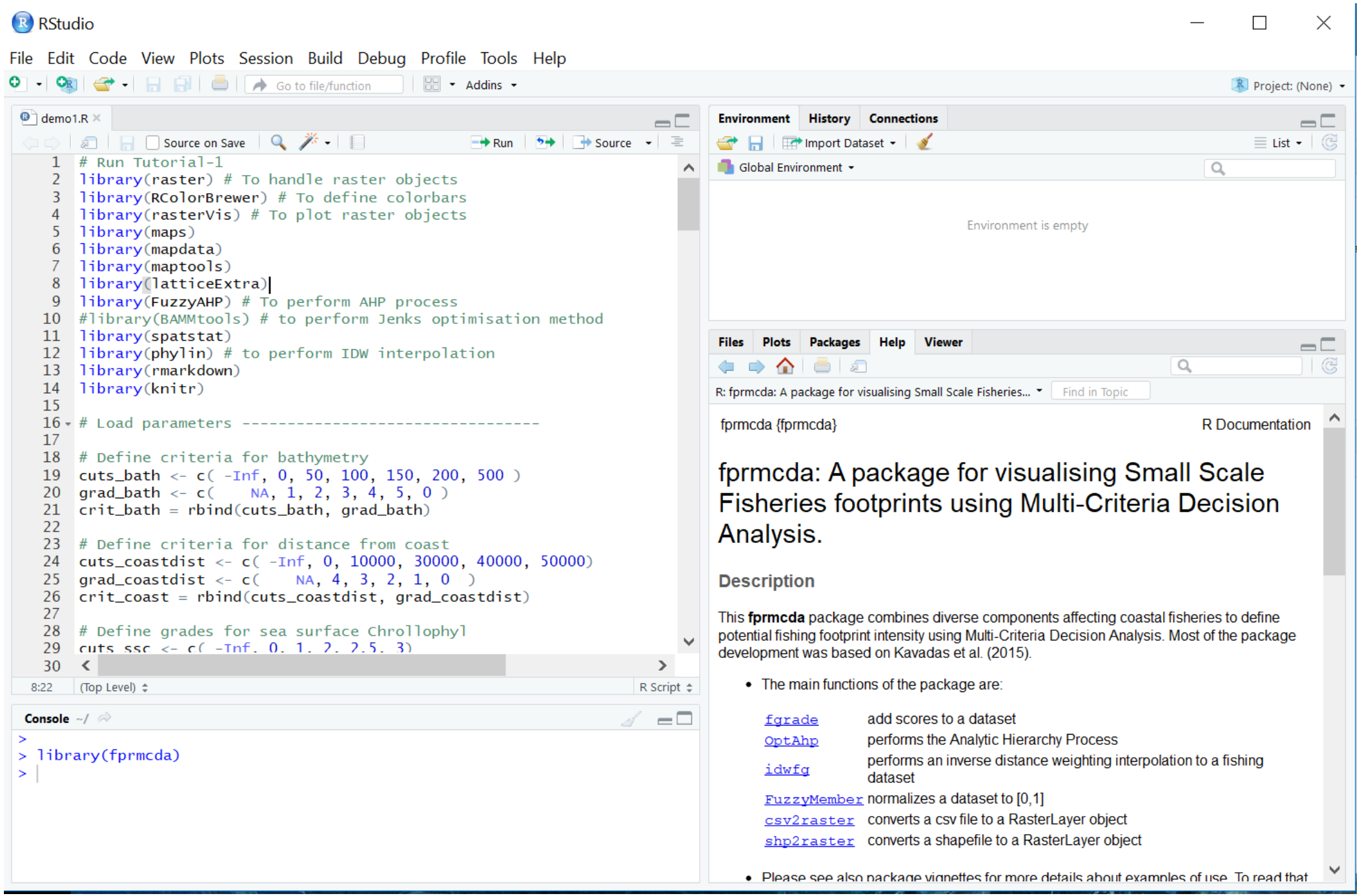
OptAhp(PairwiseMatrix, lambda = 0.5)
Compute the weights of analytic hierarchy process by adjusting the pair-wise comparison matrix.

idwfg(dataframe, rmask, method = "Shephard", p = 2, R = 2, N = 15)
Interpolate Fishing Gear data using Inverse Distance Weighting algorithm

FuzzyMember (x)
Normalises a data object x to [0,1]

csv2raster(dataframe, value, map.projection)
Converts a dataframe with x,y locations and values to a RasterLayer object.

shp2raster (shpfile, value, map.projection = proj4string(shpfile))
Converts a shapefile to RasterLayer object.


RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
Project: (None)
demo1.R
Source on Save
Run
Source
1 # Run Tutorial-1
2 library(raster) # To handle raster objects
3 library(RColorBrewer) # To define colorbars
4 library(rasterVis) # To plot raster objects
5 library(maps)
6 library(mapdata)
7 library(maptools)
8 library(latticeExtra)
9 library(FuzzyAHP) # To perform AHP process
10 #library(BAMMtools) # to perform Jenks optimisation method
11 library(spatstat)
12 library(phylin) # to perform IDW interpolation
13 library(rmarkdown)
14 library(knitr)
15
16 # Load parameters ---------------------------------
17
18 # Define criteria for bathymetry
19 cuts_bath <- c(-Inf, 0, 50, 100, 150, 200, 500)
20 grad_bath <- c(NA, 1, 2, 3, 4, 5, 0)
21 crit_bath = rbind(cuts_bath, grad_bath)
22
23 # Define criteria for distance from coast
24 cuts_coastdist <- c(-Inf, 0, 10000, 30000, 40000, 50000)
25 grad_coastdist <- c(NA, 4, 3, 2, 1, 0)
26 crit_coast = rbind(cuts_coastdist, grad_coastdist)
27
28 # Define grades for sea surface Chrollophyl
29 cuts_ssc <- c(-Inf, 0, 1, 2, 2.5, 3)
30
8:22 (Top Level) R Script
Console ~/
> library(fprmcda)
>
Environment History Connections
Import Dataset
List
Global Environment
Environment is empty
Files Plots Packages Help Viewer
R: fprmcda: A package for visualising Small Scale Fisheries...
Find in Topic
fprmcda {fprmcda} R Documentation
fprmcda: A package for visualising Small Scale Fisheries footprints using Multi-Criteria Decision Analysis.
Description
This fprmcda package combines diverse components affecting coastal fisheries to define potential fishing footprint intensity using Multi-Criteria Decision Analysis. Most of the package development was based on Kavadas et al. (2015).
The main functions of the package are:
fgrade add scores to a dataset
OptAhp performs the Analytic Hierarchy Process
idwfg performs an inverse distance weighting interpolation to a fishing dataset
FuzzyMember normalizes a dataset to [0,1]
csv2raster converts a csv file to a RasterLayer object
shp2raster converts a shapefile to a RasterLayer object
Please see also package vignettes for more details about examples of use. To read that

Tutorial

Fishing footprint of small scale coastal fisheries: the *fprmcda* Package

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Contents

1 Introduction

The *fprmcda* package is a tool for visualising fishing pressure for small scale coastal fisheries. It uses the multi-criteria decision analysis (MCDA) to quantify the synergistic effect of environmental and fishing factors. For more information, please see the publication associated with the *fprmcda* package (Kavadas et al., 2015).

From the package home page on CRAN, https://cran.r-project.org/package=fprmcda, links to the development source tree and documentation are found.

Two tutorials are presented here. The first shows a *fprmcda* analysis of a dataset produced for the publication associated with the fprmcda package (Kavadas et al., 2015). The second tutorial demonstrates an analysis for ????. The general workflow of the MCDA analysis can be seen in Fig. 1.

2 Preliminaries

To install R/fprmcda, you need first to install the package. Type (within R) install.packages("fprmcda"). Package *fprmcda* can then be load by

```
library(fprmcda)
help(fprmcda)
```

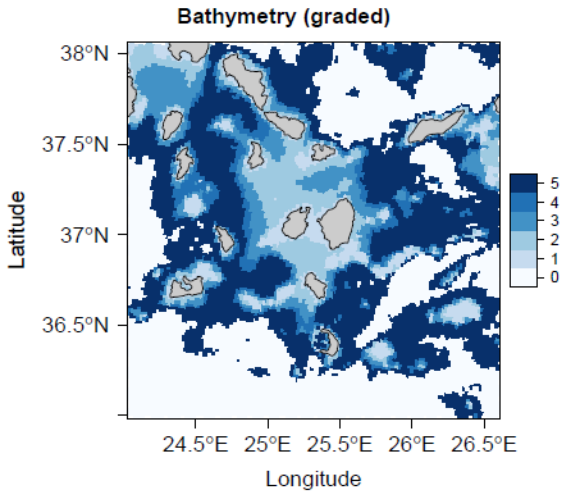



Figure 3: Bathymetry with scores.

We can plot the ranked raster object using the `leveplot` function of the *rasterVis* package as

```
# Create a color palette
buls <- brewer.pal(n=9,"Blues")
# Plot the ranked raster
levelplot(ratify(DataRank[[1]]),
          cuts = max(values(DataRank[[1]]), na.rm=TRUE),
          margin = F,
          col.regions = buls,
          main = "Bathymetry (graded)",
          att = "ID",
          scales = list(cex=1.2),
          xlab = list("Longitude",cex=1.2),
          ylab = list("Latitude",cex=1.2))+
   # Add map on the leveplot
   latticeExtra::layer({
   ext <- as.vector(extent(DataRank[[1]]))
   boundaries <- map('worldHires', fill=TRUE,
                     xlim=ext[1:2], ylim=ext[3:4],
                     plot=FALSE)
   IDs <- sapply(strsplit(boundaries$names, ":"), function(x) x[1])
   bPols <- map2SpatialPolygons(boundaries, IDs=IDs,
                                proj4string=CRS(projection(DataRank[[1]])))
   sp.polygons(bPols, fill='grey80', data=list(bPols=bPols))
                       })
```

Shiny apps

~/R/win-library/3.5/fprmcda/shiny-examples/shiny1 - Shiny

http://127.0.0.1:5441 | Open in Browser | Publish

IDW Interpolation

Apply Inverse Distance Weight Interpolation to fishing ports assigned with GTL (blue dots)

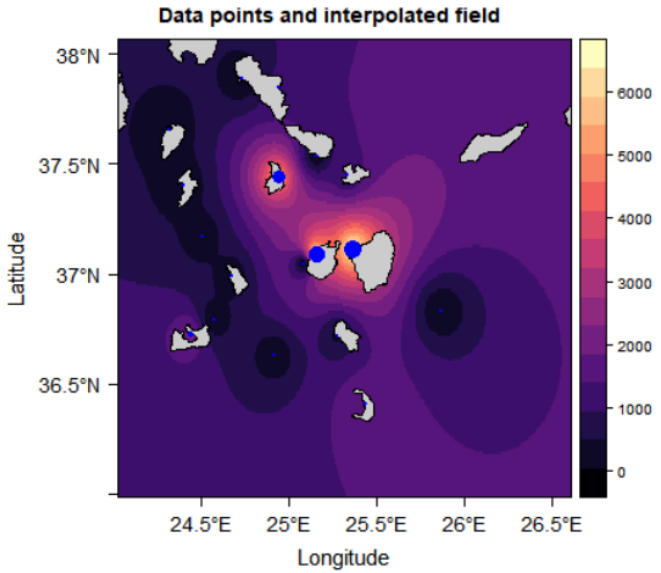
Interpolation method

Shephard

Weighting factor

1 2 10

1 2 3 4 5 6 7 8 9 10



The error of the interpolation is: 2294.4

Data to interpolate

	lon	lat	gtl
1	24.4450	36.7250	1952.3905
2	24.9401	37.8474	966.9861
3	25.0858	37.0446	194.9013
4	24.9403	37.4403	4779.9484
5	24.9215	36.6278	77.2409
6	24.7333	37.8867	62.1200
7	25.2800	36.7200	400.0253
8	24.6800	36.9900	129.5990
9	25.8700	36.8300	116.1159
10	24.5800	36.7900	80.1530
11	24.3179	37.6585	20.0995