Application of the processed survey data in the analytical hierarchy process (AHP)

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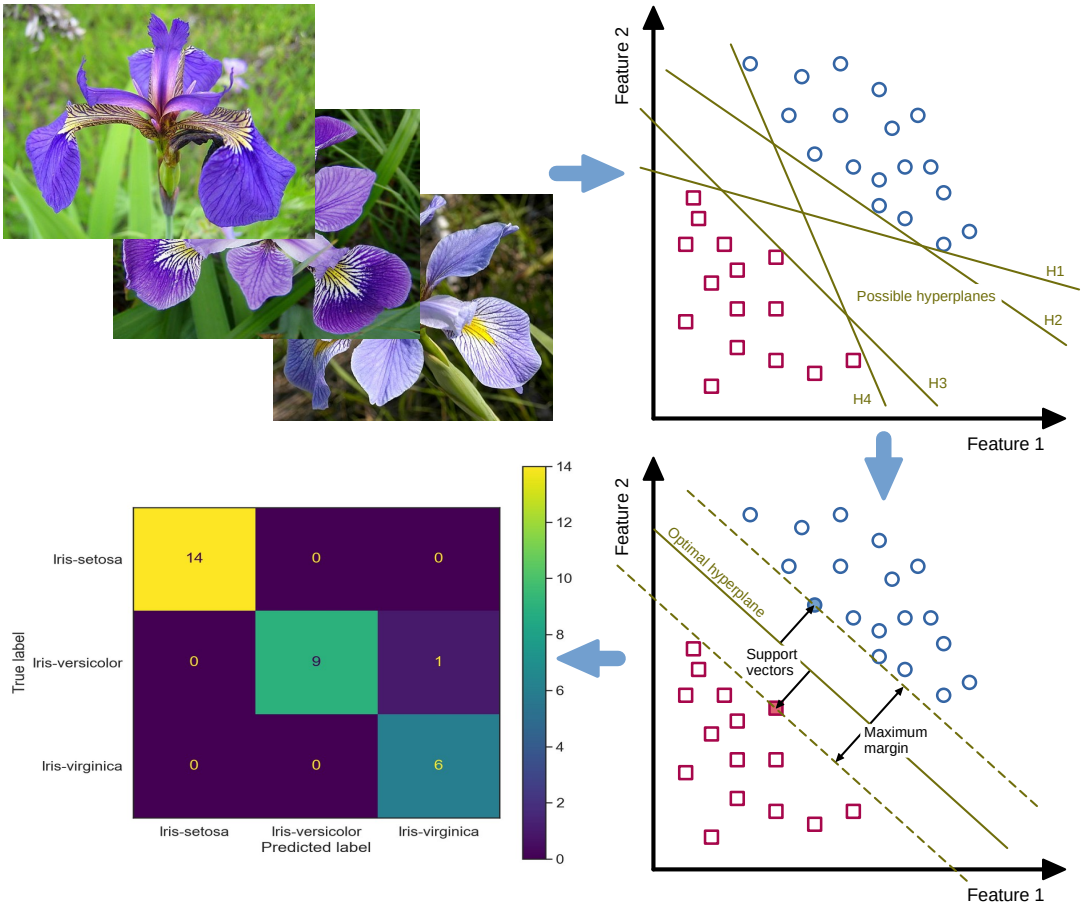

This is a placeholder for the abstract that needs to be added later.

Contents

1 Introduction

Why we use a Jupyter notebook to to publish the R program examples:

Jupyter is a new **open source** alternative to the proprietary numerical software Mathematica from **Wolfram Research** that is well on the way to become a **standard for exchanging research results** (Somers 2018; Romer 2018).

Originally Jupyter was intended as an IDE for the programming languages **Julia** and **Python**. Besides that it is also possible to install other interpreter kernels, such as the **IRkernel** for R. This can be interesting if the IDE **RStudio Desktop** is not available on the target platform used. For example, it is very difficult to install RStudio on the ARM-based embedded computer **Raspberry Pi** due to many

technical dependencies. In contrast, using the R kernel in JupyterLab on the Raspberry Pi works very well and performant.

2 Global settings and dependencies

2.1 Install missing packages if not present yet

Attention: For some R packages several dependencies have to be installed first with `apt install <package name>`.

Dependencies for package `ahpsurvey`:
- R package `randomNames` (it depends on R 4.0, refer to https://cran.r-project.org/web/packages/randomNames/index.html)

Drawback for **Raspbian buster**: the dependency `randomNames` is not available for R v3.5.2 as it depends on R (4.0). Upgrading R in Raspbian following the instruction on https://cran.rstudio.com/bin/linux/debian/#debian-buster-stable does not work so far ...

[132]:
```
# List of R packages that are used in this script
list.of.packages <- c("data.table", "ggplot2", "tidyr", "dplyr", "magrittr",␣
 ↪"ahpsurvey", "knitr", "IRdisplay", "forcats")

# Query the already installed packages and save the missing ones in a new list
missing.packages <- list.of.packages[!(list.of.packages %in% installed.
 ↪packages()[,"Package"])]

# Install missing packages
if(length(missing.packages)) {
    install.packages(missing.packages)
} else {
    print("All required packages are installed.")
}
```

```
[1] "All required packages are installed."
```

2.2 Load package `data.table`

The package `data.table` is used to read and manipulate tables (`data.table` inherits from `data.frame`). Install and load it:

[2]:
```
library(data.table)
```

2.3 Load package `ggplot2`

The package `ggplot2` is used to plot diagrams. Install and load it:

[3]:
```
library(ggplot2)
```

2.4 Load packages `knitr` and `IRdisplay`

The `kable()` function from the package `knitr` is used to output dataframes as a markdown tables.

The `display_markdown()` function from the package `IRdisplay` renders the markdown table in the notebook as well as in the PDF version.

[4]:
```
library(knitr)
library(IRdisplay)
```

2.5 Load package `tidyr`

The package `tidyr` is used to **reshape** the dataframes and provides functions like `gather()` or `spread()`. Some examples for the application can be found here: Reshaping Your Data with tidyrReshaping Your Data with tidyr.

Install and load it:

[5]:
```
library(tidyr)
```

2.6 Load package `dplyr`

The package `dplyr` is necessary to manipulate dataframes using functions like `select()`, `mutate()` and `left_join()`. Install and load it:

Hint: Setting the parameter `warn.conflicts=FALSE` when calling the `library()` function silences annoying messages about masked functions.

[6]:
```
library(dplyr, warn.conflicts=FALSE)
```

2.7 Use pipes for better coding

HINT: The pipe functionality is already available by loading the library `tidyr` - so you don't have to load it explicitly.

What pipes like `%>%` are and how to use them is described here: `https://statistik-dresden.de/archives/15679`.

Before using pipes in R, you have to install and load the package `magrittr`:

[7]:
```
library(magrittr, warn.conflicts=FALSE)
```

2.8 Load package `forcats`

The `fct_inorder()` function from the package `forcats` is used to reorder the discrete levels of diagram axes according to the intended order of attributes.

[134]:
```
library(forcats)
```

2.9 Load package `ahpsurvey`

The package `ahpsurvey` contains all the necessary mathematical and statistical methods to run the analytical hierarchy process (AHP).

[8]:
```
library(ahpsurvey)
```

3 Functions for processing AHP

3.1 Set globally used input and output folders

[9]:
```
str_input_path = "./output_data_manipulated"
str_output_path = "./output_data_AHP"
```

3.2 Function to read in the processed survey data from CSV files to dataframes

Define a function for reading in a CSV file to a date frame.

[10]:
```
func_readCSVdata_to_dataframe <- function(str_CSVfilename) {

  df_CSVdata <- fread(
    file = str_CSVfilename, encoding = "UTF-8",
    header = TRUE, sep = "\t", quote = "\""
    )

  return(df_CSVdata)
}
```

3.3 Function to format dataframes as a markdown tables

Following function formats given dataframes as markdown tables using the `kable()` function from the `knitr` package.

The `display_markdown()` function from the package `IRdisplay` renders the markdown table in the notebook as well as in the PDF version.

[11]:
```
func_render_md_tables <- function(df_table, str_table_header) {
    # format the dataframe as a markdown table using the 'kable()' function from␣
 ↪the 'knitr' package
    table_out <- kable(
        df_table,
        format = "markdown",
        # digits = 2,
        caption = str_table_header)

    display_markdown(as.character(table_out))
}
```

3.4 Function for generating a dataframe with *eigentrue values* (weights)

[12]:
```
func_genEigentrue_to_dataframe <- function(df_surveyData, vec_attributes) {
  list_mat_judgement <- df_surveyData %>%
    ahp.mat(vec_attributes, negconvert = TRUE)

  df_eigentrue <- ahp.indpref(list_mat_judgement, vec_attributes, method = "eigen")

  return(df_eigentrue)
}
```

3.5 Function for generating an array with consistency ratios

[13]:
```
func_genCR_to_arr <- function(df_surveyData, vec_attributes) {
  arr_cr <- df_surveyData %>%
    ahp.mat(vec_attributes, negconvert = TRUE) %>%
    ahp.cr(vec_attributes, ri=0.58)

  return(arr_cr)
}
```

3.6 Function for generating a dataframe with consistency ratios

[14]:
```
func_genCR_to_dataframe <- function(df_surveyData, vec_attributes, arr_cr,␣
↪consistency_thres=0.1, str_CRlabel) {
  df_cr <- df_surveyData %>%
    ahp.mat(vec_attributes, negconvert = TRUE) %>%
    ahp.cr(vec_attributes, ri=0.58) %>%
    data.frame() %>%
    mutate(rowid = 1:length(arr_cr), arr_cr.dum = as.factor(ifelse(arr_cr <=␣
↪consistency_thres, 1, 0)))

  # rename column with consistency ratios
  colnames(df_cr)[1] <- str_CRlabel

  return(df_cr)
}
```

3.7 Function for visualizing individual priorities and consistency ratios

[202]:
```
func_visuPriosCRs <- function(df_surveyData, df_cr, arr_cr, consistency_thres = 0.
↪1, vec_attributes, df_eigentrue, vec_labels, str_image_filename, str_title) {
  # Select columns 'arr_cr.dum' and 'rowid' from input dataframe 'df_cr'
  # 'arr_cr.dum': Binary representation of the consistency ratio (0: inconsistent;␣
↪1: consistent)
  df_cr_sel <- df_cr %>%
    select(arr_cr.dum, rowid)

  # Generate AHP pairwise matrices from survey data
  mat_ahp <- ahp.mat(df_surveyData, atts = vec_attributes, negconvert = TRUE)

  # Compute priority weights of individual decision-makers
  df_prio_weights <- ahp.indpref(mat_ahp, vec_attributes, method = "eigen")

  # Add column 'rowid' from dataframe 'df_eigentrue'
  df_prio_weights <- mutate(df_prio_weights, rowid = 1:nrow(df_eigentrue))

  # Left join dataframes 'df_prio_weights' and 'df_cr_sel' by column 'rowid'
  df_prio_weights_binCR <- left_join(df_prio_weights, df_cr_sel, by = "rowid")

  # Gather columns of 'df_prio_weights_binCR' into key-value pairs
  # The function 'all_of(vec_attributes)' selects data-variables listed in the␣
↪character vector 'vec_attributes'
  li_binCR_attr_weights <- gather(df_prio_weights_binCR, all_of(vec_attributes),␣
↪key = "var", value = "pref")

  # Create the violin plots with overlaid box plots.
  # Important: The function "fct_inorder()" is necessary to reorder the discrete␣
↪levels
  # of the diagram axes according to the intended order of the attributes.
  # Otherwise, the order will be automatically set alphanumerically and will not␣
↪match
  # the attribute labels later.
  # refer: https://stackoverflow.com/a/41417136
  plt <- ggplot(li_binCR_attr_weights, aes(x = fct_inorder(var), y = pref)) +
    # Add a violin plot
    geom_violin(alpha = 0.6, width = 0.8, color = "transparent", fill = "gray") +
```

```
    # 'geom_jitter()' is a shortcut for 'geom_point(position = "jitter")'
    # Adds a small amount of random variation to the location of each point
    # to handle overplotting caused by discreteness in smaller datasets
    geom_jitter(alpha = 0.6, height = 0, width = 0.1, aes(color = arr_cr.dum)) +
    # Add a box plot
    geom_boxplot(alpha = 0, width = 0.3, color = "#808080") +
    # Set discrete levels of the diagram X-axis according to the corresponding␣
  ↪attribute labels
    scale_x_discrete("Attribute", label = vec_labels) +

    # Configure the diagram Y-axis to display continuos data with
    # scale in percent and choose where the ticks appear by setting 'breaks'
    scale_y_continuous("Weight (dominant eigenvalue)",
                       labels = scales::percent,
                       breaks = c(seq(0,0.7,0.1))) +

    # Hide the title of the legend
    guides(color=guide_legend(title=NULL)) +

    # Set the discrete color scale according to the binarized consistency ratio
    # and use the Unicode character '\u2264' for '<='
    scale_color_discrete(breaks = c(0,1),
                         labels = c(paste("CR >", consistency_thres),
                                    paste("CR \u2264", consistency_thres))) +

    # Set caption text to be displayed in the bottom-right of the plot
    # with number of rows and mean value of the consistency ratio
    labs(NULL, caption = paste("n =", nrow(df_surveyData), ",", "Mean CR =",
                               round(mean(arr_cr), 3))) +

    # Set theme of the plot to 'theme_light()'
    theme_light() +

    # Set the title of the diagram
    ggtitle(str_title)

  print(plt)

  # Save generated ggplot graphics to PNG image files
  ggsave(filename = str_image_filename, width = 7, height = 7, dpi = 300)
}
```

3.8 Function for generating geometric mean values from individual judgement matrices

[17]:
```
func_aggpref_gmean <- function(df_surveyData, vec_attributes, arr_cr,␣
  ↪consistency_thres=0.1, str_CRlabel) {
  df_cr <- df_surveyData %>%
    ahp.mat(vec_attributes, negconvert = TRUE) %>%
    ahp.cr(vec_attributes, ri=0.58) %>%
    data.frame() %>%
    mutate(rowid = 1:length(arr_cr), arr_cr.dum = as.factor(ifelse(arr_cr <=␣
  ↪consistency_thres, 1, 0)))

  # rename column with consistency ratios
  colnames(df_cr)[1] <- str_CRlabel
```

```
  # combine dataframe 'df_cr' with raw survey data ('df_surveyData')
  df_cr_wRaw <- cbind(df_cr, df_surveyData)

  # remove rows, where 'arr_cr.dum' == 0 (inconsistent data)
  df_cr_wRaw_cons <- df_cr_wRaw[df_cr_wRaw$arr_cr.dum != 0, ]

  # get individual judgement matrices from last 3 columns
  list_mat_judgement <- df_cr_wRaw_cons[tail(names(df_cr_wRaw_cons), 3)] %>%
    ahp.mat(vec_attributes, negconvert = TRUE)

  # get geometric mean values from judgement matrices
  list_gmean_l <- ahp.aggpref(list_mat_judgement, vec_attributes, method = "eigen",␣
 ↪aggmethod = "geometric")

  return(list_gmean_l)
}
```

3.9 Function for normalizing the geometric mean values

[18]:
```
func_norm_gmean <- function(list_gmeans) {
  # normalization so that the sum of the geometric mean values is 1 (corresponds to␣
 ↪100%)
  df_gmean_l <- data.frame(list_gmeans)
  # rename column with geometric mean values (raw)
  colnames(df_gmean_l)[1] <- "gmean.raw"

  gmean_sum <- 0
  for ( val in list_gmeans ) {
    gmean_sum <- gmean_sum + val
  }
  df_gmean_l["Sum", 1] <- gmean_sum

  for (idx in 1:length(list_gmeans)) {
    gmean_norm <- list_gmeans[[idx]] / gmean_sum
    df_gmean_l[idx, "gmean.norm"] <- gmean_norm
  }

  gmean_sum_norm <- 0
  # iterate over all rows except the last, because this is the sum itself
  for ( row in 1:(nrow(df_gmean_l)-1) ) {
    gmean_sum_norm <- gmean_sum_norm + df_gmean_l[row, 2]
  }
  df_gmean_l["Sum", 2] <- gmean_sum_norm

  return(df_gmean_l)
}
```

3.10 Function to process the ahpsurvey and create violin plots

[203]:
```
func_process_ahpsurvey <- function(df_csvInputFiles, str_participants_group,␣
 ↪str_input_path, str_output_path, df_attributes_labels) {
    row_start = 1
    row_end = 3
```

```
  df_outputTable <- data.table()

  for ( file_idx in 1:nrow(df_csvInputFiles) ) {
      # create dataframe from current input CSV file
      str_filename <- paste(str_input_path, df_csvInputFiles[file_idx,␣
↪filenames], sep="/")
      df_processed_survey_data <- func_readCSVdata_to_dataframe(str_filename)

      # create vectors for attributes and labels from a subset of dataframe␣
↪'df_attributes_labels_XXX'
      vec_atts <- df_attributes_labels[c(row_start:row_end), attr]
      vec_labels <- df_attributes_labels[c(row_start:row_end), labels]

      # shift row interval for next iteration
      row_start = row_start + 3
      row_end = row_end + 3

      # create title string for violin plots
      str_violin_title = "Violins display priorities and consistency ratios for␣
↪attributes:"
      str_violin_title <- paste(str_violin_title, vec_atts[1], sep = " ")
      # extend title string by looping through attributes, starting with 2nd␣
↪element
      for ( idx in 2:length(vec_atts) ) {
          str_violin_title <- paste(str_violin_title, vec_atts[idx], sep = ", ")
      }
      # print(str_violin_title)

      # generate dataframe with eigentrue values (weights)
      df_eigentrue_weights <-␣
↪func_genEigentrue_to_dataframe(df_processed_survey_data, vec_atts)

      # generate an array with consistency ratios
      arr_CRs <- func_genCR_to_arr(df_processed_survey_data, vec_atts)

      # generate an extended dataframe with consistency ratios
      consistency_thres = 0.1
      str_CRlabel <- paste("CR", df_csvInputFiles[file_idx, keys], sep="_")
      df_CRs <- func_genCR_to_dataframe(df_processed_survey_data, vec_atts,␣
↪arr_CRs, consistency_thres, str_CRlabel)

      str_image_filename <- paste("ahp_violin", str_participants_group,␣
↪df_csvInputFiles[file_idx, keys], sep="_")
      str_image_filename <- paste(str_image_filename, ".png", sep="")
      str_image_filename <- paste(str_output_path, str_image_filename, sep="/")
      func_visuPriosCRs(df_processed_survey_data, df_CRs, arr_CRs,␣
↪consistency_thres, vec_atts, df_eigentrue_weights, vec_labels,␣
↪str_image_filename, str_violin_title)

      # combine dataframes of eigentrue values (weights) with consistency ratios
      df_outputTable <- cbind(df_outputTable, df_eigentrue_weights)
      # add only specific columns of 'df_CRs' (omit column 'row_id')
      df_outputTable <- cbind(df_outputTable, df_CRs[c(1, 3)])
  }

  # extend file name by path
```

```
    str_CSVfilename_output <- paste("rdata", str_participants_group,␣
↪"eigentrue_CRs", sep="_")
    str_CSVfilename_output <- paste(str_CSVfilename_output, ".csv", sep="")
    str_CSVfilename_output <- paste(str_output_path, str_CSVfilename_output, sep="/
↪")

    # write dataframe 'df_outputTable' to CSV file for further statistical analysis
    write.table(df_outputTable, file = str_CSVfilename_output,
                fileEncoding = "UTF-8", row.names = FALSE,
                col.names = TRUE, sep = "\t", quote = TRUE)
}
```

3.11 Function to calculate aggregated preference weights for consistent datasets

[20]:
```
func_calc_pref_weights <- function(df_csvInputFiles, str_input_path,␣
↪df_attributes_labels) {
    row_start = 1
    row_end = 3

    for ( file_idx in 1:nrow(df_csvInputFiles) ) {
        # create dataframe from current input CSV file
        str_filename <- paste(str_input_path, df_csvInputFiles[file_idx,␣
↪filenames], sep="/")
        str_file_description <- df_csvInputFiles[file_idx, descriptions]

        df_processed_survey_data <- func_readCSVdata_to_dataframe(str_filename)

        # create vectors for attributes and labels from a subset of dataframe␣
↪'df_attributes_labels_XXX'
        vec_atts <- df_attributes_labels[c(row_start:row_end), attr]
        vec_labels <- df_attributes_labels[c(row_start:row_end), labels]

        # shift row interval for next iteration
        row_start = row_start + 3
        row_end = row_end + 3

        # generate an array with consistency ratios
        arr_CRs <- func_genCR_to_arr(df_processed_survey_data, vec_atts)

        str_CRlabel <- paste("CR", df_csvInputFiles[file_idx, keys], sep="_")

        list_gmean <- func_aggpref_gmean(df_processed_survey_data, vec_atts,␣
↪arr_CRs, consistency_thres=0.1, str_CRlabel)

        df_gmean <- func_norm_gmean(list_gmean)

        # store dataframe of main criteria to calculate the total weights of␣
↪sub-criteria
        if ( str_file_description == "criteria (main criteria)" ) {
            df_gmean_main_criteria <- df_gmean
        } else if ( str_file_description == "environmental sub-criteria" ) {
            # multiply column 'gmean.norm' of sub-criteria dataframe by 'Envi'␣
↪value from main criteria dataframe
            # and store the result in the new column 'gmean.total'
            df_gmean$gmean.total <- df_gmean$gmean.norm *␣
↪df_gmean_main_criteria["Envi", "gmean.norm"]
```

```
            # sum up the values of the new column 'gmean.total' and write to row␣
 ↪'Sum' of the same column
            df_gmean["Sum", "gmean.total"] <- sum(df_gmean[c(1:3), "gmean.total"])
        } else if ( str_file_description == "social sub-criteria" ) {
            df_gmean$gmean.total <- df_gmean$gmean.norm *␣
 ↪df_gmean_main_criteria["Soci", "gmean.norm"]

            df_gmean["Sum", "gmean.total"] <- sum(df_gmean[c(1:3), "gmean.total"])
        } else if ( str_file_description == "economic sub-criteria" ) {
            df_gmean$gmean.total <- df_gmean$gmean.norm *␣
 ↪df_gmean_main_criteria["Econ", "gmean.norm"]

            df_gmean["Sum", "gmean.total"] <- sum(df_gmean[c(1:3), "gmean.total"])
        }

        func_render_md_tables(df_gmean, paste("Aggregated weights for ",␣
 ↪str_file_description))
    }
}
```

4 Create dataframes (tables) handling the file names of processed survey data

4.1 File table for all participants

[21]:
```
df_csvInputFiles_all <- data.table(
  file_idx = 1:4,
  keys = c("crit", "env", "soc", "eco"),
  filenames = c("rdata_all_crit_AHP_edible_Cities_2022-03-18_09-53.csv",
                "rdata_all_env_AHP_edible_Cities_2022-03-18_09-53.csv",
                "rdata_all_soc_AHP_edible_Cities_2022-03-18_09-53.csv",
                "rdata_all_eco_AHP_edible_Cities_2022-03-18_09-53.csv"),
  descriptions = c("criteria (main criteria)",
                   "environmental sub-criteria",
                   "social sub-criteria",
                   "economic sub-criteria")
)

func_render_md_tables(df_csvInputFiles_all, "File table for all participants")
```

Table 1: File table for all participants

file_idx	keys	filenames	descriptions
1	crit	rdata_all_crit_AHP_edible_Cities_2022-03-18_09-53.csv	criteria (main criteria)
2	env	rdata_all_env_AHP_edible_Cities_2022-03-18_09-53.csv	environmental sub-criteria
3	soc	rdata_all_soc_AHP_edible_Cities_2022-03-18_09-53.csv	social sub-criteria
4	eco	rdata_all_eco_AHP_edible_Cities_2022-03-18_09-53.csv	economic sub-criteria

4.2 File table for city administrations

[22]:
```
df_csvInputFiles_CA <- data.table(
  file_idx = 1:4,
  keys = c("crit", "env", "soc", "eco"),
  filenames = c("rdata_CA_crit_AHP_edible_Cities_2022-03-18_10-28.csv",
                "rdata_CA_env_AHP_edible_Cities_2022-03-18_10-28.csv",
                "rdata_CA_soc_AHP_edible_Cities_2022-03-18_10-28.csv",
                "rdata_CA_eco_AHP_edible_Cities_2022-03-18_10-28.csv"),
  descriptions = c("criteria (main criteria)",
                   "environmental sub-criteria",
                   "social sub-criteria",
                   "economic sub-criteria")
)

func_render_md_tables(df_csvInputFiles_CA, "File table for city administrations")
```

Table 2: File table for city administrations

file_idx	keys	filenames	descriptions
1	crit	rdata_CA_crit_AHP_edible_Cities_2022-03-18_10-28.csv	criteria (main criteria)
2	env	rdata_CA_env_AHP_edible_Cities_2022-03-18_10-28.csv	environmental sub-criteria
3	soc	rdata_CA_soc_AHP_edible_Cities_2022-03-18_10-28.csv	social sub-criteria
4	eco	rdata_CA_eco_AHP_edible_Cities_2022-03-18_10-28.csv	economic sub-criteria

4.3 File table for non-governmental organizations

[23]:
```
df_csvInputFiles_NGO <- data.table(
  file_idx = 1:4,
  keys = c("crit", "env", "soc", "eco"),
  filenames = c("rdata_NGO_crit_AHP_edible_Cities_2022-03-18_10-40.csv",
                "rdata_NGO_env_AHP_edible_Cities_2022-03-18_10-40.csv",
                "rdata_NGO_soc_AHP_edible_Cities_2022-03-18_10-40.csv",
                "rdata_NGO_eco_AHP_edible_Cities_2022-03-18_10-40.csv"),
  descriptions = c("criteria (main criteria)",
                   "environmental sub-criteria",
                   "social sub-criteria",
                   "economic sub-criteria")
)

func_render_md_tables(df_csvInputFiles_NGO, "File table for non-governmental␣
 ↪organizations")
```

Table 3: File table for non-governmental organizations

file_idx	keys	filenames	descriptions
1	crit	rdata_NGO_crit_AHP_edible_Cities_2022-03-18_10-40.csv	criteria (main criteria)
2	env	rdata_NGO_env_AHP_edible_Cities_2022-03-18_10-40.csv	environmental sub-criteria
3	soc	rdata_NGO_soc_AHP_edible_Cities_2022-03-18_10-40.csv	social sub-criteria

file_idx	keys	filenames	descriptions
4	eco	rdata_NGO_eco_AHP_edible_Cities_2022-03-18_10-40.csv	economic sub-criteria

4.4 File table for practitioners and experts

[24]:
```
df_csvInputFiles_PE <- data.table(
  file_idx = 1:4,
  keys = c("crit", "env", "soc", "eco"),
  filenames = c("rdata_PE_crit_AHP_edible_Cities_2022-03-18_10-41.csv",
                "rdata_PE_env_AHP_edible_Cities_2022-03-18_10-41.csv",
                "rdata_PE_soc_AHP_edible_Cities_2022-03-18_10-41.csv",
                "rdata_PE_eco_AHP_edible_Cities_2022-03-18_10-41.csv"),
  descriptions = c("criteria (main criteria)",
                   "environmental sub-criteria",
                   "social sub-criteria",
                   "economic sub-criteria")
)

func_render_md_tables(df_csvInputFiles_PE, "File table for practitioners and␣
 ↪experts")
```

Table 4: File table for practitioners and experts

file_idx	keys	filenames	descriptions
1	crit	rdata_PE_crit_AHP_edible_Cities_2022-03-18_10-41.csv	criteria (main criteria)
2	env	rdata_PE_env_AHP_edible_Cities_2022-03-18_10-41.csv	environmental sub-criteria
3	soc	rdata_PE_soc_AHP_edible_Cities_2022-03-18_10-41.csv	social sub-criteria
4	eco	rdata_PE_eco_AHP_edible_Cities_2022-03-18_10-41.csv	economic sub-criteria

4.5 Table with attributes and labels

[25]:
```
df_attributes_labels <- data.table(
  # idx = 1:12,
  attr = c("Envi", "Soci", "Econ",
           "Clim", "BDiv", "CiEc",
           "KEdu", "Comm", "Part",
           "Qual", "LVCs", "Affo"),
  labels = c("Environment", "Society", "Economy",
             "Microclimate and Hydrology", "Biodiversity", "Circular economy",
             "Knowledge and Education", "Community Building", "Participation",
             "Food Quality and Safety", "Local Value Chains", "Food Affordability")
)

# print.data.frame(df_attributes_labels, right=FALSE)
func_render_md_tables(df_attributes_labels, "Table with attributes and labels")
```

Table 5: Table with attributes and labels

attr	labels
Envi	Environment
Soci	Society
Econ	Economy
Clim	Microclimate and Hydrology
BDiv	Biodiversity
CiEc	Circular economy
KEdu	Knowledge and Education
Comm	Community Building
Part	Participation
Qual	Food Quality and Safety
LVCs	Local Value Chains
Affo	Food Affordability

5 Exploit datasets of own survey with package ahpsurvey for each group of participants

5.1 All participants

[204]:
```
func_process_ahpsurvey(df_csvInputFiles_all, "all", str_input_path,␣
↪str_output_path, df_attributes_labels)
```

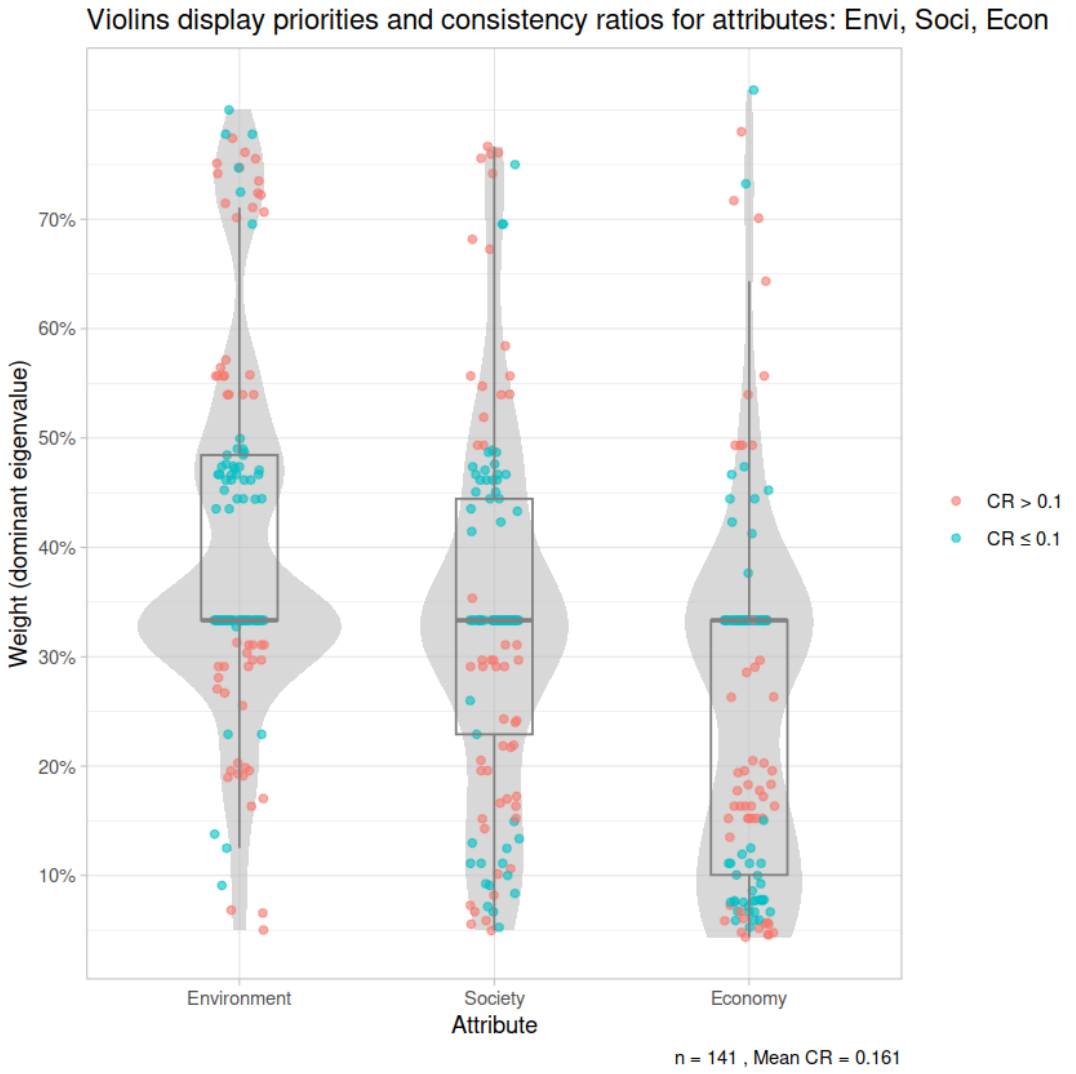

Figure 1: Series of violin plots that display the priorities and consistency ratios of all participants

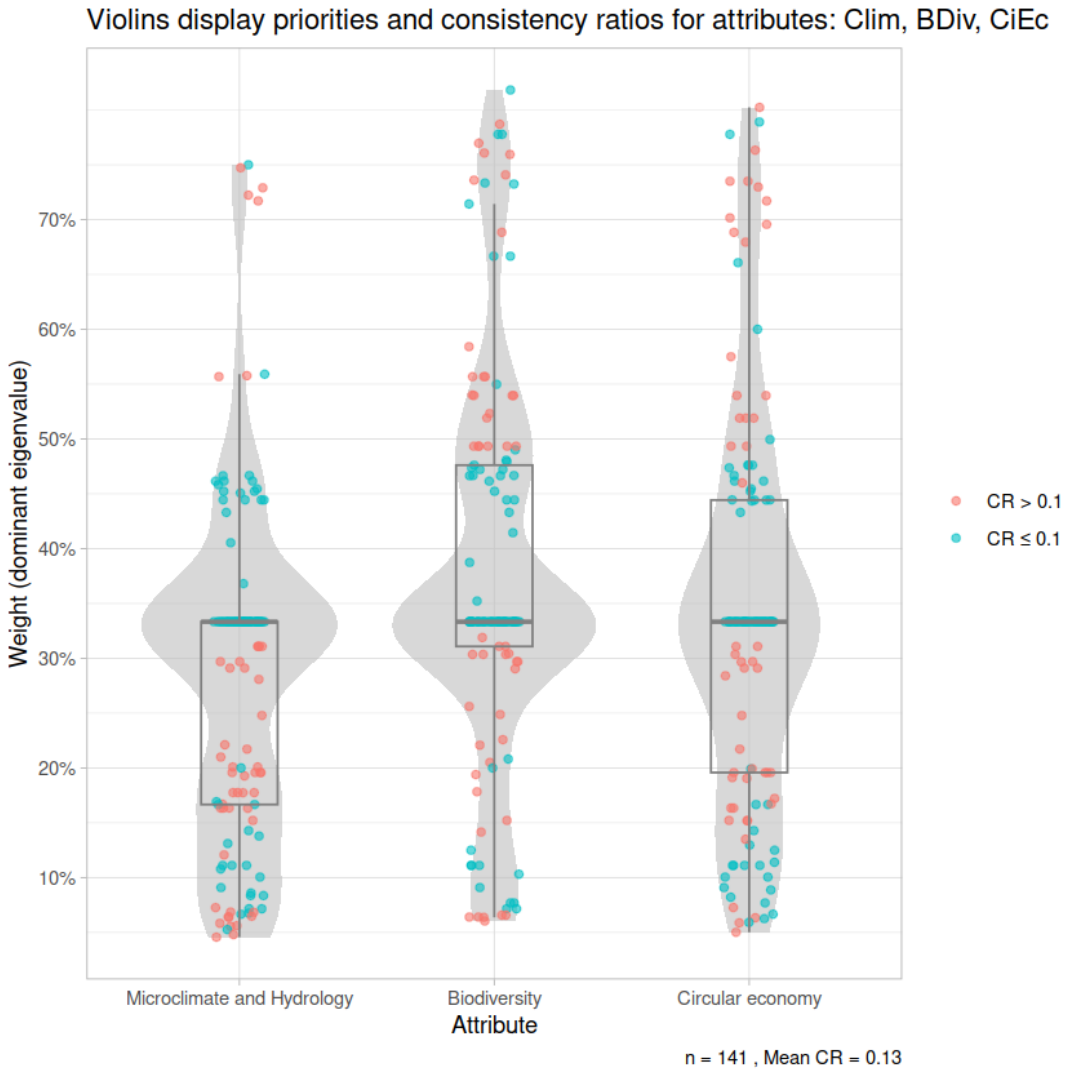

Figure 2: Series of violin plots that display the priorities and consistency ratios of all participants

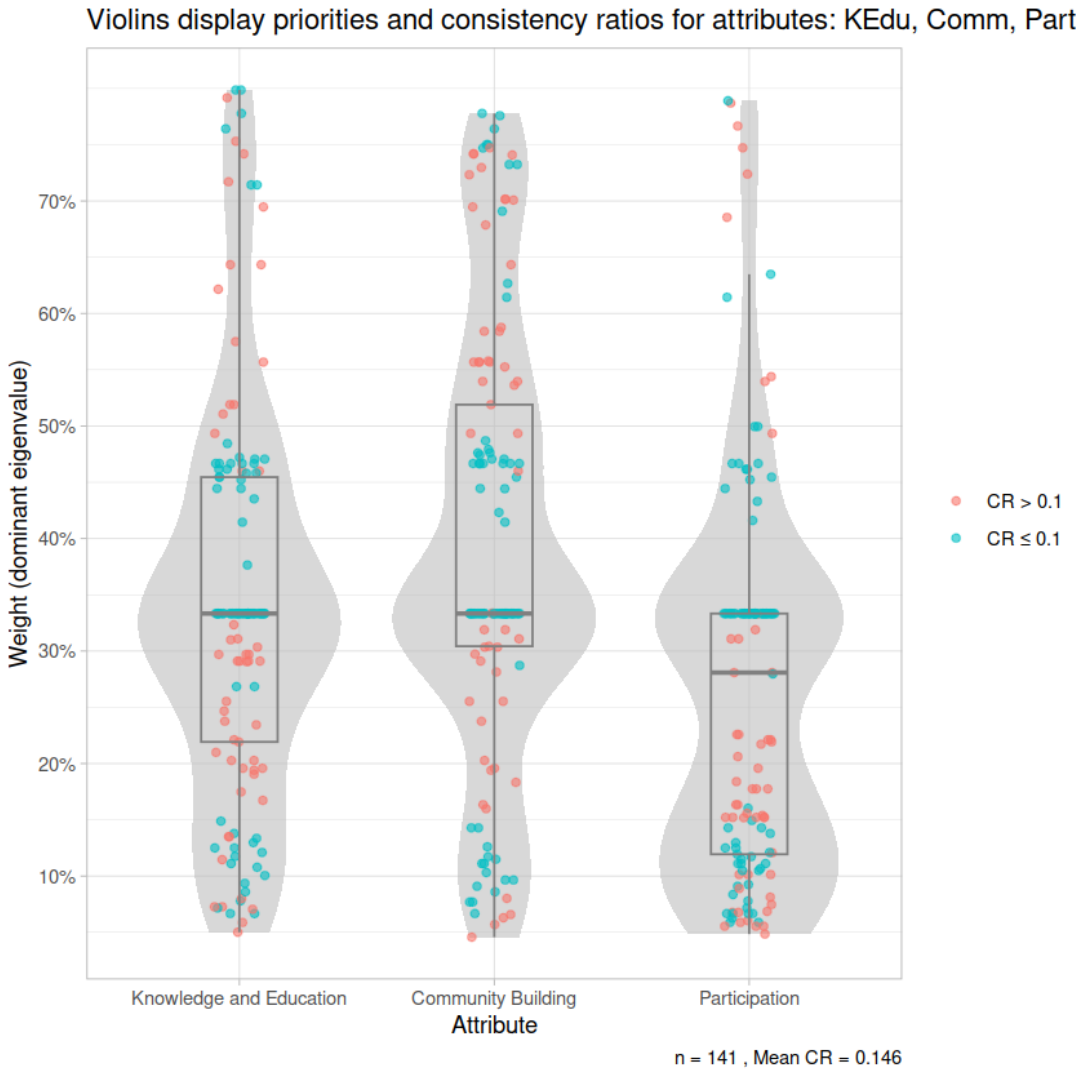

Figure 3: Series of violin plots that display the priorities and consistency ratios of all participants

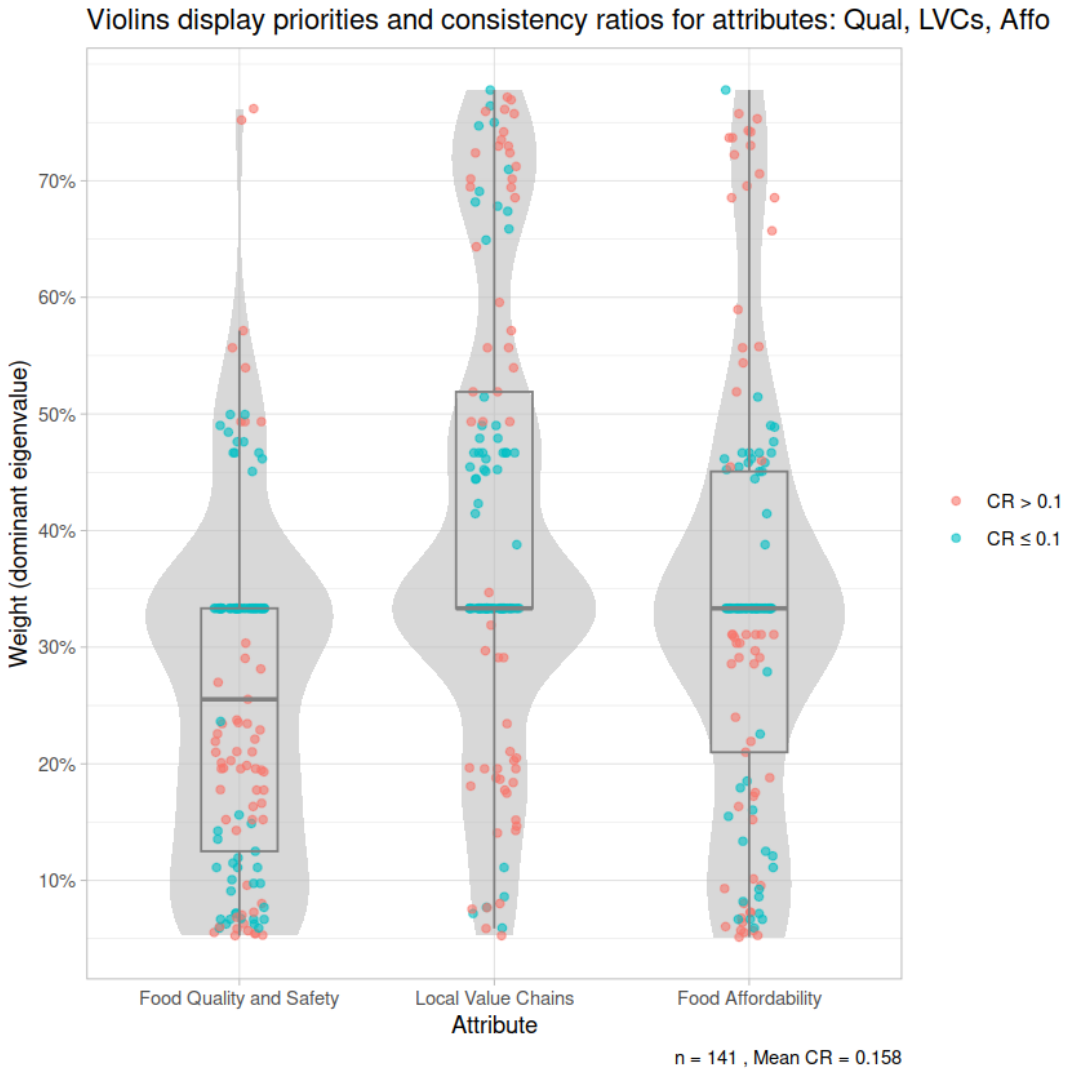

Figure 4: Series of violin plots that display the priorities and consistency ratios of all participants

5.2 Participants of city administrations

[196]:
```
func_process_ahpsurvey(df_csvInputFiles_CA, "CA", str_input_path, str_output_path,␣
↪df_attributes_labels)
```

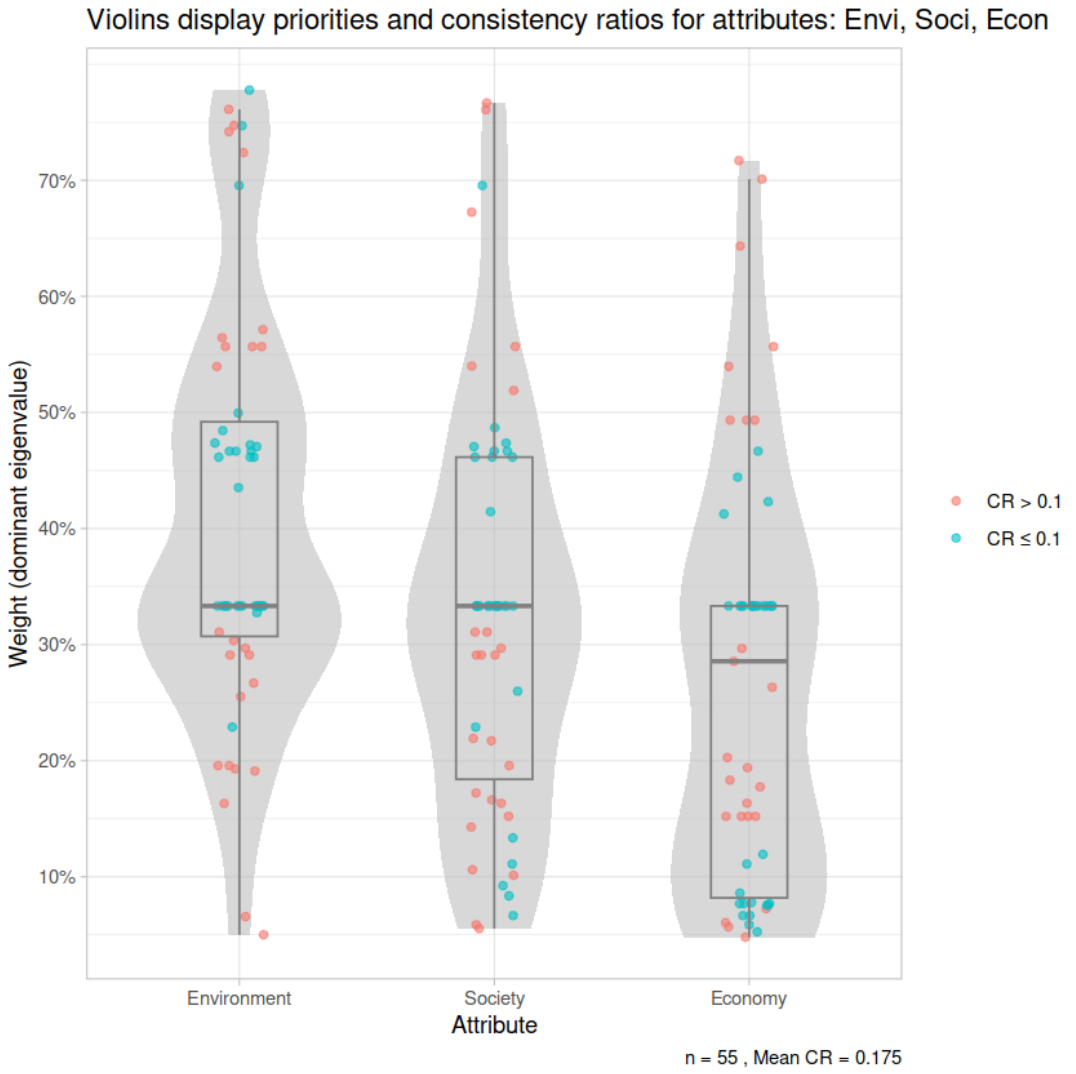

Figure 5: Series of violin plots that display the priorities and consistency ratios of city administrations

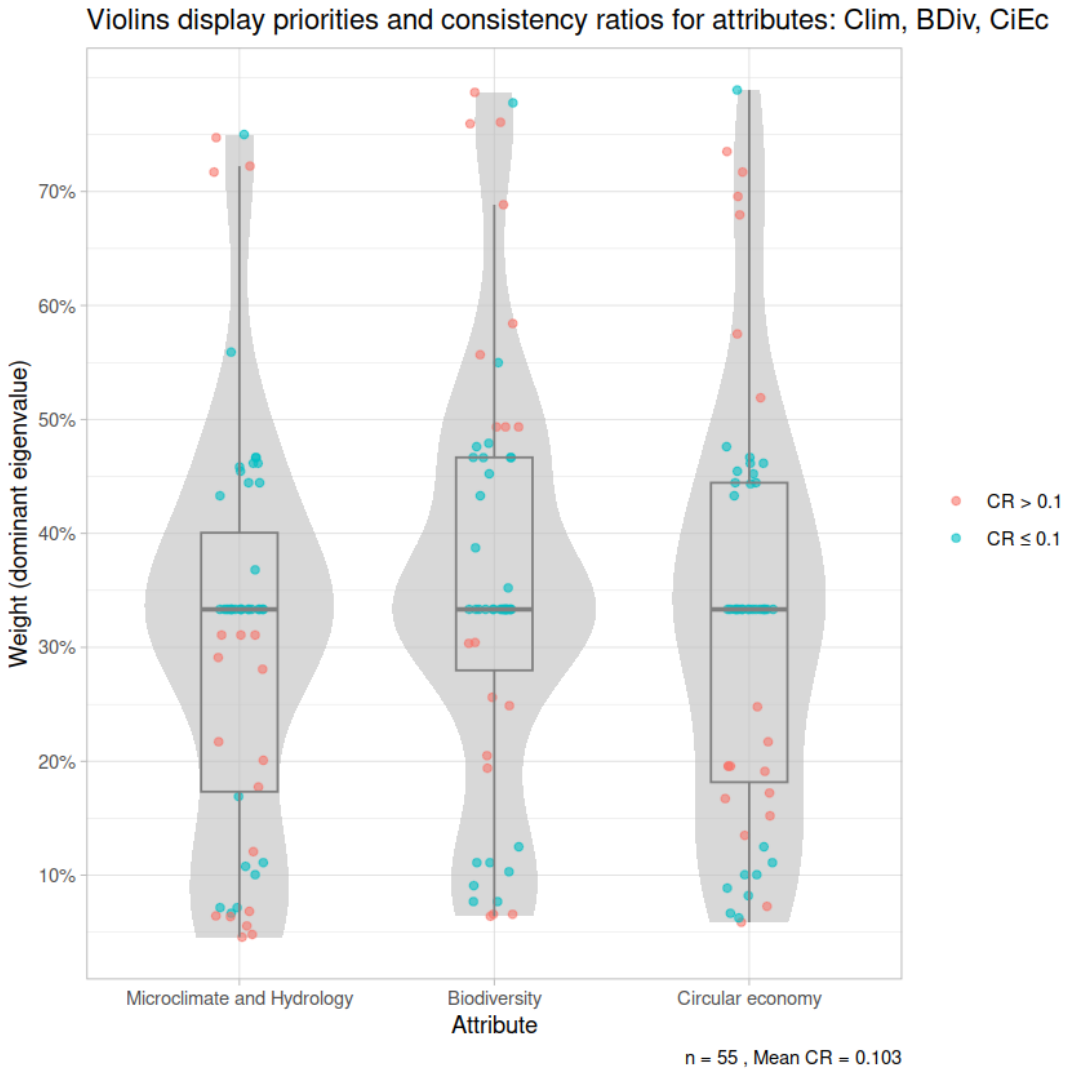

Figure 6: Series of violin plots that display the priorities and consistency ratios of city administrations

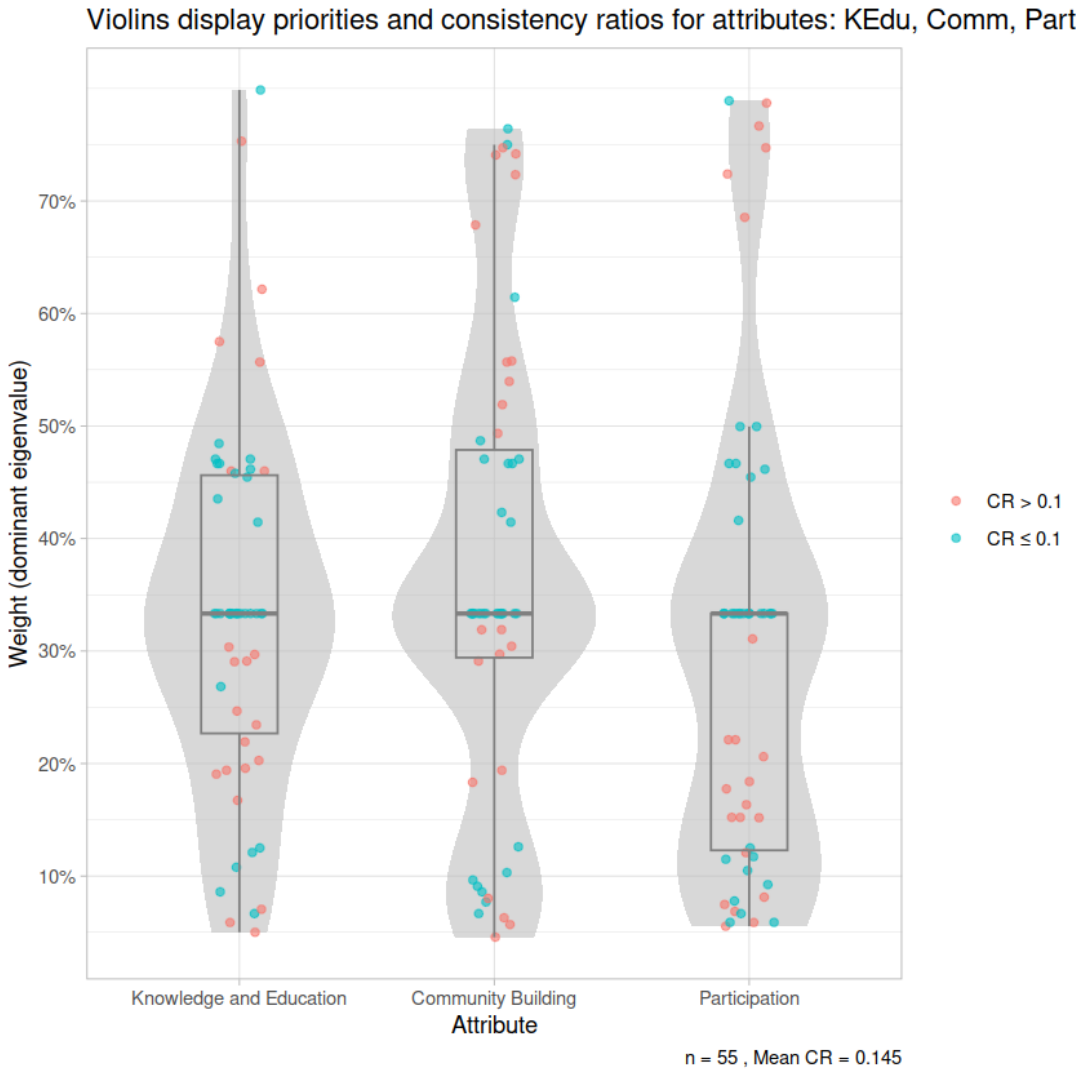

Figure 7: Series of violin plots that display the priorities and consistency ratios of city administrations

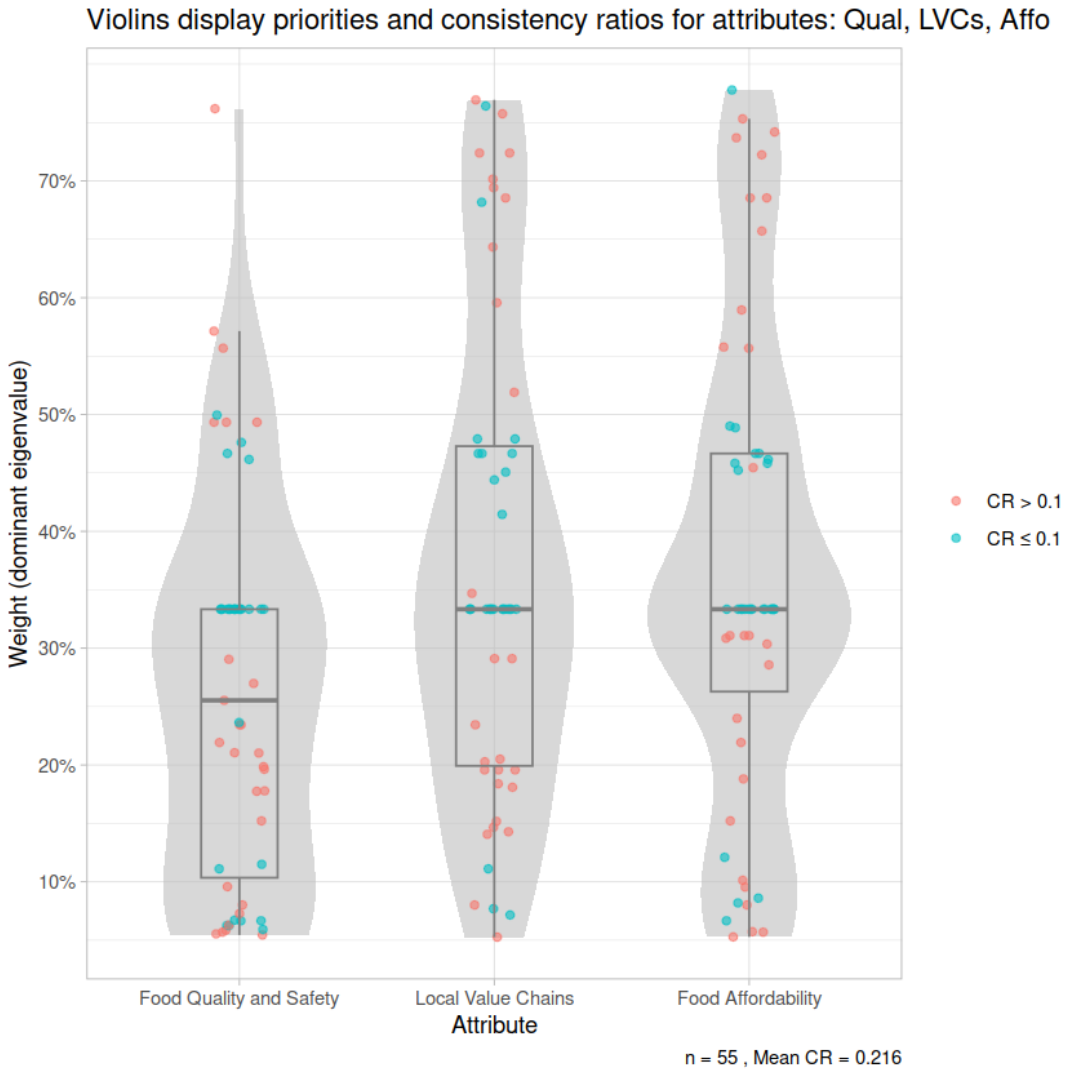

Figure 8: Series of violin plots that display the priorities and consistency ratios of city administrations

5.3 Participants of non-governmental organizations

[205]:
```
func_process_ahpsurvey(df_csvInputFiles_NGO, "NGO", str_input_path,␣
↪str_output_path, df_attributes_labels)
```

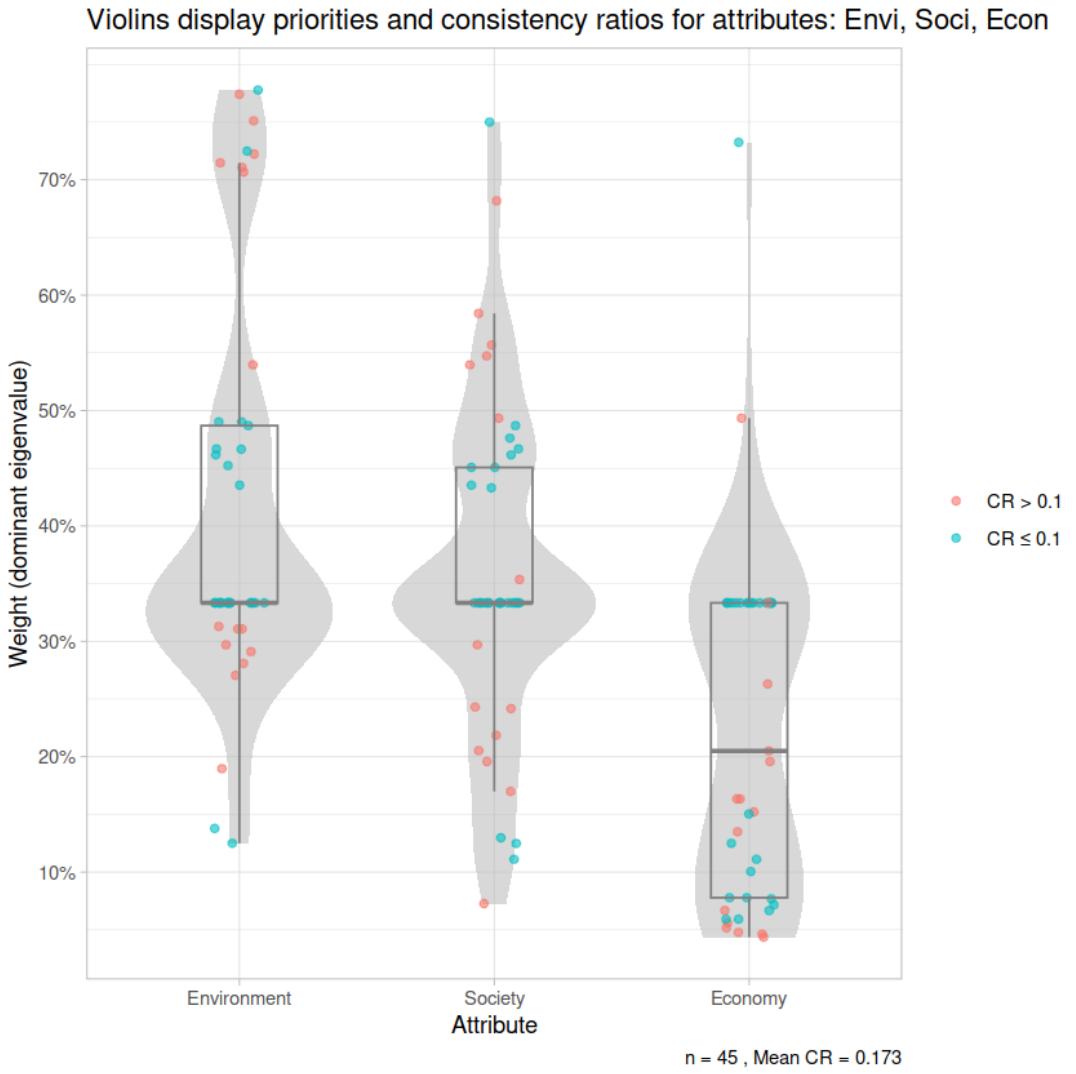

Figure 9: Series of violin plots that display the priorities and consistency ratios of non-governmental organizations

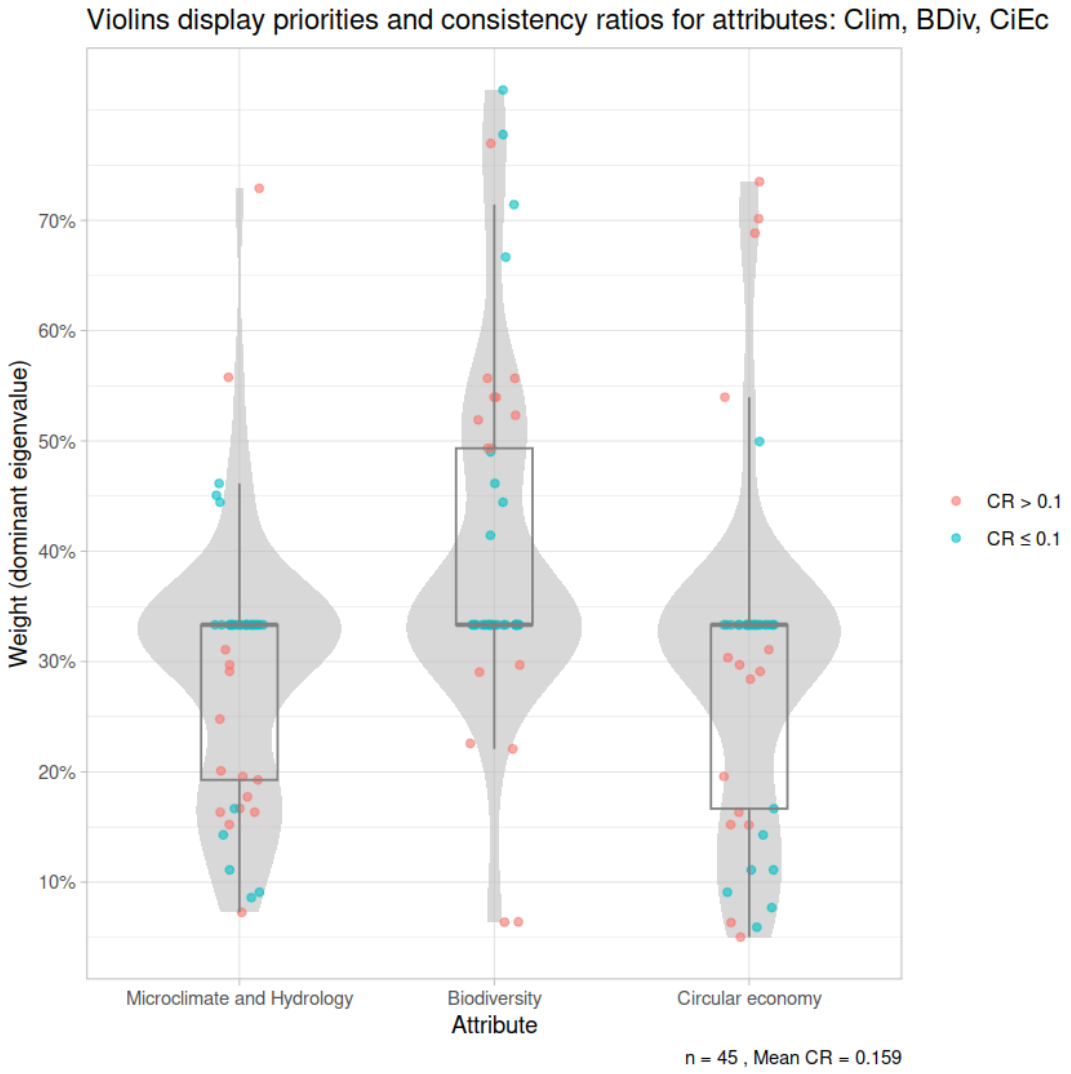

Figure 10: Series of violin plots that display the priorities and consistency ratios of non-governmental organizations

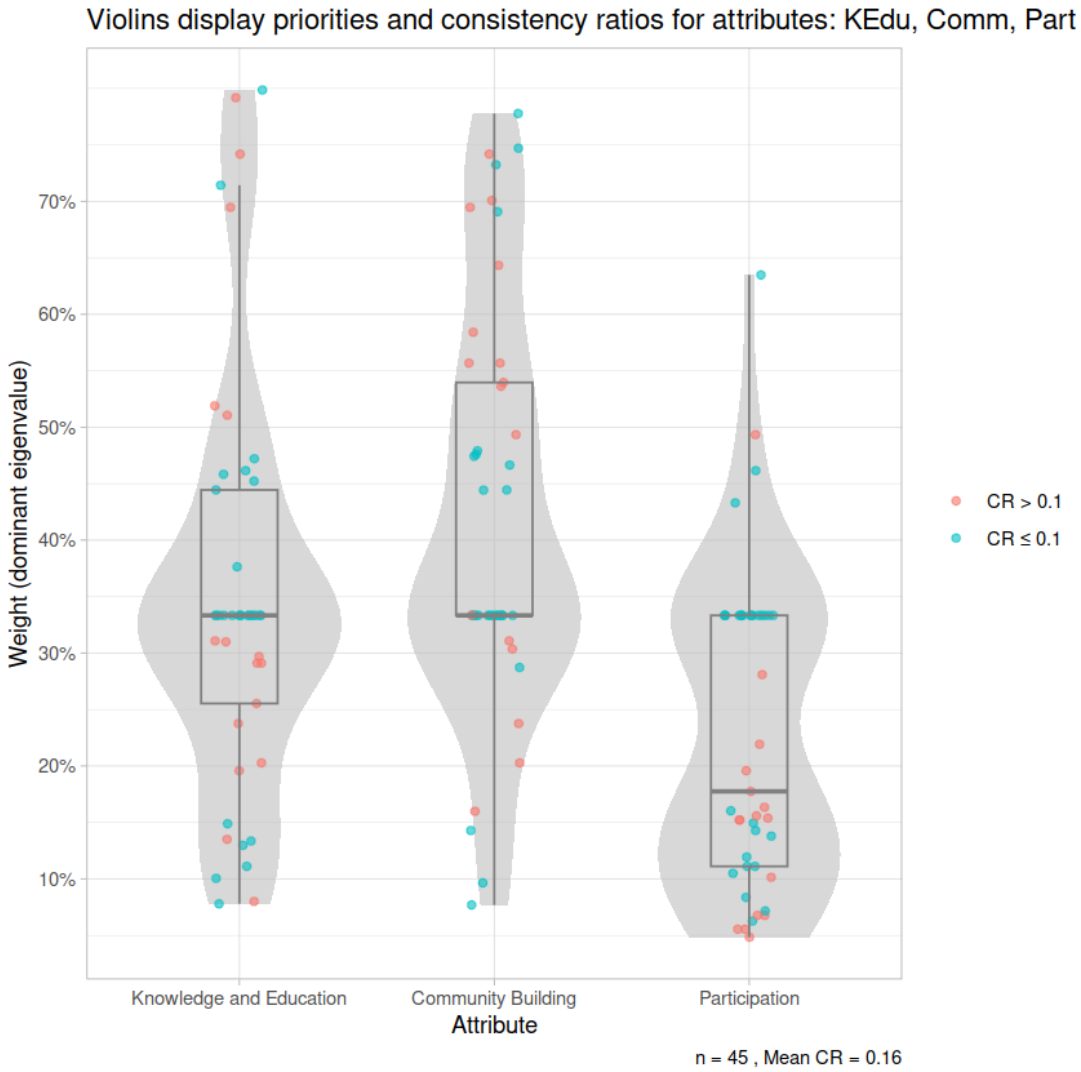

Figure 11: Series of violin plots that display the priorities and consistency ratios of non-governmental organizations

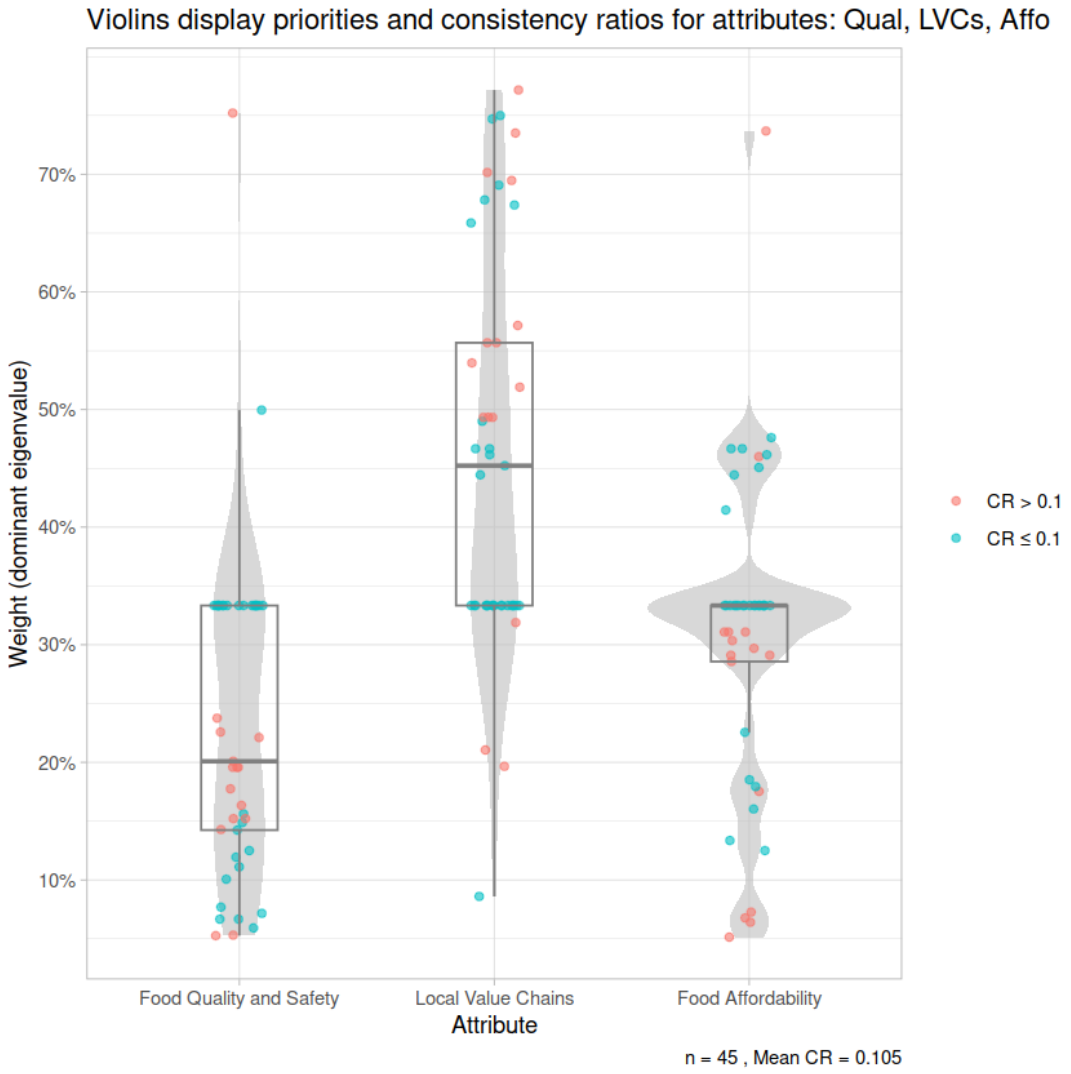

Figure 12: Series of violin plots that display the priorities and consistency ratios of non-governmental organizations

5.4 Participants of practitioners and experts

[206]:
```
func_process_ahpsurvey(df_csvInputFiles_PE, "PE", str_input_path, str_output_path,␣
↪df_attributes_labels)
```

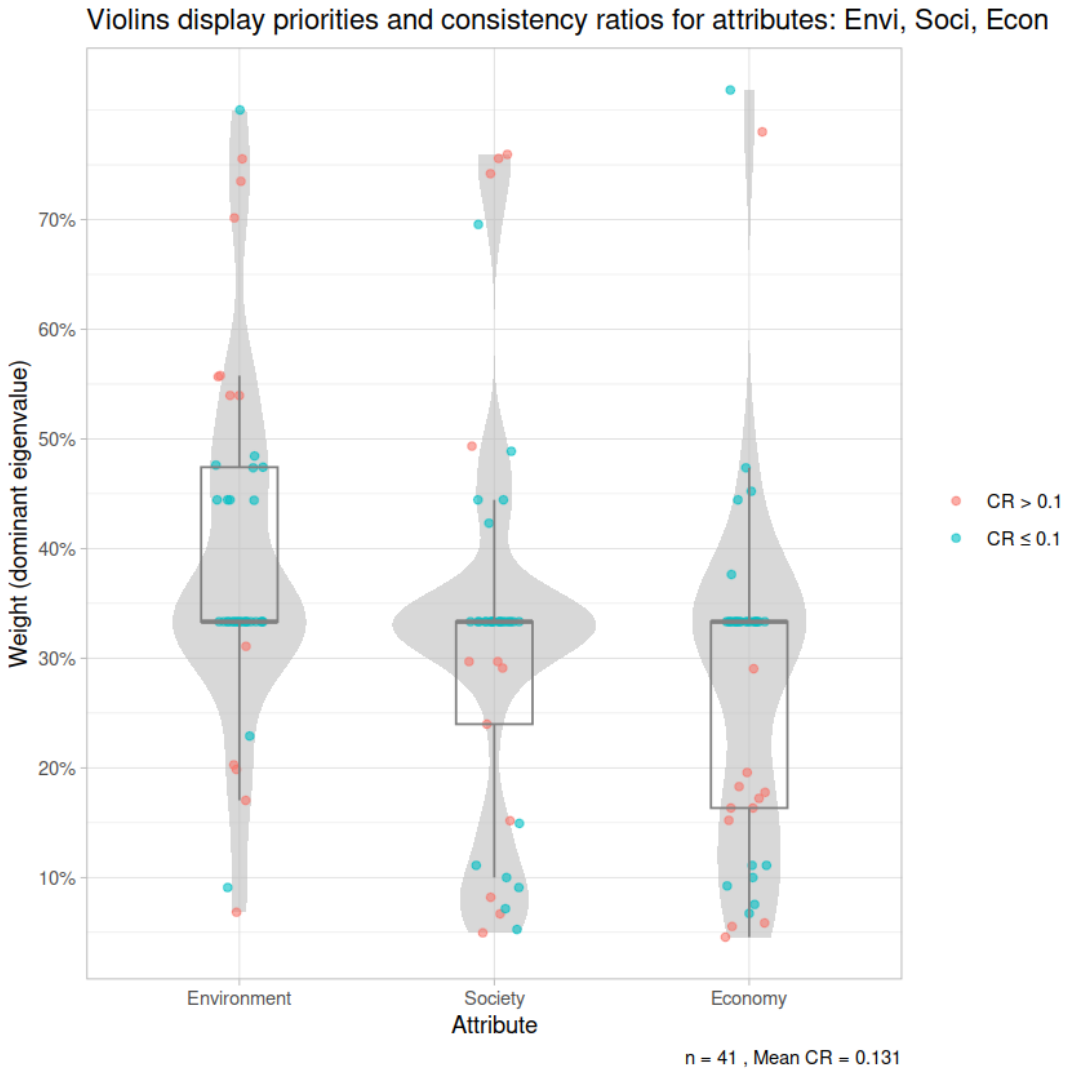

Figure 13: Series of violin plots that display the priorities and consistency ratios of practitioners and experts

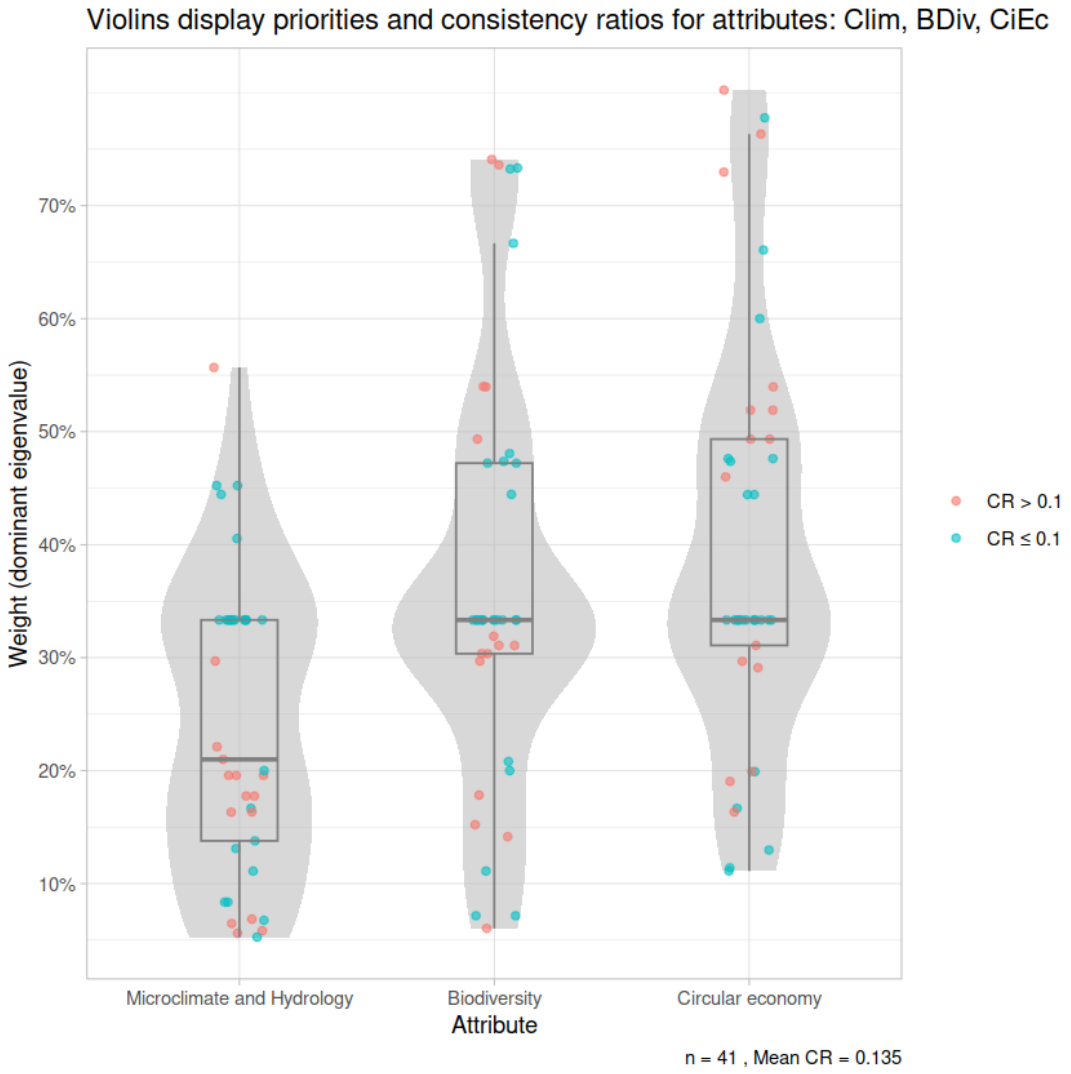

Figure 14: Series of violin plots that display the priorities and consistency ratios of practitioners and experts

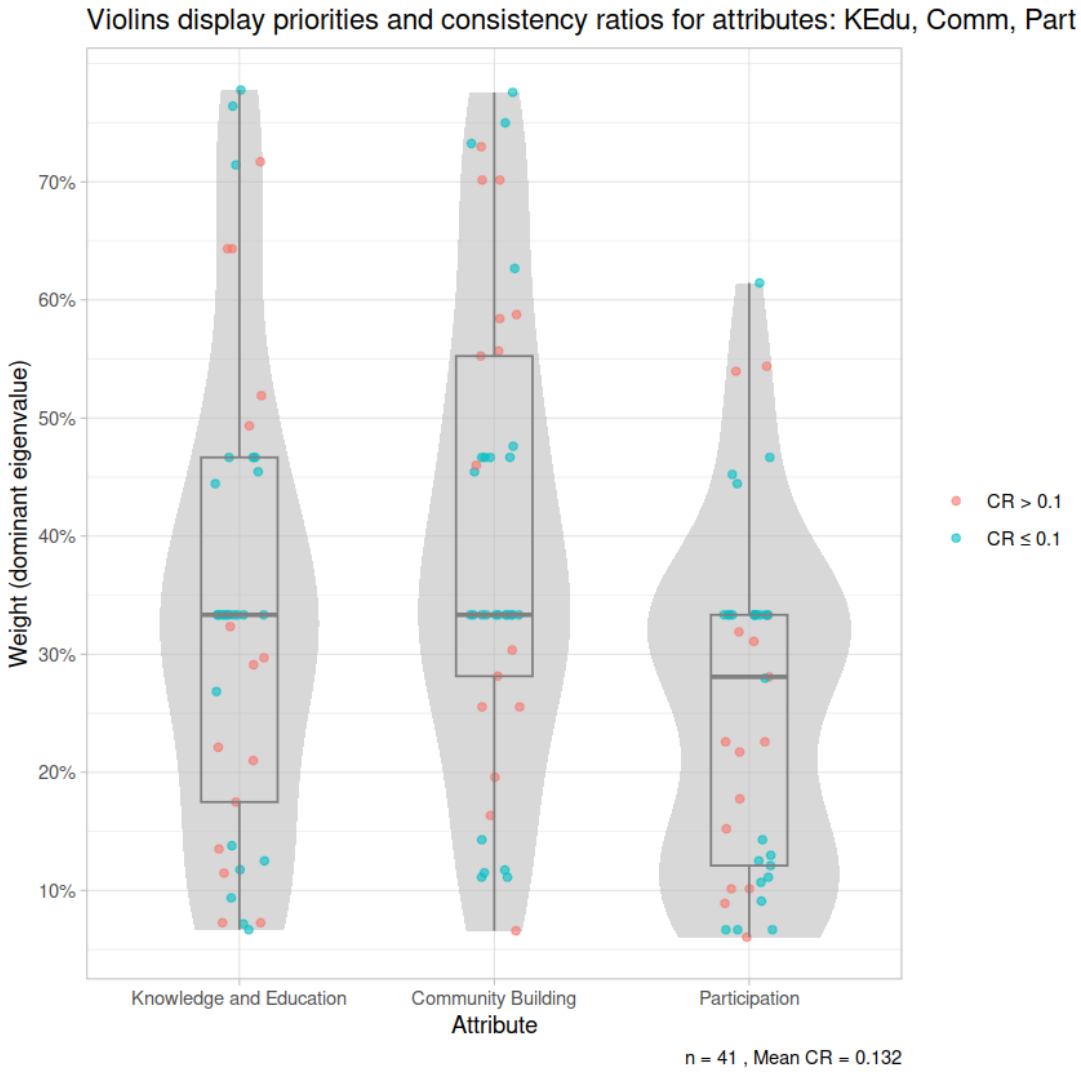

Figure 15: Series of violin plots that display the priorities and consistency ratios of practitioners and experts

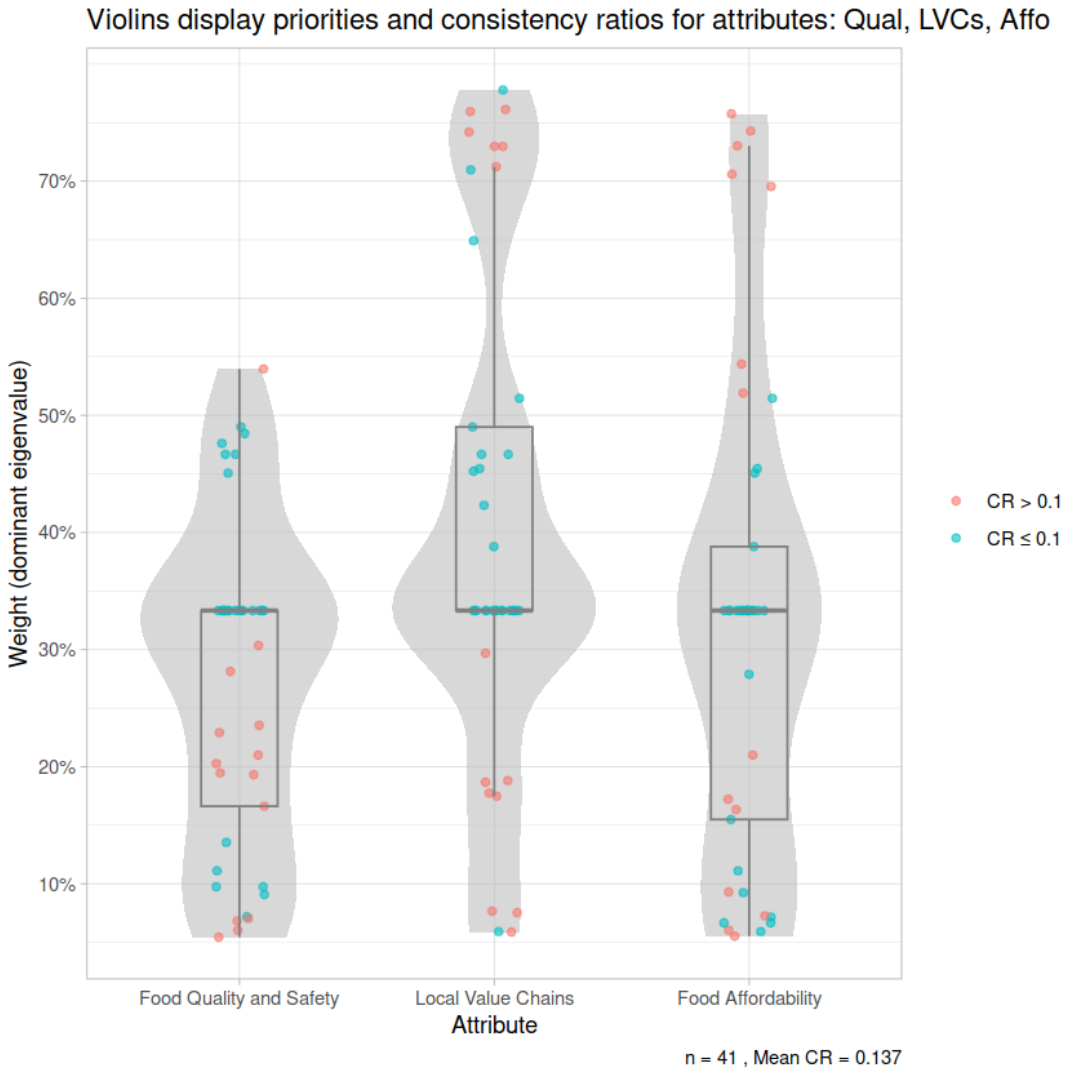

Figure 16: Series of violin plots that display the priorities and consistency ratios of practitioners and experts

5.5 Calculation of aggregated preference weights for consistent datasets

[207]:
```
func_calc_pref_weights(df_csvInputFiles_all, str_input_path, df_attributes_labels)
```

Table 6: Aggregated weights for criteria (main criteria)

	gmean.raw	gmean.norm
Envi	0.3739039	0.4179807
Soci	0.3023657	0.3380094
Econ	0.2182787	0.2440099
Sum	0.8945482	1.0000000

Table 7: Aggregated weights for environmental sub-criteria

	gmean.raw	gmean.norm	gmean.total
Clim	0.2741300	0.3089871	0.1291506
BDiv	0.3291718	0.3710277	0.1550824

	gmean.raw	gmean.norm	gmean.total
CiEc	0.2838874	0.3199852	0.1337476
Sum	0.8871892	1.0000000	0.4179807

Table 8: Aggregated weights for social sub-criteria

	gmean.raw	gmean.norm	gmean.total
KEdu	0.3018698	0.3512801	0.1187360
Comm	0.3212634	0.3738480	0.1263641
Part	0.2362090	0.2748719	0.0929093
Sum	0.8593422	1.0000000	0.3380094

Table 9: Aggregated weights for economic sub-criteria

	gmean.raw	gmean.norm	gmean.total
Qual	0.2329901	0.2625724	0.0640703
LVCs	0.3666029	0.4131498	0.1008127
Affo	0.2877435	0.3242777	0.0791270
Sum	0.8873365	1.0000000	0.2440099

6 Summary and outlook

7 References

Online references

Romer, Paul (Apr. 13, 2018). *Jupyter, Mathematica, and the Future of the Research Paper*. English. URL: https://paulromer.net/jupyter-mathematica-and-the-future-of-the-research-paper/ (visited on 09/08/2022) (cit. on p. 2).

Somers, James (Apr. 5, 2018). *The Scientific Paper Is Obsolete*. English. The Atlantic. URL: https://www.theatlantic.com/science/archive/2018/04/the-scientific-paper-is-obsolete/556676/ (visited on 09/08/2022) (cit. on p. 2).