Package ‘tools4MCDA’

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Type Package

Title Tools for estimate fishing effort, weight and value of landings using Multi-Criteria Decision Analysis

Version 0.1

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Description Tools for estimate fishing effort, weight and value of landings in the format of table I and table H of the Fisheries Dependent Information data call using Multi-Criteria Decision Analysis and information based on table G and table A

Depends R (>= 4.1.2)

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Suggests
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License GPL (>= 2)

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`add_LPUE` *Add a field related to Landings Per Unit of Effort (LPUE) in the dataframe derived based on MCDA*

Description

Using the predicted species distribution to estimate a proxy of LPUE. The fields for LPUE by species are added to the dataframe derived from MCDA. The above is then used for estimating landings' weight and value.

Usage

```
add_LPUE(
  data_FPI = sample_FPIq,
  spec = c("HKE", "MUT"),
  folder = "",
  name = c("hke.txt", "mut.txt"),
  field = c("grid_code", "grid_code"),
  LON = "POINT_X",
  LAT = "POINT_Y",
  sep = ","
)
```

Arguments

`data_FPI`	The dataframe derived by MCDA
`spec`	An object including the species that will be included in the MCDA dataframe in 3 alpha code format. For example c("HKE","MUT")
`folder`	The folder path that contains the species distribution outcomes (in a text format e.g. txt, csv)

`name`	An object with the name of the files. For example c("hke.txt","mut.txt").
`field`	The field which is containing the predicted values of species distribution that will be used as a proxy for LPUE. For example c("grid_code","grid_code")
`LON`	The field containing longitude values.The field should be in "".
`LAT`	The field containing latitude values.The field should be in "".
`sep`	The separator

Value

Return a dataframe including a field to be used as a proxy for LPUE and species.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
data(sample_FPIq)
data_with_LPUE<-add_LPUE(data_FPI=sample_FPIq,spec=c("HKE","MUT"),folder="_Your_folder_",name=c("hke.txt","
```

---

add_LPUE_year — *Add a field related to Landings Per Unit of Effort (LPUE) in the dataframe derived based on MCDA*

Description

Using the predicted species distribution to estimate a proxy of LPUE. The fields for LPUE by species are added to the dataframe derived from MCDA. The above is then used for estimating landings' weight and value.

Usage

```
add_LPUE_year(
  data_FPI = sample_FPIq,
  spec = c("HKE", "MUT"),
  folder = "",
  name = c("hke.txt", "mut.txt"),
  field = c("grid_code", "grid_code"),
  LON = "POINT_X",
  LAT = "POINT_Y",
  sep = ",",
  year
)
```

Arguments

data_FPI	The dataframe derived by MCDA
spec	An object including the species that will be included in the MCDA dataframe in 3 alpha code format. For example c("HKE","MUT")
folder	The folder path that contains the species distribution outcomes (in a text format e.g. txt, csv)
name	An object with the name of the files. For example c("hke.txt","mut.txt").
field	The field which is containing the predicted values of species distribution that will be used as a proxy for LPUE. For example c("grid_code","grid_code")
LON	The field containing longitude values.The field should be in "".
LAT	The field containing latitude values.The field should be in "".
sep	The separator
year	year of species distribution

Value

Return a dataframe including a field to be used as a proxy for LPUE and species.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
data(sample_FPIq)
data_with_LPUE<-add_LPUE_year(data_FPI=sample_FPIq,spec=c("HKE","MUT"),folder="_Your_folder_",name=c("hke.c
```

---

bubble_plot_year *Create a bubble map by year*

Description

Create a bubble map by year to plot the Activity index by port.

Usage

```
bubble_plot_year(
  data,
  field,
  map_sf,
  xlim = c(19, 24),
  ylim = c(36, 40),
  years,
  ncol = 3,
  classes = waiver(),
  LegendTitle,
  PlotTitle,
  limits = NULL,
  max_size = 6
)
```

Arguments

`data`	a dataframe with the Activity index by port
`field`	the field to be plotted. The field should be previously classified using the tools4MCDA::classify function.
`map_sf`	the polygon for the base map in sf format.
`xlim`	limits on x axis
`ylim`	limits on y axis
`years`	column including years in the data
`ncol`	number of columns of the plot
`classes`	number of the classes or function
`LegendTitle`	The title of the legend
`PlotTitle`	The title of the plot
`limits`	
`max_size`	maximum size of the bubble

Value

Returns a plot

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
library(sf)
library(sfheaders)
library(ggplot2)
library(tidyr)
library(BAMMtools)

data("fleet_reg_year")

#Define year and country
ye<-2019
country="GRC"

# unite gear_type and vessel_length
fleet_reg_year<-unite(fleet_reg_year, col='key', c('MAIN_FISHING_GEAR', 'vessel_length'), sep='_', remove=FA

#Bubble maps by year

#base map for bubble plots
poly<- map_data("world")
map_sf <- sfheaders::sf_polygon(obj = poly, x = "long", y = "lat", polygon_id = "group")
sf::st_crs(map_sf) <- 4326

# classify values for plotting
fleet_reg_year<-fleet_reg_year[fleet_reg_year[1]==country,]
i<-"GTR_VL0612"
```

```
fleet<-fleet_reg_year[fleet_reg_year$key==i,]
classes<-as.data.frame(getJenksBreaks(as.numeric(fleet$SUM_LOA_GT),7))
colnames(classes)<-"classes"
classes$key<-i
cla3<-as.numeric(classes[,1])
cla3<-cla3[-7]
fl_yy<-fleet_reg_year[fleet_reg_year$key==i,]
fl_yy$kmcl<-as.numeric(tools4MCDA::classify(data_field=as.numeric(fl_yy[,"SUM_LOA_GT"]),cuts=cla3, scores=c
fl_yy$x<-as.numeric(fl_yy$LONGITUDE)
fl_yy$y<-as.numeric(fl_yy$LATITUDE)
fl_yy$SUM_LOA_GT<-as.numeric(fl_yy$SUM_LOA_GT)
fl_yy<-fl_yy[fl_yy$YEAR==ye,]

# bubble plot
bubble_plot_year(data=fl_yy,field='kmcl',map_sf=map_sf,
          xlim=c(as.numeric(min(fl_yy$x)),as.numeric(max(fl_yy$x))),ylim=c(as.numeric(min(fl_yy$y)),as.num
               classes=cla3, ncol=1,
          limits=(c(0,as.numeric(max(fl_yy[,"SUM_LOA_GT"])))),PlotTitle=paste0(i,fl_yy$YEAR),
               LegendTitle=paste0(i,fl_yy$YEAR), max_size = 4)
```

`catch_ERSlevel` *Convert the estimated landings weight or value for SSF expressed in tonnes or euro using Fishing Pressure Index and Landings Per Unit of Effort as a proxy in a grid cell of 0.5*0.5 decimal degrees (csquare) in order to inform Table H.*

Description

Convert in csquare (0.5 * 0.5 dd) the combined outcome resulted based on FPI (estimated by MCDA), the LPUE and the Fisheries Dependent Information (FDI) data (Table A in the data call) to perform spatial estimations of landings weight or value and inform the Table H.

Usage

```
catch_ERSlevel(data_FPI, ERS_poly, LON = "LON", LAT = "LAT", parameter = "LW")
```

Arguments

`data_FPI`	A data frame with Fishing effort estimations after running the function FDays_SSF. The above data frame should contain the fields: Fishing Effort, LON (longitude in WGS84), LAT (latitude in WGS84), gear (values: GNS, GTR, LLS), year, vessel_length_cat (values: "VL0006","VL0010","VL0612",), quarter (values: 1-4), GSA (a field including information for the Geographical Subarea in the following format: GSA20, Country in the following format : GRC)
`ERS_poly`	A polygon shapefile with ERS rectangle (csquare of 0.5*0.5) in an 'sf' format
`LON`	Name of Longitude field in FPI table using "". The longitude should be in decimal degrees and in a geographical coordinate system WGS84
`LAT`	Name of Latitude field in FPI table "". The longitude should be in decimal degrees and in a geographical coordinate system WGS84
`parameter`	Name of the field that contains the landings weight or value in the data table using "".

Value

Return of a data.frame including landings weight or value by grid cell of 0.5*0.5 decimal degrees to be used for the creation of table H.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)

#load Data
data(FPIe_a)
data(ERS_poly)

# Define country
FPIe_a$Country<-"GRC"

# Estimate landings weight in a fine scale
result_q_catch<- landings_SSF(data=FPIe_a,Sub.region="Sub.region", Country="Country",
                   FE="FPI", LPUE="LPUE", species="species", table_a=table_a,gear="gear_type",year="year",
                   quarter="quarter", vessel_length_cat="vessel_length",fishing_tech ="fishing_tech",target
                        metier="metier",parameter = "totwghtlandg",LON="LON",LAT="LAT")

# Estimate landings weight by rectangle 0.5*0.5 decimal degrees
ERS_q_catch<-catch_ERSlevel(data_FPI=result_q_catch, ERS_poly=ERS_poly, parameter= "LW")
```

---

check_FDays

Compare fishing effort in days at sea estimated using Fishing Pressure Index (from MCDA) as a proxy and table_G on fishing effort estimations by GSA/gear/metier/quarter/fishing_tech/target_assemblage/year/country

---

Description

Combine Fishing effort estimations expressed in fishing days with Fishing Pressure Index (FPI- estimated by MCDA) with Fisheries Dependent Information (FDI) data (Table G in the data call) to perform comparisons by of the outcomes by GSA/gear/metier/quarter/fishing_tech/target_assemblage/year/country.

Usage

```
check_FDays(
  data,
  Sub.region,
  Country,
  FDays,
  table_g_effort,
  gear,
  metier,
  fishing_tech,
  target_assemblage,
```

```
  year,
  quarter,
  vessel_length_cat,
  LON,
  LAT
)
```

Arguments

data A data frame with Fishing effort estimations in Days at Sea in fine spatial scale. The above data frame should contain the fields: LON(longitude in WGS84), LAT(latitude in WGS84), gear(values: GNS, GTR, LLS), year, vessel_length_cat (values:VL006, VL0010,VL0612), quarter(values 1-4), GSA (a field including information for the Geographical Subarea in the following format: GSA20), Country in the following format (GRC)++

Sub.region The field of GSAs included in data using "".

Country The field of Country included in data using "".

FDays The field that contains information expressed in days at sea in a fine scale included the data table using "".

table_g_effort The data frame of the FDI Effort by country.csv. The above table is based on Table G in the data call (Fisheries Dependent Information (FDI) data)

gear The field in FPI table that contains the gear using "".Values: GNS, GTR, LLS

metier The field in FPI table that contains the metier using "".

fishing_tech The field in FPI table that contains the fishing technique using "".

target_assemblage The field in FPI table that contains the target assemblage using "".

year The field in FPI table that contains the year using "".

quarter The field in FPI table that contains the quarter using "".

vessel_length_cat The field in FPI table that contains the vessel length category using "". Values: VL006, VL0010, VL0612

LON Name of Longitude field in FPI table using "". The longitude should be in decimal degrees and in a geographical coordinate system WGS84

LAT Name of Latitude field in FPI table "". The latitude should be in decimal degrees and in a geographical coordinate system WGS84

Value

Return of a data.frame including FPI and Fishing days by grid cell.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)

#load Data
data(FPIe)
```

```
data(ERS_poly)

# Define country
FPIe$Country<-"GRC"

# Estimate Fishing Days in a fine scale
result_q<- FDays_SSF(data=FPIe,Sub.region="Sub.region", Country="Country", FPIc="FPI",
                    table_g_effort=table_g_effort,vessel_length_cat="vessel_length",
             year="year", quarter="quarter",gear="gear_type",fishing_tech="fishing_tech",
             target_assemblage="target_assemblage", metier="metier",LON="LON", LAT="LAT")

# Estimate Fishing Days by rectangle 0.5*0.5 decimal degrees
ERS_q<-Fdays_ERSlevel(data_FPI=result_q, ERS_poly=ERS_poly, LON="LON",LAT="LAT",parameter= "FDays")

result_q<- FDays_SSF(data=FPIe,Sub.region="Sub.region", Country="Country", FPIc="FPI",
                    table_g_effort=table_g_effort,vessel_length_cat="vessel_length",
             year="year", quarter="quarter",gear="gear_type",fishing_tech="fishing_tech",
             target_assemblage="target_assemblage", metier="metier",LON="LON", LAT="LAT")

#check Days at sea result
check_Fdays<-check_FDays(data=result_q,Sub.region="Sub.region",Country="Country",FDays="FDays",
                table_g_effort=table_g_effort,gear="gear_type",year="year",quarter="quarter",
                vessel_length_cat="vessel_length",fishing_tech="fishing_tech", target_assemblage="target_as
                        metier="metier",LON="LON",LAT="LAT")
```

---

check_landings — *Compare fishing effort in days at sea estimated using Fishing Pressure Index (from MCDA) as a proxy with table_A on landings estimations by GSA/gear/metier/quarter/fishing_tech/target_assemblage/year/country/species*

Description

Use the produced information that combines Fishing effort estimations expressed in fishing days with Fishing Pressure Index (FPI- estimated by MCDA) to perform comparisons with Fisheries Dependent Information (FDI) data (Table A in the data call) by GSA/gear/metier/quarter/fishing_tech/target_assemblage/yea

Usage

```
check_landings(
  data,
  Sub.region,
  Country,
  FE,
  LPUE,
  species,
  table_a,
  gear,
  year,
  quarter,
  metier,
  fishing_tech,
  target_assemblage,
```

```
  vessel_length_cat,
  parameter = "totwghtlandg",
  LW,
  LON,
  LAT
)
```

Arguments

data	A data frame with FE estimations (e.g. by MCDA and FDI) and species LPUE produced after running the tools4MCDA::landings_SSF function. The above data frame should contain the fields: LON(longitude in WGS84), LAT(latitude in WGS84), gear (values: GNS, GTR, LLS), year, vessel_length_cat , quarter(values 1-4), GSA (a field including information for the Geographical Subarea in the following format: GSA20, Country in the following format : GRC), FE (estimated fishing effort or the Fishing Pressure Index by MCDA), LPUE(estimated landings per unit effort)
Sub.region	The field of GSAs included in data using "".
Country	The field of Country included in data using "".
FE	The field in the FPI table that contains the fishing effort or the Fishing Pressure Index by MCDA using ""
LPUE	The field in the FPI table that contains the Landings Per Unit Effort using ""
species	The field in the FPI table that contains the species using ""
table_a	The data frame of the FDI "catches" (landing weight, landing value, discard weight) by country.csv. The above table is based on Table A in the data call (Fisheries Dependent Information (FDI) data and contains information about landing weight and value of landings)
gear	The field in FPI table that contains the gear using "". Values: SSF, GNS, GTR, LLS
year	The field in FPI table that contains the year using "".
quarter	The field in FPI table that contains the quarter using ""
metier	The field in FPI table that contains the metier using ""
fishing_tech	The field in FPI table that contains the fishing technique using ""
target_assemblage	The field in FPI table that contains the target assemblage using ""
vessel_length_cat	The field in FPI table that contains the vessel length category using "". Values: VL006, VL0010, VL0612
parameter	The field from table A to be used for performing spatial estimations. Values: "totwghtlandg", "totvallandg"
LW	The field in the FPI table that contains the total weight of landings or value by species using "". This is estimated from tools4MCDA::landings_SSF (NOT REVISE)
LON	Name of Longitude field in FPI table using "". The longitude should be in decimal degrees and in a geographical coordinate system WGS84
LAT	Name of Latitude field in FPI table "". The latitude should be in decimal degrees and in a geographical coordinate system WGS84

Value

Return of a data.frame including landing weight or value.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
library(ggplot2)

data(FPIe_a)
data(table_a)

FPIe_a$Country<-"GRC"

#Estimate catch from FPI, table a (GSA, country, mandatory fields)
result_q_catch<- landings_SSF(data=FPIe_a,Sub.region="Sub.region", Country="Country",
                    FE="FPI", LPUE="LPUE", species="species", table_a=table_a,gear="gear_type",year="year",
                    quarter="quarter", vessel_length_cat="vessel_length",fishing_tech ="fishing_tech",target
                          metier="metier",parameter = "totwghtlandg",LON="LON",LAT="LAT")

result_q_value<- landings_SSF(data=FPIe_a,Sub.region="Sub.region", Country="Country",
                    FE="FPI", LPUE="LPUE", species="species", table_a=table_a,gear="gear_type",year="year",
                    quarter="quarter", vessel_length_cat="vessel_length",fishing_tech ="fishing_tech",target
                           metier="metier",parameter = "totvallandg",LON="LON",LAT="LAT")

#check Landing weight result
check_weight<-check_landings(data=result_q_catch,Sub.region="Sub.region", Country="Country",
                  FE="FPI", LPUE="LPUE", species="species", table_a=table_a,gear="gear_type",year="year",
                  quarter="quarter", vessel_length_cat="vessel_length",fishing_tech ="fishing_tech",target_a
                  metier="metier",LON="LON",LAT="LAT",parameter = "totwghtlandg", LW="LW")

#check Landing value result
check_value<-check_landings(data=result_q_value,Sub.region="Sub.region", Country="Country",
                  FE="FPI", LPUE="LPUE", species="species", table_a=table_a,gear="gear_type",year="year",
                  quarter="quarter", vessel_length_cat="vessel_length",fishing_tech ="fishing_tech",target_
                  metier="metier",LON="LON",LAT="LAT",parameter = "totvallandg", LW="LW")
```

---

chl_nc_to_df   *Convert monthly Chlorophyll-a netCDF dataset to a dataframe*

Description

Using the monthly Aqua-MODIS Chlorophyll-a concentration netCDF datasets and convert to a dataframe. The dataframe can be produced for a certain area. The Clorophyll-a netCDF datasets are based on the level-3 products produced and archived by the NASA Ocean Biology Processing Group (NASA Ocean Biology Processing Group, 2024, Level-3 Ocean Color Data, NASA Ocean Biology Distributed Active Archive Center. https://oceancolor.gsfc.nasa.gov/l3) .

Usage

```
chl_nc_to_df(file_path, lonmax = 26, lonmin = 18, latmax = 43, latmin = 33)
```

Arguments

`file_path`	The file path for the netCDF monthly file for Aqua-MODIS Chlorophyll-a concentration. The netCDF file is in mapped-SMI format.
`lonmax`	Maximum longitude value of the selected area (in decimal degrees).
`lonmin`	Minimum longitude value of the selected area (in decimal degrees).
`latmax`	Maximum latitude value of the selected area (in decimal degrees).
`latmin`	Minimum latitude value of the selected area (in decimal degrees).

Value

Return a dataframe including longitude, latitude, chlorophyll-a value, year, month and quarter.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)

#Convert netCDF to dataframe for a certain geographical area
#Example for Greece
chl_df<-chl_nc_to_df(file_path="~.nc", lonmax=26, lonmin=18, latmax=43, latmin=33)
```

---

classify *Classify a dataframe*

Description

Classify a dataframe based on scores and cuts

Usage

```
classify(
  data_field,
  cuts = c(10, 50, max(data$kg_km2)),
  scores = c(10, 50, max(data$kg_km2))
)
```

Arguments

`data_field`	dataframe to be classified
`cuts`	a numeric object including the values for the classification
`scores`	a numeric object including the scores

Value

Return a dataframe with classified values

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
library(sf)
library(sfheaders)
library(ggplot2)
library(tidyr)
library(BAMMtools)

data("fleet_reg_year")

#Define year and country
ye<-2019
country="GRC"

# unite gear_type and vessel_length
fleet_reg_year<-unite(fleet_reg_year, col='key', c('MAIN_FISHING_GEAR', 'vessel_length'), sep='_', remove=FA

#base map for bubble plots
poly<- map_data("world")
map_sf <- sfheaders::sf_polygon(obj = poly, x = "long", y = "lat", polygon_id = "group")
sf::st_crs(map_sf) <- 4326

# classify values for plotting
fleet_reg_year<-fleet_reg_year[fleet_reg_year[1]==country,]
i<-"GTR_VL0612"
fleet<-fleet_reg_year[fleet_reg_year$key==i,]
classes<-as.data.frame(getJenksBreaks(as.numeric(fleet$SUM_LOA_GT),7))
colnames(classes)<-"classes"
classes$key<-i
cla3<-as.numeric(classes[,1])
cla3<-cla3[-7]
fl_yy<-fleet_reg_year[fleet_reg_year$key==i,]
fl_yy$kmcl<-classify(data_field=as.numeric(fl_yy[,"SUM_LOA_GT"]),cuts=cla3, scores=cla3)
```

`create_tableH` *Converts the estimated spatial landings' weight and value in the format of table H of the FDI data call*

Description

Using the predicted spatial landings' weight and value in a csquare of 0.5 * 0.5 decimal degrees cell size to export a dataframe in the format of spatial landings (Table H) of the FDI data call.

Usage

```
create_tableH(
  data = ERS_gns_06_q_catch,
  country = "Country",
  year = "year",
  quarter = "quarter",
  vessel_length = "vessel_length",
  fishing_tech = "fishing_tech",
  gear_type = "gear_type",
  target_assemblage = "target_assemblage",
  mesh_size_range = "NK",
  metier = "metier",
  metier_7 = "NK",
  supra_region = "MBS",
  sub_region = "Sub.region",
  eez_indicator = "NA",
  geo_indicator = "NK",
  specon_tech = "NK",
  deep = "NA",
  rectangle_type = "05*05",
  latitude = "csq_y",
  longitude = "csq_x",
  c_square = "NA",
  species = "species",
  totwghtlandg = "parameter",
  totvallandg = "parameter2",
  confidential = "N"
)
```

Arguments

`data`	The dataframe derived in ERS level and includes information of landings' weight and value
`country`	The name of the field in the dataframe containing the country
`year`	The name of the field in the dataframe containing the year
`quarter`	The name of the field in the dataframe containing the quarter
`vessel_length`	The name of the field in the dataframe containing the vessel length
`fishing_tech`	The name of the field in the dataframe containing the fishing technique
`gear_type`	The name of the field in the dataframe containing the gear type
`target_assemblage`	The name of the field in the dataframe containing the target assemblage
`mesh_size_range`	Value for mesh_size_range
`metier`	The name of the field in the dataframe containing the metier
`metier_7`	Value for metier_7
`supra_region`	Value for supra_region (default is "MBS")
`sub_region`	The name of the field of the dataframe containing the sub region (GSA)
`eez_indicator`	Value for eez_indicator

geo_indicator	Value for geo_indicator
specon_tech	Value for specon_tech
deep	Value for deep
rectangle_type	Value for rectangle_type
latitude	The name of the field in the dataframe containing the latitude
longitude	The name of the field in the dataframe containing the longitude
c_square	Value for c_square
species	The name of the field in the dataframe containing the species
totwghtlandg	The name of the field in the dataframe containing the landing weight
totvallandg	The name of the field in the dataframe containing the landing value
confidential	Value for confidential

Value

Return a dataframe in the format of table H (spatial landings) of the FDI data call.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)

#load Data
data(FPIe_a)
data(ERS_poly)

# Define country
FPIe_a$Country<-"GRC"

# Estimate landings weight in a fine scale
result_q_catch<- landings_SSF(data=FPIe_a,Sub.region="Sub.region", Country="Country",
                   FE="FPI", LPUE="LPUE", species="species", table_a=table_a,gear="gear_type",year="year",
                   quarter="quarter", vessel_length_cat="vessel_length",fishing_tech ="fishing_tech",target
                         metier="metier",parameter = "totwghtlandg",LON="LON",LAT="LAT")

result_q_value<- landings_SSF(data=FPIe_a,Sub.region="Sub.region", Country="Country",
                   FE="FPI", LPUE="LPUE", species="species", table_a=table_a,gear="gear_type",year="year",
                   quarter="quarter", vessel_length_cat="vessel_length",fishing_tech ="fishing_tech",target
                          metier="metier",parameter = "totvallandg",LON="LON",LAT="LAT")

# Estimate landings weight by rectangle 0.5*0.5 decimal degrees
ERS_q_catch<-catch_ERSlevel(data_FPI=result_q_catch, ERS_poly=ERS_poly, parameter= "LW")
ERS_q_value<-catch_ERSlevel(data_FPI=result_q_value, ERS_poly=ERS_poly, parameter= "LW")

library(dbplyr)
ERS_q_value<-ERS_q_value %>%
 dplyr::rename(
   parameter2 = parameter
 )

ERS_q_catch_value<-cbind(ERS_q_catch,ERS_q_value[15])
```

```
#create table H for the data call
tableH_landings_SSF<-create_tableH(data=ERS_q_catch_value,country="Country", year="year", quarter="quarter"
                    fishing_tech="fishing_tech", gear_type="gear_type", target_assemblage="target_assembl
                    mesh_size_range="NK", metier="metier", metier_7="NK", supra_region="MBS",
                    sub_region="Sub.region", eez_indicator="NA", geo_indicator="NK", specon_tech="NK",
                    deep="NA", rectangle_type="05*05", latitude="csq_y", longitude="csq_x", c_square="NA"
                    totwghtlandg="parameter",totvallandg="parameter2", confidential="N")
```

`create_tableI` *Converts the estimated spatial fishing effort in the format of table I of the FDI data call*

Description

Using the predicted spatial fishing effort in a csquare of 0.5 * 0.5 decimal degrees cell size to export a dataframe in the format of spatial effort (Table I) of the FDI data call.

Usage

```
create_tableI(
  data = ERS_gns_06_q,
  country = "Country",
  year = "year",
  quarter = "quarter",
  vessel_length = "vessel_length",
  fishing_tech = "fishing_tech",
  gear_type = "gear_type",
  target_assemblage = "target_assemblage",
  mesh_size_range = "NK",
  metier = "metier",
  metier_7 = "NK",
  supra_region = "MBS",
  sub_region = "Sub.region",
  eez_indicator = "NA",
  geo_indicator = "NK",
  specon_tech = "NK",
  deep = "NA",
  rectangle_type = "05*05",
  latitude = "csq_y",
  longitude = "csq_x",
  c_square = "NA",
  totfishdays = "parameter",
  confidential = "N"
)
```

Arguments

`data`	The dataframe derived in ERS level and includes information of effort
`country`	The name of the field in the dataframe containing the country
`year`	The name of the field in the dataframe containing the year

quarter	The name of the field in the dataframe containing the quarter
vessel_length	The name of the field in the dataframe containing the vessel length
fishing_tech	The name of the field in the dataframe containing the fishing technique
gear_type	The name of the field in the dataframe containing the gear type
target_assemblage	The name of the field in the dataframe containing the target assemblage
mesh_size_range	Value for mesh_size_range
metier	The name of the field in the dataframe containing the metier
metier_7	Value for metier_7
supra_region	Value for supra_region (default is "MBS")
sub_region	The name of the field in the dataframe containing the sub region (GSA)
eez_indicator	Value for eez_indicator
geo_indicator	Value for geo_indicator
specon_tech	Value for specon_tech
deep	Value for deep
rectangle_type	Value for rectangle_type
latitude	The name of the field in the dataframe containing the latitude
longitude	The name of the field in the dataframe containing the longitude
c_square	Value for c_square
totfishdays	The name of the field in the dataframe containing the fishing days
confidential	Value for confidential
species	The name of the field in the dataframe containing the species

Value

Return a dataframe in the format of table I (spatial effort) of the FDI data call.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)

#load Data
data(FPIe)
data(ERS_poly)

# Define country
FPIe$Country<-"GRC"

# Estimate Fishing Days in a fine scale
result_q<- FDays_SSF(data=FPIe,Sub.region="Sub.region", Country="Country", FPIc="FPI",
                    table_g_effort=table_g_effort,vessel_length_cat="vessel_length",
             year="year", quarter="quarter",gear="gear_type",fishing_tech="fishing_tech",
             target_assemblage="target_assemblage", metier="metier",LON="LON", LAT="LAT")
```

```
# Estimate Fishing Days by rectangle 0.5*0.5 decimal degrees
ERS_q<-Fdays_ERSlevel(data_FPI=result_q, ERS_poly=ERS_poly, LON="LON",LAT="LAT",parameter= "FDays")

#create table I in the data call format
tableI_seffort_SSF<-create_tableI(data=ERS_q,country="Country", year="year", quarter="quarter", vessel_lengt
                      fishing_tech="fishing_tech", gear_type="gear_type", target_assemblage="target_assembl
                      mesh_size_range="NK", metier="metier", metier_7="NK", supra_region="MBS",
                      sub_region="Sub.region", eez_indicator="NA", geo_indicator="NK", specon_tech="NK",
                      deep="NA", rectangle_type="05*05", latitude="csq_y", longitude="csq_x", c_square="NA",
                                totfishdays="parameter",confidential="N")
```

ERA5NetcdfToCsv — *Convert netcdf containing meteorological data from Copernicus products to a data.frame and store in a csv.*

Description

Convert netcdf containing meteorological data to data.frame to be used in the function meteoCr. The data are based on ERA5 hourly data on single levels from 1940 to present from Copernicus Products (Spatial resolution: 0.25*0.25 decimal degrees). Citation: -Hersbach, H., Bell, B., Berrisford, P., Biavati, G., Horanyi, A., Munoz Sabater, J., Nicolas, J., Peubey, C., Radu, R., Rozum, I., Schepers, D., Simmons, A., Soci, C., Dee, D., Thepaut, J-N. (2023): ERA5 hourly data on single levels from 1940 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS), DOI: 10.24381/cds.adbb2d47 (Accessed on DD-MMM-YYYY) -Copernicus Climate Change Service, Climate Data Store, (2023): ERA5 hourly data on single levels from 1940 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS), DOI: 10.24381/cds.adbb2d47 (Accessed on DD-MMM-YYYY)

Usage

```
ERA5NetcdfToCsv(nc_data)
```

Arguments

nc_data	The path that netcdf data are stored.

Value

Return of a data.frame.

Author(s)

I. Maina

Examples

```
# Example
library(ncdf4) # package for netcdf manipulation
library(raster) # package for raster manipulation
library(ggplot2)
library(RNetCDF)
```

```
meteo_data<-ERA5NetcdfToCsv(nc_data = ".ERA5data.nc")
```

---

export_to_csv5 *Convert rasters to dataframe by year*

Description

Convert rasters to dataframe by year

Usage

```
export_to_csv5(
  data_interpolation = idw_rasters,
  years = ye,
  name = "idw_rasters"
)
```

Arguments

data_interpolation	rasters to be converted in csv
years	a numeric object including the years
name	name of the data to be extracted

Value

Return rasters with interpolated values

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
library(tidyr)
library(raster)

data("fleet_reg_year")
data("dfcut2")

#DEFINE COUNTRY, GSA, year_start, year_end
country<-"GRC"
GSA<-20

#crop the area
dfcut2$lon<-as.numeric(dfcut2$x)
dfcut2$lat<-as.numeric(dfcut2$y)
dfcut2<-joinFPI_GSA(data_FPI=dfcut2,GSA_poly = GSA_poly,field_GSA="SMU_CODE",LON="x",LAT="y")
dfcut2<-dfcut2[dfcut2$SMU_CODE %in% GSA,]
```

```
#Activity Index (Ac) estimation

# unite gear_type and vessel_length
fleet_reg_year<-unite(fleet_reg_year, col='key', c('MAIN_FISHING_GEAR', 'vessel_length'), sep='_', remove=FA
# select country
fleet_reg_year<-fleet_reg_year[fleet_reg_year[1]==country,]

#Preparing the data for Ac estimation loop by fishing gear and vessel length categories
fl<-"GNS_VL0006"
fleet<-fleet_reg_year[fleet_reg_year$key==fl,]
fleet<-fleet[fleet$COUNTRY==country,]
fleet$x<-as.numeric(fleet$LONGITUDE)
fleet$y<-as.numeric(fleet$LATITUDE)
fleet$SUM_LOA_GT<-as.numeric(fleet$SUM_LOA_GT)
fleet$YEAR<-as.integer(fleet$YEAR)
ye<-2019

#IDW by year
Ac_year<-idw_year(data=fleet,field="SUM_LOA_GT",years=ye, p=2,R=2,N=15,method="Shepard",dfcut=dfcut2,crs_ra

#export IDW by year to a data frame
SSF_ac<-export_to_csv5(data_interpolation=Ac_year,years=ye,name="idw_Ac")
```

`Fdays_ERSlevel` *Convert the estimated fishing effort for SSF expressed in days at sea using Fishing Pressure Index as a proxy in a grid cell of 0.5*0.5 decimal degrees (csquare) in order to inform Table I.*

Description

Convert in csquare (0.5 * 0.5 dd) the combined Fishing Pressure Index (FPI- estimated by MCDA) with Fisheries Dependent Information (FDI) data (Table G in the data call) to perform spatial estimations of fishing effort (days at sea) and inform the Table I.

Usage

```
Fdays_ERSlevel(
  data_FPI,
  ERS_poly,
  LON = "LON",
  LAT = "LAT",
  parameter = "FDays"
)
```

Arguments

`data_FPI`	A data frame with Fishing effort estimations after running the function FDays_SSF. The above data frame should contain the fields: Fishing Effort, LON(longitude in WGS84), LAT(latitude in WGS84), gear:(values: GNS, GTR, LLS), year, vessel_length_cat (values: "VL0006","VL0010","VL0612",), quarter (values: 1-4), GSA (a field including information for the Geographical Subarea in the following format: GSA20, Country in the following format : GRC)
`ERS_poly`	A polygon shapefile with ERS rectangle (csquare of 0.5*0.5) in an 'sf' format

LON	Name of Longitude field in FPI table using "". The longitude should be in decimal degrees and in a geographical coordinate system WGS84
LAT	Name of Latitude field in FPI table "". The longitude should be in decimal degrees and in a geographical coordinate system WGS84
FDays	Name of the fishing days in the data table in "".

Value

Return of a data.frame including Fishing days by grid cell of 0.5*0.5 decimal degrees to be used for the creation of table I.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
#load Data
data(FPIe)
data(ERS_poly)

# Define country
FPIe$Country<-"GRC"

# Estimate Fishing Days in a fine scale
result_q<- FDays_SSF(data=FPIe,Sub.region="Sub.region", Country="Country", FPIc="FPI",
                  table_g_effort=table_g_effort,vessel_length_cat="vessel_length",
            year="year", quarter="quarter",gear="gear_type",fishing_tech="fishing_tech",
            target_assemblage="target_assemblage", metier="metier",LON="LON", LAT="LAT")

# Estimate Fishing Days by rectangle 0.5*0.5 decimal degrees
ERS_q<-Fdays_ERSlevel(data_FPI=result_q, ERS_poly=ERS_poly, LON="LON",LAT="LAT",parameter= "FDays")
```

FDays_SSF   *Estimate fishing effort for SSF expressed in days at sea using Fishing Pressure Index as a proxy*

Description

Combine Fishing Pressure Index (FPI- estimated by MCDA) with Fisheries Dependent Information (FDI) data (Table G in the data call) to perform spatial estimations of fishing effort (days at sea).

Usage

```
FDays_SSF(
  data,
  Sub.region,
  Country,
  FPIc,
  table_g_effort,
  gear,
```

```
  metier,
  year,
  quarter,
  vessel_length_cat,
  fishing_tech,
  target_assemblage,
  LON,
  LAT
)
```

Arguments

`data`	A data frame with FPI estimations (MCDA). The above data frame should contain the fields: LON(longitude in WGS84), LAT(latitude in WGS84), gear(values: GNS, GTR, LLS), year, vessel_length_cat (values: "VL0006","VL0612"), quarter(values: 1-4), GSA (a field including information for the Geographical Subarea in the following format: GSA20, Country in an Alpha 3 code format : GRC)
`Sub.region`	The field of GSAs included in data using "".
`Country`	The field of Country included in data using "".
`FPIc`	The field of Fishing pressure Index estimated by MCDA and included in data using "".
`table_g_effort`	a dataframe similar to Table G (as in the FDI data call)
`gear`	The field in FPI table that contains the gear using "".Values: SSF, GNS, GTR, LLS
`metier`	The field in FPI table that contains the metier using "". Values should be the same as in table G
`year`	The field in FPI table that contains the year using "".
`quarter`	The field in FPI table that contains the quarter using "". Values: 1-4.
`vessel_length_cat`	The field in FPI table that contains the vessel length category using "". Values: VL006, VL0612
`fishing_tech`	The field in FPI table that contains the fishing_tech using "". Values should be the same as in table G
`target_assemblage`	The field in FPI table that contains the target assemblage using "". Values should be the same as in table G
`LON`	Name of Longitude field in FPI table using "". The longitude should be in decimal degrees and in a geographical coordinate system WGS84
`LAT`	Name of Latitude field in FPI table "". The longitude should be in decimal degrees and in a geographical coordinate system WGS84

Value

Return of a data.frame including FPI and Fishing days by grid cell.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)

#load Data
data(FPIe)
data(ERS_poly)

# Define country
FPIe$Country<-"GRC"

# Estimate Fishing Days in a fine scale
result_q<- FDays_SSF(data=FPIe,Sub.region="Sub.region", Country="Country", FPIc="FPI",
                    table_g_effort=table_g_effort,vessel_length_cat="vessel_length",
             year="year", quarter="quarter",gear="gear_type",fishing_tech="fishing_tech",
             target_assemblage="target_assemblage", metier="metier",LON="LON", LAT="LAT")
```

`fgrade` *Grading of a dataset*

Description

Grades a dataset based on scores.

Usage

```
fgrade(object, cuts, scores)
```

Arguments

`object`	The data object to apply the criteria. Data can be vectors, matrices, dataframes, shapefiles and rasters.
`cuts`	Cuts of the data, on which we define the scores.
`scores`	Integer scores based on cuts (values MUST be between 0 and 5).

Value

Return of data object with values from 0 to 5.

Author(s)

D. Politikos

Examples

```
  #------------ Example 1 -----------#
  library(tools4MCDA)
  object <- runif(100, -1000, 1000)
  # Assign cuts
  cuts <- c(-Inf, 0, 50, 100, 150, 200, 500)
  # Assign scores
  scores <- c(NA, 1, 2, 3, 4, 5, 0)
  object_scored = fgrade(object, cuts, scores)
```

```
# Plot of object and scored object

par(mfrow=c(2,1))
hist(object)
barplot(table(object_scored), main = "Scored object")

#------------ Example 2 -----------#
library(tools4MCDA)
library(raster)
# Generate a raster r
r <- raster(ncol=5, nrow=5)
raster::values(r) <- rnorm(25, 10, 10)
# Assign cuts and scores
cuts <- c(-Inf, 0, 5, 10, 15, 20)
scores <- c(1, 2, 3, 4, 5, 0)
# Create the scored raster: r_scored
r_scored = r
# Update r_scored based on cuts and scores
raster::values(r_scored) = fgrade(raster::values(r_scored), cuts, scores)
# Make the plots of r and r_scored rasters

par(mfrow=c(2,1))
plot(r, main = "Unscored")
plot(r_scored, main = "Scored")
```

`from_df_to_tiff` *Convert a dataframe to Raster (TIFF)*

Description

Convert a dataframe including geographical coordinates (longitude, latitude) and a field related to fishing effort, weight or value of landings to Raster (in TIFF format). This function was created to support analysis by quarter.

Usage

```
from_df_to_tiff(
  data = tableH_landings_SSF_4p,
  quarter = qu,
  parameter = "",
  LON = "longitude",
  LAT = "latitude",
  folder = "C:/outcomes",
  r = r
)
```

Arguments

`data`	The dataframe to be converted in Raster
`quarter`	A numeric object including the quarters that data are available. For example c(1,2,3,4) .

parameter	The field that will be included in the values of the raster. The field should be in "". For example "totfishdays".
LON	The field of the dataframe including longitude values.The field should be in "".
LAT	The field of the dataframe including latitude values.The field should be in "".
folder	The folder path to save the derived tiff files.
r	A raster object

Value

Return rasters in tiff format.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)

#load Data
data(FPIe)
data(ERS_poly)

# Define country
FPIe$Country<-"GRC"

# Estimate Fishing Days in a fine scale
result_q<- FDays_SSF(data=FPIe,Sub.region="Sub.region", Country="Country", FPIc="FPI",
                    table_g_effort=table_g_effort,vessel_length_cat="vessel_length",
             year="year", quarter="quarter",gear="gear_type",fishing_tech="fishing_tech",
             target_assemblage="target_assemblage", metier="metier",LON="LON", LAT="LAT")

# Estimate Fishing Days by rectangle 0.5*0.5 decimal degrees
ERS_q<-Fdays_ERSlevel(data_FPI=result_q, ERS_poly=ERS_poly, LON="LON",LAT="LAT",parameter= "FDays")

#create table I in the data call format
tableI_seffort_SSF<-create_tableI(data=ERS_q,country="Country", year="year", quarter="quarter", vessel_lengt
                      fishing_tech="fishing_tech", gear_type="gear_type", target_assemblage="target_assembl
                      mesh_size_range="NK", metier="metier", metier_7="NK", supra_region="MBS",
                      sub_region="Sub.region", eez_indicator="NA", geo_indicator="NK", specon_tech="NK",
                      deep="NA", rectangle_type="05*05", latitude="csq_y", longitude="csq_x", c_square="NA",
                                totfishdays="parameter",confidential="N")

r1<-rasterFromXYZ(tableI_seffort_SSF[, c('longitude', 'latitude','totfishdays')])

tableI_seffort_SSF_4p<-unite(tableI_seffort_SSF, col='key', c('year','vessel_length','fishing_tech', 'gear_t
p<-"2019_VL0006_DFN_GNS_DEF_GNS_DEF_>0_0_0"
tableI_seffort_SSF_4p<-tableI_seffort_SSF_4p[tableI_seffort_SSF_4p$key=="2019_VL0006_DFN_GNS_DEF_GNS_DEF_>0

# TABLE I: SPATIAL EFFORT
result_q_4p<-tableI_seffort_SSF_4p[tableI_seffort_SSF_4p$key==p,]
qu<-as.numeric(unique(result_q_4p$quarter))
from_df_to_tiff(data=result_q_4p,quarter=qu,parameter="totfishdays",LON="longitude", LAT="latitude",
               folder="<Your Path>",r=r1)
```

fuzzyMember *Normalization of a data object*

Description

It normalizes a data object x to [0,1] using the formula (x-xmin)/(xmax-xmin).

Usage

```
fuzzyMember(x, class = F)
```

Arguments

x	The data object can be a vector, matrix, dataframe, Shapefile, or RasterLayer object.
class	If missing, the class is numeric, otherwise must be defined. Other options are Shapefile and RasterLayer objects.

Value

A data object with values in [0,1].

Author(s)

D. Politikos

Examples

```
library(raster)
library(tools4MCDA)
#-- Example 1 --#
x <- rnorm(100)
fuzzyMember(x)

#-- Example 2 --#
v1 <- rnorm(10)
v2 <- rpois(10,lambda=2)
v3 <- rexp(10)
x <- data.frame(v1,v2,v3)
fuzzyMember(x$v1)
apply(x, 2, fuzzyMember)

#-- Example 3 --#
r <- raster(ncol=5, nrow=5)
r <- init(r, rnorm)
rFM <- fuzzyMember(r, "raster")
par(mfrow=c(2,1))
plot(r)
plot(rFM)
```

`getConsistentAHP` *Analytic Hierarchy Process (AHP)*

Description

Compute the weights of analytic hierarchy process by adjusting the pair-wise comparison matrix till consistency ratio criterion is achieved (C.R. <0.1).

Usage

```
getConsistentAHP(pairwise_matrix, lambda = 0.5)
```

Arguments

`pairwise_matrix`
: The nxn pair-wise comparison matrix.

`lambda`
: A weighting factor in (0,1). Default value is 0.5. The higher the lambda value the higher the adjustment to the pair-wise comparison matrix.

Value

`weights`
: Weights to measure the importance of each component (1,2,...,n).

`cr`
: The consistency ratio.

`pairwise_matrix_adj`
: The adjusted pairwise matrix with acceptable consistency (C.R. < 0.1).

`delta`
: Measure the maximum absolute difference of elements between the pairwise matrix and adjusted pairwise matrix. It should be <2.

`sig`
: A metric that measures the standard deviation of the difference of elements between the pairwise matrix and adjusted pairwise matrix. It should be ~1.

Author(s)

D. Politikos

References

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

Saaty, T.L. (2001). Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World, New Edition 2001 (3 Revised). Pittsburgh, PA: RWS Publications, ISBN 978-0962031786.

Xu, Z. (2004). A practical method for improving consistency of judgment matrix in the ahp. Journal of Systems Science and Complexity, 17(2).

Examples

```
## Not run:
library(FuzzyAHP)
library(tools4MCDA)
matrix_values <- c(1,3,4,5,7,
                  1/3,1,2,2,4,
                  1/4,1/2,1,2,3,
                  1/5,1/2,1/2,1,3,
                  1/7,1/4,1/3,1/3,1)
matrix_values = matrix(matrix_values,nrow = 5,ncol = 5, byrow = TRUE)
ahp_outputs = getConsistentAHP(matrix_values)
ahp_outputs

## End(Not run)
```

---

getCR *Analytic Hierarchy Process (AHP)*

Description

Compute the consistency ratio of the initial pair-wise comparison matrix

Usage

```
getCR(pairwise_matrix)
```

Arguments

`pairwise_matrix`
The nxn pair-wise comparison matrix.

Value

`cr` The consistency ratio.

Author(s)

D. Politikos, I. Maina

References

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

Saaty, T.L. (2001). Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World, New Edition 2001 (3 Revised). Pittsburgh, PA: RWS Publications, ISBN 978-0962031786.

Xu, Z. (2004). A practical method for improving consistency of judgment matrix in the ahp. Journal of Systems Science and Complexity, 17(2).

Examples

```
library(FuzzyAHP)
library(tools4MCDA)
matrix_values <- c(1,3,4,5,7,
                  1/3,1,2,2,4,
                  1/4,1/2,1,2,3,
                  1/5,1/2,1/2,1,3,
                  1/7,1/4,1/3,1/3,1)
matrix_values = matrix(matrix_values,nrow = 5,ncol = 5, byrow = TRUE)
ahp_outputs = getCR(matrix_values)
ahp_outputs
```

`idw_year` *Perform spatial interpolation Inverse Distance weighted by year*

Description

Perform spatial interpolation Inverse Distance weighted by year

Usage

```
idw_year(
  data,
  field = "kg_km2",
  years = ye,
  p = 2,
  R = 2,
  N = 15,
  method = "Shepard",
  dfcut = dfcut,
  crs_raster = "+init=EPSG:4326"
)
```

Arguments

`data`	a dataframe with Activity index (i.e. a proxy of capacity Sum of L*GT) by registration port, geographical coordinates (x,y) and year
`p`	power
`R`	radious
`N`	number of neighbors
`method`	method of interpolation default is "Shepard"
`dfcut`	a grid to include the interpolated values
`parameter`	The field of the dataframe that will perform the interpolation

Value

Return rasters with interpolated values

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
library(tidyr)
library(raster)

data("fleet_reg_year")
data("dfcut2")

#DEFINE COUNTRY, GSA, year_start, year_end
country<-"GRC"
GSA<-20

#crop the area
dfcut2$lon<-as.numeric(dfcut2$x)
dfcut2$lat<-as.numeric(dfcut2$y)
dfcut2<-joinFPI_GSA(data_FPI=dfcut2,GSA_poly = GSA_poly,field_GSA="SMU_CODE",LON="x",LAT="y")
dfcut2<-dfcut2[dfcut2$SMU_CODE %in% GSA,]

#Activity Index (Ac) estimation

# unite gear_type and vessel_length
fleet_reg_year<-unite(fleet_reg_year, col='key', c('MAIN_FISHING_GEAR', 'vessel_length'), sep='_', remove=FA
# select country
fleet_reg_year<-fleet_reg_year[fleet_reg_year[1]==country,]

#Preparing the data for Ac estimation loop by fishing gear and vessel length categories
fl<-"GNS_VL0006"
fleet<-fleet_reg_year[fleet_reg_year$key==fl,]
fleet<-fleet[fleet$COUNTRY==country,]
fleet$x<-as.numeric(fleet$LONGITUDE)
fleet$y<-as.numeric(fleet$LATITUDE)
fleet$SUM_LOA_GT<-as.numeric(fleet$SUM_LOA_GT)
fleet$YEAR<-as.integer(fleet$YEAR)
ye<-2019

#IDW by year
Ac_year<-idw_year(data=fleet,field="SUM_LOA_GT",years=ye, p=2,R=2,N=15,method="Shepard",dfcut=dfcut2,crs_ra

#plot
plot(stack(Ac_year))
```

`incr_extent` *Increase the extent of a dataframe*

Description

Add longitude and latitude to increase the extent of a dataframe based on a tolerance value. The dataframe should include the following fields: longitude, latitude, quarter (values: 1-4), year.

Usage

```
incr_extent(
  df = chl_y_q,
  tolerance = 2,
```

```
  LON = "x",
  LAT = "y",
  year = "year",
  quarter = "quarter"
)
```

Arguments

`df`	a dataframe with the following fields: longitude, latitude, quarter (values: 1-4), year.
`tolerance`	a number to increase the extent
`LON`	the name of longitude field using ""
`LAT`	the name of latitude field using ""
`year`	the name of year field using ""
`quarter`	the name of quarter field using ""

Value

Returns a dataframe

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
data(chl_y_q)
chl_increase_extent<-incr_extent(df = chl_y_q, tolerance=2, LON="x", LAT="y", year="year", quarter="quarter")
```

`joinFPI_EEZ` *Combine Fishing Pressure Index (FPI- estimated by MCDA) with EEZ polygons to estimate the country*

Description

Combine Fishing Pressure Index (FPI- estimated by MCDA) with EEZ polygons to estimate the country.

Usage

```
joinFPI_EEZ(data_FPI, EEZ_poly, field_country = "Territory1", LON, LAT)
```

Arguments

`data_FPI`	A data frame with FPI estimations. The above data frame should contain the fields: LON(longitude in WGS84), LAT(latitude in WGS84), gear:(values- SSF, GNS, GTR, LLS), year, vessel_length_cat (values-all, +++), quarter(values 1-4, or 0 for annual estimations)
`EEZ_poly`	The sf polygon of EEZ.

`field_country`	The field that contains numerical information for the country using "" e.g. "Territory1" .
`LON`	Name of Longitude field in FDI table. The longitude should be in a geographical coordinate system WGS84
`LAT`	Name of Latitude field in FDI table. The longitude should be in a geographical coordinate system WGS84

Value

Return of a data.frame of FPI with information by GSA.

Author(s)

I. Maina

Examples

```
#Read_grid4MCDA (A reference grid for performing the analysis)
data("dfcut2")
#dfcut2<-read.csv2(file = paste0(general$input_data,"/mcda/grid_MEDBS_005.txt"), header = TRUE, sep= ",")

##MASK the reference grid by country for performing the analysis
#Please upload a more refined polygon of your country's Exlusive Economic Zone or fishing area

#Read EEZ polygons
EEZ_poly_path<-paste0("--PATH TO EEZ data--")
EEZ_poly_layer_name<-"EEZ_GRC"
EEZ_poly<- read_sf(dsn = EEZ_poly_path, layer = EEZ_poly_layer_name)

#mask reference grid with EEZ and extract a csv
dfcut2_EEZ<-joinFPI_EEZ(data_FPI=dfcut2,EEZ_poly = EEZ_poly,field_country="TERRITORY1",LON="x",LAT="y")
```

`joinFPI_GSA` *Combine Fishing Pressure Index (FPI- estimated by MCDA) with GSA polygons to estimate the Geographical Sub-Area.*

Description

Combine Fishing Pressure Index (FPI- estimated by MCDA) with GSA polygons to estimate the Geographical Sub-Area.

Usage

```
joinFPI_GSA(data_FPI, GSA_poly, field_GSA = "SMU_CODE", LON, LAT)
```

Arguments

`data_FPI`	A data frame with FPI estimations. The above data frame should contain the fields: LON(longitude in WGS84), LAT(latitude in WGS84), gear (values- SSF, GNS, GTR, LLS), year, vessel_length_cat , quarter(values 1-4, or 0 for annual estimations)
`GSA_poly`	The sf polygon of GSAs.

`field_GSA`	The field that contains numerical information for the GSA using "".
`LON`	Name of Longitude field in FDI table. The longitude should be in a geographical coordinate system WGS84
`LAT`	Name of Latitude field in FDI table. The longitude should be in a geographical coordinate system WGS84

Value

Return of a data.frame of FPI with information by GSA.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
library(sf)

data("dfcut2")
data("GSA_poly")

dfcut2<-joinFPI_GSA(data_FPI=dfcut2,GSA_poly = GSA_poly,field_GSA="SMU_CODE",LON="x",LAT="y")
```

`landings_SSF` *Estimate landing weight or value using Fishing effort and landings per unit effort as a proxy*

Description

Combine Fishing Pressure Index (FPI- estimated by MCDA) with Fisheries Dependent Information (FDI) data (Table A in the data call) to perform spatial estimations of fishing effort (days at sea). Subsequently, this information is combined with landings per unit effort that can be estimated through predictive models. Finally all the above information is combined with table A from FDI data call to estimate landing weight and landing value in a fine spatial scale (e.g. ERS grid). The function can be used for discards as well if this information is provided instead of LPUE.

Usage

```
landings_SSF(
  data,
  Sub.region,
  Country,
  FE,
  LPUE,
  species,
  table_a,
  gear,
  year,
  quarter,
  metier,
  fishing_tech,
```

```
    target_assemblage,
    vessel_length_cat,
    parameter = "totwghtlandg",
    LON,
    LAT
  )
```

Arguments

data	A data frame with FE estimations (e.g. by MCDA and FDI) and species LPUE. The above data frame should contain the fields: LON(longitude in WGS84), LAT(latitude in WGS84), gear (values- SSF, GNS, GTR, LLS), year, vessel_length_cat , quarter(values 1-4, or 0 for annual estimations), GSA (a field including information for the Geographical Subarea in the following format: GSA20, Country in the following format : Greece), FE (estimated fishing effort), LPUE(estimated landings per unit effort)
Sub.region	The field of GSAs included in data using "".
Country	The field of Country included in data using "".
FE	the field in the FPI table that contains the fishing effort or the Fishing Pressure Index estimated from MCDA using ""
LPUE	the field in the FPI table that contains the landings per unit effort by species using "". The values should be normalized in a scale: 0-1
species	the field in the FPI table that contains the species (in 3 alpha code) using ""
table_a	The data frame of the FDI "catches" by country. The above table is based on Table A of the data call of Fisheries Dependent Information -FDI and contains information about landing weight and value of landings.
gear	The field in FPI table that contains the gear using "".Values: GNS, GTR, LLS
year	The field in FPI table that contains the year using "".
quarter	The field in FPI table that contains the quarter using "".
metier	The field in FPI table that contains the metier using "".
fishing_tech	The field in FPI table that contains the fishing technique using "".
target_assemblage	The field in FPI table that contains the target assemblage using "".
vessel_length_cat	The field in FPI table that contains the vessel length category using "". Values: NK, VL006, VL0010, VL0612, VL1012, VL1218, VL1824, VL2440, VL40XX
parameter	The field from table a to be used for performing spatial estimations. Values: "totwghtlandg", "totvallandg"
LON	Name of Longitude field in FPI table using "". The longitude should be in decimal degrees and in a geographical coordinate system WGS84
LAT	Name of Latitude field in FPI table "". The longitude should be in decimal degrees and in a geographical coordinate system WGS84

Value

Return of a data.frame including FPI and Fishing days by grid cell.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
library(ggplot2)

data(FPIe_a)
data(table_a)

FPIe_a$Country<-"GRC"

#Estimate catch from FPI, table a (GSA, country, mandatory fields)
result_q_catch<- landings_SSF(data=FPIe_a,Sub.region="Sub.region", Country="Country",
                    FE="FPI", LPUE="LPUE", species="species", table_a=table_a,gear="gear_type",year="year",
                    quarter="quarter", vessel_length_cat="vessel_length",fishing_tech ="fishing_tech",target
                         metier="metier",parameter = "totwghtlandg",LON="LON",LAT="LAT")


result_q_value<- landings_SSF(data=FPIe_a,Sub.region="Sub.region", Country="Country",
                    FE="FPI", LPUE="LPUE", species="species", table_a=table_a,gear="gear_type",year="year",
                    quarter="quarter", vessel_length_cat="vessel_length",fishing_tech ="fishing_tech",target
                          metier="metier",parameter = "totvallandg",LON="LON",LAT="LAT")
```

---

maps_year — *Mapping by year and fishing gear type*

Description

Create plots presenting the spatial distribution of fishing effort, landings weight or value by year, fishing gear type, metier etc.

Usage

```
maps_year(
  data_df,
  years = ye,
  parameter = "",
  xlim = c(19, 24),
  ylim = c(36, 40),
  LON = "longitude",
  LAT = "latitude",
  ylab = "kg/km2",
  PlotTitle = "HKE",
  poly = poly,
  r = r
)
```

Arguments

`data_df`	The dataframe to be plotted
`years`	The field of years in the dataframe in ""
`parameter`	The field in the dataframe that will be plotted. The field should be in "". For example "totfishdays".

xlim	A numeric object with the minimum and maximum longitude values to be plotted. For example c(19,24)
ylim	A numeric object with the minimum and maximum latitude values to be plotted. For example c(36,40)
LON	The field of the dataframe including longitude values.The field should be in "".
LAT	The field of the dataframe including latitude values.The field should be in "".
ylab	The label in the legend of the plot in "".
PlotTitle	The title of the plot in "".
poly	A coastline polygon
r	A raster object

Value

Return maps by year, quarter etc.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
library(ggplot2)
library(raster)
library(rasterVis)

data("sample_FPIq")
data("dfcut2")
poly<- map_data("world")

#DEFINE COUNTRY, GSA, year_start, year_end
country<-"GRC"
GSA<-20

#crop the area and create a raster
dfcut2$lon<-as.numeric(dfcut2$x)
dfcut2$lat<-as.numeric(dfcut2$y)
dfcut2<-joinFPI_GSA(data_FPI=dfcut2,GSA_poly = GSA_poly,field_GSA="SMU_CODE",LON="x",LAT="y")
dfcut2<-dfcut2[dfcut2$SMU_CODE %in% GSA,]
r<-rasterFromXYZ(dfcut2[, c('lon', 'lat')])
crs(r) <- CRS(paste('+init=EPSG:4326'))

#preparing outcomes from MCDA
FPI_all<-unite(sample_FPIq, col='key', c('year','vessel_length','gear_type'), sep='_', remove=FALSE)

#Select gear type and vessel length category
p<-"2019_VL0006_GNS"
result_q_4p<-FPI_all[FPI_all$key==p,]
result_q_4p<-result_q_4p[result_q_4p$quarter==1,]

maps_year(data_df=result_q_4p, years = 2019, parameter = "FPI", xlim = c(19,24), ylim = c(36, 40), LON = "LON",
         ylab = "proxy of FE", PlotTitle = "FPI 2019", poly = poly, r = r)
```

`maps_year_quarter` *Mapping by quarter, year and fishing gear type*

Description

Create plots presenting the spatial distribution of fishing effort, landings weight or value by year, quarter, fishing gear type, metier etc.

Usage

```
maps_year_quarter(
  data_df,
  quarter = qu,
  parameter = "",
  xlim = c(19, 24),
  ylim = c(36, 40),
  LON = "longitude",
  LAT = "latitude",
  ylab = "kg/km2",
  PlotTitle = "HKE",
  poly = poly,
  r = r
)
```

Arguments

`data_df`	The dataframe to be plotted
`quarter`	A numeric object including the quarters that data are available. For example c(1,2,3,4) .
`parameter`	The field in the dataframe that will be plotted. The field should be in "". For example "totfishdays".
`xlim`	A numeric object with the minimum and maximum longitude values to be plotted. For example c(19,24)
`ylim`	A numeric object with the minimum and maximum latitude values to be plotted. For example c(36,40)
`LON`	The field of the dataframe including longitude values.The field should be in "".
`LAT`	The field of the dataframe including latitude values.The field should be in "".
`ylab`	The label in the legend of the plot in "".
`PlotTitle`	The title of the plot in "".
`poly`	A raster object

Value

Return maps by year, quarter etc.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
library(ggplot2)
library(raster)
library(rasterVis)

data("sample_FPIq")
data("dfcut2")
poly<- map_data("world")

#DEFINE COUNTRY, GSA, year_start, year_end
country<-"GRC"
GSA<-20

#crop the area and create a raster
dfcut2$lon<-as.numeric(dfcut2$x)
dfcut2$lat<-as.numeric(dfcut2$y)
dfcut2<-joinFPI_GSA(data_FPI=dfcut2,GSA_poly = GSA_poly,field_GSA="SMU_CODE",LON="x",LAT="y")
dfcut2<-dfcut2[dfcut2$SMU_CODE %in% GSA,]
r<-rasterFromXYZ(dfcut2[, c('lon', 'lat')])
crs(r) <- CRS(paste('+init=EPSG:4326'))

#preparing outcomes from MCDA
FPI_all<-unite(sample_FPIq, col='key', c('year','vessel_length','gear_type'), sep='_', remove=FALSE)

#Select gear type and vessel length category
p<-"2019_VL0006_GNS"
result_q_4p<-FPI_all[FPI_all$key==p,]

#estimate quarter
qu<-order(as.numeric(unique(result_q_4p$quarter)), decreasing = TRUE)

#Create maps
maps_year_quarter(data_df=result_q_4p,quarter=qu, parameter="FPI",xlim=c(min(result_q_4p$LON),max(result_q_
          ylim=c(min(result_q_4p$LAT),max(result_q_4p$LAT)), LON="LON", LAT="LAT",ylab="FPI",
               PlotTitle=paste(unique(result_q_4p$key)),
               poly=poly, r=r)
```

---

meteoCr *Create meteorological criterion*

Description

Score a netcdf spatiotemporal dataset based on meteorological criteria.

Usage

```
meteoCr(
  data,
  time_start = 21,
  time_end = 4,
  temp_step = "quarter",
  diff_temp = 4
)
```

Arguments

`data`	The path that meteorological data or a data frame generated by ERA5NetcdfToCsv or MeteoNetcdfToCsv are stored .
`time_start`	Time (expressed in hours) of a fishing trip starts.
`time_end`	Time (expressed in hours) of a fishing trip ends.
`temp_step`	Temporal step of the outcome. Values: "quarter" (default), "month", "year"
`diff_temp`	Parameter for estimating the extreme temperature Values. The default is 4 that means the extreme temperature can be 4 Co less that the max value.

Value

Return of a data.frame.

Author(s)

I. Maina

Examples

```
 # Example 1
 library(tools4MCDA) # package for raster manipulation

 meteo_data<-ERA5NetcdfToCsv(nc_data = ".ERA5data.nc")
meteo2017_q<-meteoCr(data = meteo_data, time_start=21, time_end=4, temp_step="quarter", diff_temp=4)
```

`MeteoNetcdfToCsv` *Convert netcdf containing meteorological data to csv.*

Description

Convert netcdf containing meteorological data to csv. Outcomes can be used in the function meteoCr.

Usage

```
MeteoNetcdfToCsv(nc_data)
```

Arguments

`nc_data`	The path that netcdf data are stored.

Value

Return of a data.frame.

Author(s)

I. Maina

Examples

```
# Example
library(ncdf4) # package for netcdf manipulation
library(raster) # package for raster manipulation
library(ggplot2)

meteo2018_q<-MeteoNetcdfToCsv(nc_data = ".data.nc")
```

---

sample_raster *Extract values from a raster in a data frame with longitude, latitude*

Description

Sample values and include in a data.frame (grid) with geographical coordinates.

Usage

```
sample_raster(raster_FPI = r_cdist, df_grid = sample, LON = "x", LAT = "y")
```

Arguments

raster_FPI	A raster with values to extract
df_grid	The dataframe with geographical coordinates that the raster_FPI will be extracted.
LON	Name of Longitude field in df_grid in "". The longitude should be in a geographical coordinate system WGS84
LAT	Name of Latitude field in df_grid in "". The longitude should be in a geographical coordinate system WGS84

Value

Return of a data.frame with the values of the raster incorporated in the selected grid.

Author(s)

I. Maina

Examples

```
library(tools4MCDA)
library(dplyr)

#load data
data("dfcut2")
data("cdist_r")

#select a sub-area
GSA<-20

#create GRID for sample
dfcut2$lon<-as.numeric(dfcut2$x)
```

```
dfcut2$lat<-as.numeric(dfcut2$y)
r<-rasterFromXYZ(dfcut2[, c('lon', 'lat')])
crs(r) <- CRS('+init=EPSG:4326')
sample<-as.data.frame(dfcut2, xy=TRUE)
sample<-joinFPI_GSA(data_FPI=sample,GSA_poly = GSA_poly,field_GSA="SMU_CODE",LON="x",LAT="y")
sample<-sample[sample$SMU_CODE %in% GSA,]

#plot initial data
r_cdist <- rasterFromXYZ(cdist_r[, c('x', 'y', 'cdist')])
crs(r_cdist) <- CRS('+init=EPSG:4326')
plot(r_cdist)
sf::sf_use_s2(FALSE)

#sample from raster
cdist_r_GSA20<-sample_raster(raster_FPI=r_cdist, df_grid=sample, LON="x", LAT="y")
cdist_r_GSA20 <- cdist_r_GSA20 %>% rename("cdist" = "layer")

#plot data after sample
cdist_r_GSA20 <- rasterFromXYZ(cdist_r_GSA20[, c('LON', 'LAT', 'cdist')])
crs(cdist_r_GSA20) <- CRS('+init=EPSG:4326')
plot(cdist_r_GSA20)
```

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