

# TITLE X

Supplemental materials for submittal to X

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## Supplemental Materials Summary

This analysis focuses on examining if how stakeholder engagement, and the level of engagement, impacts whether a solution for research outcomes is proposed and/or implemented. This meta-synthesis of 483 papers were evaluated and coded using several differing engagement scales. Additionally, each paper was coded by the geographic scale, and whether a computational model was used as part of the research.

# Variable Summary

Below is a list of the categorical variables generated from the literature reviews

Table 1: Table T1: Variable Descriptions

Variable Name	Description
Year	Year of citation
Solution Proposed	Was a solution proposed?
Solution Implemented	Was a solution implemented?
Solution Type	If a solution was proposed, what was the solution type? Groups include: Technology, Policy, Institutional, Social, Economic, Ecological, and Educational.
Researcher Type	What was the research type? Groups include: NGO, English, Math, Computer Science, Physics, Engineering, Interdisciplinary, Social Science, Economics, Agriculture, and Other
Stakeholder Type	What was the stakeholder type? Groups include: Farmers, Combined Government, Combined Coalition, Combined Industry, Migrants, Youth, Public, Univerity, and Experts
Stakeholder engagement Scale - Ghodsvali	If a stakeholder was engaged, categorization of the engagement using the Ghodsvali scale. Groups include: Nominal, Instrumental, Representation, and Transformative
Geographical Type	What the geography type? Groups include: Not Described, Local, Regional, National, Multinational, Global, and No Geography
Region	What was the country?

# Chi-Square Testing

## Chi Square Testing: solution proposed or not vs. stakeholder engagement

Chi Square and Fishers Exact Test on contingency table with Solution/No Solution as the explanatory variable, and engaged stakeholder/did not engage stakeholder as the response variable.

### ChiSquare = 46: Fishers Exact Test Odds Ratio: 19: Not Independent

Both chi square and fishers exact test were significant, with a chi square approximation of ~46, which is well above the critical value (3.84 with one degree of freedom). Fishers Exact Test returned an odds ratio of ~19. The alternative hypothesis: true odds ratio is not equal to 1, therefore the null hypothesis is rejected - the groups are not independent.

The Fishers Exact Test defaults to associating the odds ratio (which can represent effect size) with the first cell. In this instance “The odds of having a solution is 19 times that for an engaged stakeholder”. You could flip the response and explanatory variables, but the odds ratio would stay the same.

For more info on this topic see: Kim HY. Statistical notes for clinical researchers: Chi-squared test and Fisher’s exact test. Restor Dent Endod. 2017 May;42(2):152-155. doi: 10.5395/rde.2017.42.2.152. Epub 2017 Mar 30. PMID: 28503482; PMCID: PMC5426219.

```
## Loading required package: grid

##           stakeholder
## solution    N      Y
##           N 389   76
##           Y   4   14

## Number of cases in table: 483
## Number of factors: 2
## Test for independence of all factors:
##  Chisq = 43.14, df = 1, p-value = 5.104e-11
##  Chi-squared approximation may be incorrect

##
##  Fisher’s Exact Test for Count Data
##
## data:  solution_stakeholder
## p-value = 4.019e-08
## alternative hypothesis: true odds ratio is not equal to 1
## 95 percent confidence interval:
##   5.385841 76.064980
## sample estimates:
## odds ratio
##   17.75835

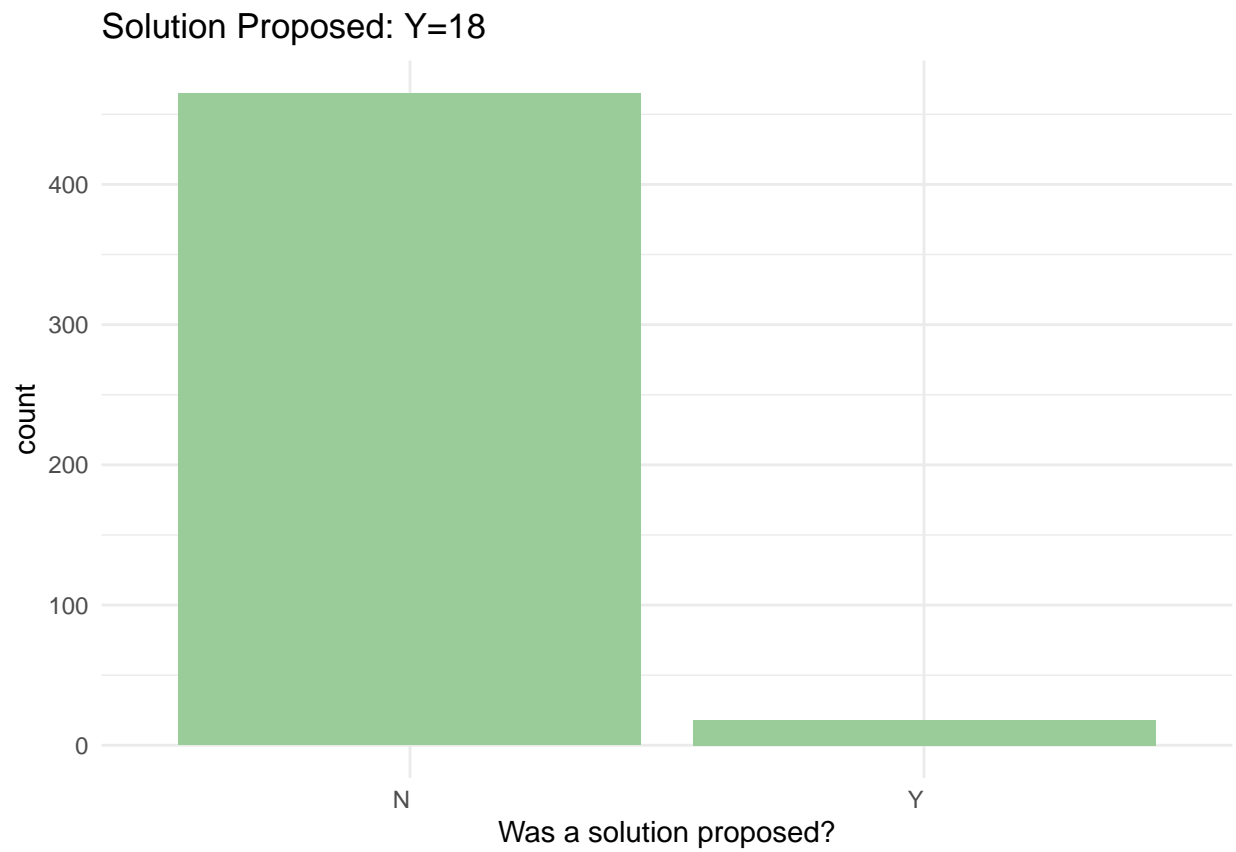
##
## Barnard’s Unconditional Test
##
##           Treatment I Treatment II
## Outcome I           76          465
## Outcome II          14           18
##
```

```
## Null hypothesis: Treatments have no effect on the outcomes
## Score statistic = 4.48684
## Nuisance parameter = 0.99 (One sided), 0.01 (Two sided)
## P-value = 0.000218524 (One sided), 0.000218524 (Two sided)
```

```
##              X^2 df    P(> X^2)
## Likelihood Ratio 31.288  1 2.2245e-08
## Pearson          43.137  1 5.1036e-11
##
## Phi-Coefficient   : 0.299
## Contingency Coeff.: 0.286
## Cramer's V        : 0.299
```

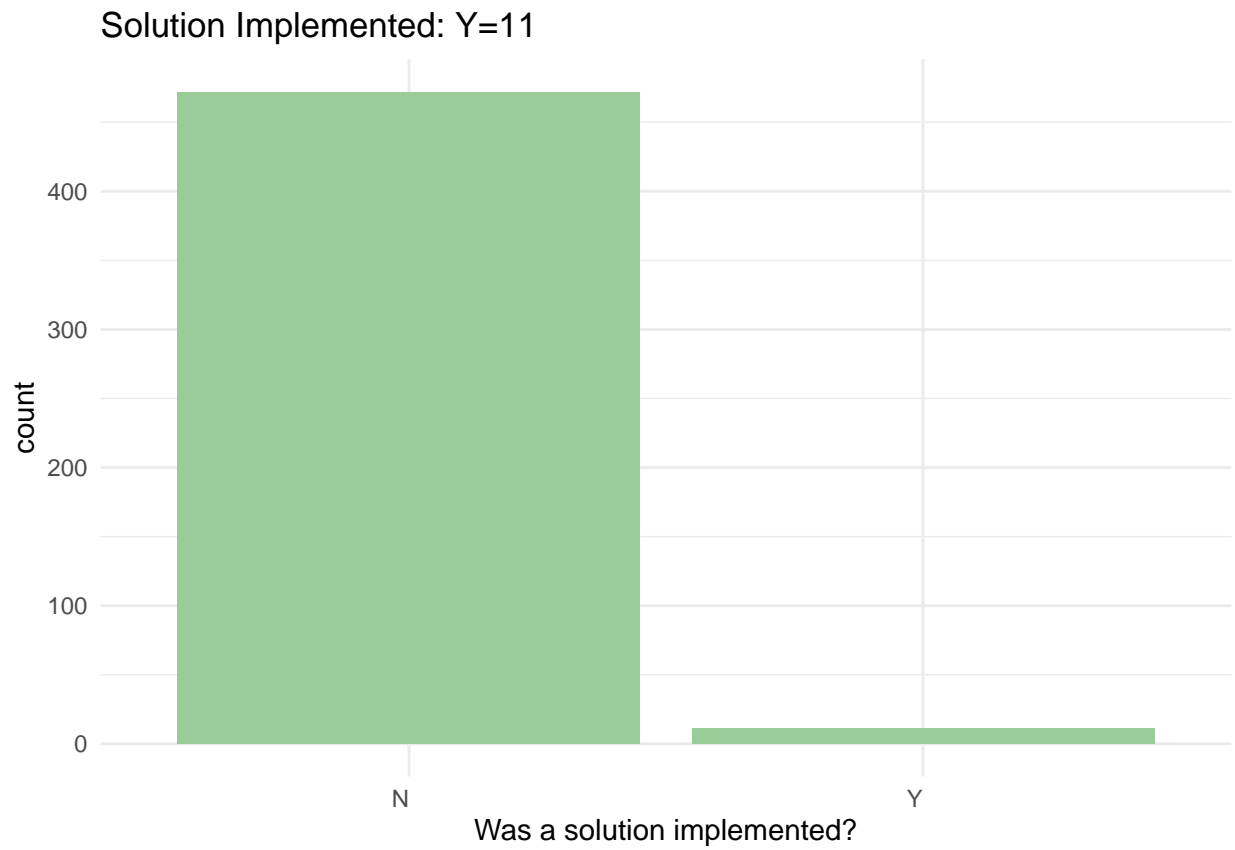
## Summary Statistics Graphs

Were solutions proposed in the set of all papers?

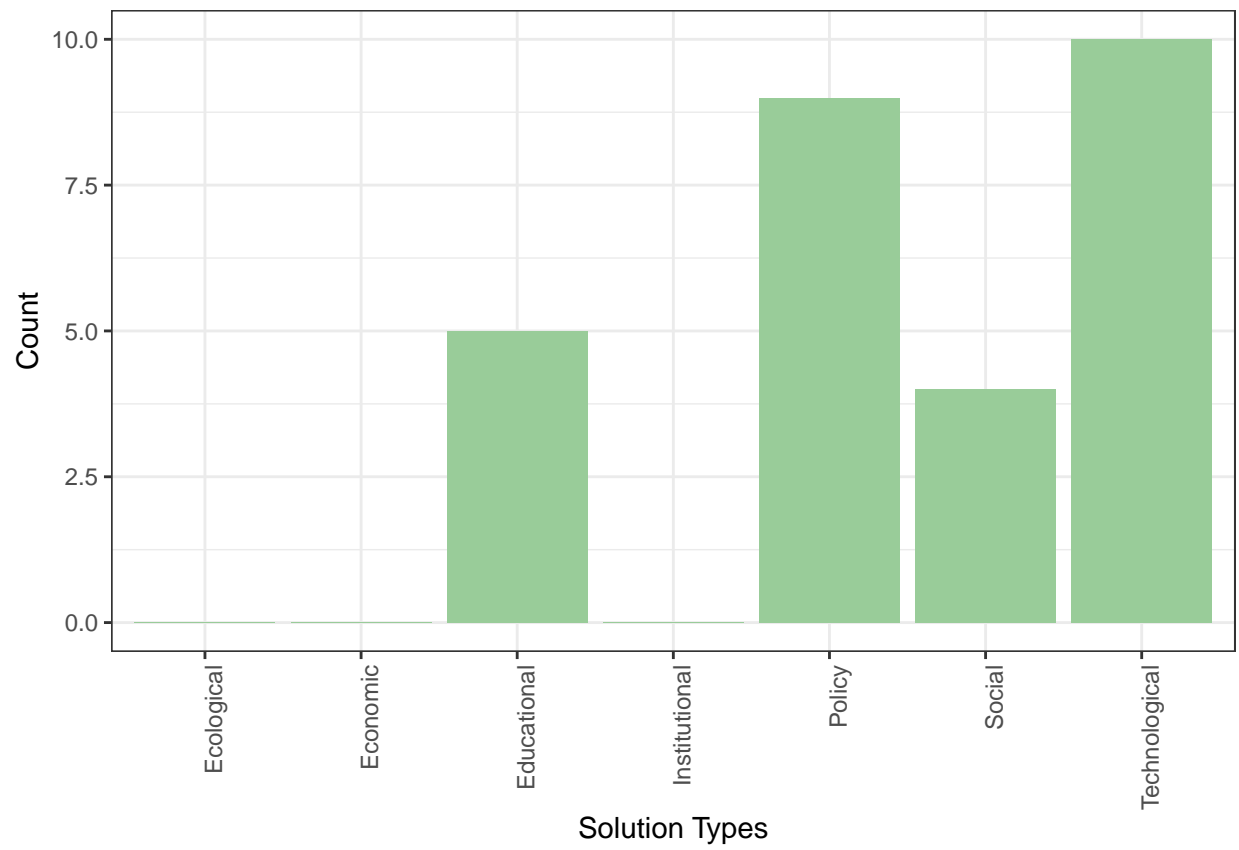




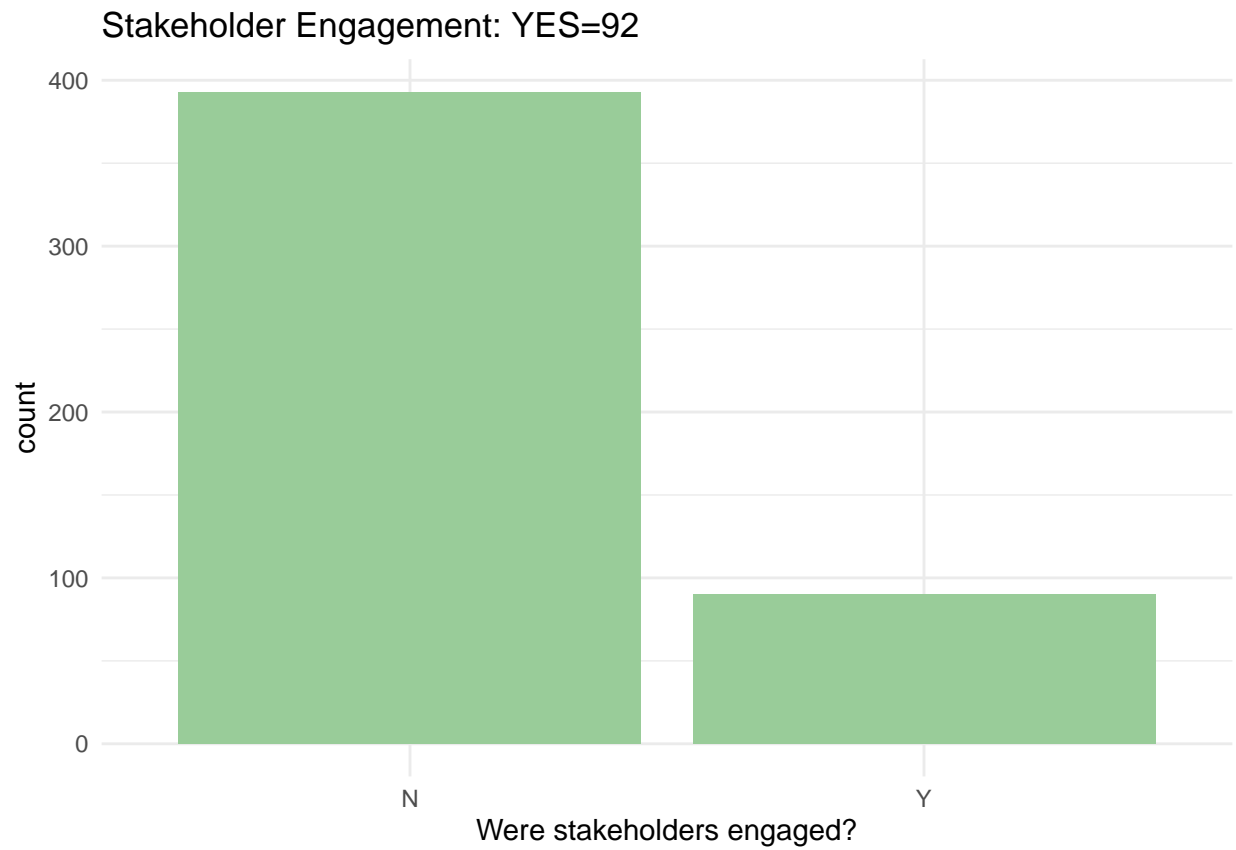
Were solutions implemented in the set of all papers?



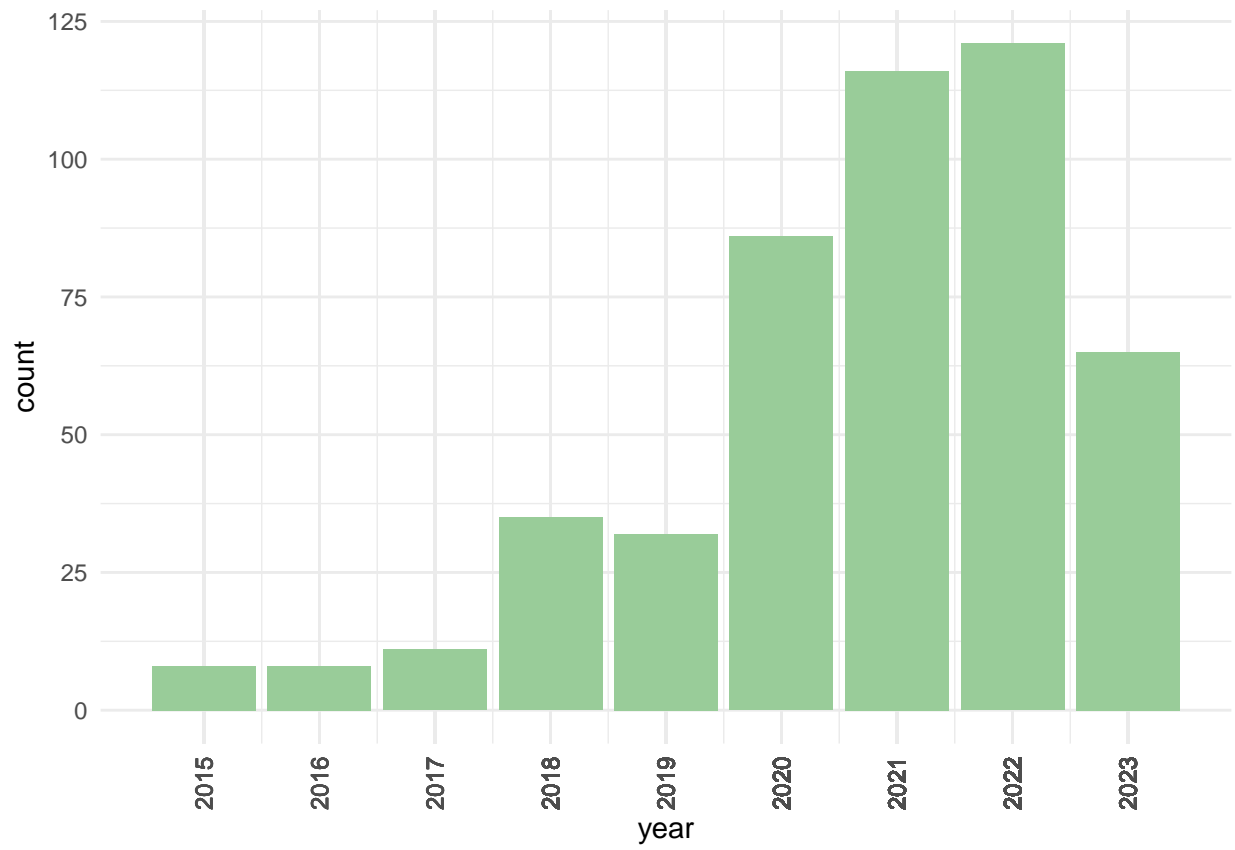
What were the solution types?



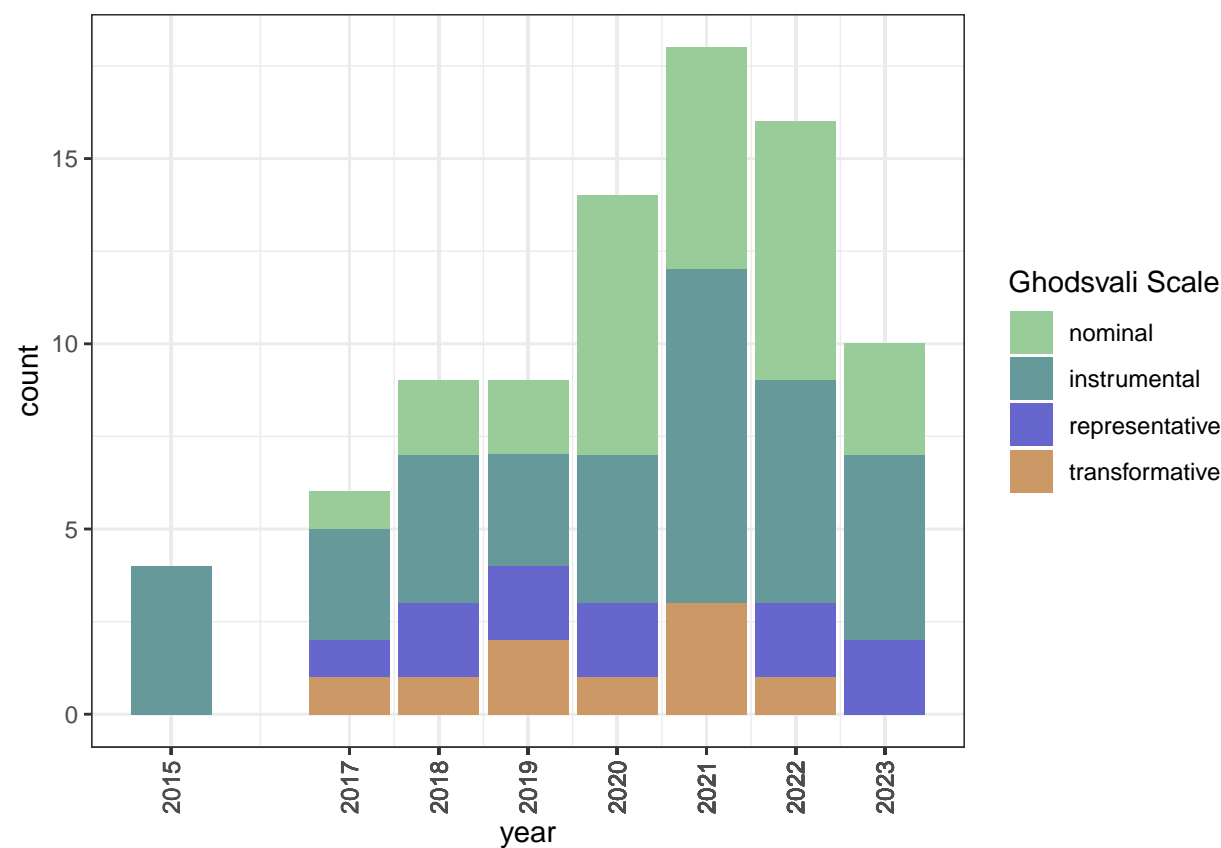
Were stakeholders engaged?



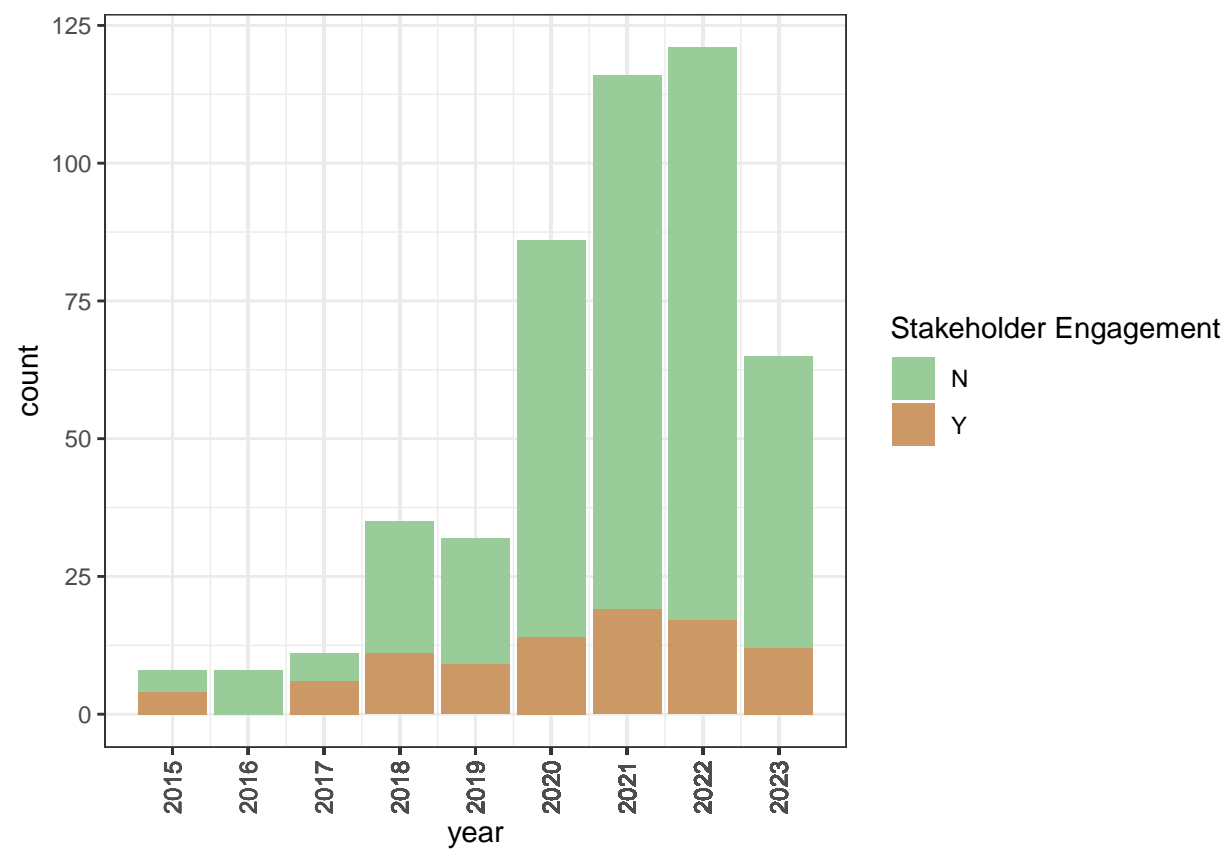
All FEWS papers by year



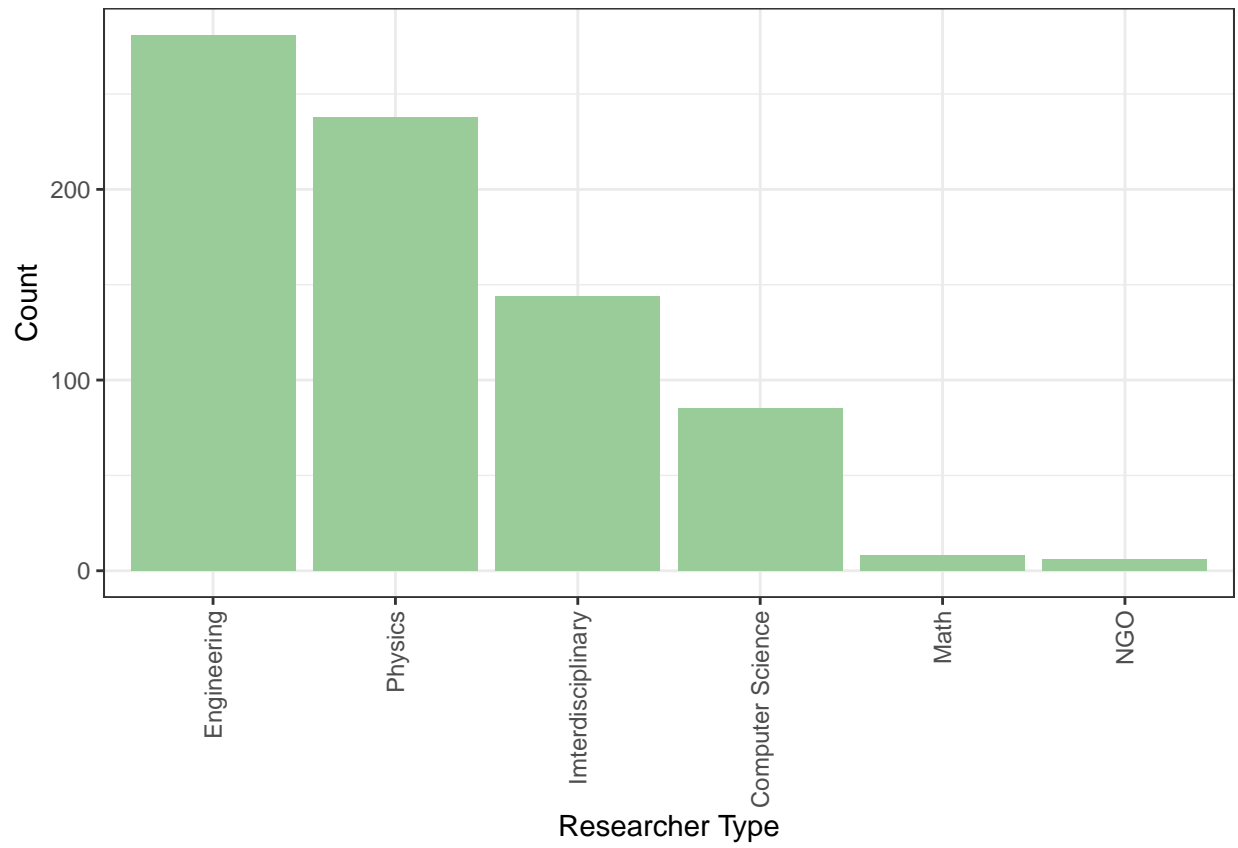
Level of stakeholder engagement by year - Ghodsvali scale



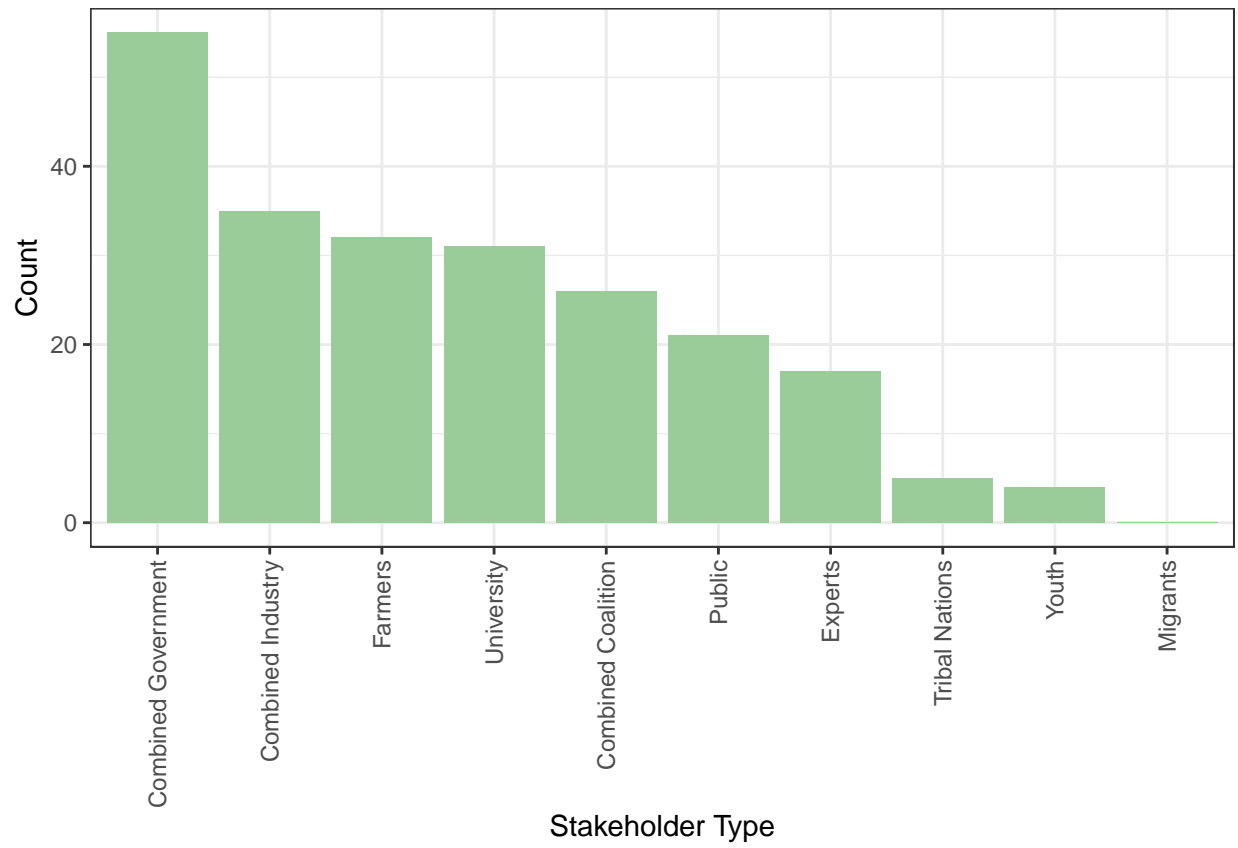
Stakeholder engagement by year



## Researcher types

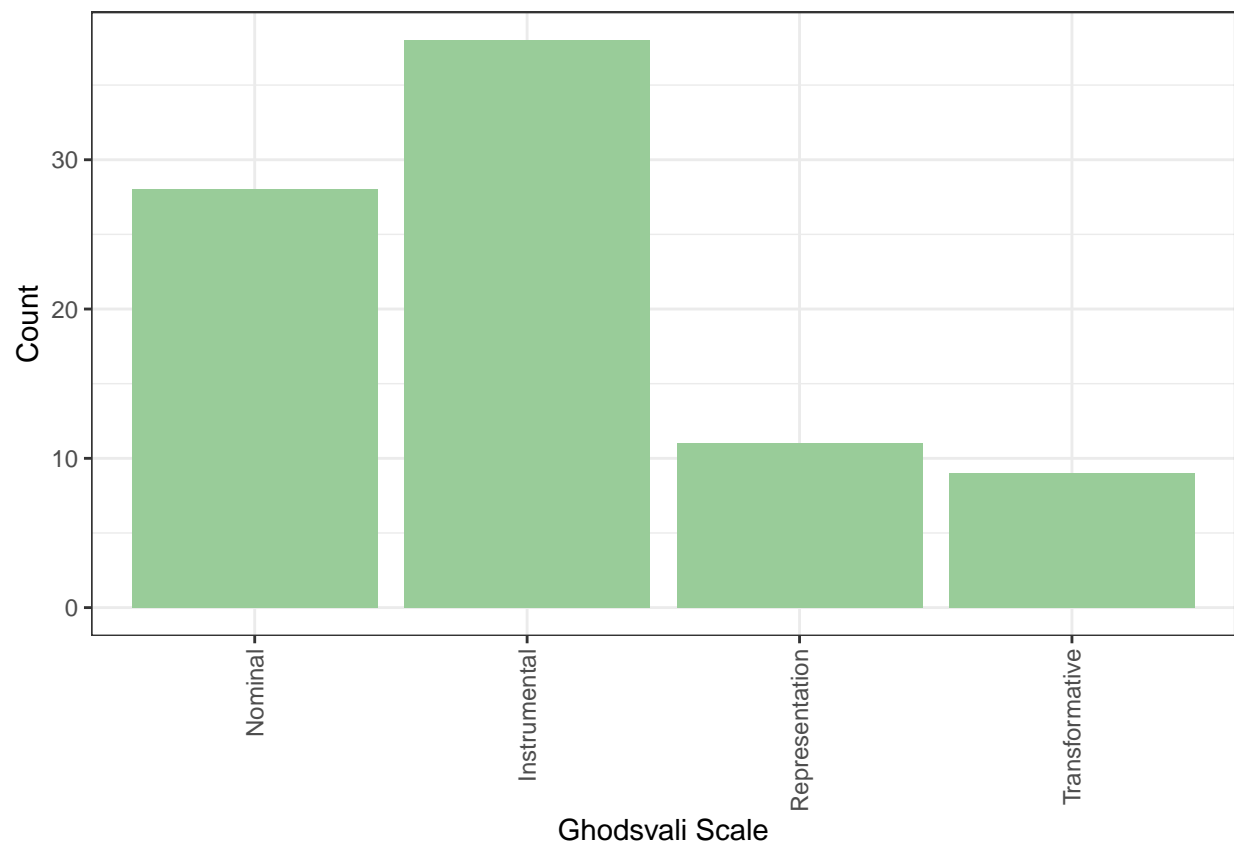


## Stakeholder types

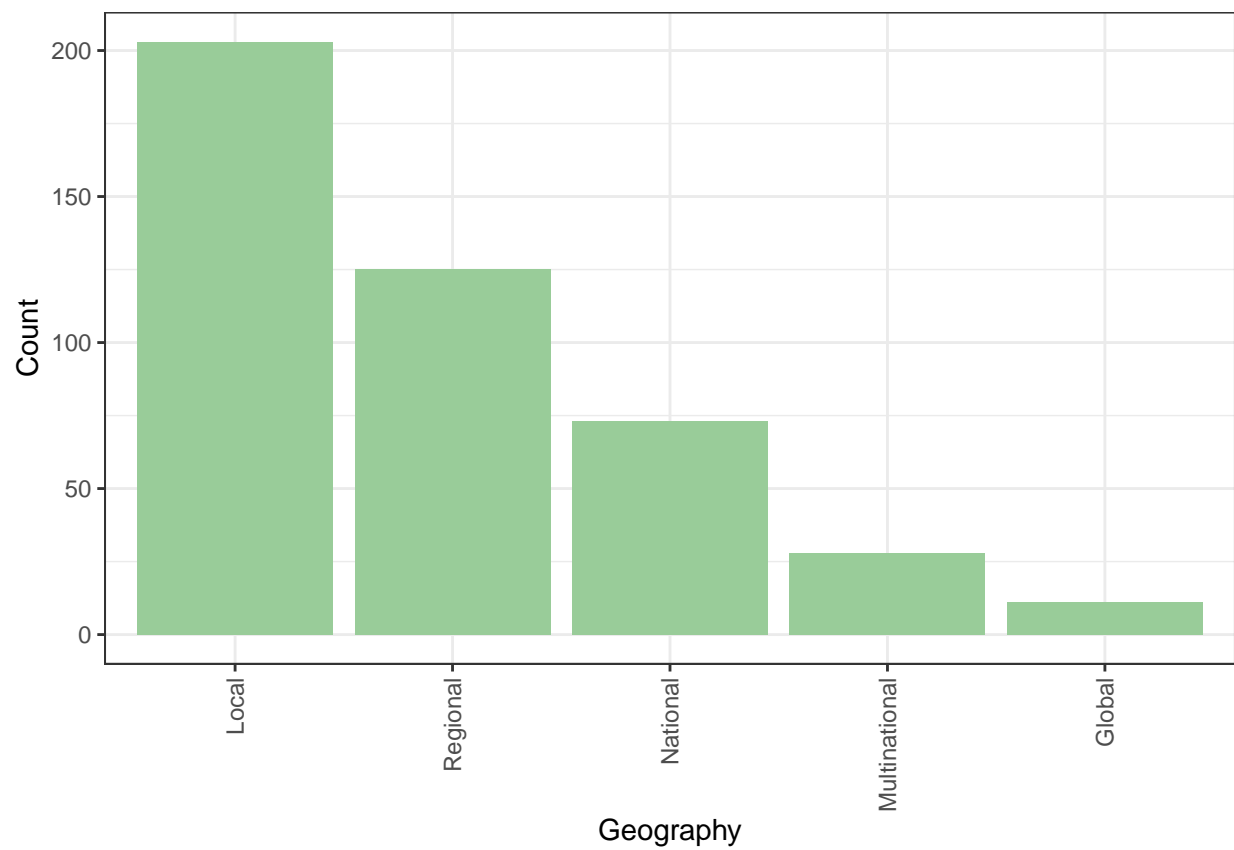




Ghodsvali scale breakdown



Geographic location breakdown



# Ghodsvali Scale Modeling - solution proposed

## Ghodsvali scale regression

Ghodsvali scale regression testing on whether a solution was proposed or not

```
##
## Call:
## glm(formula = solution_proposed_YN ~ STE_G_nominal + STE_G_instrumental +
##       STE_G_representation + STE_G_transformative, family = binomial(link = "logit"),
##       data = crcdata)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.7344  -0.1423  -0.1423  -0.1423   3.0324
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    -4.5875     0.5025  -9.129  < 2e-16 ***
## STE_G_nominal     1.2917     1.1356   1.137  0.25535
## STE_G_instrumental  2.1308     0.7839   2.718  0.00656 **
## STE_G_representation  3.6067     0.8431   4.278 1.89e-05 ***
## STE_G_transformative  5.8403     0.9463   6.172 6.74e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 153.748  on 482  degrees of freedom
## Residual deviance:  96.785  on 478  degrees of freedom
## AIC: 106.79
##
## Number of Fisher Scoring iterations: 7
```

## Ghodsvali scale odds

Odds of Ghodsvali scale predicting whether a solution was proposed or not

```
##
## Logistic regression predicting solution_proposed_YN : Y vs N
##
##               crude OR(95%CI)      adj. OR(95%CI)      P(Wald's test) P(LR-test)
## STE_G_nominal: 1 vs 0      0.95 (0.12,7.44)      3.64 (0.39,33.7)      0.255      0.318
##
## STE_G_instrumental: 1 vs 0    2.46 (0.68,8.9)      8.42 (1.81,39.14)      0.007      0.015
##
## STE_G_representation: 1 vs 0  11.42 (2.75,47.41)     36.84 (7.06,192.33)    < 0.001     < 0.001
##
## STE_G_transformative: 1 vs 0 147.32 (27.42,791.53) 343.87 (53.82,2197.12) < 0.001     < 0.001
##
## Log-likelihood = -48.3926
## No. of observations = 483
## AIC value = 106.7851
```

## Ghodsvali Ensembled Decision Tree with Feature Importance

Ghodsvali ensembled decision tree with solution proposed being the dependent variable

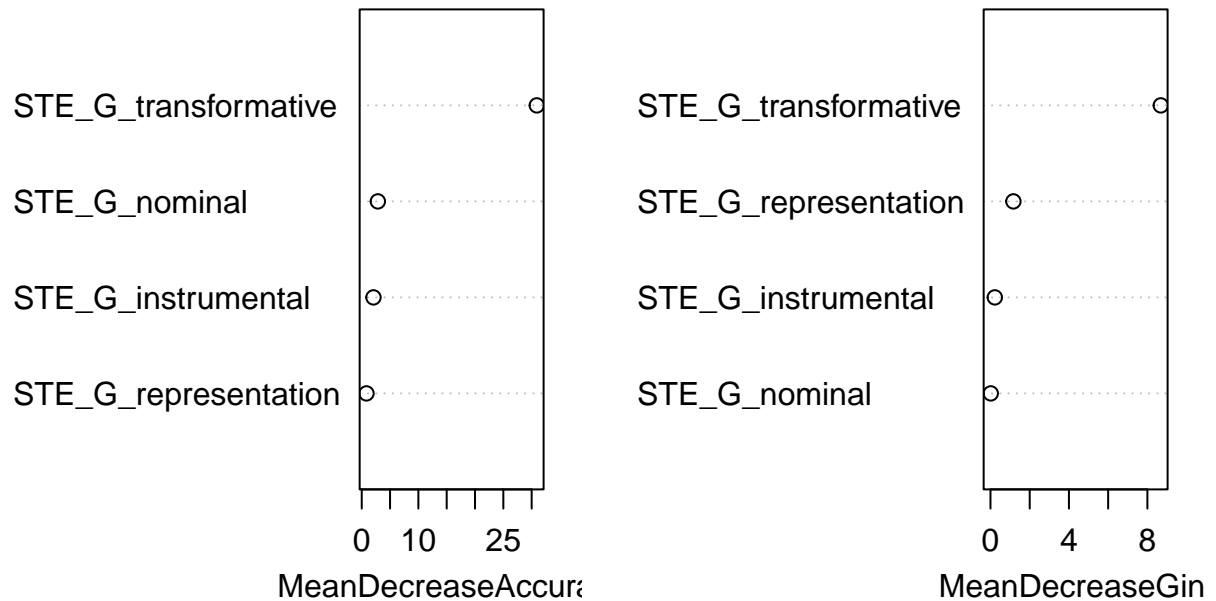
```
##
## Call:
##  randomForest(formula = solution_proposed_YN ~ STE_G_nominal + STE_G_instrumental + STE_G_representative,
##              Type of random forest: classification
##              Number of trees: 500
##              No. of variables tried at each split: 2
##              OOB estimate of error rate: 2.12%
## Confusion matrix:
##      N Y class.error
## N 318 0  0.0000000
## Y   7 5  0.5833333

## Confusion Matrix and Statistics
##
##              Reference
## Prediction  N    Y
##      N 145    4
##      Y   2    2
##
##              Accuracy : 0.9608
##              95% CI : (0.9166, 0.9855)
##      No Information Rate : 0.9608
##      P-Value [Acc > NIR] : 0.6063
##
##              Kappa : 0.3806
##
##  Mcnemar's Test P-Value : 0.6831
##
##              Sensitivity : 0.9864
##              Specificity : 0.3333
##              Pos Pred Value : 0.9732
##              Neg Pred Value : 0.5000
##              Prevalence : 0.9608
##              Detection Rate : 0.9477
##              Detection Prevalence : 0.9739
##              Balanced Accuracy : 0.6599
##
##              'Positive' Class : N
##
```

### No. of Nodes for the Trees



## Top 10 – Variable Importance



```
##                               N      Y MeanDecreaseAccuracy MeanDecreaseGini
## STE_G_nominal                0.0000000 2.610176          2.8495061      0.01407228
## STE_G_instrumental          -2.4603017 3.518427          2.0722870      0.22160713
## STE_G_representation        -0.3495235 1.599972          0.8395988      1.16878564
## STE_G_transformative        30.2772886 32.843860          30.9050689      8.68365750

## Confusion Matrix and Statistics
##
##           Reference
## Prediction  N  Y
##           N 13  3
##           Y  0  6
##
##           Accuracy : 0.8636
##           95% CI : (0.6509, 0.9709)
##           No Information Rate : 0.5909
##           P-Value [Acc > NIR] : 0.006001
##
##           Kappa : 0.7027
##
## Mcnemar's Test P-Value : 0.248213
##
##           Sensitivity : 1.0000
##           Specificity : 0.6667
##           Pos Pred Value : 0.8125
```

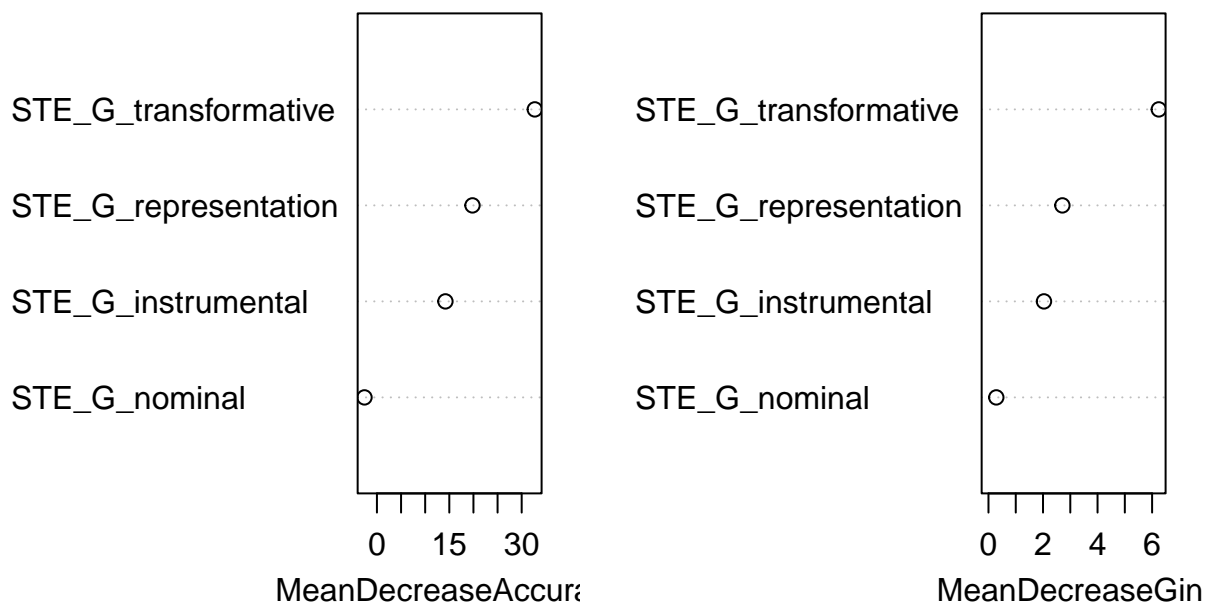
```
##          Neg Pred Value : 1.0000
##          Prevalence : 0.5909
##          Detection Rate : 0.5909
##          Detection Prevalence : 0.7273
##          Balanced Accuracy : 0.8333
##
##          'Positive' Class : N
##
```

### Balanced Model – No. of Nodes for the Trees

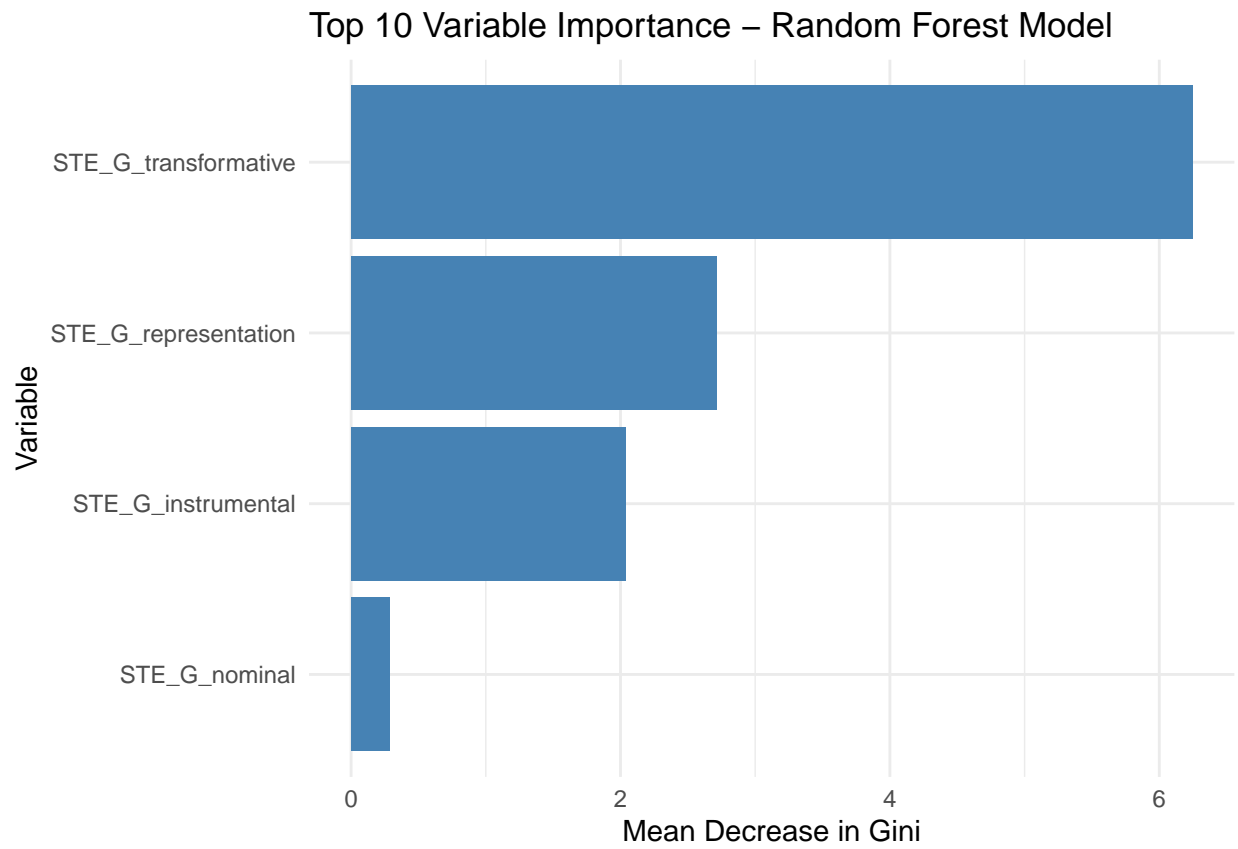




## Balanced Mode – Top 10 – Variable Importance



##		N	Y	MeanDecreaseAccuracy	MeanDecreaseGini
##	STE_G_nominal	-5.060963	1.302665	-2.580894	0.2868039
##	STE_G_instrumental	9.862356	15.728857	14.195396	2.0350014
##	STE_G_representation	17.114165	18.774930	19.800104	2.7099657
##	STE_G_transformative	27.344434	32.762998	32.715086	6.2451878



## Stakeholder Engagement Modeling - solution proposed

**QUESTION:** Does engaging stakeholders increase the likelihood that a solution will be proposed/implemented?

Here we use classical logistic regression using a binomial function to determine if engaging stakeholders (Y/N) increases the odds that a solution will be proposed.

```
##
## Call:
## glm(formula = solution_proposed_YN ~ S_stakeholder_engagement_YN,
##      family = binomial, data = crcdata)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -0.5815  -0.1430  -0.1430  -0.1430   3.0290
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    -4.5773     0.5026  -9.108  < 2e-16 ***
## S_stakeholder_engagement_YNY  2.8856     0.5806   4.970 6.71e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 153.75  on 482  degrees of freedom
## Residual deviance: 122.46  on 481  degrees of freedom
## AIC: 126.46
##
## Number of Fisher Scoring iterations: 7
```

## ODDS RATIOS: Does engaging stakeholders increase the likelihood that a solution will be proposed/implemented?

Odds of whether engaging stakeholders increases the likelihood that a solution will be proposed?

```
##
## Logistic regression predicting solution_proposed_YN : Y vs N
##
##                               OR(95%CI)          P(Wald's test) P(LR-test)
## S_stakeholder_engagement_YN: Y vs N 17.91 (5.74,55.91) < 0.001      < 0.001
##
## Log-likelihood = -61.23
## No. of observations = 483
## AIC value = 126.4599
```

## Diversity of stakeholders vs solution

**QUESTION:** Does the diversity of stakeholders increase the likelihood that a solution will be proposed?

Regression testing of whether Diversity of stakeholders predicts if a solution was proposed (Y/N). In order to represent diversity, we have used a simple ratio calculation which sums the number of stakeholders involved divided by the total number of possible stakeholder options. A ratio which is closer to 1 has a greater level of stakeholder diversity.

```
##
## Call:
## glm(formula = solution_proposed_YN ~ ST_ratio, family = binomial,
##      data = crcdata)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.3676  -0.1869  -0.1869  -0.1869   2.8482
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -4.0385     0.3569 -11.314 < 2e-16 ***
## ST_ratio       6.7128     1.2280   5.466 4.6e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 153.75  on 482  degrees of freedom
## Residual deviance: 126.74  on 481  degrees of freedom
## AIC: 130.74
##
## Number of Fisher Scoring iterations: 6
```

**ODDS RATIOS: Does the diversity of stakeholders increase the likelihood that a solution will be proposed?**

```
##
## Logistic regression predicting solution_proposed_YN : Y vs N
##
##               OR(95%CI)               P(Wald's test) P(LR-test)
## ST_ratio (cont. var.) 822.84 (74.13,9133.12) < 0.001      < 0.001
##
## Log-likelihood = -63.371
## No. of observations = 483
## AIC value = 130.742
```

**QUESTION: If diversity of stakeholders does not increase proposing/implementing solutions, which stakeholders are more associated with proposing/implementing solutions?**

Regression testing for diversity of stakeholders used to predict whether a solution was proposed

```
##
## Call:
## glm(formula = solution_proposed_YN ~ ST_farmers + ST_combined_gov +
##      ST_combined_coalition + ST_combined_industry + ST_public +
##      ST_university + ST_experts, family = binomial, data = crcdata)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.2146  -0.1352  -0.1352  -0.1352   3.0658
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    -4.6904     0.5050  -9.287  < 2e-16 ***
## ST_farmers       0.5870     0.7238   0.811    0.417
## ST_combined_gov  4.0098     0.7989   5.019 5.18e-07 ***
## ST_combined_coalition -0.1027    0.8789  -0.117    0.907
## ST_combined_industry -1.0527    0.7426  -1.418    0.156
## ST_public        0.7677     0.7908   0.971    0.332
## ST_university    -0.2103    0.8365  -0.251    0.802
## ST_experts       -0.4590     0.7884  -0.582    0.560
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 153.75  on 482  degrees of freedom
## Residual deviance: 103.49  on 475  degrees of freedom
## AIC: 119.49
##
## Number of Fisher Scoring iterations: 7
```

## ODDS RATIOS: Diversity of stakeholders vs solution

Odds whether Diversity of stakeholders predicts if a solution was proposed (Y/N). In order to represent diversity, we have used a simple ratio calculation which sums the number of stakeholders involved divided by the total number of possible stakeholder options. A ratio which is closer to 1 has a greater level of stakeholder diversity.

```
##
## Logistic regression predicting solution_proposed_YN : Y vs N
##
##               crude OR(95%CI)      adj. OR(95%CI)      P(Wald's test) P(LR-test)
## ST_farmers: 1 vs 0      6.24 (2.07,18.79)      1.8 (0.44,7.43)      0.417      0.42
##
## ST_combined_gov: 1 vs 0      36.2 (11.39,115.06)      55.13 (11.52,263.88)      < 0.001      < 0.001
##
## ST_combined_coalition: 1 vs 0      8.13 (2.65,24.93)      0.9 (0.16,5.05)      0.907      0.907
##
## ST_combined_industry: 1 vs 0      5.58 (1.86,16.68)      0.35 (0.08,1.5)      0.156      0.144
##
## ST_public: 1 vs 0      9.93 (2.87,34.34)      2.15 (0.46,10.15)      0.332      0.34
##
## ST_university: 1 vs 0      8.8 (3.05,25.39)      0.81 (0.16,4.18)      0.802      0.801
##
## ST_experts: 1 vs 0      4.97 (1.32,18.71)      0.63 (0.13,2.96)      0.56      0.552
##
## Log-likelihood = -51.7449
## No. of observations = 483
## AIC value = 119.4899
```

## DECISION TREE: Ensembled Decision Tree - Diversity of stakeholders vs solution ->

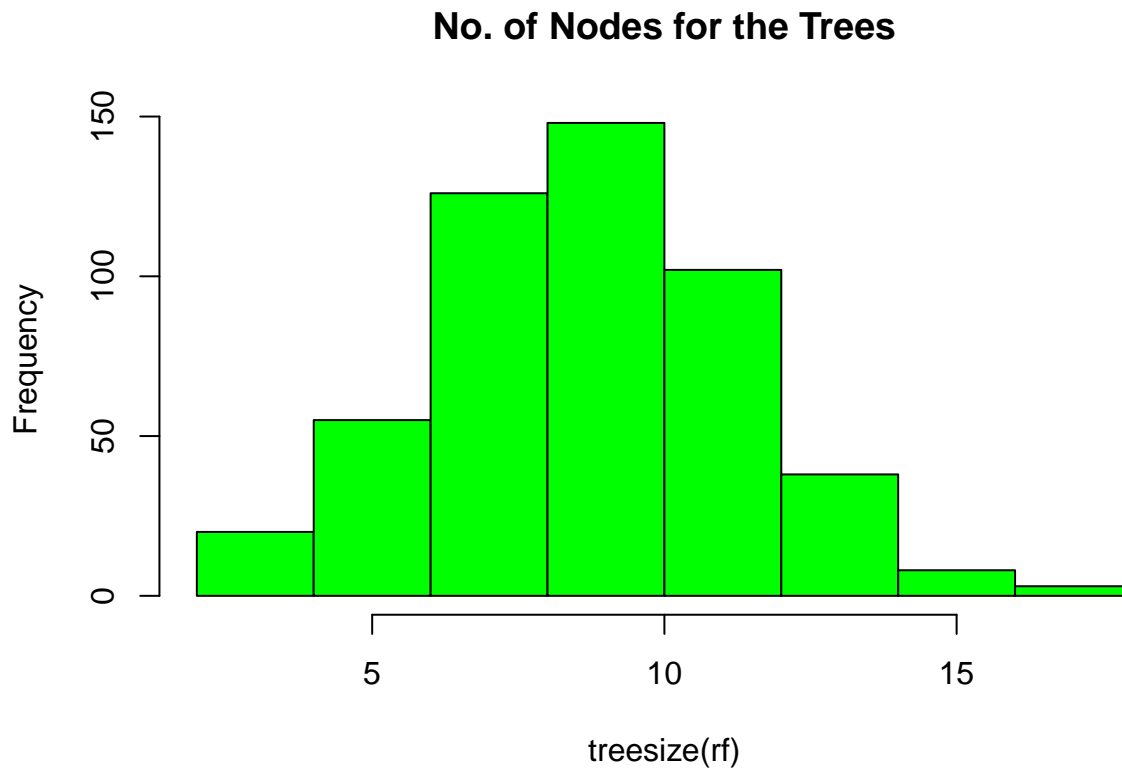
```
##
## Call:
## randomForest(formula = solution_proposed_YN ~ ST_farmers + ST_combined_gov +      ST_combined_coali
##               Type of random forest: classification
##               Number of trees: 500
## No. of variables tried at each split: 2
##
##               OOB estimate of  error rate: 3.64%
## Confusion matrix:
##      N Y class.error
## N 318 0           0
## Y  12 0           1

## Confusion Matrix and Statistics
##
##               Reference
## Prediction    N    Y
##      N 147    6
##      Y   0    0
##
##               Accuracy : 0.9608
```

```

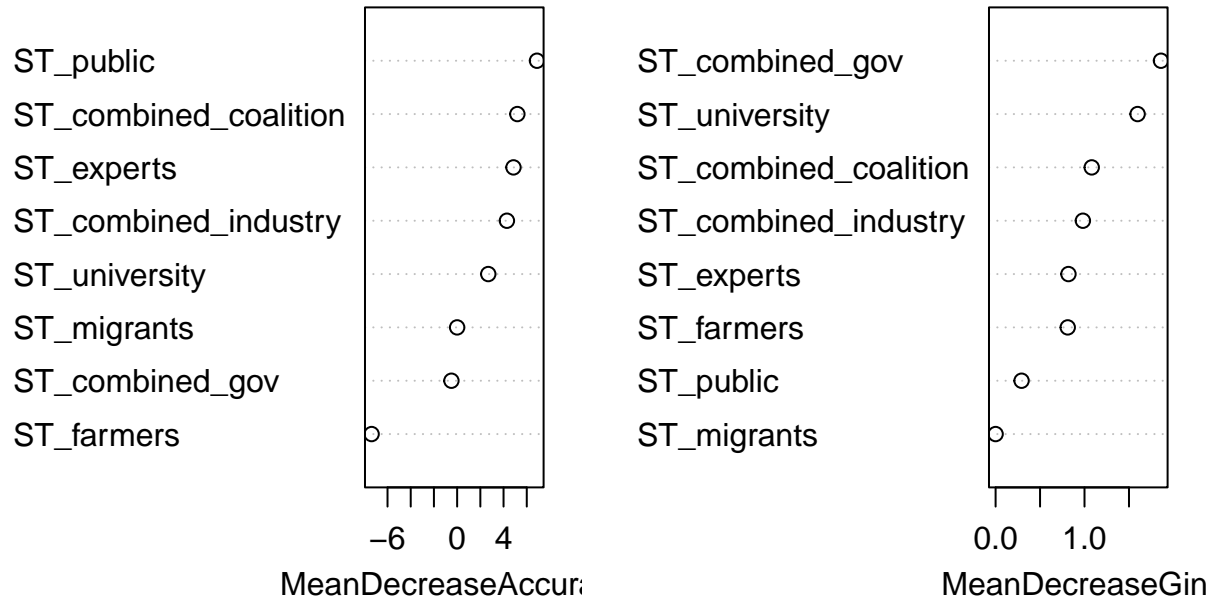
##          95% CI : (0.9166, 0.9855)
##    No Information Rate : 0.9608
##    P-Value [Acc > NIR] : 0.60632
##
##          Kappa : 0
##
##    McNemar's Test P-Value : 0.04123
##
##          Sensitivity : 1.0000
##          Specificity : 0.0000
##    Pos Pred Value : 0.9608
##    Neg Pred Value :    NaN
##          Prevalence : 0.9608
##    Detection Rate : 0.9608
##    Detection Prevalence : 1.0000
##    Balanced Accuracy : 0.5000
##
##    'Positive' Class : N
##

```

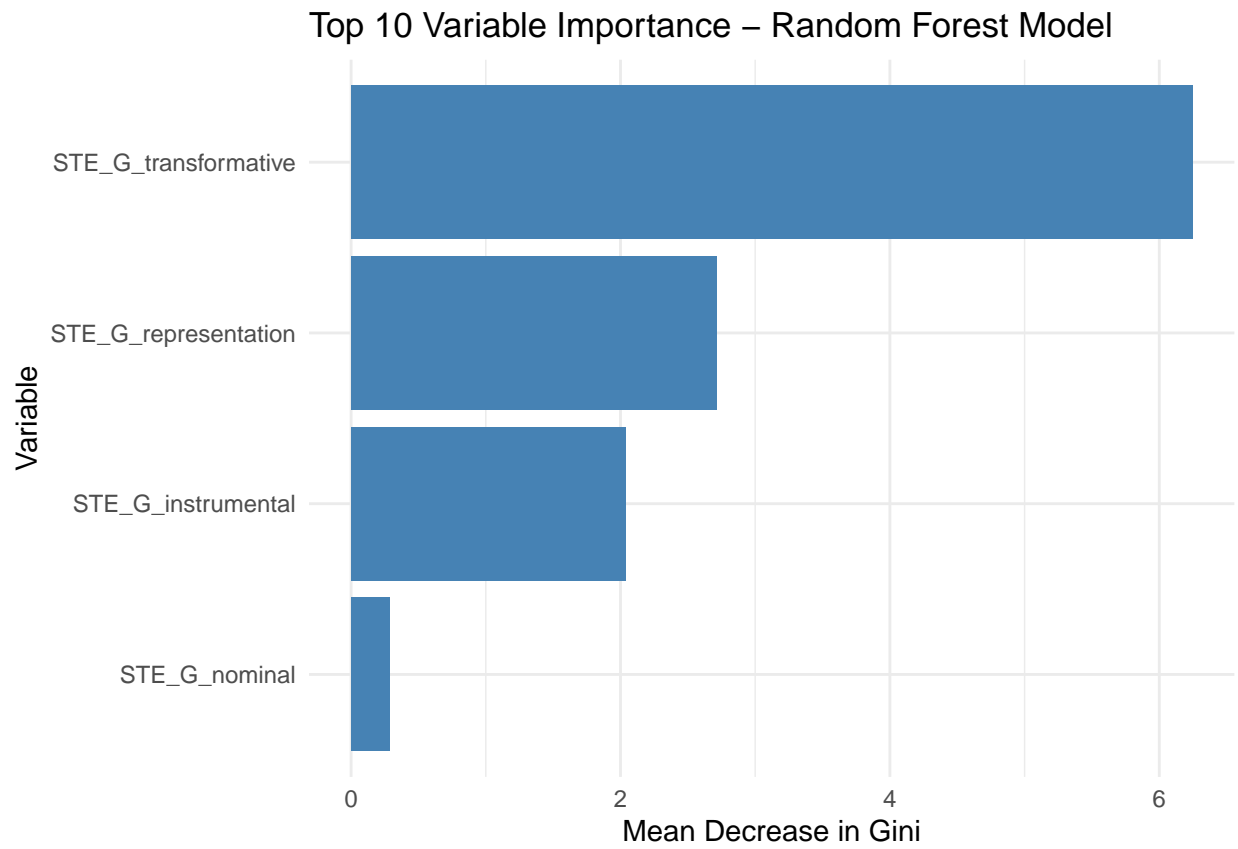




## Top 10 – Variable Importance



##	N		Y	MeanDecreaseAccuracy	MeanDecreaseGini
## ST_farmers	-8.777496	4.3809245		-7.3721450	0.8112868
## ST_combined_gov	-2.066005	7.9685945		-0.4921922	1.8599838
## ST_combined_coalition	5.892092	-2.6622001		5.1893136	1.0811956
## ST_combined_industry	4.849517	-3.4966026		4.2885592	0.9817205
## ST_migrants	0.000000	0.0000000		0.0000000	0.0000000
## ST_public	6.841555	1.6042011		6.8809319	0.2920537
## ST_university	2.725558	-0.3349692		2.6828827	1.5970035
## ST_experts	5.074284	-1.2977588		4.8538534	0.8192716



## Researcher Modeling - solution proposed

**QUESTION:** Does researcher type increase the likelihood that a solution will be proposed?

Regression of whether researcher type predicts if a solution was proposed (Y/N).

```
##
## Call:
## glm(formula = solution_proposed_YN ~ R_ngo + R_eng + R_math +
##      R_compsci + R_phys + R_interdis + R_socsci + R_economics +
##      R_ag + R_other, family = binomial, data = crcdata)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -0.7818  -0.2676  -0.1968  -0.1633   2.8523
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -3.32515    0.57570  -5.776 7.66e-09 ***
## R_ngo        -14.30039   1500.10090  -0.010  0.9924
## R_eng         -0.60890    0.52621  -1.157  0.2472
## R_math       -13.08984   1340.85939  -0.010  0.9922
## R_compsci     -0.08763    0.66877  -0.131  0.8957
## R_phys        -0.26009    0.50876  -0.511  0.6092
## R_interdis     1.50781    0.53459   2.820  0.0048 **
## R_socsci      -0.38366    0.66670  -0.575  0.5650
## R_economics   -0.98563    1.06464  -0.926  0.3546
## R_ag          -0.37850    0.78165  -0.484  0.6282
## R_other        1.13626    1.13748   0.999  0.3178
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 153.75  on 482  degrees of freedom
## Residual deviance: 137.74  on 472  degrees of freedom
## AIC: 159.74
##
## Number of Fisher Scoring iterations: 16
```

## ODDS RATIOS: Does researcher type increase the likelihood that a solution will be proposed?

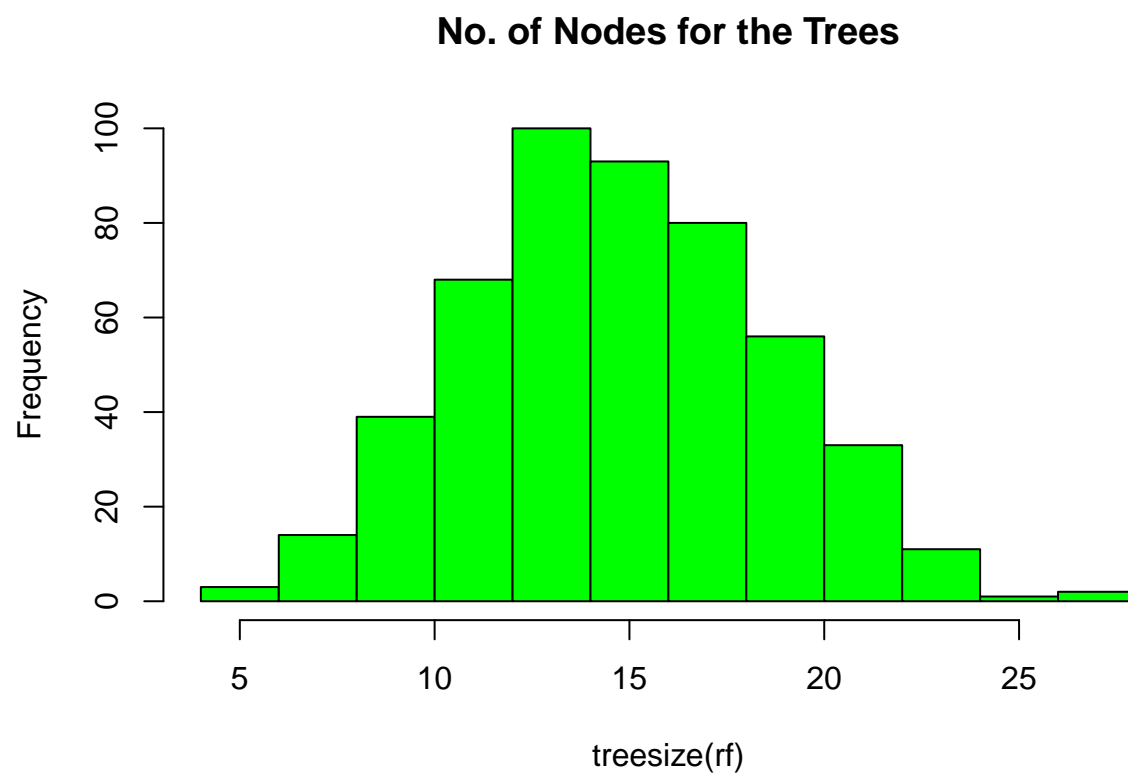
Odds of whether researcher type predicts if a solution was proposed (Y/N). A ratio which is closer to 1 has a greater level of researcher diversity.

```
##
## Logistic regression predicting solution_proposed_YN : Y vs N
##
##          crude OR(95%CI)    adj. OR(95%CI)    P(Wald's test) P(LR-test)
## Rngo: 1 vs 0      0 (0,Inf)      0 (0,Inf)      0.992      0.481
##
## Reng: 1 vs 0      0.44 (0.17,1.16)  0.54 (0.19,1.53)  0.247      0.242
##
## Rmath: 1 vs 0     0 (0,Inf)      0 (0,Inf)      0.992      0.661
##
## Rcompsci: 1 vs 0  0.93 (0.26,3.3)  0.92 (0.25,3.4)  0.896      0.895
##
## Rphys: 1 vs 0     0.82 (0.32,2.11)  0.77 (0.28,2.09)  0.609      0.608
##
## Rinterdis: 1 vs 0 5.05 (1.86,13.72) 4.52 (1.58,12.88) 0.005      0.004
##
## Rsocsci: 1 vs 0   0.93 (0.26,3.3)  0.68 (0.18,2.52)  0.565      0.552
##
## Reconomics: 1 vs 0 0.33 (0.04,2.49)  0.37 (0.05,3.01)  0.355      0.293
##
## Rag: 1 vs 0       0.5 (0.11,2.21)  0.68 (0.15,3.17)  0.628      0.614
##
## Rother: 1 vs 0    2.22 (0.27,18.07) 3.12 (0.34,28.95) 0.318      0.373
##
## Log-likelihood = -68.8704
## No. of observations = 483
## AIC value = 159.7409
```

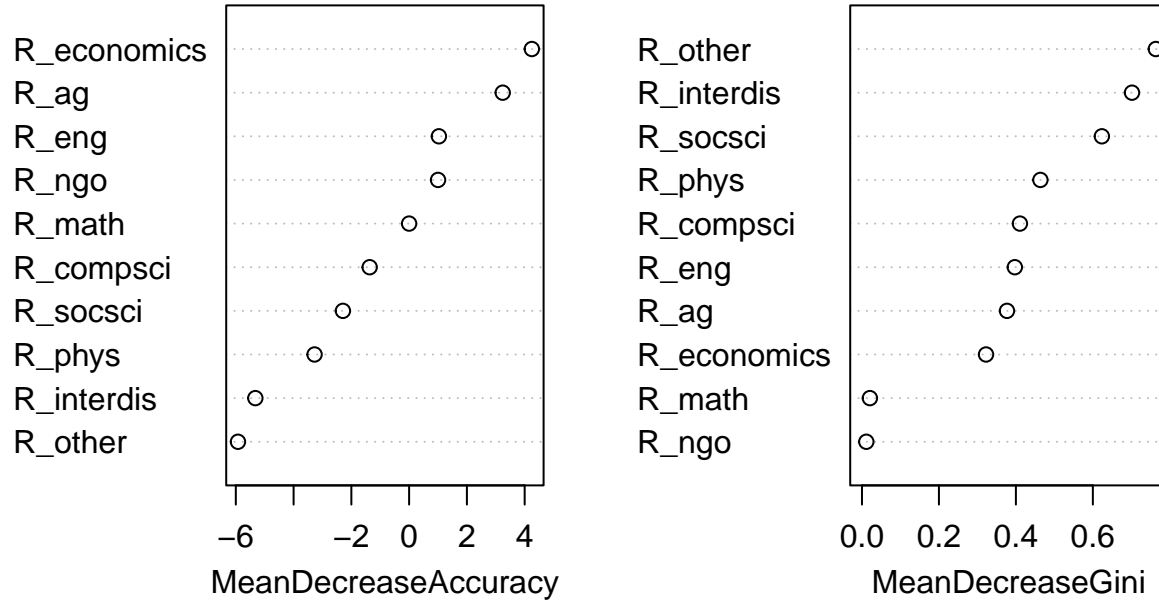
## DECISON TREE: Researcher Type Ensembled Decision Tree - researcher type vs solution

```
##
## Call:
## randomForest(formula = solution_proposed_YN ~ R_ngo + R_eng + R_math + R_compsci + R_phys + R_
##               Type of random forest: classification
##               Number of trees: 500
## No. of variables tried at each split: 3
##
## OOB estimate of error rate: 3.64%
## Confusion matrix:
##      N Y class.error
## N 318 0           0
## Y  12 0           1

## Confusion Matrix and Statistics
##
##               Reference
## Prediction    N    Y
##      N 147    6
##      Y   0    0
##
##               Accuracy : 0.9608
##               95% CI : (0.9166, 0.9855)
##      No Information Rate : 0.9608
##      P-Value [Acc > NIR] : 0.60632
##
##               Kappa : 0
##
## McNemar's Test P-Value : 0.04123
##
##               Sensitivity : 1.0000
##               Specificity : 0.0000
##      Pos Pred Value : 0.9608
##      Neg Pred Value : NaN
##      Prevalence : 0.9608
##      Detection Rate : 0.9608
##      Detection Prevalence : 1.0000
##      Balanced Accuracy : 0.5000
##
##      'Positive' Class : N
##
```

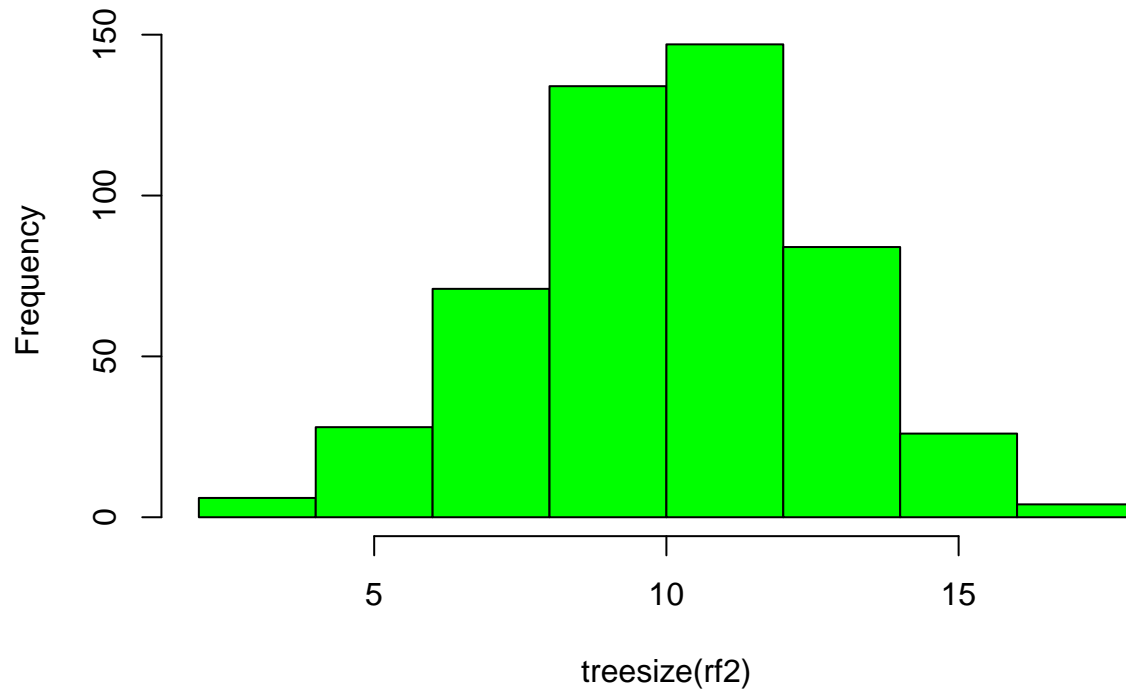


## Top 10 – Variable Importance



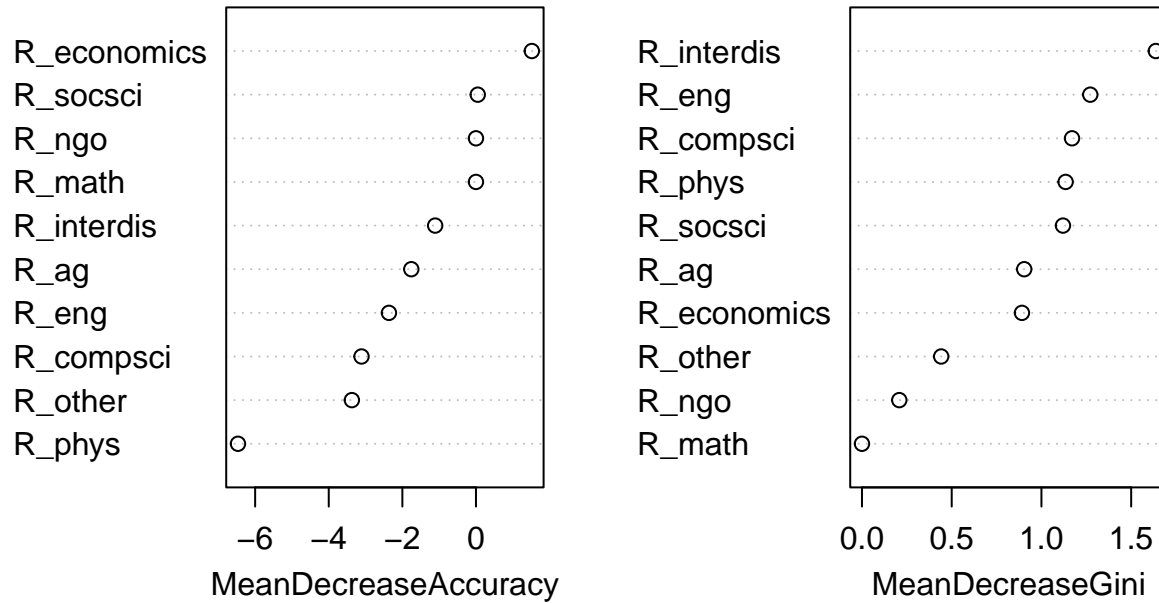
##	N	Y	MeanDecreaseAccuracy	MeanDecreaseGini
## R_ngo	1.001002	0.000000	1.001002	0.01130222
## R_eng	2.545433	-4.720178	1.030085	0.39723340
## R_math	0.000000	0.000000	0.000000	0.02059270
## R_compsci	-1.110362	-2.207220	-1.365429	0.41046958
## R_phys	-3.061126	-1.397694	-3.274342	0.46369497
## R_interdis	-5.392560	1.001002	-5.324441	0.70176539
## R_socsci	-2.409116	1.001002	-2.292692	0.62346790
## R_economics	4.261605	0.000000	4.248551	0.32239766
## R_ag	3.206240	1.001002	3.240509	0.37686875
## R_other	-5.767448	-1.999690	-5.925466	0.76373669

### Balanced Model – No. of Nodes for the Trees

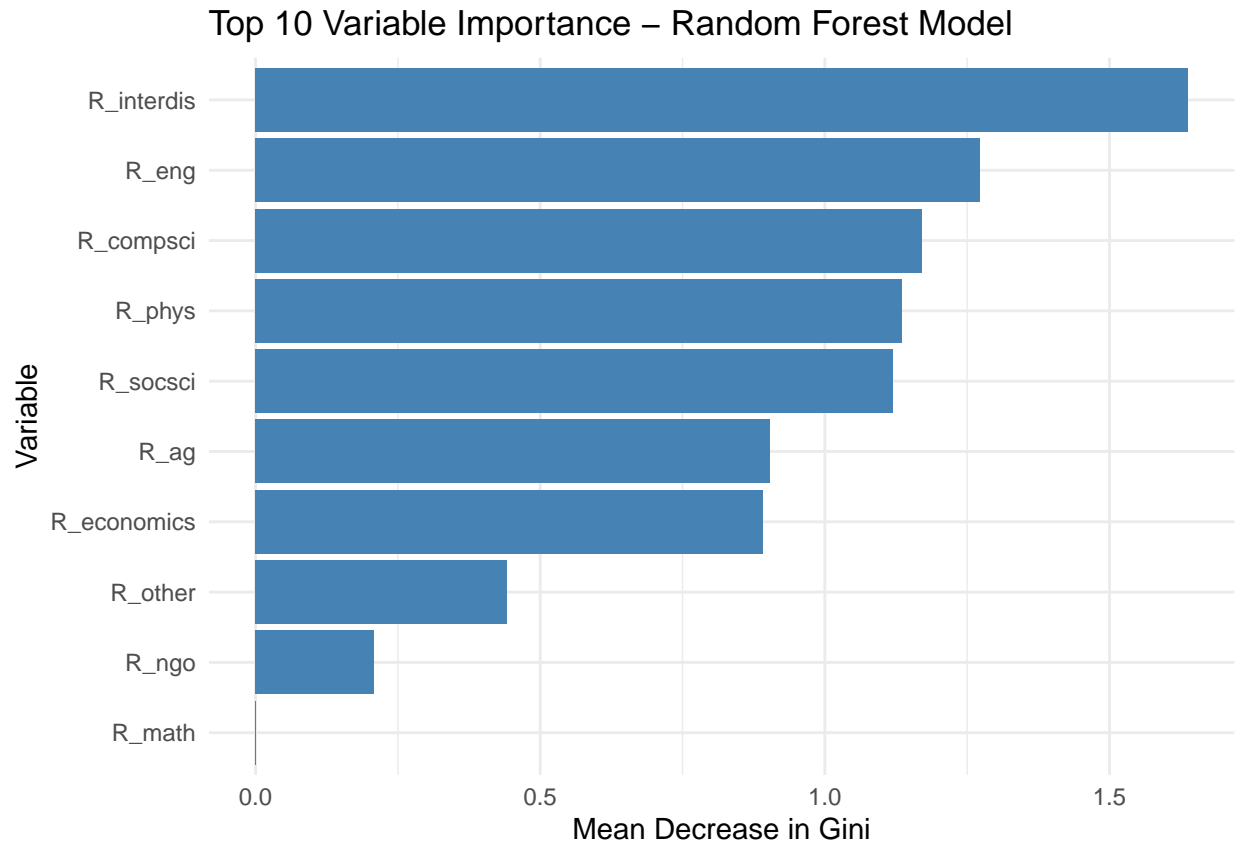




## Balanced Model – Top 10 – Variable Importance



##	N		Y	MeanDecreaseAccuracy	MeanDecreaseGini
## R_ngo	0.0000000	0.0000000		0.00000000	0.2079498
## R_eng	-3.5080722	0.2824357		-2.36487090	1.2720908
## R_math	0.0000000	0.0000000		0.00000000	0.0000000
## R_compsci	-1.5404837	-3.7021751		-3.10979537	1.1703700
## R_phys	-6.2753608	-2.5179735		-6.46652840	1.1347099
## R_interdis	-2.6021854	1.8262306		-1.10878058	1.6374554
## R_socsci	1.5592110	-2.6016421		0.04869905	1.1198976
## R_economics	0.4311494	2.1955701		1.51805351	0.8912926
## R_ag	-0.2682838	-2.9621819		-1.75741293	0.9039319
## R_other	-2.6418598	-3.3987604		-3.37214891	0.4414520



## Researcher Diversity Modeling - solution proposed

**QUESTION:** Does the diversity of researchers increases the likelihood that a solution will be proposed?

Regression of whether Diversity of researchers predicts if a solution was proposed (Y/N). In order to represent diversity, we have used a simple ratio calculation which sums the number of researcher types involved, divided by the total number of possible researcher options. A ratio which is closer to 1 has a greater level of researcher diversity.

```
##
## Call:
## glm(formula = solution_proposed_YN ~ ST_ratio, family = binomial,
##      data = crcdata)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -0.2906  -0.2833  -0.2762  -0.2693   2.6209
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -3.1437     0.4846  -6.487 8.78e-11 ***
## ST_ratio      -0.5161     2.0451  -0.252  0.801
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 153.75  on 482  degrees of freedom
## Residual deviance: 153.68  on 481  degrees of freedom
## AIC: 157.68
##
## Number of Fisher Scoring iterations: 6
```

## ODDS RATIOS: Does the diversity of researchers increases the likelihood that a solution will be proposed?

Odds of whether Diversity of researchers predicts if a solution was proposed (Y/N). In order to represent diversity, we have used a simple ratio calculation which sums the number of researcher types involved, divided by the total number of possible researcher options. A ratio which is closer to 1 has a greater level of researcher diversity.

```
##
## Logistic regression predicting solution_proposed_YN : Y vs N
##
##               OR(95%CI)          P(Wald's test) P(LR-test)
## ST_ratio (cont. var.) 0.6 (0.01,32.86)  0.801          0.799
##
## Log-likelihood = -76.8414
## No. of observations = 483
## AIC value = 157.6829
```

# Stakeholder Engagement Modeling - Ghodsvali

## Regression Testing - Stakeholder type vs level of engagement (Ghodsvali)

```
## Response ST_farmers :
##
## Call:
## lm(formula = ST_farmers ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.4444  0.0000  0.0000  0.0000  0.7273
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    2.829e-16  1.025e-02   0.000      1
## STE_G_nominal    3.929e-01  3.992e-02   9.841 < 2e-16 ***
## STE_G_instrumental 3.684e-01  3.467e-02  10.627 < 2e-16 ***
## STE_G_representation 2.727e-01  6.241e-02   4.370 1.52e-05 ***
## STE_G_transformative 4.444e-01  6.882e-02   6.458 2.62e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2042 on 478 degrees of freedom
## Multiple R-squared:  0.3332, Adjusted R-squared:  0.3276
## F-statistic: 59.71 on 4 and 478 DF,  p-value: < 2.2e-16
##
##
## Response ST_combined_gov :
##
## Call:
## lm(formula = ST_combined_gov ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.68421 -0.00252 -0.00252 -0.00252  0.99748
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.002519  0.008868   0.284   0.776
## STE_G_nominal    0.283195  0.034548   8.197 2.28e-15 ***
## STE_G_instrumental 0.681692  0.030003  22.721 < 2e-16 ***
## STE_G_representation 0.997481  0.054006  18.470 < 2e-16 ***
## STE_G_transformative 0.997481  0.059559  16.748 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1767 on 478 degrees of freedom
## Multiple R-squared:  0.6938, Adjusted R-squared:  0.6913
## F-statistic: 270.8 on 4 and 478 DF,  p-value: < 2.2e-16
##
##
```

```

## Response ST_tribal :
##
## Call:
## lm(formula = ST_tribal ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.1429  0.0000  0.0000  0.0000  0.9737
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1.263e-16  4.816e-03   0.000   1.000
## STE_G_nominal    1.429e-01  1.876e-02   7.613 1.44e-13 ***
## STE_G_instrumental  2.632e-02  1.630e-02   1.615   0.107
## STE_G_representation -2.775e-17  2.933e-02   0.000   1.000
## STE_G_transformative -2.724e-17  3.235e-02   0.000   1.000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.09597 on 478 degrees of freedom
## Multiple R-squared:  0.1103, Adjusted R-squared:  0.1029
## F-statistic: 14.82 on 4 and 478 DF, p-value: 2.004e-11
##
##
## Response ST_combined_coalition :
##
## Call:
## lm(formula = ST_combined_coalition ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.66667 -0.00252 -0.00252 -0.00252  0.99748
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.002519  0.009299   0.271  0.78661
## STE_G_nominal    0.104624  0.036230   2.888  0.00406 **
## STE_G_instrumental  0.339586  0.031463  10.793 < 2e-16 ***
## STE_G_representation 0.270208  0.056635   4.771 2.44e-06 ***
## STE_G_transformative 0.664148  0.062459  10.633 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1853 on 478 degrees of freedom
## Multiple R-squared:  0.3329, Adjusted R-squared:  0.3273
## F-statistic: 59.64 on 4 and 478 DF, p-value: < 2.2e-16
##
##
## Response ST_combined_industry :
##
## Call:
## lm(formula = ST_combined_industry ~ STE_G_nominal + STE_G_instrumental +

```

```

##      STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min        1Q      Median        3Q        Max
## -0.63636 -0.00252 -0.00252 -0.00252  0.99748
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.002519   0.009921   0.254  0.79969
## STE_G_nominal    0.176053   0.038653   4.555 6.67e-06 ***
## STE_G_instrumental 0.523797   0.033568  15.604 < 2e-16 ***
## STE_G_representation 0.633845   0.060423  10.490 < 2e-16 ***
## STE_G_transformative 0.219703   0.066637   3.297  0.00105 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1977 on 478 degrees of freedom
## Multiple R-squared:  0.4246, Adjusted R-squared:  0.4198
## F-statistic: 88.19 on 4 and 478 DF,  p-value: < 2.2e-16
##
##
## Response ST_migrants :
##
## Call:
## lm(formula = ST_migrants ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min        1Q      Median        3Q        Max
##       0         0         0         0         0
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)           0           0      NaN      NaN
## STE_G_nominal           0           0      NaN      NaN
## STE_G_instrumental       0           0      NaN      NaN
## STE_G_representation       0           0      NaN      NaN
## STE_G_transformative       0           0      NaN      NaN
##
## Residual standard error: 0 on 478 degrees of freedom
## Multiple R-squared:    NaN, Adjusted R-squared:    NaN
## F-statistic:    NaN on 4 and 478 DF,  p-value: NA
##
##
## Response ST_youth :
##
## Call:
## lm(formula = ST_youth ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min        1Q      Median        3Q        Max
## -0.05263 -0.00252 -0.00252 -0.00252  0.99748
##

```

```

## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.002519   0.004508   0.559  0.57659
## STE_G_nominal      0.033195   0.017563   1.890  0.05936 .
## STE_G_instrumental 0.050113   0.015252   3.286  0.00109 **
## STE_G_representation -0.002519  0.027455  -0.092  0.92694
## STE_G_transformative -0.002519  0.030278  -0.083  0.93373
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.08982 on 478 degrees of freedom
## Multiple R-squared:  0.02782, Adjusted R-squared:  0.01969
## F-statistic:  3.42 on 4 and 478 DF, p-value: 0.009011
##
##
## Response ST_public :
##
## Call:
## lm(formula = ST_public ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.2857   0.0000   0.0000   0.0000   0.8684
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -2.526e-18  8.355e-03   0.000 1.000000
## STE_G_nominal     2.857e-01  3.255e-02   8.777 < 2e-16 ***
## STE_G_instrumental 1.316e-01  2.827e-02   4.654 4.21e-06 ***
## STE_G_representation 1.818e-01  5.089e-02   3.573 0.000389 ***
## STE_G_transformative 2.222e-01  5.612e-02   3.960 8.64e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1665 on 478 degrees of freedom
## Multiple R-squared:  0.1923, Adjusted R-squared:  0.1855
## F-statistic: 28.44 on 4 and 478 DF, p-value: < 2.2e-16
##
##
## Response ST_university :
##
## Call:
## lm(formula = ST_university ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.55556 -0.00252 -0.00252 -0.00252  0.99748
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.002519   0.009911   0.254 0.799480
## STE_G_nominal      0.140338   0.038611   3.635 0.000309 ***

```



```

## STE_G_instrumental    0.418534    0.033531   12.482 < 2e-16 ***
## STE_G_representation 0.452027    0.060358    7.489 3.37e-13 ***
## STE_G_transformative 0.553037    0.066564    8.308 1.01e-15 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1975 on 478 degrees of freedom
## Multiple R-squared:  0.3575, Adjusted R-squared:  0.3521
## F-statistic: 66.5 on 4 and 478 DF,  p-value: < 2.2e-16
##
##
## Response ST_experts :
##
## Call:
## lm(formula = ST_experts ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.28947 -0.00252 -0.00252 -0.00252  0.99748
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.002519   0.009180   0.274   0.7839
## STE_G_nominal    0.176053   0.035764   4.923 1.18e-06 ***
## STE_G_instrumental 0.286955   0.031059   9.239 < 2e-16 ***
## STE_G_representation 0.270208   0.055907   4.833 1.81e-06 ***
## STE_G_transformative 0.108592   0.061656   1.761  0.0788 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1829 on 478 degrees of freedom
## Multiple R-squared:  0.2039, Adjusted R-squared:  0.1972
## F-statistic: 30.61 on 4 and 478 DF,  p-value: < 2.2e-16

```

## Regression Testing - Stakeholder type vs solution

```
##
## Call:
## glm(formula = solution_proposed_YN ~ ST_farmers + ST_combined_gov +
##      ST_tribal + ST_combined_coalition + ST_combined_industry +
##      ST_migrants + ST_youth + ST_public + ST_university + ST_experts,
##      family = binomial, data = crcdata)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -1.1927  -0.1364  -0.1364  -0.1364   3.0602
##
## Coefficients: (1 not defined because of singularities)
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    -4.67323    0.50476  -9.258 < 2e-16 ***
## ST_farmers       0.56210    0.72644   0.774  0.439
## ST_combined_gov  3.96372    0.80612   4.917 8.79e-07 ***
## ST_tribal      -14.36229  1623.97493  -0.009  0.993
## ST_combined_coalition -0.01271    0.87795  -0.014  0.988
## ST_combined_industry -0.97124    0.74281  -1.308  0.191
## ST_migrants              NA          NA      NA      NA
## ST_youth        -15.26565  1784.23408  -0.009  0.993
## ST_public        0.74554    0.79355   0.940  0.347
## ST_university    -0.23106    0.82786  -0.279  0.780
## ST_experts       -0.29851    0.80371  -0.371  0.710
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 153.75  on 482  degrees of freedom
## Residual deviance: 102.25  on 473  degrees of freedom
## AIC: 122.25
##
## Number of Fisher Scoring iterations: 16
```

## Geographic Location Modeling - solution proposed

QUESTION: Does the geographic location of the study increase the likelihood of proposed/implemented solutions?

```
##
## Call:
## glm(formula = solution_proposed_YN ~ G_local + G_regional + G_national +
##       G_multinational + G_global, family = binomial, data = crcdata)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -0.5090  -0.3117  -0.2450  -0.2450   2.7091
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)   -3.6437     0.9147  -3.984 6.79e-05 ***
## G_local         0.6433     0.9908   0.649   0.516
## G_regional     0.1523     1.0042   0.152   0.879
## G_national     1.0220     1.0071   1.015   0.310
## G_multinational -14.9224  1232.6632  -0.012   0.990
## G_global      -14.9224  1966.6497  -0.008   0.994
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 153.75  on 482  degrees of freedom
## Residual deviance: 148.27  on 477  degrees of freedom
## AIC: 160.27
##
## Number of Fisher Scoring iterations: 17
```

# **ODDS RATIOS: Does the geographic location of the study increase the likelihood of proposed/implemented solutions?**

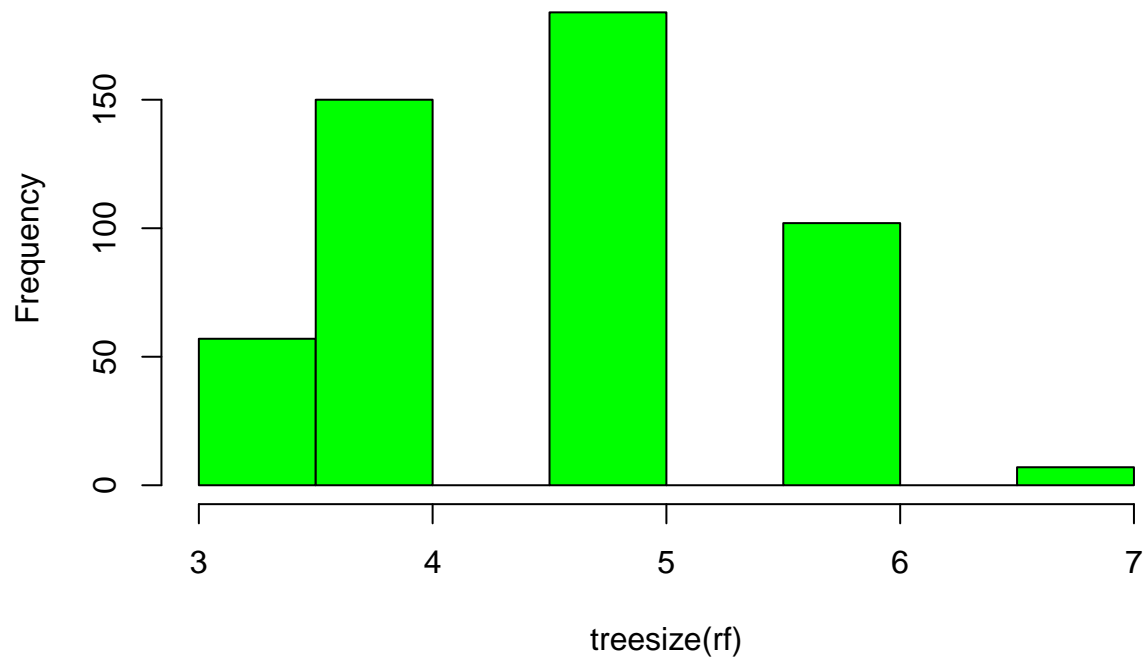
```
##
## Logistic regression predicting solution_proposed_YN : Y vs N
##
##          crude OR(95%CI)   adj. OR(95%CI)   P(Wald's test) P(LR-test)
## G_local: 1 vs 0          1.45 (0.53,3.96)   1.9 (0.27,13.27)  0.516          0.494
##
## G_regional: 1 vs 0       0.68 (0.25,1.84)   1.16 (0.16,8.33)  0.879          0.878
##
## G_national: 1 vs 0       2.25 (0.78,6.5)    2.78 (0.39,20)    0.31           0.277
##
## G_multinational: 1 vs 0  0 (0,Inf)          0 (0,Inf)          0.99           0.285
##
## G_global: 1 vs 0         0 (0,Inf)          0 (0,Inf)          0.994          0.475
##
## Log-likelihood = -74.1333
## No. of observations = 483
## AIC value = 160.2665
```

## DECISON TREE: Geographic area Ensembled Decision Tree - Geographic area vs solution

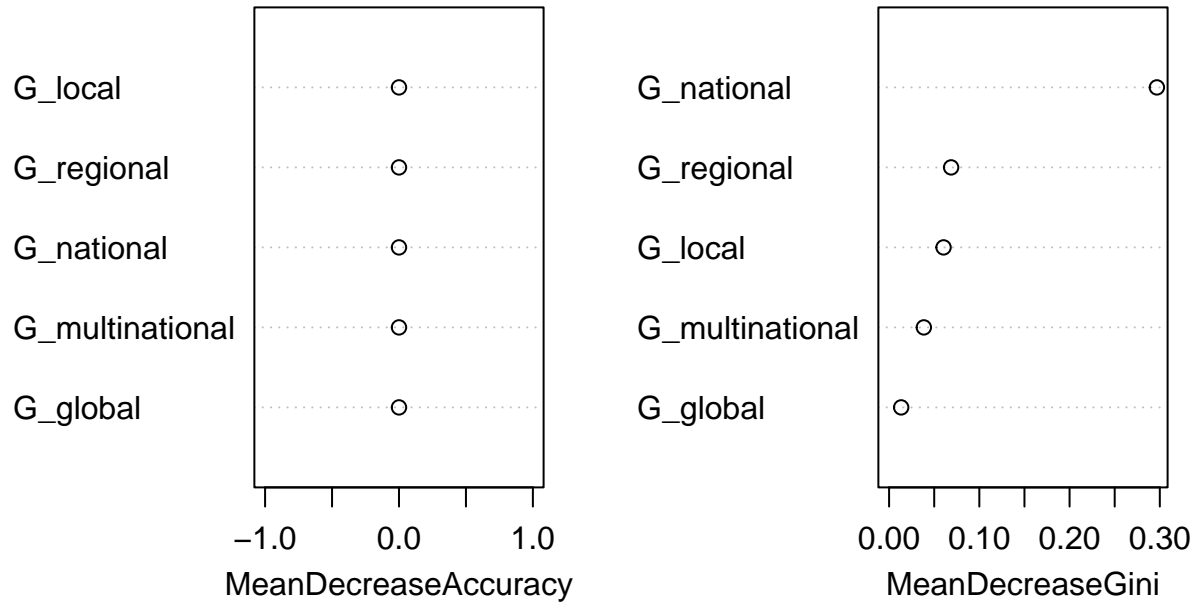
```
##
## Call:
## randomForest(formula = solution_proposed_YN ~ G_local + G_regional +      G_national + G_multination
##               Type of random forest: classification
##               Number of trees: 500
## No. of variables tried at each split: 2
##
##               OOB estimate of  error rate: 3.64%
## Confusion matrix:
##      N Y class.error
## N 318 0           0
## Y  12 0           1

## Confusion Matrix and Statistics
##
##               Reference
## Prediction    N    Y
##      N 147    6
##      Y   0    0
##
##               Accuracy : 0.9608
##               95% CI : (0.9166, 0.9855)
##      No Information Rate : 0.9608
##      P-Value [Acc > NIR] : 0.60632
##
##               Kappa : 0
##
##      McNemar's Test P-Value : 0.04123
##
##               Sensitivity : 1.0000
##               Specificity : 0.0000
##      Pos Pred Value : 0.9608
##      Neg Pred Value :   NaN
##      Prevalence : 0.9608
##      Detection Rate : 0.9608
##      Detection Prevalence : 1.0000
##      Balanced Accuracy : 0.5000
##
##      'Positive' Class : N
##
```

### No. of Nodes for the Trees



## Top 10 – Variable Importance



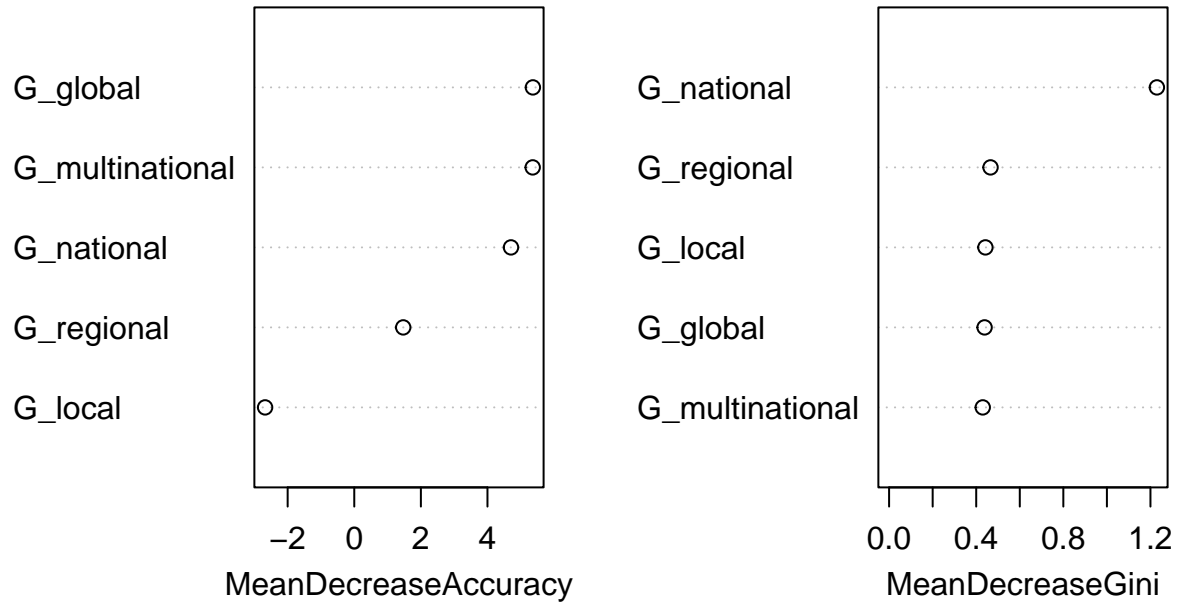
```
##      N Y MeanDecreaseAccuracy MeanDecreaseGini
## G_local 0 0 0 0.06034211
## G_regional 0 0 0 0.06873373
## G_national 0 0 0 0.29674447
## G_multinational 0 0 0 0.03848745
## G_global 0 0 0 0.01339159
```

### Balanced Model – No. of Nodes for the Trees



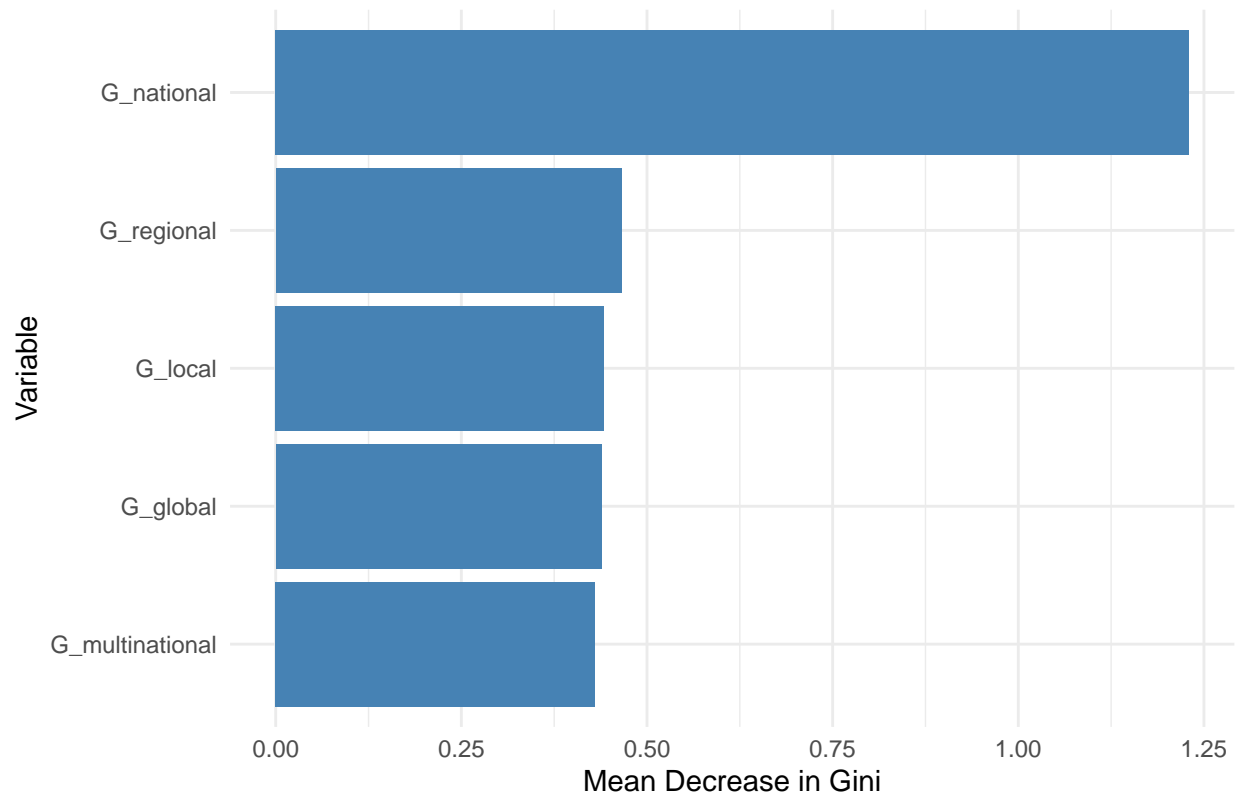


## Balanced Model – Top 10 – Variable Importance



##	N	Y	MeanDecreaseAccuracy	MeanDecreaseGini
## G_local	1.027629	-5.354141	-2.677505	0.4422253
## G_regional	3.227648	-2.858525	1.469859	0.4656785
## G_national	1.501660	5.983360	4.705676	1.2295193
## G_multinational	5.317768	1.614880	5.357814	0.4299825
## G_global	5.490292	2.766211	5.363641	0.4384266

Top 10 Variable Importance – Random Forest Model



## Regional Location Modeling - solution proposed

**QUESTION:** Does the regional location of the study increase the likelihood of proposed/implemented solutions? Regions were grouped in: Europe/Asia, Middle East/Global - and Other.

**RESULTS:** A bias-reduced logistic regression indicated that region was significantly associated with whether a solution was proposed, Chisquare = 7.28,  $p = .026$ .

```
##
## Call:
## glm(formula = solution_proposed_YN ~ L_region_3, family = binomial,
##      data = crcdata, method = "brglmFit")
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -0.4009  -0.3788  -0.1930  -0.1930   2.8257
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    -3.9737     0.4311  -9.217  < 2e-16 ***
## L_region_3EuropeAsia  1.4932     0.5485   2.722  0.00648 **
## L_region_3GlobalME   1.3752     0.6545   2.101  0.03563 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 153.76  on 482  degrees of freedom
## Residual deviance: 145.04  on 480  degrees of freedom
## AIC: 151.04
##
## Type of estimator: AS_mixed (mixed bias-reducing adjusted score equations)
## Number of Fisher Scoring iterations: 3
```

**ODDS RATIOS:** Does the regional location of the study increase the likelihood of proposed/implemented solutions?

**RESULTS:** Compared to other regions, cases from Europe and Asia had 3.77 times higher odds of proposing a solution (95% CI [1.35, 10.48],  $p = .011$ ). Global and Middle East cases also had higher odds (OR = 3.35, 95% CI [0.97, 11.57]), though this effect was marginal ( $p = .056$ ).

##	OR	2.5 %	97.5 %
## (Intercept)	0.01880342	0.008077381	0.04377268
## L_region_3EuropeAsia	4.45134158	1.519125103	13.04332462
## L_region_3GlobalME	3.95567490	1.096799990	14.26637862

## DECISON TREE: Region area Ensembled Decision Tree - Region area vs solution

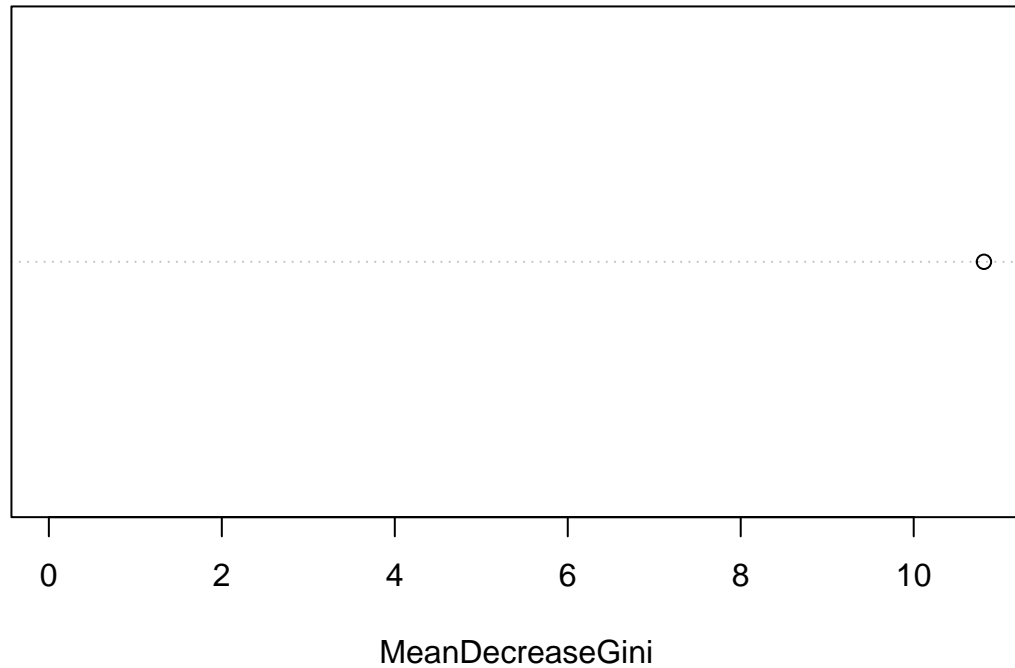
```
##
## Call:
## randomForest(formula = solution_proposed_YN ~ ., data = train,          proximity = TRUE, importance = '
##           Type of random forest: classification
##           Number of trees: 1000
## No. of variables tried at each split: 3
##
##           OOB estimate of  error rate: 48.67%
## Confusion matrix:
##      N   Y class.error
## N 142 146   0.5069444
## Y   0  12   0.0000000

## Confusion Matrix and Statistics
##
##           Reference
## Prediction  N   Y
##      N  58   2
##      Y  77   4
##
##           Accuracy : 0.4397
##           95% CI : (0.3563, 0.5257)
##      No Information Rate : 0.9574
##      P-Value [Acc > NIR] : 1
##
##           Kappa : 0.0138
##
##      McNemar's Test P-Value : <2e-16
##
##           Sensitivity : 0.42963
##           Specificity : 0.66667
##           Pos Pred Value : 0.96667
##           Neg Pred Value : 0.04938
##           Prevalence : 0.95745
##           Detection Rate : 0.41135
##      Detection Prevalence : 0.42553
##           Balanced Accuracy : 0.54815
##
##           'Positive' Class : N
##
```

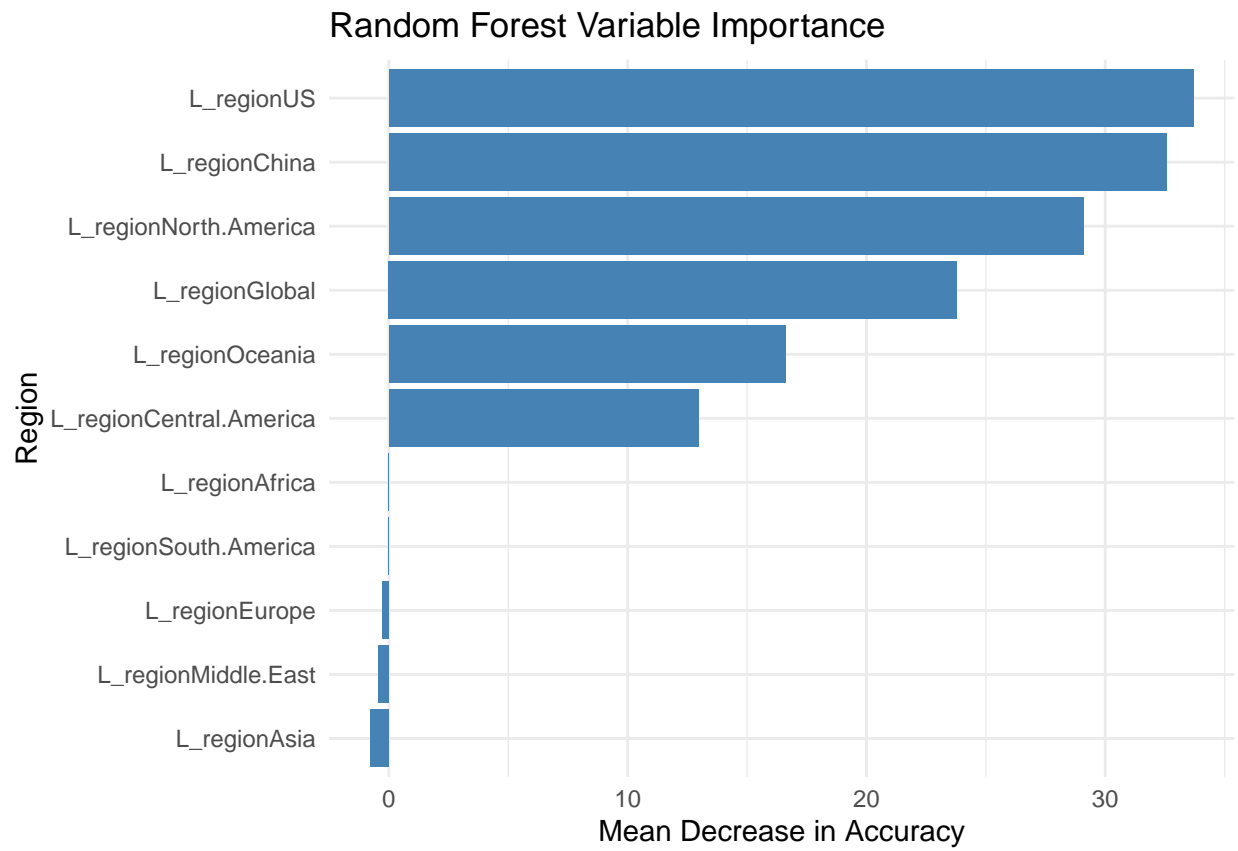
### No. of Nodes for the Trees



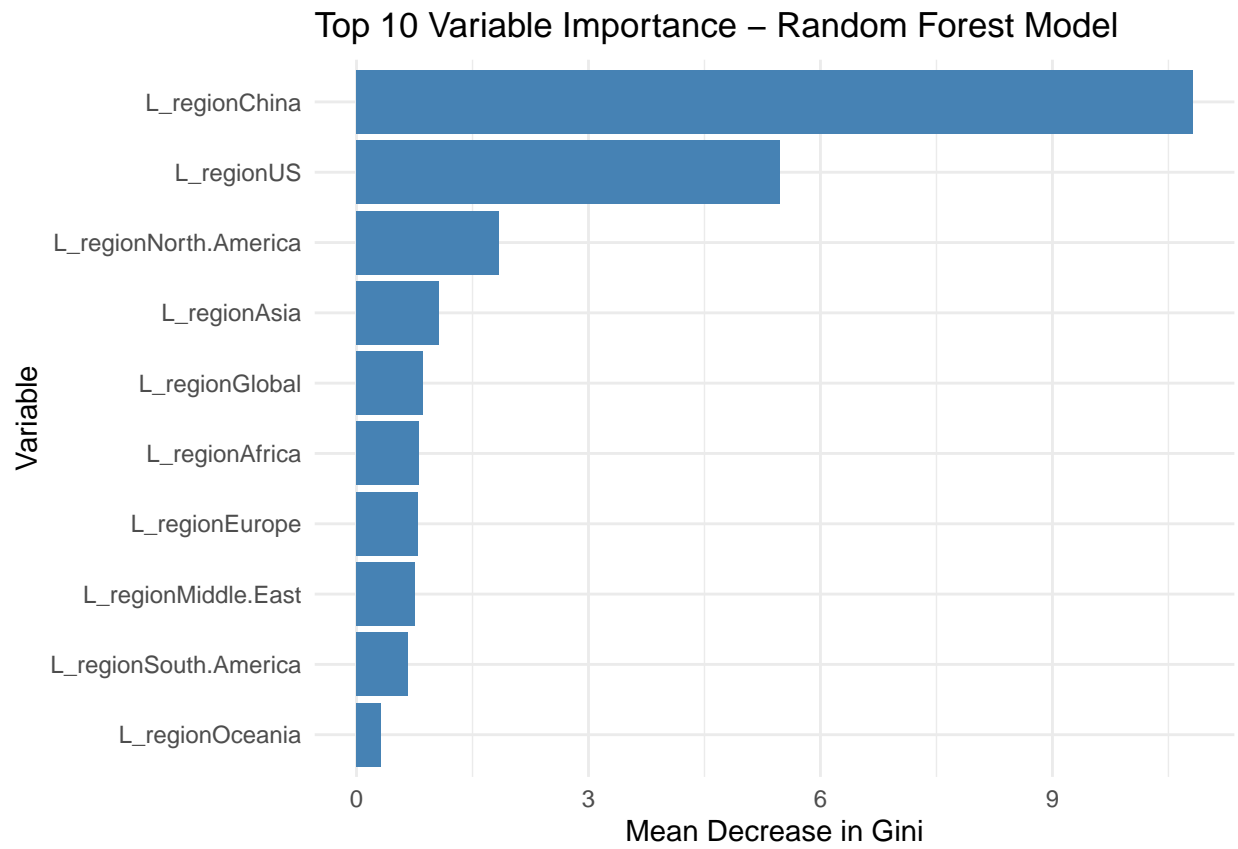
## Top 10 – Variable Importance



##		N	Y	MeanDecreaseAccuracy	MeanDecreaseGini
##	L_regionAfrica	1.0933895	-5.452981	0.003298512	0.8072409
##	L_regionAsia	0.0273873	-4.314722	-0.779705873	1.0689579
##	L_regionCentral.America	12.9998947	2.645574	12.969412515	0.2235869
##	L_regionChina	29.8633065	24.597473	32.565561078	10.8122942
##	L_regionEurope	-0.3400512	1.175147	-0.275919239	0.7892525
##	L_regionGlobal	23.8582712	6.071100	23.790215443	0.8636361
##	L_regionMiddle.East	-0.7597452	2.935461	-0.440067723	0.7561429
##	L_regionNorth.America	28.8473223	9.097030	29.086505006	1.8417100
##	L_regionOceania	16.7398361	4.005763	16.600204791	0.3224700
##	L_regionSouth.America	2.0247652	-6.355594	-0.007166369	0.6604102
##	L_regionUS	31.5190738	18.773142	33.684062103	5.4730018







# Multivariate Stakeholder Engagement Modeling - geographic area

## Regression Testing - stakeholder type vs geographic area - interactions and effects

```
## Response ST_farmers :
##
## Call:
## lm(formula = ST_farmers ~ G_local + G_regional + G_national +
##     G_multinational + G_global, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.13252 -0.07882 -0.07882 -0.03983  0.96429
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.003012   0.037040   0.081   0.9352
## G_local        0.092694   0.042943   2.159   0.0314 *
## G_regional     0.075806   0.040938   1.852   0.0647 .
## G_national     0.036814   0.046694   0.788   0.4308
## G_multinational 0.032702   0.059799   0.547   0.5847
## G_global      -0.003012   0.083558  -0.036   0.9713
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2484 on 477 degrees of freedom
## Multiple R-squared:  0.01488,    Adjusted R-squared:  0.004555
## F-statistic: 1.441 on 5 and 477 DF,  p-value: 0.208
##
##
## Response ST_combined_gov :
##
## Call:
## lm(formula = ST_combined_gov ~ G_local + G_regional + G_national +
##     G_multinational + G_global, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.1856 -0.1224 -0.1182 -0.0724  0.9286
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.0724005  0.0474942   1.524   0.128
## G_local        0.0631993  0.0550635   1.148   0.252
## G_regional     0.0458261  0.0524928   0.873   0.383
## G_national     0.0500214  0.0598732   0.835   0.404
## G_multinational -0.0009719  0.0766760  -0.013   0.990
## G_global      -0.0724005  0.1071409  -0.676   0.500
##
## Residual standard error: 0.3185 on 477 degrees of freedom
## Multiple R-squared:  0.007008,    Adjusted R-squared:  -0.003401
## F-statistic: 0.6733 on 5 and 477 DF,  p-value: 0.6439
##
##
```

```

## Response ST_tribal :
##
## Call:
## lm(formula = ST_tribal ~ G_local + G_regional + G_national +
##     G_multinational + G_global, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.03201 -0.01790 -0.00493 -0.00070  0.99507
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.0007018  0.0150616   0.047  0.9629
## G_local       0.0313073  0.0174620   1.793  0.0736 .
## G_regional    0.0042243  0.0166468   0.254  0.7998
## G_national   -0.0011306  0.0189872  -0.060  0.9525
## G_multinational -0.0007018  0.0243158  -0.029  0.9770
## G_global     -0.0007018  0.0339770  -0.021  0.9835
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.101 on 477 degrees of freedom
## Multiple R-squared:  0.01641,    Adjusted R-squared:  0.0061
## F-statistic: 1.592 on 5 and 477 DF,  p-value: 0.1608
##
##
## Response ST_combined_coalition :
##
## Call:
## lm(formula = ST_combined_coalition ~ G_local + G_regional + G_national +
##     G_multinational + G_global, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.06859 -0.06404 -0.06404 -0.03983  0.96429
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.046854  0.033790   1.387  0.166
## G_local      -0.007028  0.039175  -0.179  0.858
## G_regional    0.017186  0.037346   0.460  0.646
## G_national    0.021736  0.042597   0.510  0.610
## G_multinational -0.011139  0.054551  -0.204  0.838
## G_global     -0.046854  0.076225  -0.615  0.539
##
## Residual standard error: 0.2266 on 477 degrees of freedom
## Multiple R-squared:  0.004245,    Adjusted R-squared: -0.006193
## F-statistic: 0.4067 on 5 and 477 DF,  p-value: 0.8442
##
##
## Response ST_combined_industry :
##
## Call:
## lm(formula = ST_combined_industry ~ G_local + G_regional + G_national +

```

```

##      G_multinational + G_global, data = crcdata)
##
## Residuals:
##      Min        1Q      Median        3Q        Max
## -0.10574 -0.08867 -0.08186 -0.07173  0.95214
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.04786    0.03872   1.236   0.217
## G_local         0.02387    0.04489   0.532   0.595
## G_regional      0.04081    0.04280   0.954   0.341
## G_national      0.03401    0.04882   0.697   0.486
## G_multinational -0.04786    0.06252  -0.766   0.444
## G_global       -0.04786    0.08736  -0.548   0.584
##
## Residual standard error: 0.2597 on 477 degrees of freedom
## Multiple R-squared:  0.009003, Adjusted R-squared:  -0.001384
## F-statistic: 0.8667 on 5 and 477 DF, p-value: 0.5033
##
##
## Response ST_migrants :
##
## Call:
## lm(formula = ST_migrants ~ G_local + G_regional + G_national +
##      G_multinational + G_global, data = crcdata)
##
## Residuals:
##      Min        1Q      Median        3Q        Max
##       0         0         0         0         0
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)          0          0      NaN     NaN
## G_local              0          0      NaN     NaN
## G_regional           0          0      NaN     NaN
## G_national           0          0      NaN     NaN
## G_multinational      0          0      NaN     NaN
## G_global             0          0      NaN     NaN
##
## Residual standard error: 0 on 477 degrees of freedom
## Multiple R-squared:   NaN, Adjusted R-squared:   NaN
## F-statistic:   NaN on 5 and 477 DF, p-value: NA
##
##
## Response ST_youth :
##
## Call:
## lm(formula = ST_youth ~ G_local + G_regional + G_national + G_multinational +
##      G_global, data = crcdata)
##
## Residuals:
##      Min        1Q      Median        3Q        Max
## -0.02258 -0.01618 -0.00493 -0.00493  0.99507
##

```

```

## Coefficients:
##           Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.022584   0.013552   1.666   0.0963 .
## G_local       -0.006404   0.015711  -0.408   0.6838
## G_regional    -0.017658   0.014978  -1.179   0.2390
## G_national    -0.022496   0.017084  -1.317   0.1885
## G_multinational -0.022584   0.021878  -1.032   0.3025
## G_global      -0.022584   0.030571  -0.739   0.4604
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.09089 on 477 degrees of freedom
## Multiple R-squared:  0.006742, Adjusted R-squared: -0.00367
## F-statistic: 0.6475 on 5 and 477 DF, p-value: 0.6635
##
##
## Response ST_public :
##
## Call:
## lm(formula = ST_public ~ G_local + G_regional + G_national +
##     G_multinational + G_global, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.08838 -0.04640 -0.01970  0.00000  0.98030
##
## Coefficients:
##           Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.04640   0.02719   1.707   0.0885 .
## G_local       0.04198   0.03152   1.332   0.1835
## G_regional    -0.02669   0.03005  -0.888   0.3748
## G_national    -0.04697   0.03427  -1.371   0.1712
## G_multinational -0.04640   0.04389  -1.057   0.2910
## G_global      -0.04640   0.06133  -0.757   0.4497
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1823 on 477 degrees of freedom
## Multiple R-squared:  0.03325, Adjusted R-squared:  0.02312
## F-statistic: 3.281 on 5 and 477 DF, p-value: 0.006344
##
##
## Response ST_university :
##
## Call:
## lm(formula = ST_university ~ G_local + G_regional + G_national +
##     G_multinational + G_global, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.09641 -0.07882 -0.07882 -0.03178  0.96822
##
## Coefficients:
##           Estimate Std. Error t value Pr(>|t|)

```

```

## (Intercept)      0.069515   0.036570   1.901   0.0579 .
## G_local          -0.037731   0.042398  -0.890   0.3740
## G_regional       0.009302   0.040419   0.230   0.8181
## G_national       0.026892   0.046101   0.583   0.5600
## G_multinational -0.033801   0.059039  -0.573   0.5672
## G_global         -0.069515   0.082497  -0.843   0.3999
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2453 on 477 degrees of freedom
## Multiple R-squared:  0.01095,    Adjusted R-squared:  0.0005834
## F-statistic: 1.056 on 5 and 477 DF,  p-value: 0.384
##
##
## Response ST_experts :
##
## Call:
## lm(formula = ST_experts ~ G_local + G_regional + G_national +
##     G_multinational + G_global, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.05911 -0.05911 -0.04140 -0.02404  0.97596
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   0.045898   0.030507   1.505   0.133
## G_local       -0.021862   0.035368  -0.618   0.537
## G_regional     0.013215   0.033717   0.392   0.695
## G_national    -0.004503   0.038458  -0.117   0.907
## G_multinational -0.010184   0.049251  -0.207   0.836
## G_global      -0.045898   0.068819  -0.667   0.505
##
## Residual standard error: 0.2046 on 477 degrees of freedom
## Multiple R-squared:  0.00598,    Adjusted R-squared:  -0.004439
## F-statistic: 0.5739 on 5 and 477 DF,  p-value: 0.72

```

# Multivariate Geographic Modeling - Ghodsvali

## Regression Testing - Geographic area vs engagement (Ghodsvali) - interactions and effects

```
## Response G_local :
##
## Call:
## lm(formula = G_local ~ STE_G_nominal + STE_G_instrumental + STE_G_representation +
##     STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.5556 -0.2343 -0.2343  0.4444  0.8182
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.23426    0.02176  10.763 < 2e-16 ***
## STE_G_nominal      0.26574    0.08479   3.134  0.00183 **
## STE_G_instrumental  0.05522    0.07364   0.750  0.45371
## STE_G_representation -0.05244    0.13255  -0.396  0.69256
## STE_G_transformative 0.32130    0.14618   2.198  0.02843 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4336 on 478 degrees of freedom
## Multiple R-squared:  0.02981,    Adjusted R-squared:  0.02169
## F-statistic: 3.671 on 4 and 478 DF,  p-value: 0.005873
##
##
## Response G_regional :
##
## Call:
## lm(formula = G_regional ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.5454 -0.4156 -0.4156  0.5844  0.8889
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.41562    0.02477  16.782 <2e-16 ***
## STE_G_nominal      0.01295    0.09649   0.134  0.8933
## STE_G_instrumental  0.08438    0.08379   1.007  0.3144
## STE_G_representation 0.12984    0.15083   0.861  0.3898
## STE_G_transformative -0.30451    0.16634  -1.831  0.0678 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4935 on 478 degrees of freedom
## Multiple R-squared:  0.01092,    Adjusted R-squared:  0.00264
## F-statistic: 1.319 on 4 and 478 DF,  p-value: 0.2619
```

```

##
##
## Response G_national :
##
## Call:
## lm(formula = G_national ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.2727 -0.1587 -0.1587 -0.1316  0.8684
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.15869    0.01794   8.845 <2e-16 ***
## STE_G_nominal     -0.15869    0.06990  -2.270  0.0236 *
## STE_G_instrumental -0.02711    0.06070  -0.447  0.6553
## STE_G_representation 0.11404    0.10927   1.044  0.2972
## STE_G_transformative 0.06353    0.12050   0.527  0.5983
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3575 on 478 degrees of freedom
## Multiple R-squared:  0.01428,    Adjusted R-squared:  0.006031
## F-statistic: 1.731 on 4 and 478 DF,  p-value: 0.1419
##
##
## Response G_multinational :
##
## Call:
## lm(formula = G_multinational ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.11111 -0.06297 -0.06297 -0.06297  0.97368
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.06297    0.01176   5.354 1.34e-07 ***
## STE_G_nominal     -0.02726    0.04582  -0.595  0.552
## STE_G_instrumental -0.03666    0.03980  -0.921  0.357
## STE_G_representation -0.06297    0.07163  -0.879  0.380
## STE_G_transformative 0.04814    0.07900   0.609  0.543
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2344 on 478 degrees of freedom
## Multiple R-squared:  0.004711,    Adjusted R-squared: -0.003618
## F-statistic: 0.5656 on 4 and 478 DF,  p-value: 0.6877
##
##
## Response G_global :
##

```



```

## Call:
## lm(formula = G_global ~ STE_G_nominal + STE_G_instrumental +
##     STE_G_representation + STE_G_transformative, data = crcdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.02771 -0.02771 -0.02771 -0.02771  0.97229
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.027708   0.007507   3.691 0.000249 ***
## STE_G_nominal    -0.027708   0.029248  -0.947 0.343949
## STE_G_instrumental -0.027708   0.025400  -1.091 0.275890
## STE_G_representation -0.027708   0.045721  -0.606 0.544793
## STE_G_transformative -0.027708   0.050423  -0.550 0.582913
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1496 on 478 degrees of freedom
## Multiple R-squared:  0.005048,    Adjusted R-squared:  -0.003277
## F-statistic: 0.6064 on 4 and 478 DF,  p-value: 0.6582

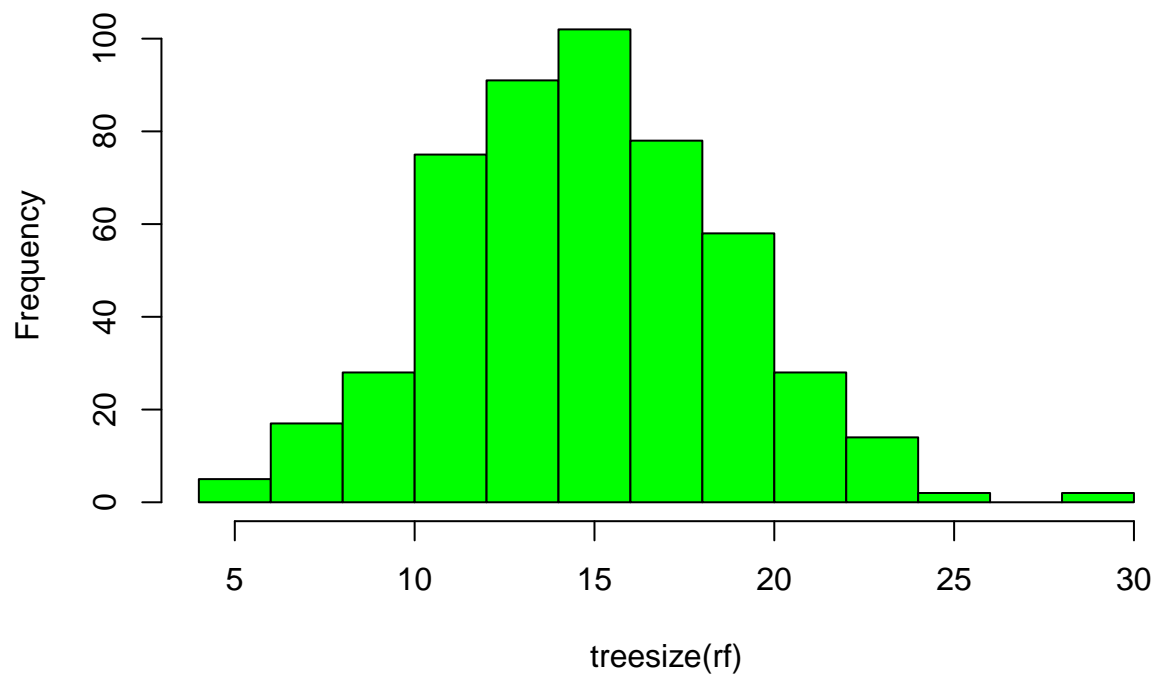
```

## ADDITIONAL ANALYSIS - ALL VARIABLES

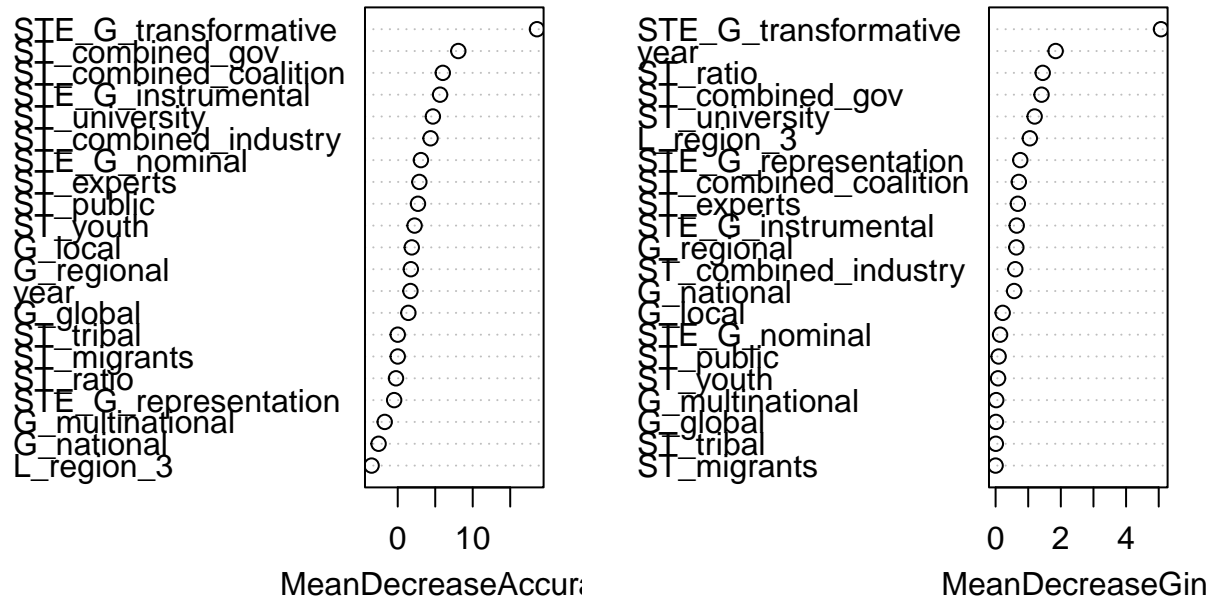
Looking at Decision Tree for all variables - with Ghodsvali scale - with solution proposed as dependent variable

```
##
## Call:
## randomForest(formula = solution_proposed_YN ~ STE_G_nominal + STE_G_instrumental + STE_G_repres
##           Type of random forest: classification
##           Number of trees: 500
## No. of variables tried at each split: 4
##
## OOB estimate of error rate: 2.42%
## Confusion matrix:
##      N Y class.error
## N 317 1 0.003144654
## Y   7 5 0.583333333
```

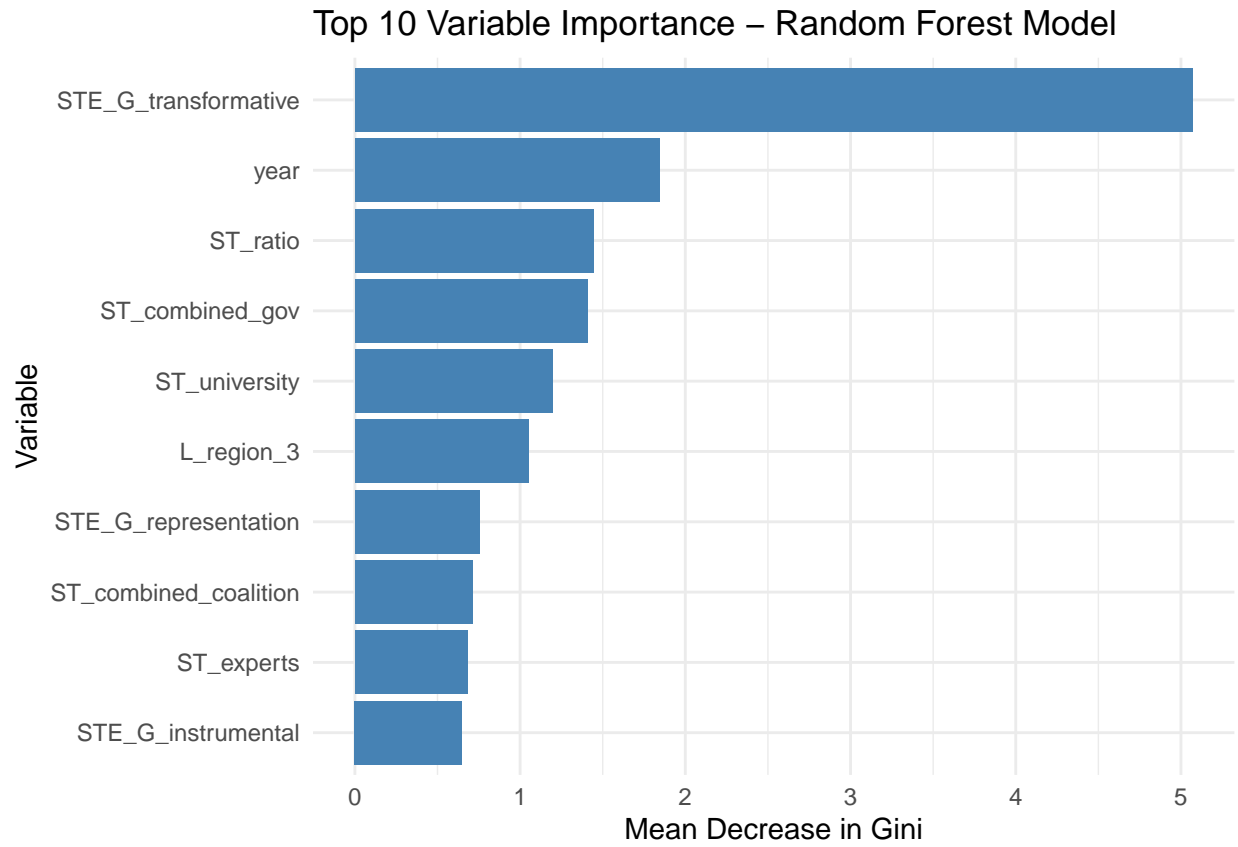
### Balanced Model – No. of Nodes for the Trees



## Balanced Model – Top 10 – Variable Importance



##	N	Y	MeanDecreaseAccuracy	MeanDecreaseGini
## STE_G_nominal	2.9278115	1.2895919	3.0910968	0.137198375
## STE_G_instrumental	6.2352532	-2.5852228	5.6449278	0.647681201
## STE_G_representation	-0.1146661	-1.1046632	-0.4769784	0.756437074
## STE_G_transformative	15.5230316	18.9027644	18.5694367	5.069771631
## ST_combined_gov	5.6213085	9.9520527	8.0778989	1.409041725
## ST_tribal	0.0000000	0.0000000	0.0000000	0.007509526
## ST_combined_coalition	6.8178602	-2.6375903	6.0102148	0.712070810
## ST_combined_industry	6.0187625	-5.0291254	4.3767371	0.603715230
## ST_migrants	0.0000000	0.0000000	0.0000000	0.000000000
## ST_youth	2.2464790	0.0000000	2.2461956	0.075491469
## ST_public	2.6826505	0.0000000	2.6977133	0.092662621
## ST_university	4.1216450	1.3659967	4.6858351	1.196934769
## ST_experts	2.6119504	2.1576750	2.8823248	0.681870242
## G_local	1.7772007	0.5453075	1.8700082	0.217988617
## G_regional	1.3512583	1.3800801	1.7467169	0.635833566
## G_national	-2.8862207	0.3503431	-2.5523338	0.568330140
## G_multinational	-1.7363062	0.0000000	-1.7366841	0.019496837
## G_global	1.4169439	0.0000000	1.4170392	0.011632594
## year	2.1682341	-1.7061691	1.6917873	1.841363838
## L_region_3	-2.8883884	-2.0557616	-3.4867335	1.050033065
## ST_ratio	-0.1903853	-0.3174168	-0.2332633	1.444727112

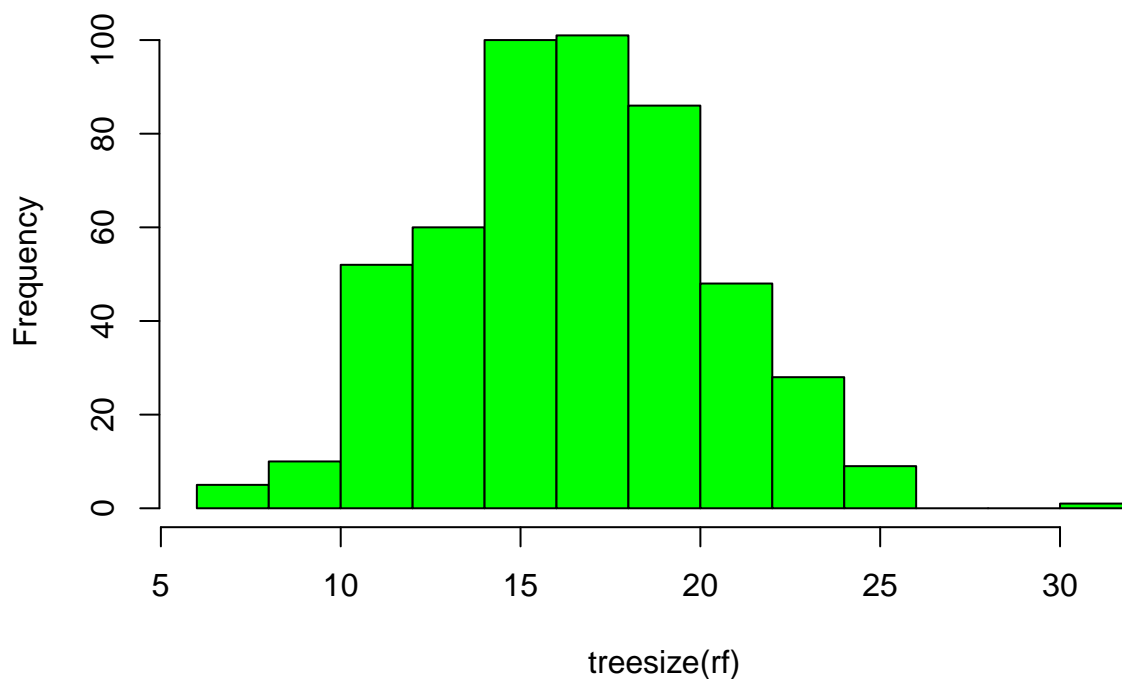


## ADDITIONAL ANALYSIS - ALL VARIABLES - minus scaling

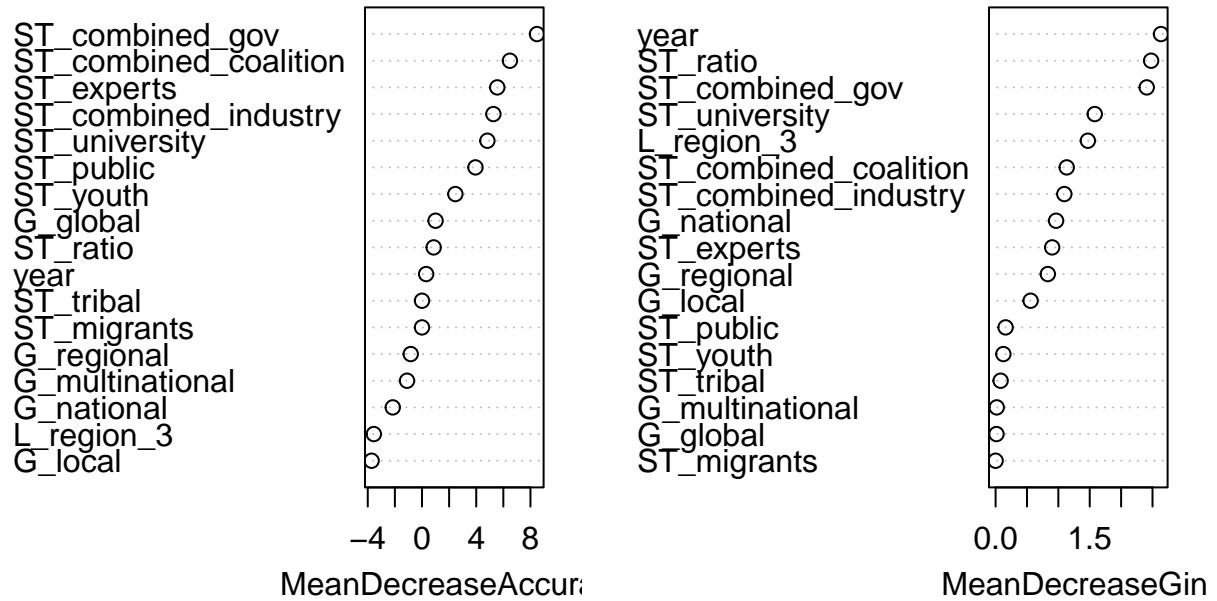
Looking at Decision Tree for all variables - minus the Ghodsvali scale - with solution proposed as dependent variable

```
##  
## Call:  
## randomForest(formula = solution_proposed_YN ~ ST_combined_gov + ST_tribal + ST_combined_coalit.  
##           Type of random forest: classification  
##           Number of trees: 500  
## No. of variables tried at each split: 4  
##  
##           OOB estimate of  error rate: 4.24%  
## Confusion matrix:  
##      N Y class.error  
## N 316 2 0.006289308  
## Y   12 0 1.000000000
```

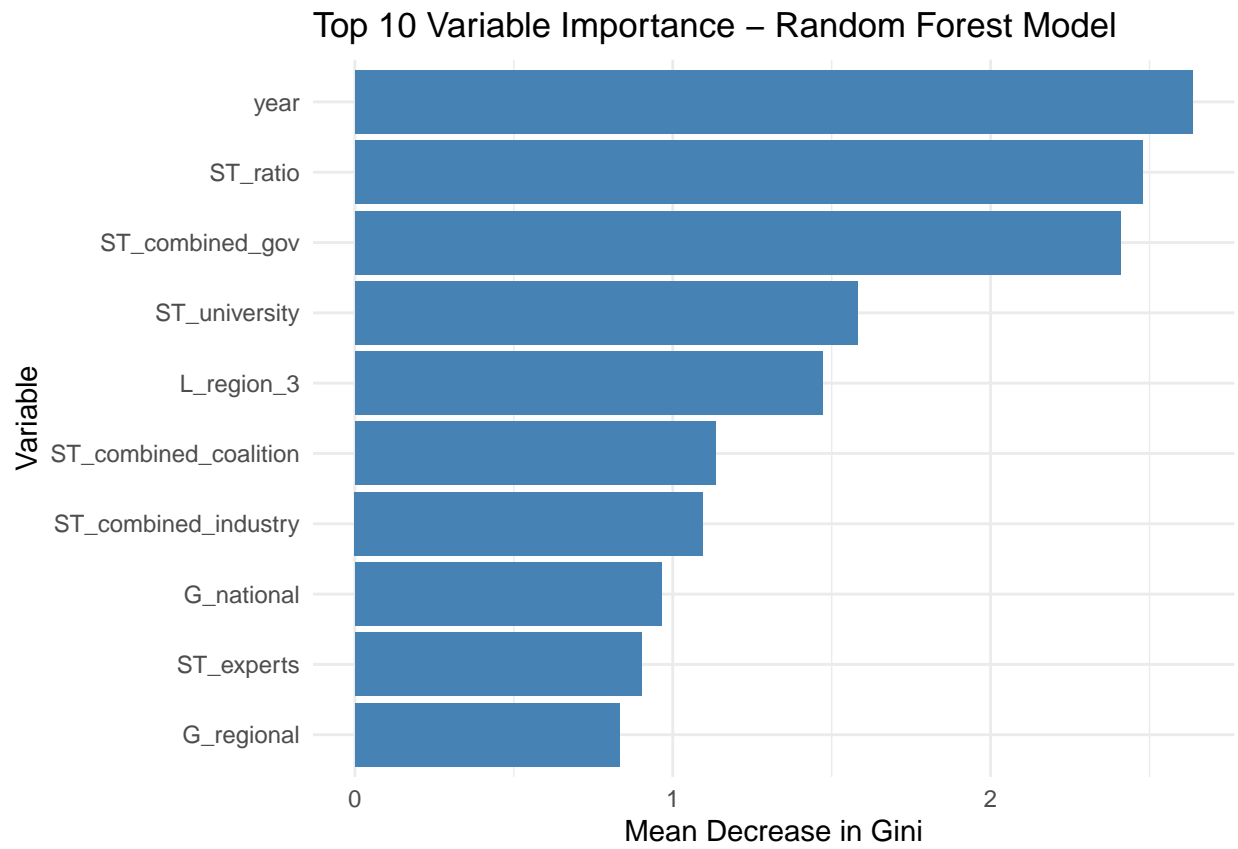
### Balanced Model – No. of Nodes for the Trees



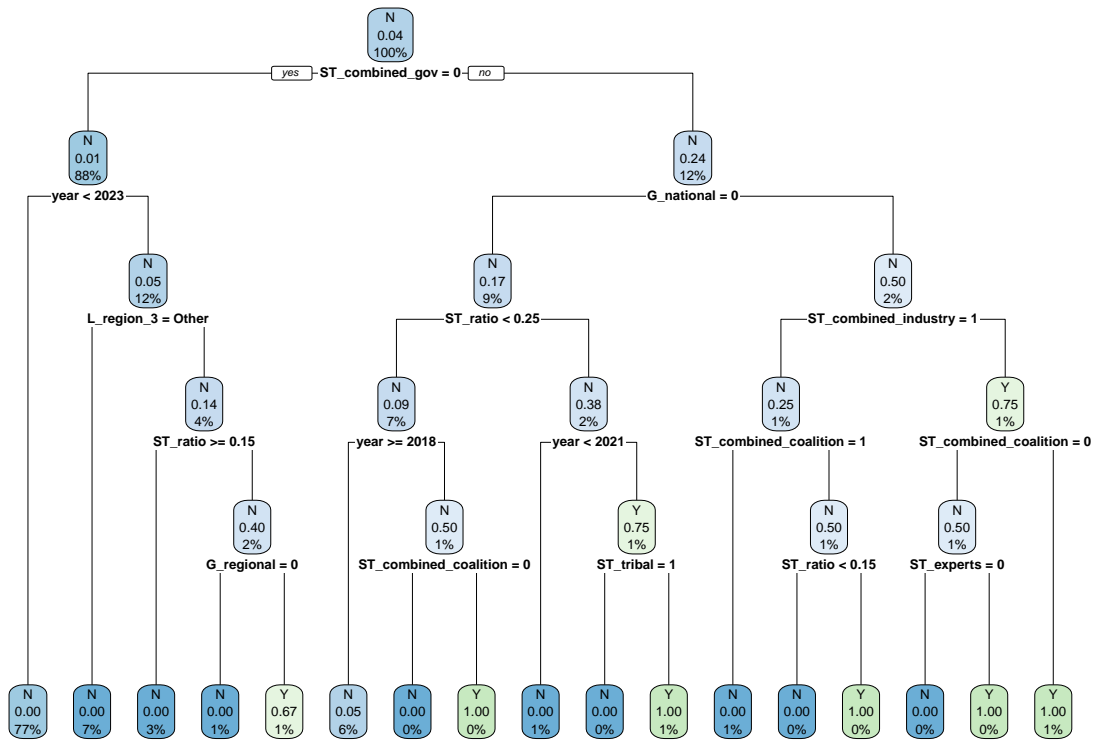
## Balanced Model – Top 10 – Variable Importance



##	N	Y	MeanDecreaseAccuracy	MeanDecreaseGini
## ST_combined_gov	5.8938680	10.1967214	8.4810617	2.40809214
## ST_tribal	0.0000000	0.0000000	0.0000000	0.08021835
## ST_combined_coalition	7.0511501	-2.1781024	6.4852868	1.13321574
## ST_combined_industry	7.0494428	-5.8103249	5.2650193	1.09489162
## ST_migrants	0.0000000	0.0000000	0.0000000	0.00000000
## ST_youth	2.4617798	0.0000000	2.4615644	0.12377439
## ST_public	3.9484772	0.0000000	3.9440283	0.15932306
## ST_university	4.1380240	2.2938248	4.8235225	1.57999093
## ST_experts	6.1203081	-0.8233244	5.5526917	0.90149153
## G_local	-2.9412037	-2.7251522	-3.7179671	0.55779205
## G_regional	-0.6413349	0.1106842	-0.8323375	0.83211241
## G_national	-2.9434811	1.4404803	-2.1549511	0.96431858
## G_multinational	-2.2466769	1.4083490	-1.1025788	0.01785968
## G_global	1.0010015	0.0000000	1.0010015	0.01394673
## year	1.9345996	-3.5434831	0.3068396	2.63517878
## L_region_3	-3.7310130	-0.2058022	-3.5522732	1.47038408
## ST_ratio	0.2433945	1.0884088	0.8612719	2.47790374



## Representative Decision Tree Plot - Balanced Model - Minus Scaling



```
## [1] "Constructing distance matrix..."
## [1] "Finding representative trees..."
```

```
## [1] "Constructing distance matrix..."
## [1] "Finding representative trees..."
```