Evidence for resilient agriculture for Land Equivalent Ratio Outcomes

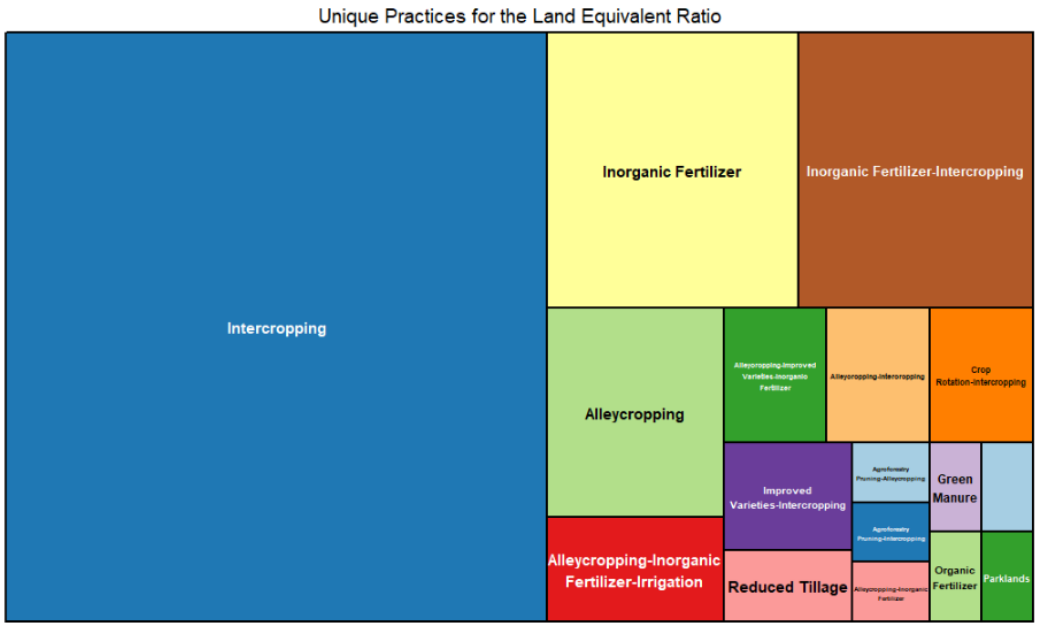
The data we are interested in, is the one the one only with **Land Equivalent Ratio.** After subsetting our data in this regard, we will be using **ERA_LER** having **808** observations and **142** variables.

Let's look at the effect on ERA practices on LER

First of all, we have in total **17 practices** for this specific LER outcome

1) "Agroforestry Pruning-Alleycropping"
2) "Alleycropping"
3) "Alleycropping-Improved Varieties-Inorganic Fertilizer"
4) "Alleycropping-Inorganic Fertilizer-Irrigation"
5) "Alleycropping-Inorganic Fertilizer"
6) "Intercropping"
7) "Inorganic Fertilizer-Intercropping"
8) "Inorganic Fertilizer"
9) "Improved Varieties-Intercropping"
10) "Reduced Tillage"
11) "Parklands"
12) "Green Manure"
13) "Crop Rotation-Intercropping"
14) "Agroforestry Pruning-Intercropping"
15) "Alleycropping-Intercropping"
16) "Organic Fertilizer"
17) "Inorganic Fertilizer-Organic Fertilizer"

Let's visualize this on the treemap to see their number before looking at the effects



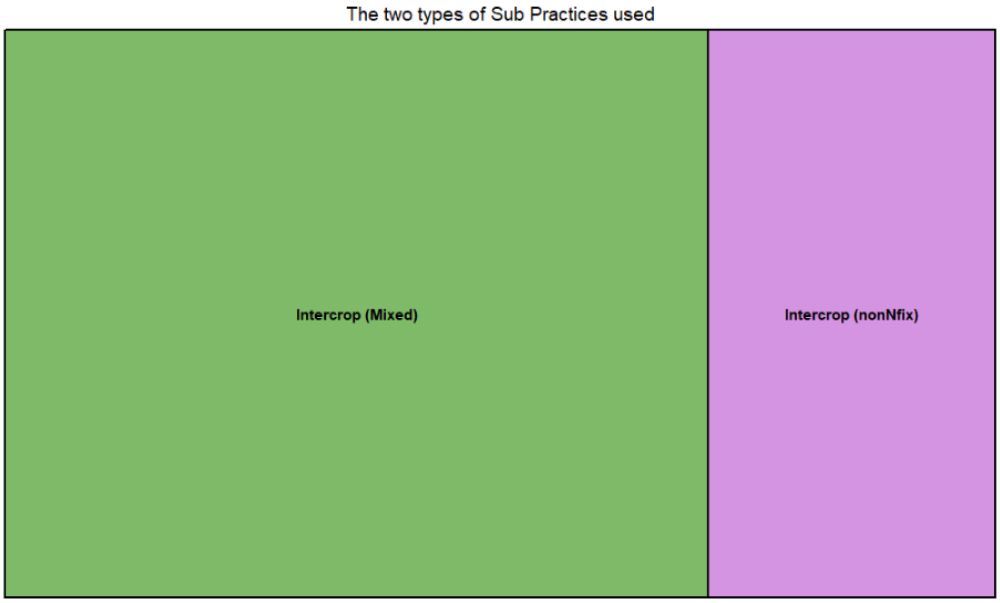
```
                                Agroforestry Pruning-Alleycropping
                                                                36
                                                     Alleycropping
                                                                49
                                Alleycropping-Inorganic Fertilizer
                                                                 2
                                       Alleycropping-Intercropping
                                                                 8
                                                      Green Manure
                                                                 6
                                                Inorganic Fertilizer
                                                                87
                Inorganic Fertilizer-Organic Fertilizer
                                                                 8
                                                Organic Fertilizer
                                                                16
                                                   Reduced Tillage
                                                                 4
                                   Agroforestry Pruning-Intercropping
                                                                16
Alleycropping-Improved Varieties-Inorganic Fertilizer
                                                                 8
       Alleycropping-Inorganic Fertilizer-Irrigation
                                                                10
                                      Crop Rotation-Intercropping
                                                                27
                                 Improved Varieties-Intercropping
                                                                23
                                Inorganic Fertilizer-Intercropping
                                                                92
                                                     Intercropping
                                                               413
                                                         Parklands
                                                                3
```

So we can see many intercropping practices **413** compare to others.

Let's subset again on the intercropping practices.

```
Data_LER_inter <- Data_LER[Data_LER$PrName == "Intercropping", ]
```

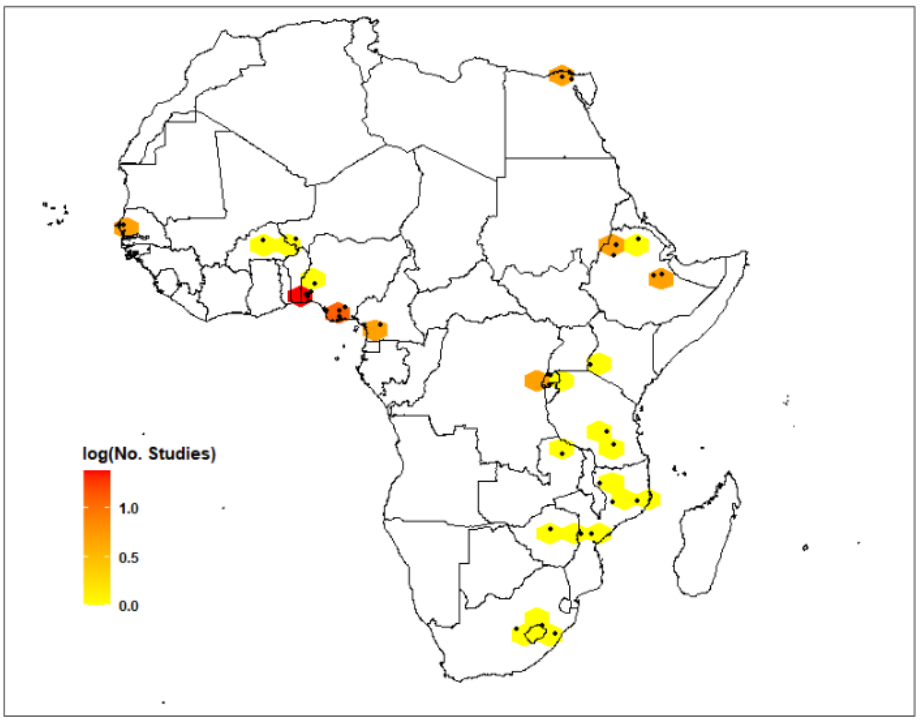
We have a new subset of data with the for LER outcome for intercropping practice. This data has **413 observations** and **142 variables**




```
Intercrop (Mixed) Intercrop (nonNfix)
              330                  83
```

Intercrop (Mixed) & Intercrop nonNfix

Let's first check where these practices are



We can also see the distribution in percentage

Burkina Faso	Cameroon	Egypt	Ethiopia	Kenya	Mozambique	Niger	Nigeria	Rwanda
7.7	2.4	4.4	6.3	15.5	11.6	2.2	32.4	2.9
Senegal	South Africa	Tanzania	Zambia	Zimbabwe				
2.9	5.6	1.7	3.9	0.5				

Number of practices Studies reporting LER

Since we many observations with the same Codes (same Authors), a single study corresponds to the unique same name within a column.

Intercropping

For intercropping reporting LER, we have a total of **413** observations. The corresponding number of Studies is **30**

```
> unique(Data_LER_inter$Code)
 [1] "NN0058"   "NN0130.3" "NN0142"   "NN0250"   "LM0141"   "HK0043"   "HK0093"   "HK0135"   "HK0181"   "HK0233"   "HK0249"
[12] "HK0300"   "JS0223"   "AN0005"   "AN0062"   "AN0076"   "AG0025"   "AG0078"   "AG0091"   "AG0104"   "AG0120"   "AG0137"
[23] "DK0016"   "DK0117"   "DK0148"   "EO0019"   "EO0024"   "EO0094"   "NJ0075"   "NJ0148"
```

Inorganic Fertilizer-Intercropping

Here we have a total of **92** observations and the number of Studies is **5**

```
> unique(Data_LER_Inor_fert_inter$Code)
[1] "NN0058" "NN0142" "HK0093" "HK0233" "JS0064"
```

Inorganic Fertilizer

Here we have a total of **87** observations and the number of Studies is **5**

```
> unique(Data_LER_Inor_fert$Code)
[1] "NN0142" "LM0066" "HK0093" "HK0233" "AG0078"
```

Alleycropping

Here we have a total of **49** observations and the number of Studies is **4**

```
> unique(Data_LER_Alleycro$Code)
[1] "LM0279" "JS0152" "JS0204" "DK0117"
```

Agroforestry Pruning-Alleycropping

Here we have a total of **36** observations and the number of Studies is **1**

```
> unique(Data_LER_Agro_prun_Alle$Code)
[1] "LM0173"
```

Crop Rotation-Intercropping

Here we have a total of **27** observations and the number of Studies is **1**

```
> unique(Data_LER_crop_rot_inter$Code)
[1] "JS0078"
```

Improved Varieties-Intercropping

Here we have a total of **23** observations and the number of Studies is **2**

```
> unique(Data_LER_impr_var_inter$Code)
[1] "NN0250" "JS0064"
```

Agroforestry Pruning-Intercropping

Here we have a total of **16** observations and the number of Studies is **1**

```
> unique(Data_LER_Agro_prun_inter$Code)
[1] "JS0164"
```

Organic Fertilizer

Here we have a total of **16** observations and the number of Studies is **1**

```
> unique(Data_LER_Org_fert$Code)
[1] "AG0078"
```

Alleycropping-Inorganic Fertilizer-Irrigation

Here we have a total of **10** observations and the number of Studies is **1**

```
> unique(Data_LER_Ally_Inor_fert_irri$Code)
[1] "JS0116"
```

Alleycropping-Intercropping

Here we have a total of **8** observations and the number of Studies is **1**

```
> unique(Data_LER_Agro_Alle_inter$Code)
[1] "JS0204"
```

Alleycropping-Improved Varieties-Inorganic Fertilizer

Here we have a total of **8** observations and the number of Studies is **1**

```
> unique(Data_LER_Agro_Alle_impro_var_inor_fer$Code)
[1] "JS0116"
```

Inorganic Fertilizer-Organic Fertilizer

Here we have a total of **8** observations and the number of Studies is **1**

```
> unique(Data_LER_inor_fer_org_fer$Code)
[1] "AG0078"
```

Reduced Tillage

Here we have a total of **4** observations and the number of Studies is **1**

```
> unique(Data_LER_redu_tillage$Code)
[1] "HK0041"
```

Parklands

Here we have a total of **3** observations and the number of Studies is **1**

```
> unique(Data_LER_parklands$Code)
[1] "JS0042"
```

Alleycropping-Inorganic Fertilizer

Here we have a total of **2** observations and the number of Studies is **1.** This is the same practice we had on *Alleycropping-Inorganic Fertilizer-Irrigation***.**

```
> unique(Data_LER_All_Inorg_fert$Code)
[1] "JS0116"
```

This is the diversity we have for our **Data_LER_inter, 48** of them

```
 [1] "Pearl millet-Cowpea"              "Yam-Maize"                      "Yam-Maize-Mucuna"
 [4] "Yam-Maize-Lima Bean"              "Yam-Maize-African Yam Bean"     "Yam-Maize-Cassava"
 [7] "Yam-Maize-Cassava-Mucuna"         "Yam-Maize-Cassava-Lima Bean"    "Yam-Maize-Cassava-African Yam Bean"
[10] "Cassava-Maize"                    "Cassava-Maize-Mucuna"           "Cassava-Maize-Lima Bean"
[13] "Cassava-Maize-African Yam Bean"   "Maize-Pigeon pea"               "Maize-Cowpea"
[16] "Maize-Bean"                       "Cassava-Maize-Melon"            "Cassava-Maize-Groundnut"
[19] "Cassava-Maize-Cowpea"             "Melon-Maize"                    "Melon-Cassava"
[22] "Sorghum-Bean"                     "Sorghum-Soybean"                "Cowpea-Cotton"
[25] "Cotton-Wheat"                     "Cowpea-Finger Millet"           "Finger Millet-Mung Bean"
[28] "Common Bean-Okra"                 "Maize-Okra"                     "Common Bean-Maize-Okra"
[31] "Butter Bean-Maize"                "Cowpea-Pearl Millet"            "Groundnut-Rice"
[34] "Cassava-Cowpea"                   "Maize-Soybean"                  "Common Bean-Maize"
[37] "Cowpea-Maize"                     "Maize-Mung Bean"                "Groundnut-Maize"
[40] "Maize-Pigeon Pea"                 "Cassava-Okra"                   "Cassava-Pepper"
[43] "Cassava-Pumpkin"                  "Lablab-Maize"                   "Lablab-Lablab"
[46] "Barley-Fava Bean"                 "Calabash-Sorghum"               "Cowpea-Sorghum"
```

Overall, let's see what we have for **every outcome** with **intercropping** practice in term of **diversity** in our **whole dataset,**

```
[1] "The diversity is 130 for Crop Yield"
[1] "The diversity is 60 for Biomass Yield"
[1] "The diversity is 26 for Soil Nitrogen"
[1] "The diversity is 21 for Soil Organic Carbon"
[1] "The diversity is 0 for Weight Gain"
[1] "The diversity is 0 for Meat Yield"
[1] "The diversity is 6 for Water Use"
[1] "The diversity is 8 for Water Use Efficiency"
[1] "The diversity is 30 for Soil Moisture"
[1] "The diversity is 1 for Pest & Pathogen (Losses)"
[1] "The diversity is 1 for Pest & Pathogen (Numbers)"
[1] "The diversity is 0 for Feed Conversion Ratio (Out In)"
[1] "The diversity is 32 for Gross Return"
[1] "The diversity is 17 for Variable Cost"
[1] "The diversity is 15 for Gross Margin"
[1] "The diversity is 3 for Soil Organic Matter"
[1] "The diversity is 8 for Cation Exchange Capacity"
[1] "The diversity is 0 for Milk Yield"
[1] "The diversity is 0 for Nitrogen Use Efficiency (ARE AGB)"
[1] "The diversity is 0 for Phosphorus Use Efficiency (ARE AGB)"

[1] "The diversity is 0 for Effective Cation Exchange Capacity"
[1] "The diversity is 0 for Phosphorus Agronomic Efficiency"
[1] "The diversity is 0 for Nitrogen Use Efficiency (Isotopic AGB)"
[1] "The diversity is 0 for Protein Conversion Ratio (In Out)"
[1] "The diversity is 0 for Methane Emissions"
[1] "The diversity is 0 for CO2 Equivalent Emissions"
[1] "The diversity is 48 for Land Equivalent Ratio"
[1] "The diversity is 0 for Benefit Cost Ratio (NRVC)"
[1] "The diversity is 7 for Net Present Value"
[1] "The diversity is 3 for Phosphorus Use Efficiency (ARE Product)"
```

This shows us first that **intercropping practice** does not only gives us **LER outcome** indeed we also have **Crop Yield** Outcome **0.31%** (Diversity); **Biomass Yield** outcome **0.37%** (Diversity); **Land Equivalent Ratio** outcome **5.94%** (Diversity)

8/808*100=5.94% 413 in total

130/ 41093*100 = 0.31% 1850 in total

60/15956*100 = 0.37% 572 in total

From this study we can conclude that, **Intercropping Practice is applied to get various outcomes among the ones we are using but for the LER outcomes, we have more diversity than other outcomes.**

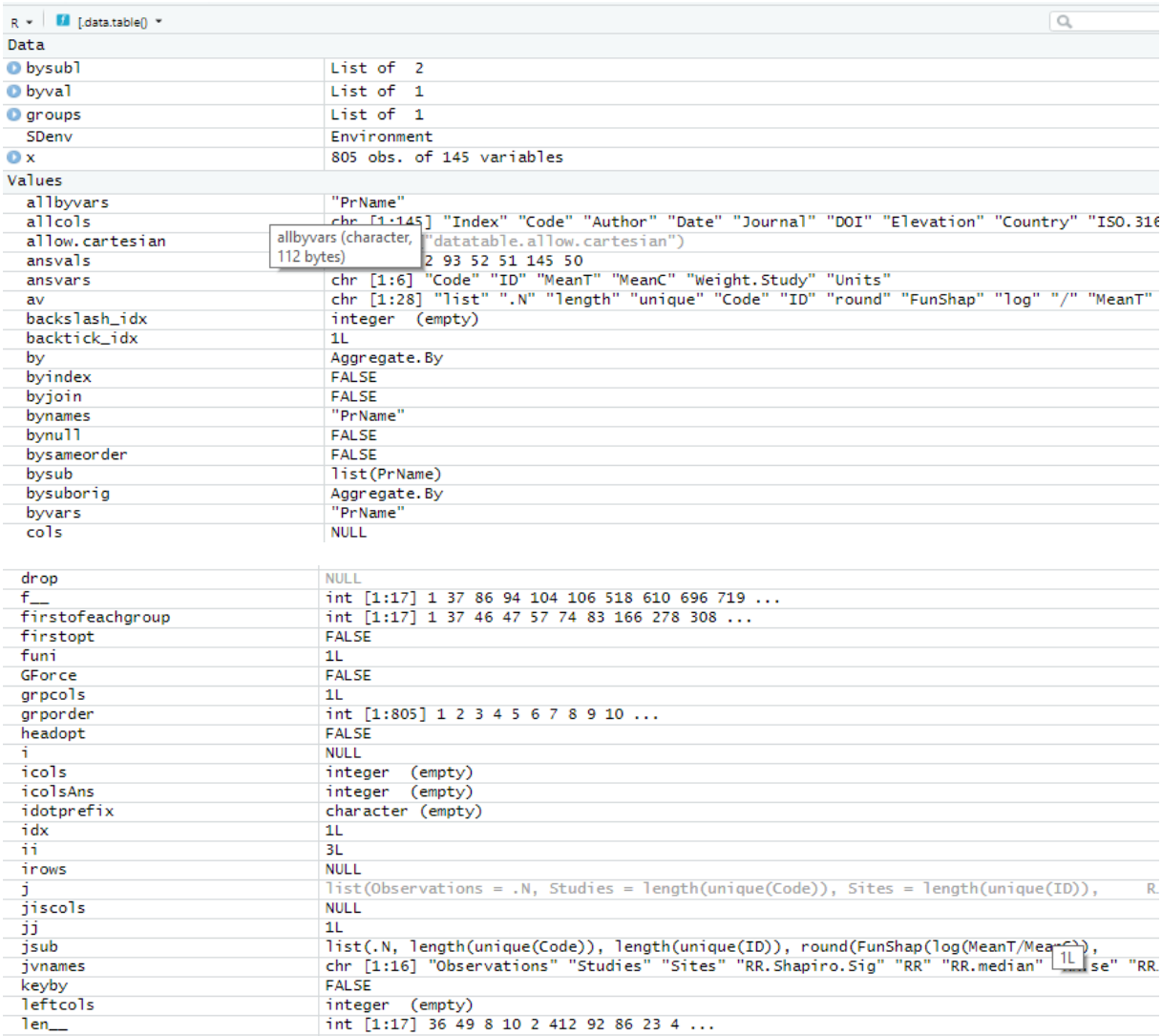
ERAAnalyse function

Here I will group some column (Variable) names and check their statistics

Aggregate By Out.SubInd:

We already know all our outcome are **Land Equivalent Ratio** but we are aggregating by this in order to have more information. By setting **rmOut** = T four extreme outliers have been removed in the row numbers **97, 101, 165, 578**

Aggregate By PrName:



lhs	NULL
missingby	FALSE
missingnomatch	TRUE
missingroll	TRUE
mult	"all"
names_i	NULL
names_x	chr [1:145] "Index" "Code" "Author" "Date" "Journal" "DOI" "Elevation" "Country" "ISO.316…
naturaljoin	FALSE
newnames	NULL
nomatch	NA_integer_
nomeanopt	FALSE
non_sdvars	character (empty)
notjoin	FALSE
o__	int [1:805] 1 2 3 4 5 6 7 8 9 10 ...
oldjsub	list(.N, length(unique(Code)), length(unique(ID)), round(FunShap(log(MeanT/MeanC)),
on	NULL
optimizedSubset	FALSE
orderedirows	TRUE
origorder	integer (empty)
rightcols	integer (empty)
roll	0
rollends	logi [1:2] FALSE TRUE
root	"list"
sdvars	chr [1:6] "Code" "ID" "MeanT" "MeanC" "Weight.Study" "Units"
subopt	FALSE

subopt	FALSE
sym	NULL
syms	character (empty)
todo	logi [1:17] FALSE FALSE FALSE FALSE FALSE FALSE ...
tt	"PrName"
use.I	FALSE
verbose	FALSE
w	int [1:6] 2 93 52 51 145 50
which	FALSE
with	TRUE
wna	logi [1:6] FALSE FALSE FALSE FALSE FALSE FALSE
xcols	int [1:6] 2 93 52 51 145 50
xcolsAns	int [1:6] 1 2 3 4 5 6
xdotcols	FALSE
xdotprefix	character (empty)
xdotprefixvals	logi [1:6] FALSE FALSE FALSE FALSE FALSE FALSE
xjiscols	NULL
xnrow	805L
unctions	
do_j_names	function (q)
dotN	function (x)
drop_dot	function (x)
dupdiff	function (x, y)
suppPrint	function (x)

```
> ERA.Analyze(Data_LER, rmOut = T, Aggregate.By = "PrName", ROUND = 5, Fast = T)
Error in weighted_se(log(MeanT/MeanC), Weight.Study, na.rm = T) :
  could not find function "weighted_se"
Called from: `[.data.table`(Data[, `:=`(N.Obs.Study, .N), by = Weight.Group][,
    `:=`(Weight.Study, (Rep^2/(2 * Rep))/N.Obs.Study)],
    , list(Observations = .N, Studies = length(unique(Code)),
        Sites = length(unique(ID)), RR.Shapiro.Sig = round(FunShap(log(MeanT/MeanC)),
            ROUND), RR = weighted.mean(log(MeanT/MeanC), Weight.Study,
            na.rm = T), RR.median = weighted.median(log(MeanT/MeanC),
            Weight.Study, na.rm = T), RR.se = weighted_se(log(MeanT/MeanC),
            Weight.Study, na.rm = T), RR.var = suppressWarnings(abs(wtd.var(log(MeanT/MeanC),
            Weight.Study, na.rm = T))), RR.Quantiles0.5 = paste(round(weighted.quantile(log(MeanT/MeanC),
            Weight.Study, probs = seq(0, 1, 0.25), na.rm = T),
            ROUND), collapse = "|"), PC.Shapiro.Sig = round(FunShap(MeanT/MeanC),
            ROUND), PC = weighted.mean(MeanT/MeanC, Weight.Study,
            na.rm = T), PC.median = weighted.median(MeanT/MeanC,
            Weight.Study, na.rm = T), PC.se = weighted_se(MeanT/MeanC,
            Weight.Study, na.rm = T), PC.var = suppressWarnings(abs(wtd.var(MeanT/MeanC,
            Weight.Study, na.rm = T))), PC.Quantiles0.5 = paste(round(weighted.quantile(MeanT/MeanC,
            Weight.Study, probs = seq(0, 1, 0.25), na.rm = T),
            ROUND), collapse = "|"), Units = if (length(unique(Units)) ==
            1) {
            unique(Units)
        } else {
            "Multiple"
        }), by = Aggregate.By)
```

Traceback Show internals

```
eval(substitute(browser(skipCalls = pos), list(pos = (length(sys.frames()) -
`[.data.table`(Data[, `:=`(N.Obs.Study, .N), by = Weight.Group][,
Data[, `:=`(N.Obs.Study, .N), by = Weight.Group][, `:=`(Weight.Study,
cbind(Data[, `:=`(N.Obs.Study, .N), by = Weight.Group][, `:=`(Weight.Study,
ERA.Analyze(Data_LER, rmOut = T, Aggregate.By = "PrName", ROUND = 5,
```