Analysis & Analyse_Function

1) Let's analyze **Outcomes** for the efficiency of **organic fertilizer** practices using **Inputs manure**.

We will analyze the **LER outcomes** for the effectiveness of **intercropping** practices using **Mixed intercrops.**

First let's explore the ERA `PracticeCodes` to see where we might find the names of the practices we are interested in. **Theme** is the highest level of organization for practice which of these relate to **intercropping**?

```
> PracticeCodes[,unique(Theme)]
 [1] "Agroforestry"         "Soil Management"        "Water Management"      "Crop Management"       "Genetic improvement"
 [6] "Nutrient Management" "Energy"                 "Animals"               "Postharvest"           "Non-CSA"
```

`Crop Management` is a sensible place to look, let's look at the practices nesting within this theme.

```
> PracticeCodes[Theme=="Crop Management",unique(Practice)]
[1] "Crop Rotation"                 "Intercropping"                 "Intercropping or Rotation"
```

The **intercropping** practice is indeed in the `Crop Management` theme, there are also sub-practices nested within practices so let's see what these are for **intercropping**

```
> PracticeCodes[Practice=="Intercropping",Subpractice.S]
[1] "Intercrop (Mixed)"         "Intercrop (nonNfix)"       "Intercrop (Nfix)"          "Intercrop (Complex)"
[5] "Intercrop (Unsp.)"         "Intercrop (Part; Mixed)"   "Intercrop (Part; nonNfix)" "Intercrop (Part; Nfix)"
[9] "Intercrop (Rot; Complex)"
```

Two of these practices seem to relate to pits `Intercrop (Mixed)` and `Intercrop (Part; Mixed)`, let's check their definitions to make sure.

```
> PracticeCodes[Subpractice.S %in% FocalPractices,Definition]
[1] "An intercropping system with a legume and non-legume. \nIntercropping is where more than one crop is grown at the same time i
n the same area of management (typically a single field), this is diversification in space rather than diversification in time. Cr
ops should be grown for harvest and not as cover crop or green manure (if the latter see the green manure practices)."

[2] "An intercropping system with a legume and non-legume where intercropping is not present every season (spatial diversification
 that is variable over time). For example a repeating sequence of Maize followed by a Maize-Cowpea intercrop, this would also get
 an intercrop rotation code.\nIntercropping is where more than one crop is grown at the same time in the same area of management
 (typically a single field), this is diversification in space rather than diversification in time. Crops should be grown for harve
st and not as cover crop or green manure (if the latter see the green manure practices)."
```

Prepare the data

Here we will apply the `ERAg::PrepareERA` function before conducting a meta-analysis based on response ratios.

```
> Data_LER_inter_Mixed.Prep <-ERAg::PrepareERA(Data = Data_LER_inter_Mixed,Perc.Neg = 0.5,RmNeg = T)
> dim(Data_LER_inter_Mixed.Prep)
[1] 330  66
> dim(Data_LER_inter_Mixed)
[1] 330 141
```

We haven't lost any data which means that there were insufficient negative outcomes to cause us an issue.

The use of outcome ratios, whilst necessary to standardize outcomes between studies, means this approach is inappropriate to study nil outcomes (e.g. total crop yield failure), a binomial approach would be better for such instances.

A Shapiro-Wilk test is applied to raw and log-transformed outcome ratios for each combination of grouping variables.

Explore Results

```
> colnames(Analysis1)
 [1] "Out.SubInd"        "SubPrName"        "Observations"     "Studies"          "Sites"            "RR.Shapiro.Sig"
 [7] "RR"                "RR.median"        "RR.var"           "RR.se"            "RR.Quantiles0.25" "PC.Shapiro.Sig"
[13] "PC"                "PC.median"        "PC.se"            "PC.var"           "PC.Quantiles0.25" "Units"
[19] "Model"             "MeanT.Obs"        "MeanT"            "MeanT.se"         "MeanC.Obs"        "MeanC"
[25] "MeanC.se"          "RR.t value"       "RR.Pr(>|t|)"      "RR.Sigma2"        "PC.t value"       "PC.Pr(>|t|)"
[31] "PC.Sigma2"         "RR.pc.se.low"     "RR.pc"            "RR.pc.se.high"    "RR.pc.jen.low"    "RR.pc.jen"
[37] "RR.pc.jen.high"    "PC.pc.se.low"     "PC.pc"            "PC.pc.se.high"
```

The data is already output as with Land Equivalent Ratio with the sub practice Intercrop (Mixed) so, the if we subset Analysis on **Out.SubInd** and **SubPrName**, we will only have one value

```
> table(Analysis1$Out.SubInd)

Land Equivalent Ratio
                    1
```

```
> table(Analysis1$SubPrName)

Intercrop (Mixed)
                1
```

To make it more interesting, let the ARAAnalyse function do it with the Data_LER

Let's check if we have lost any data

```
> Data_LER.Prep <-ERAg::PrepareERA(Data = Data_LER,Perc.Neg = 0.5,RmNeg = T)
> dim(Data_LER)
[1] 808 141
> dim(Data_LER.Prep)
[1] 808  66
```

Interesting, we haven't lost any data so the outcomes we are working with is not negative enough to cause us an issue.

Calculate Effect Sizes

The subset of data analyzed and the amount of data that are available can be observed

```
> Analysis2[,list(Out.SubInd, SubPrName, Observations, Studies, Sites)]
               Out.SubInd                                                  SubPrName Observations Studies Sites
 1: Land Equivalent Ratio  AgFor Alley (Nfix)-AgFor Prune (Unknown)-AgFor Prune Mulch (Nfix)           36       1     1
 2: Land Equivalent Ratio                                                AgFor Alley (nonNfix)            9       1     1
 3: Land Equivalent Ratio                                    AgFor Alley (Nfix)-Inputs N-Seed Improv            8       1     1
 4: Land Equivalent Ratio AgFor Alley (Nfix)-Inputs K-Inputs N-Inputs P-Irrigation Sprinkers           10       1     1
 5: Land Equivalent Ratio                                           AgFor Alley (Nfix)-Inputs N            2       1     1
 6: Land Equivalent Ratio                                                   AgFor Alley (Nfix)            6       1     1
 7: Land Equivalent Ratio                                                    Intercrop (Mixed)          330      25    31
 8: Land Equivalent Ratio                                        Inputs Urea-Intercrop (Mixed)            9       1     1
 9: Land Equivalent Ratio                                                  Intercrop (nonNfix)           82       9    10
10: Land Equivalent Ratio                                                             Inputs P           13       2     3
```

By filtering the results to combinations that meet a **minimum of 2 studies**, we obtain this

```
> Analysis2[,list(Out.SubInd, SubPrName, Observations, Studies, Sites)]
                Out.SubInd                    SubPrName Observations Studies Sites
1: Land Equivalent Ratio             Intercrop (Mixed)          330      25    31
2: Land Equivalent Ratio           Intercrop (nonNfix)           82       9    10
3: Land Equivalent Ratio                      Inputs P           13       2     3
4: Land Equivalent Ratio             Inputs N-Inputs P           20       2     3
5: Land Equivalent Ratio                      Inputs N           31       3     4
6: Land Equivalent Ratio    Inputs N-Intercrop (Mixed)           40       2     3
7: Land Equivalent Ratio Intercrop (Mixed)-Seed Improv           23       2     3
```

Response Ratios

```
> Analysis2[,list(SubPrName,RR.Shapiro.Sig, RR, RR.median, RR.var, RR.se, RR.Quantiles0.25)] %>% head
                    SubPrName RR.Shapiro.Sig       RR   RR.median  RR.var   RR.se                        RR.Quantiles0.25
1:          Intercrop (Mixed)        0.00000  0.07966  0.18232156 0.18168 0.06922   -1.7148|-0.00827|0.18232|0.40547|0.95551
2:        Intercrop (nonNfix)        0.00008  0.34574  0.38250522 0.36597 0.19307   -1.34707|0.09531|0.38251|0.66518|1.15039
3:                   Inputs P        0.67977 -0.05451 -0.04765509 0.03002 0.04289 -0.45199|-0.14951|-0.04766|0.01755|0.25131
4:          Inputs N-Inputs P        0.68067  0.12252  0.14969561 0.07958 0.12870   -0.45199|-0.04632|0.1497|0.33359|0.36367
5:                   Inputs N        0.92929  0.08012  0.06560662 0.02073 0.06164          -0.18232|0|0.06561|0.17852|0.28377
6: Inputs N-Intercrop (Mixed)        0.00004  0.52782  0.58221562 0.06546 0.09699            0|0.37097|0.58222|0.6703|0.78846
```

RR

So for our minimum of 2 studies, the **Response Ratio** for the Subpractice name **Inputs P** is **-0.05451<0.** This practice correspond to the Practice Name **Inorganic Fertilizer.**

The experimental control is **better** than the treatment

For the Other Subpractice names **RR>0**;

The experimental *treatment* is better than the *Control*

So for the following ***subpractice*** *Names,* **experimental *treatment* is better than the *Control***

"Intercrop (Mixed)"

"Intercrop (nonNfix)"

"Inputs N-Inputs P"

"Inputs N"

"Inputs N-Intercrop (Mixed)"

"Intercrop (Mixed)-Seed Improv"

RR.Shapiro.Sig

Since for *“Intercrop (Mixed)” "Intercrop (nonNfix)" and "Inputs N-Intercrop (Mixed)" we have* **<0.05.** The test results may **not be reliable** whilst the others **may be.**

mean (`RR`), median, variance, standard error and quantiles can be seen in the table

Performing tests with Argument Fast = F

lmer and **lm** models are used to estimate **means, errors** and **significance** if sufficient data exist when we set **Fast=F**

```
> Analysis2[,list(Out.SubInd,SubPrName,Model, `RR`,`RR.se`,`RR.t value`, `RR.Pr(>|t|)`, RR.Sigma2)] %>% head
                Out.SubInd                  SubPrName           Model       RR   RR.se RR.t value RR.Pr(>|t|) RR.Sigma2
1: Land Equivalent Ratio           Intercrop (Mixed) lmerModLmerTest  0.07966 0.06922    1.15081     0.25904   0.00769
2: Land Equivalent Ratio         Intercrop (nonNfix) lmerModLmerTest  0.34574 0.19307    1.79072     0.10699   0.00454
3: Land Equivalent Ratio                    Inputs P lmerModLmerTest -0.05451 0.04289   -1.27115     0.22776   0.00695
4: Land Equivalent Ratio           Inputs N-Inputs P lmerModLmerTest  0.12252 0.12870    0.95193     0.43354   0.00323
5: Land Equivalent Ratio                    Inputs N lmerModLmerTest  0.08012 0.06164    1.29982     0.28039   0.00099
6: Land Equivalent Ratio Inputs N-Intercrop (Mixed) lmerModLmerTest  0.52782 0.09699    5.44210     0.03228   0.00321
```

And some others variables

```
> Analysis2[,list(Out.SubInd,SubPrName, RR.pc.se.low, RR.pc, RR.pc.se.high, RR.pc.jen.low, RR.pc.jen.high)] %>% head
                Out.SubInd                  SubPrName RR.pc.se.low    RR.pc RR.pc.se.high RR.pc.jen.low RR.pc.jen.high
1: Land Equivalent Ratio           Intercrop (Mixed)      1.04947  8.29188      16.05337       1.43875       16.50046
2: Land Equivalent Ratio         Intercrop (nonNfix)     16.49405 41.30352      71.39660      16.75879       71.78612
3: Land Equivalent Ratio                    Inputs P     -9.28069 -5.30510      -1.15527      -8.96490       -0.81119
4: Land Equivalent Ratio           Inputs N-Inputs P     -0.61609 13.03417      28.55929      -0.45546       28.76708
5: Land Equivalent Ratio                    Inputs N      1.86518  8.34171      15.23001       1.91562       15.28706
6: Land Equivalent Ratio Inputs N-Intercrop (Mixed)     53.85340 69.52327      86.78910      54.10053       87.08914
```