# TITLE X

Supplemental materials for submittal to X

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## Contents

## 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

3 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: 17: Not Independent**

Both chi square and fishers exact test were significant, with a chi square approximation of ~43, which is well above the critical value (3.84 with one degree of freedom). Fishers Exact Test returned an odds ratio of ~17. 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 17 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
```

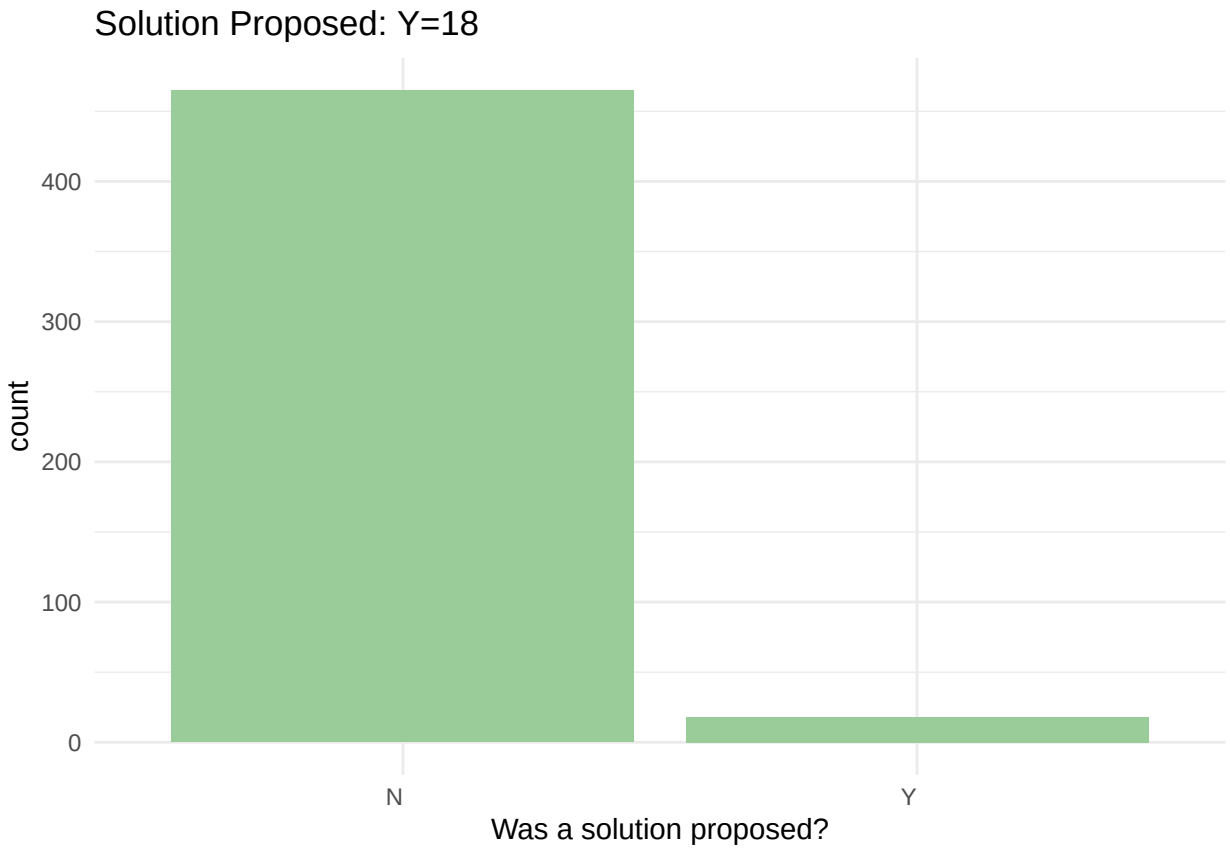
```
##
##  Fisher's Exact Test for Count Data
##
## data:  solution_stakeholder
## p-value = 4.019e-08
## alternative hypothesis: true odds ratio is not equal to 1
## 95 percent confidence interval:
##   5.385841 76.064980
## sample estimates:
## odds ratio
##   17.75835
```

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

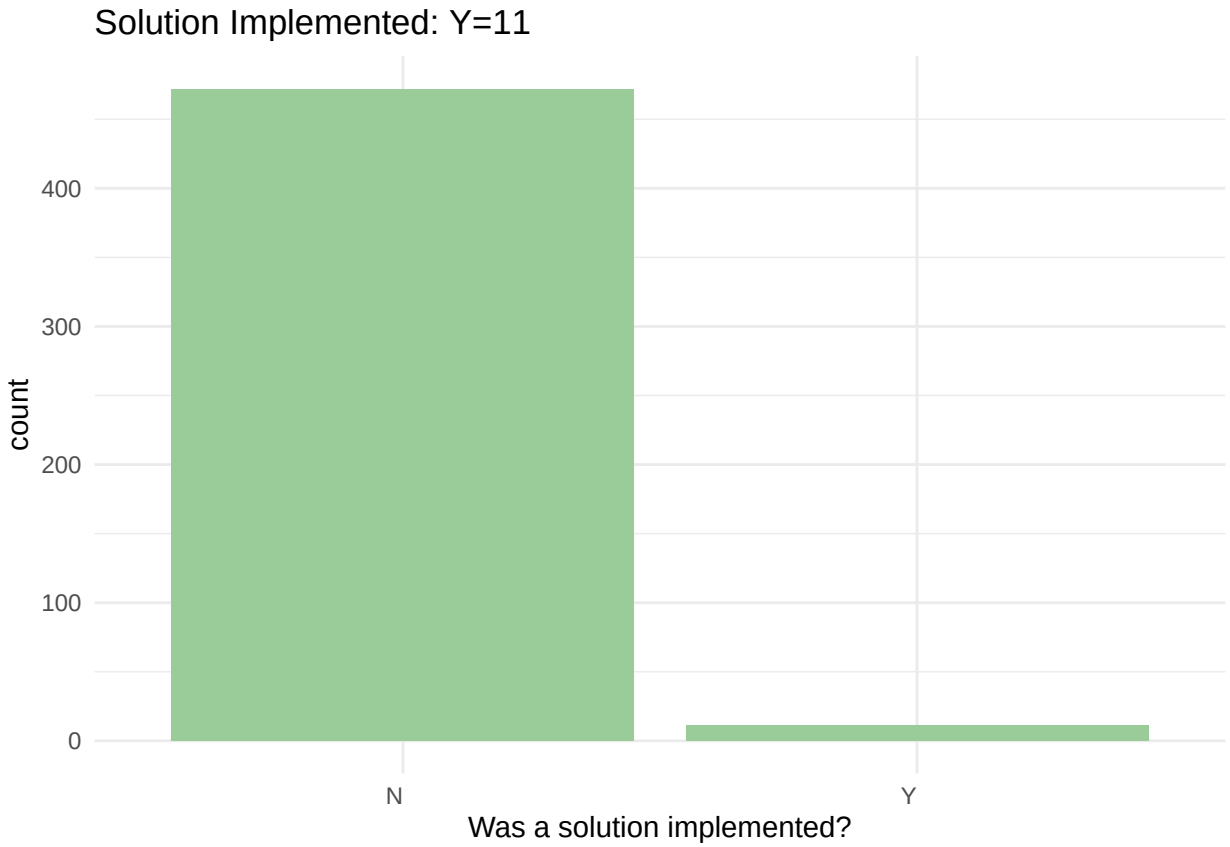
```
## Null hypothesis: Treatments have no effect on the outcomes
## Score statistic = 4.48684
## Nuisance parameter = 0.99 (One sided), 0.01 (Two sided)
## P-value = 0.000218524 (One sided), 0.000218524 (Two sided)

##                      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

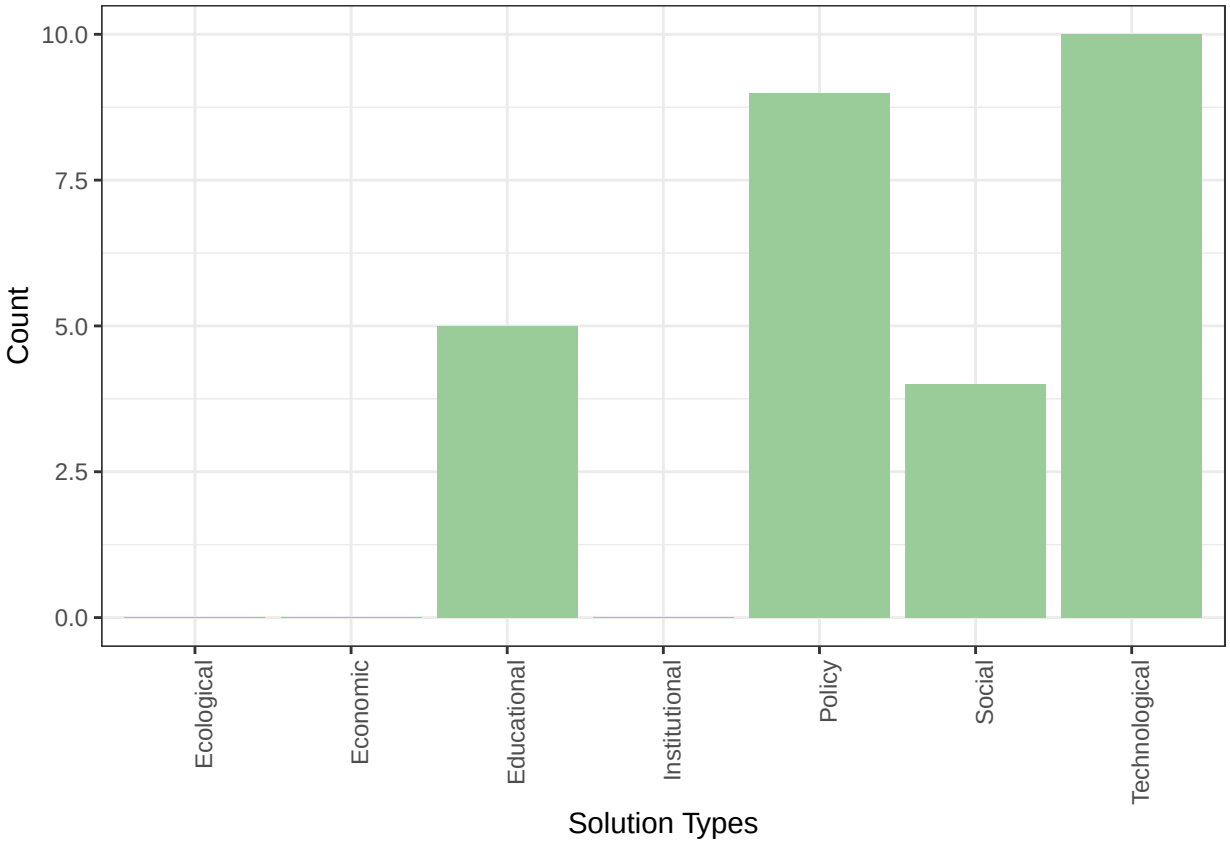
### Were solutions proposed in the set of all papers?



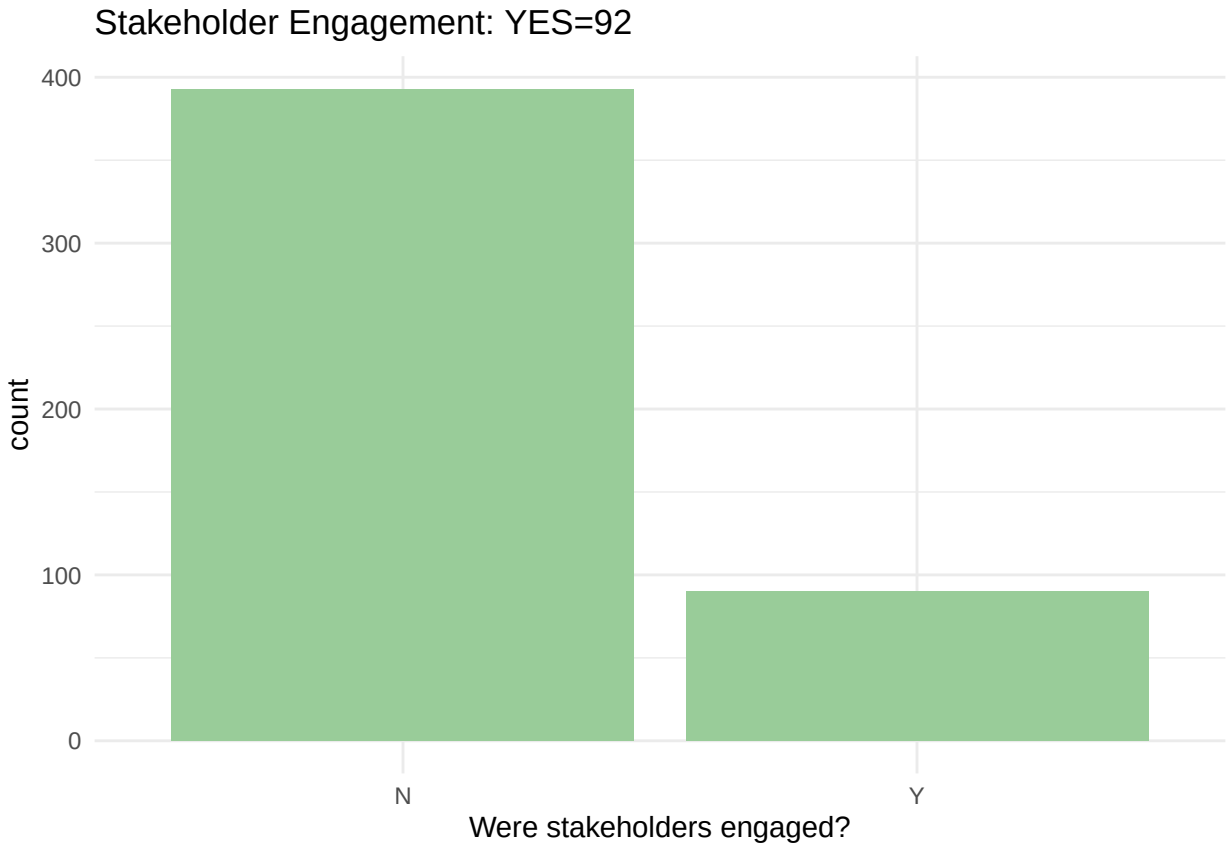
**Were solutions implemented in the set of all papers?**



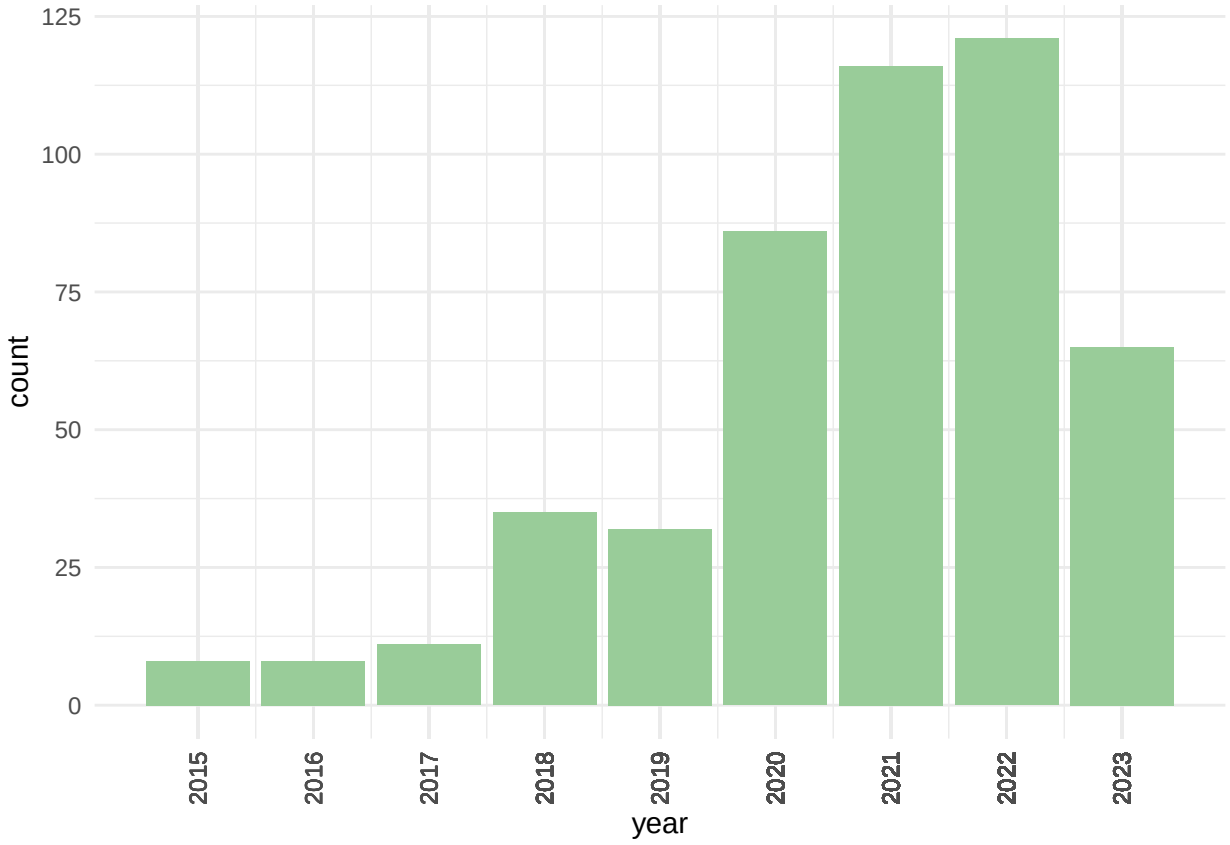
**What were the solution types?**



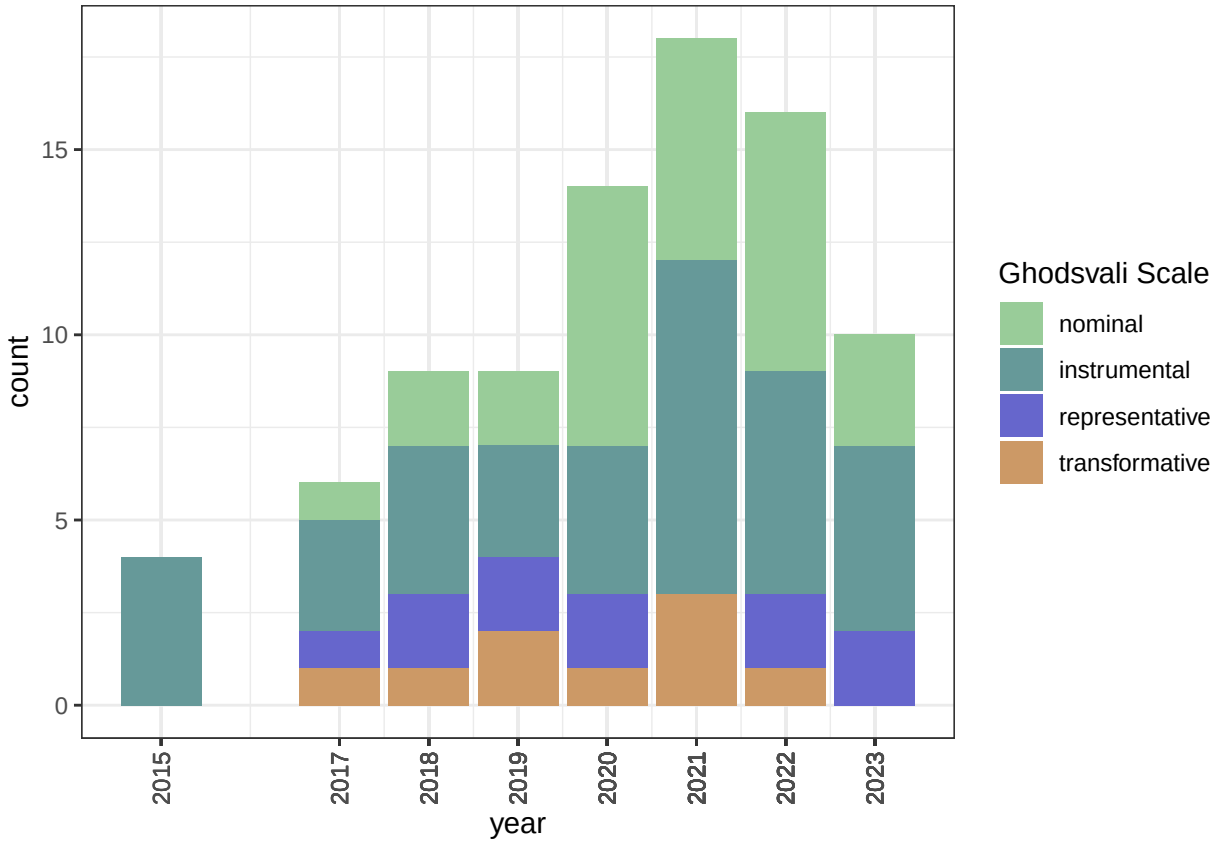
**Were stakeholders engaged?**



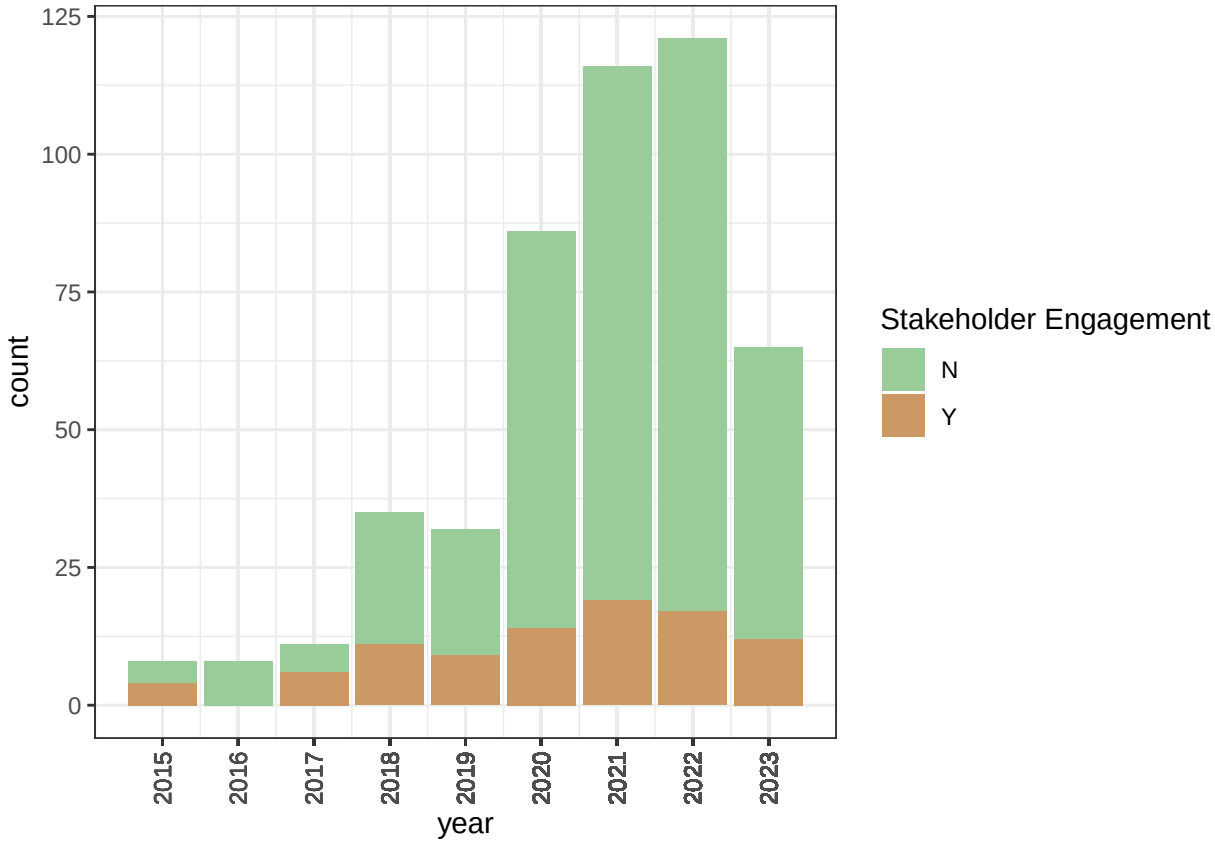
**All FEWS papers by year**



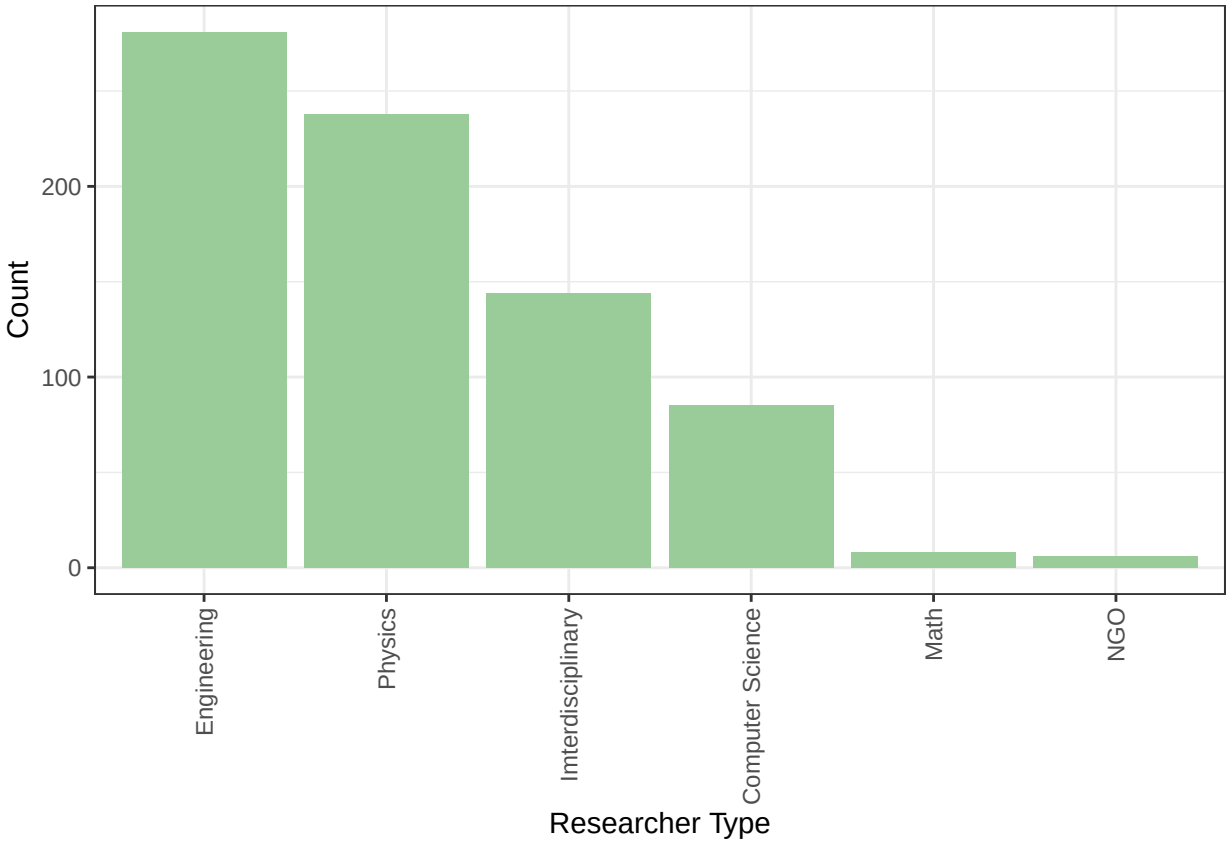
**Level of stakeholder engagement by year - Ghodsvali scale**



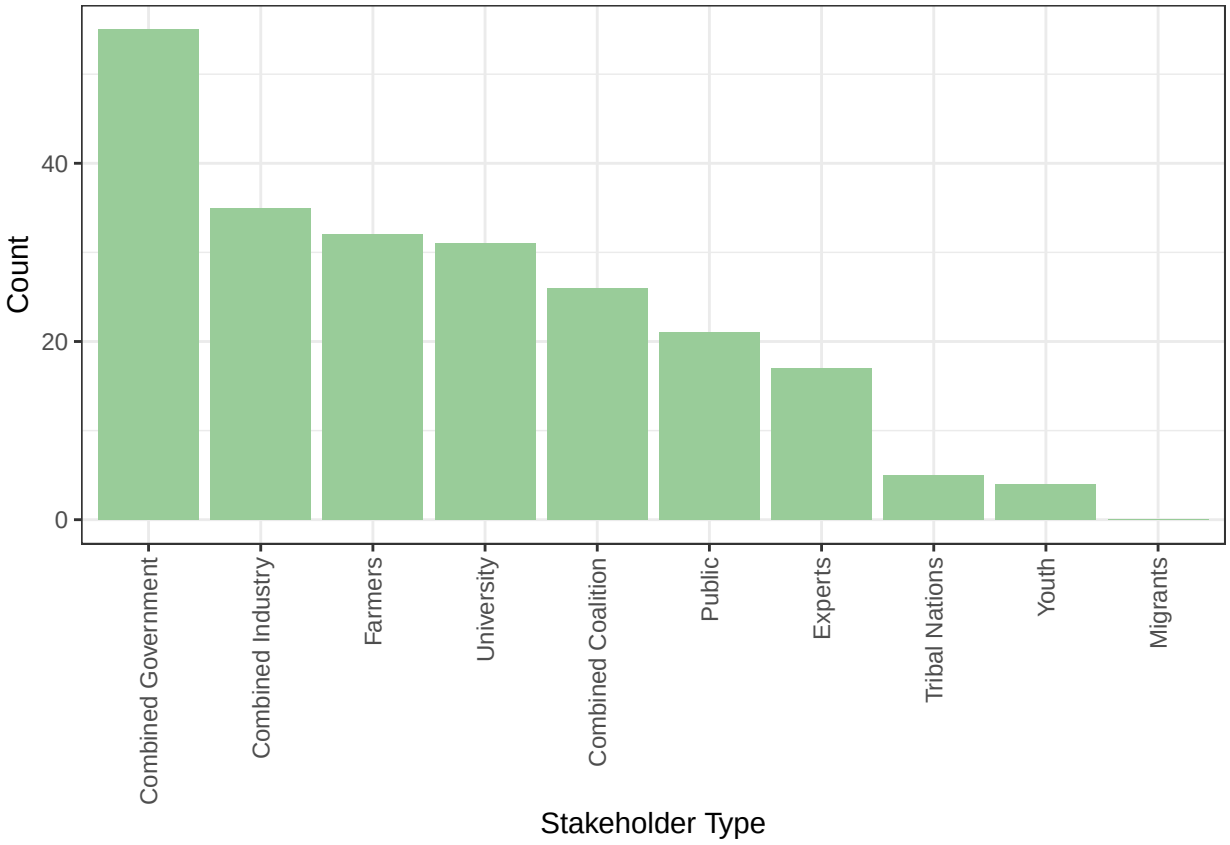
**Stakeholder engagement by year**



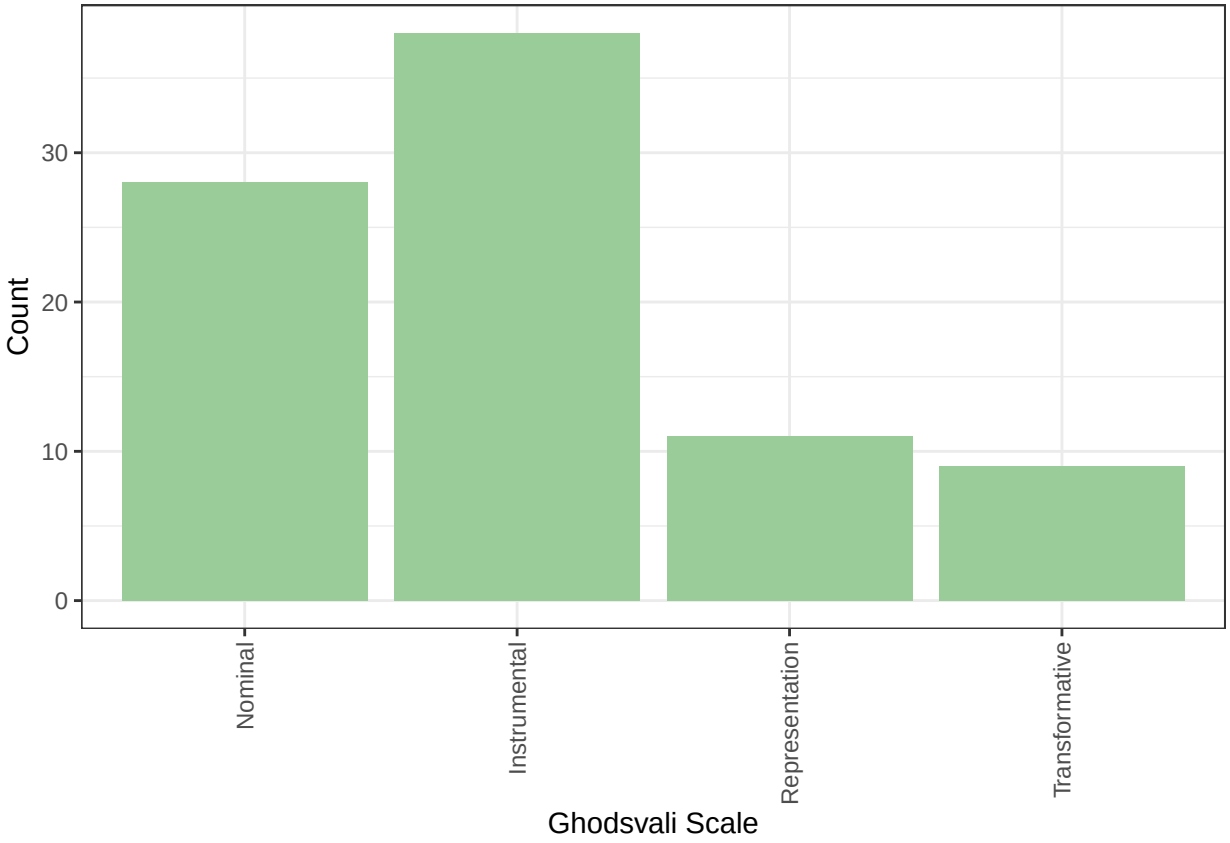
**Researcher types**



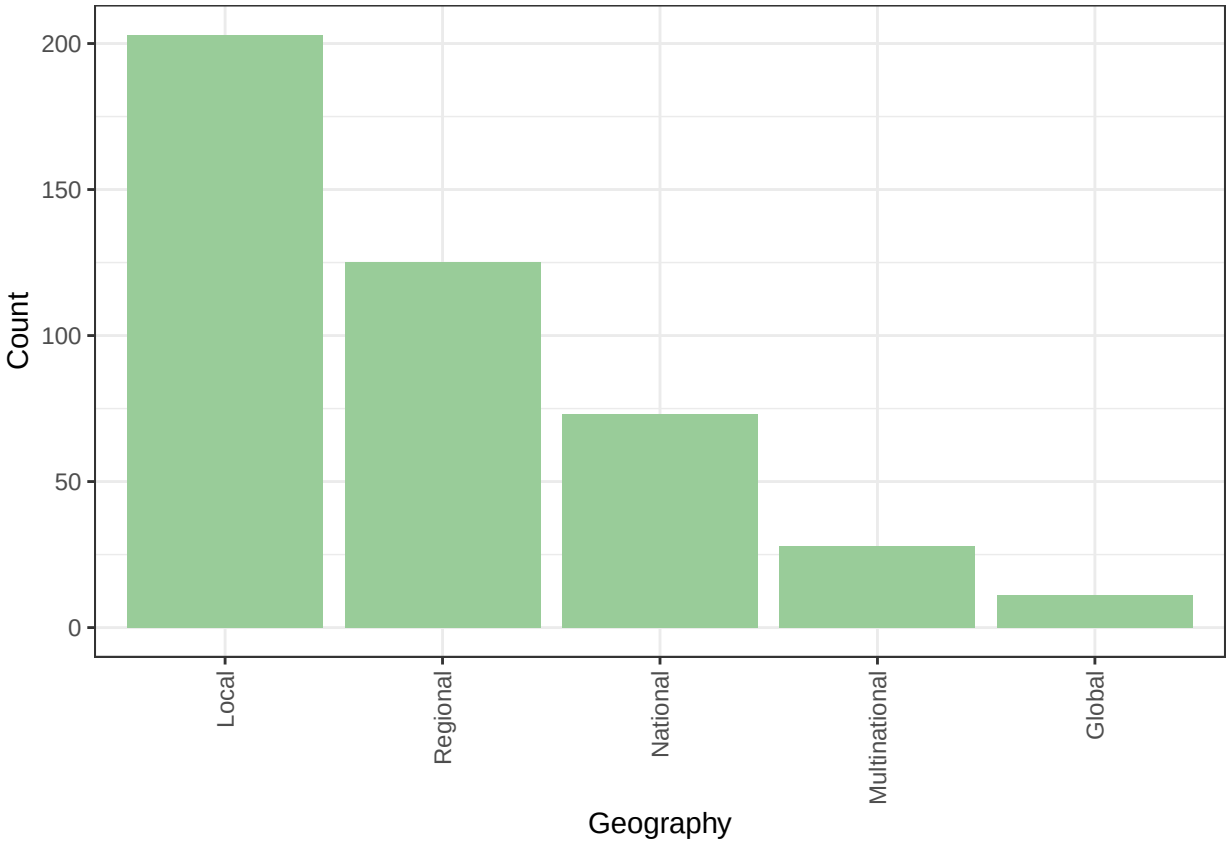
**Stakeholder types**



**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

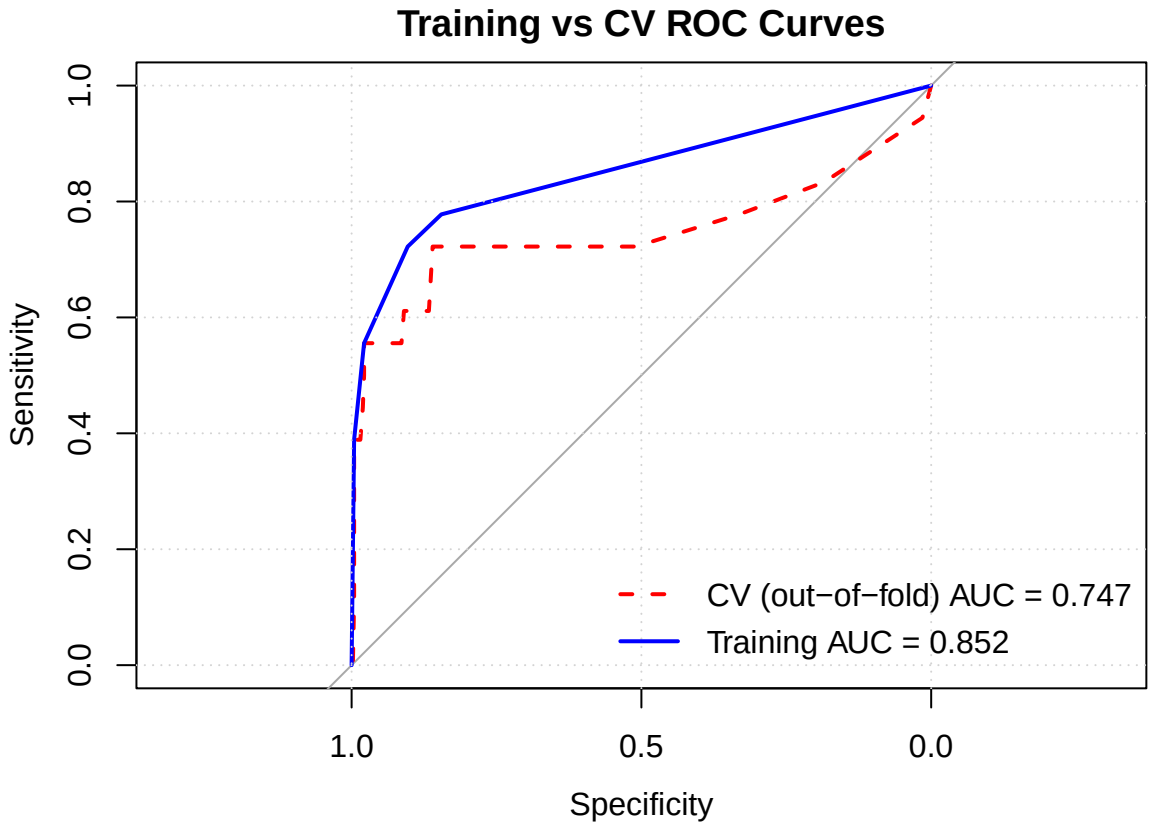
Odds of Ghodsvali scale predicting whether a solution was proposed or not

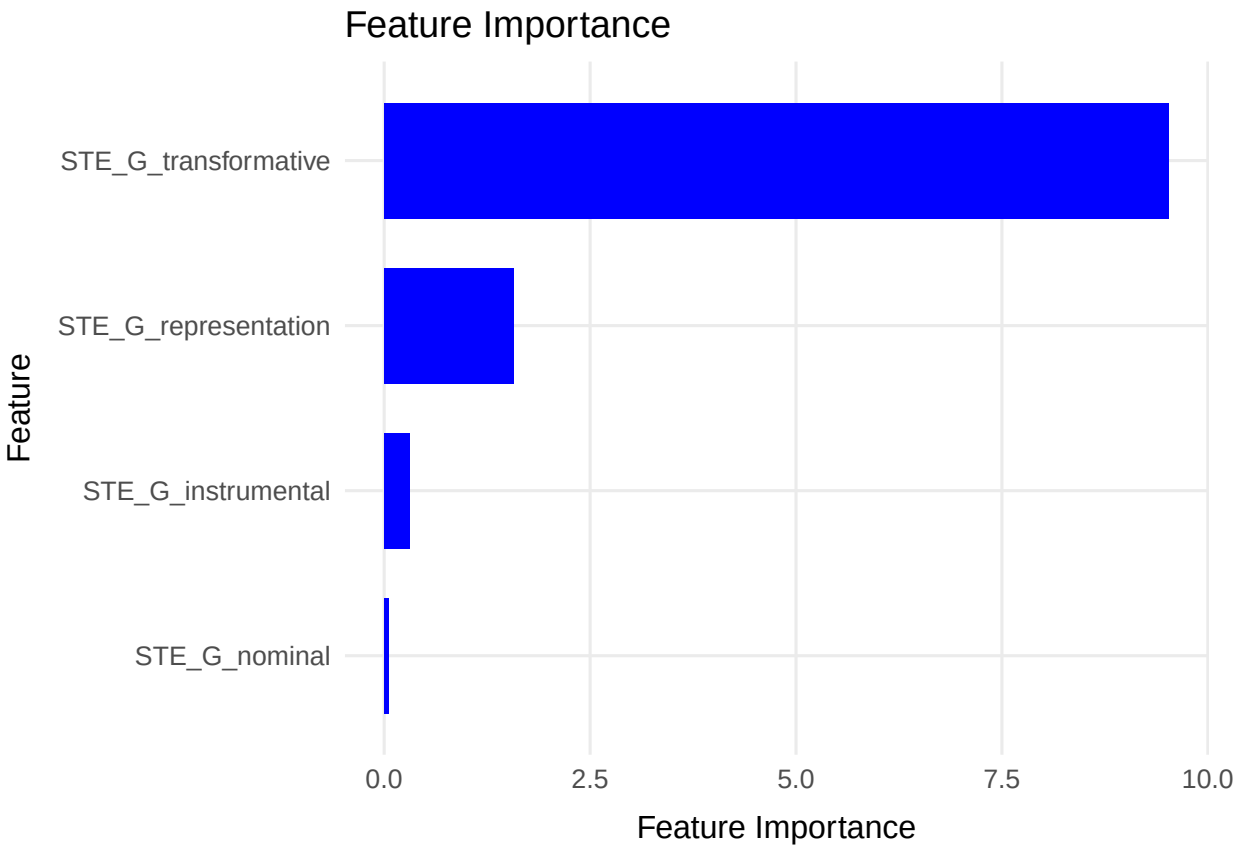
```
##
## Logistic regression predicting solution_proposed_YN : Y vs N
##
##                               crude OR(95%CI)        adj. OR(95%CI)          P(Wald's test) P(LR-tes
## STE_G_nominal: 1 vs 0         0.95 (0.12,7.44)       3.64 (0.39,33.7)        0.255          0.318
##
## STE_G_instrumental: 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

```
## **Random forest (ranger).** 1000 trees; mtry=2; min.node.size=20; 5-fold CV.

## **CV AUC:** 0.818 (SD=0.197).  **n:** 483.  **Class counts:** N=465, Y=18.

## **Top features:** STE_G_transformative, STE_G_representation, STE_G_instrumental.
```




Feature Importance
STE_G_transformative
STE_G_representation
STE_G_instrumental
STE_G_nominal
Feature
0.0
2.5
5.0
7.5
10.0
Feature Importance

# 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 calcuation 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.

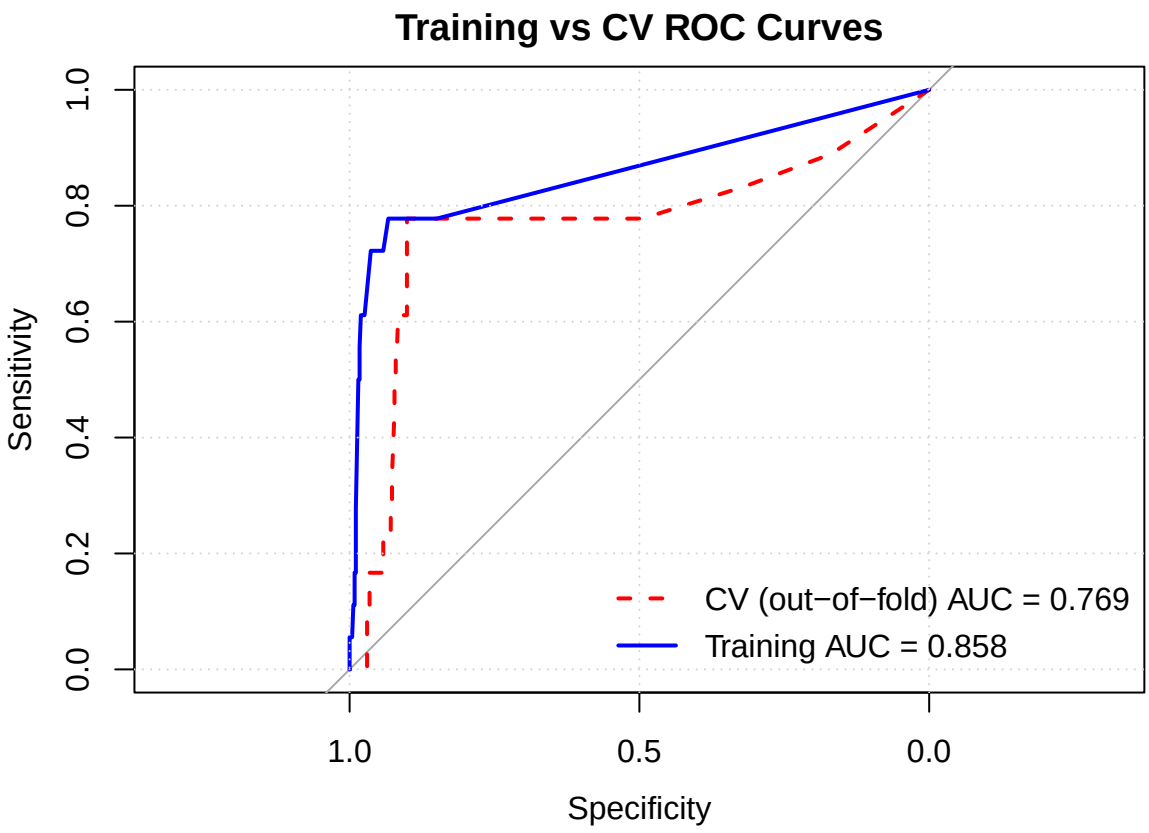
```
##
## Logistic regression predicting solution_proposed_YN : Y vs N
##
##                                 crude OR(95%CI)      adj. OR(95%CI)        P(Wald's test) P(LR-test)
## ST_farmers: 1 vs 0              6.24 (2.07,18.79)    1.8 (0.44,7.43)       0.417          0.42
##
## ST_combined_gov: 1 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
```

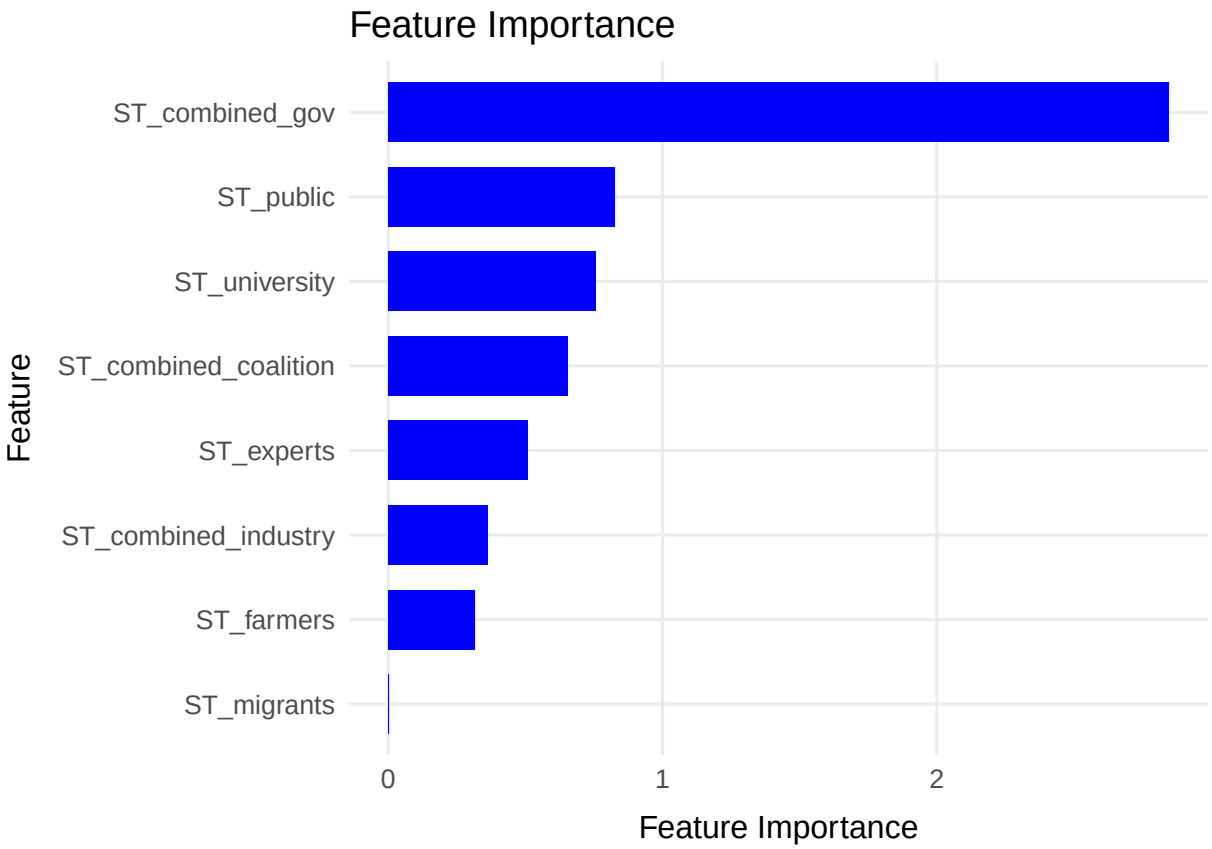
## DECISION TREE: Ensembed Decision Tree - Diversity of stakeholders vs solution –>

```
## **Random forest (ranger).** 1000 trees; mtry=2; min.node.size=30; 5-fold CV.
```

```
## **CV AUC:** 0.826 (SD=0.113).  **n:** 483.  **Class counts:** N=465, Y=18.
```

```
## **Top features:** ST_combined_gov, ST_public, ST_university.
```


Training vs CV ROC Curves
Sensitivity
0.0
0.2
0.4
0.6
0.8
1.0
1.0
0.5
0.0
Specificity
CV (out−of−fold) AUC = 0.769
Training AUC = 0.858


Feature Importance
ST_combined_gov
ST_public
ST_university
ST_combined_coalition
ST_experts
ST_combined_industry
ST_farmers
ST_migrants
Feature
0
1
2
Feature Importance

# 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
```

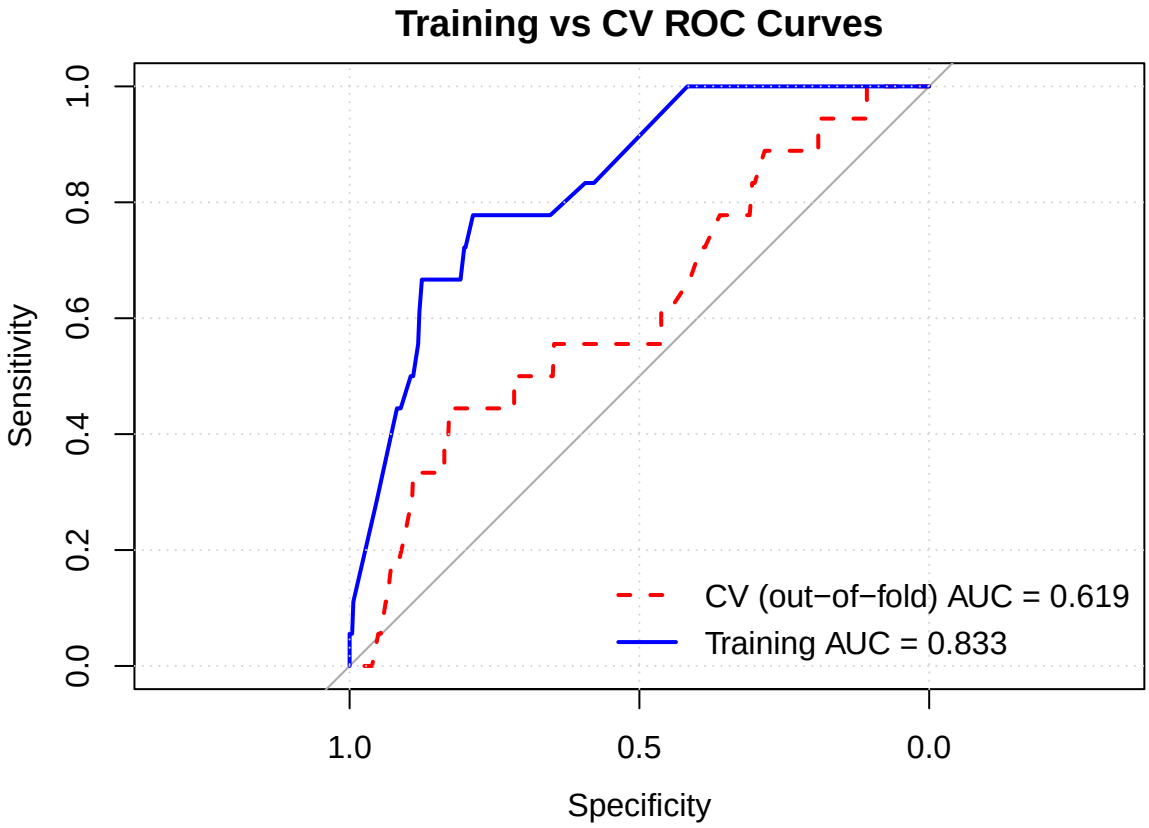
## ODDS RATIOS: Does researcher type increase the likelihood that a solution will be proposed?

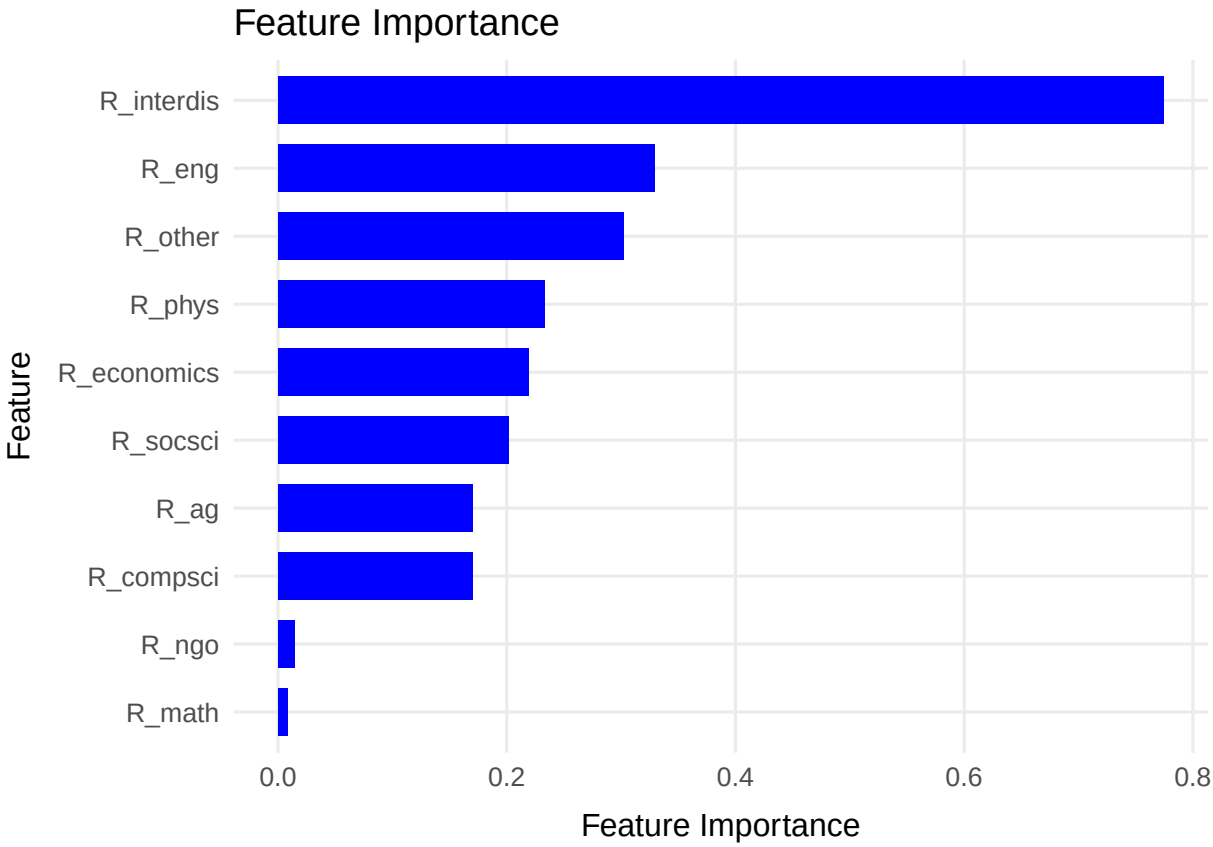
Odds of whether researcher type predicts if a solution was proposed (Y/N). A ratio which is closer to 1 has a greater level of researcher diversity.

```
##
## Logistic regression predicting solution_proposed_YN : Y vs N
##
##                       crude OR(95%CI)    adj. OR(95%CI)     P(Wald's test) P(LR-test)
## R_ngo: 1 vs 0         0 (0,Inf)          0 (0,Inf)          0.992          0.481
##
## R_eng: 1 vs 0         0.44 (0.17,1.16)   0.54 (0.19,1.53)   0.247          0.242
##
## R_math: 1 vs 0        0 (0,Inf)          0 (0,Inf)          0.992          0.661
##
## R_compsci: 1 vs 0     0.93 (0.26,3.3)    0.92 (0.25,3.4)    0.896          0.895
##
## R_phys: 1 vs 0        0.82 (0.32,2.11)   0.77 (0.28,2.09)   0.609          0.608
##
## R_interdis: 1 vs 0    5.05 (1.86,13.72)  4.52 (1.58,12.88)  0.005          0.004
##
## R_socsci: 1 vs 0      0.93 (0.26,3.3)    0.68 (0.18,2.52)   0.565          0.552
##
## R_economics: 1 vs 0   0.33 (0.04,2.49)   0.37 (0.05,3.01)   0.355          0.293
##
## R_ag: 1 vs 0          0.5 (0.11,2.21)    0.68 (0.15,3.17)   0.628          0.614
##
## R_other: 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 Ensembed Decision Tree - researcher type vs solution**

```
## **Random forest (ranger).** 1000 trees; mtry=2; min.node.size=30; 5-fold CV.

## **CV AUC:** 0.635 (SD=0.141).  **n:** 483.  **Class counts:** N=465, Y=18.

## **Top features:** R_interdis, R_eng, R_other.
```




Feature Importance
R_interdis
R_eng
R_other
R_phys
R_economics
R_socsci
R_ag
R_compsci
R_ngo
R_math
Feature
0.0
0.2
0.4
0.6
0.8
Feature Importance

# 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?

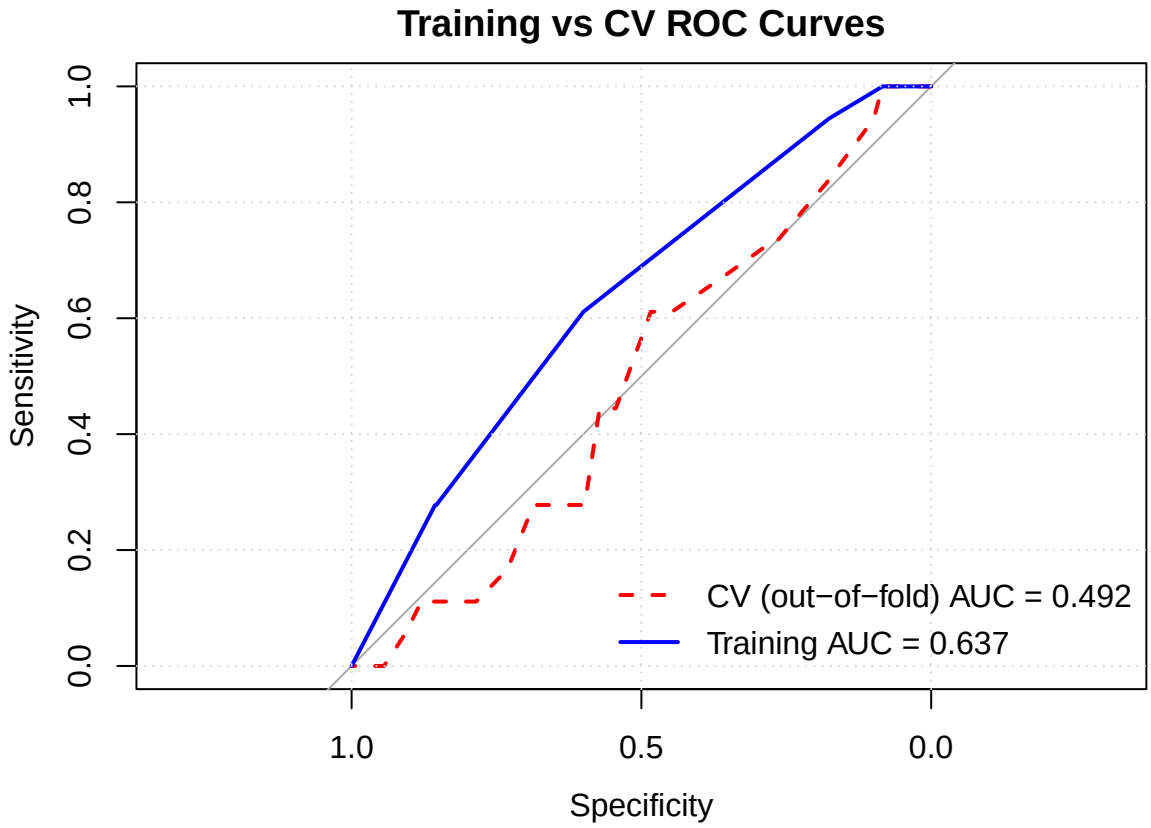
```
##
## Call:
## glm(formula = solution_proposed_YN ~ G_local + G_regional + G_national +
##     G_multinational + G_global, family = binomial, data = crcdata)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.5090  -0.3117  -0.2450  -0.2450   2.7091
##
## Coefficients:
##                  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
```

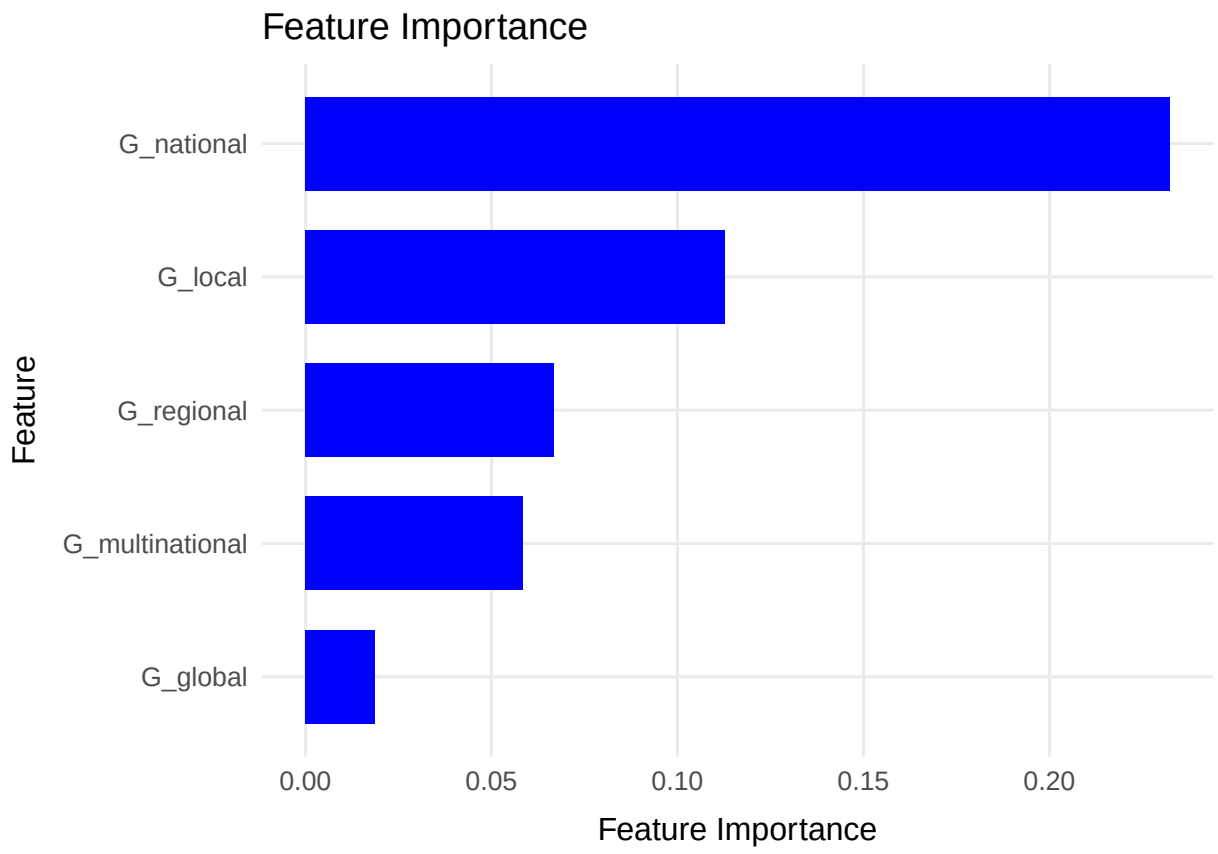
**ODDS RATIOS: Does the geographic location of the study increase the likelihood of proposed/implemented solutions?**

```
##
## 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 Ensembed Decision Tree - Geographic area vs solution**

```
## **Random forest (ranger).** 1000 trees; mtry=2; min.node.size=20; 5-fold CV.

## **CV AUC:** 0.492 (SD=0.124).  **n:** 483.  **Class counts:** N=465, Y=18.

## **Top features:** G_national, G_local, G_regional.
```




Feature Importance
G_national
G_local
G_regional
G_multinational
G_global
Feature
0.00
0.05
0.10
0.15
0.20
Feature Importance

## 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).**

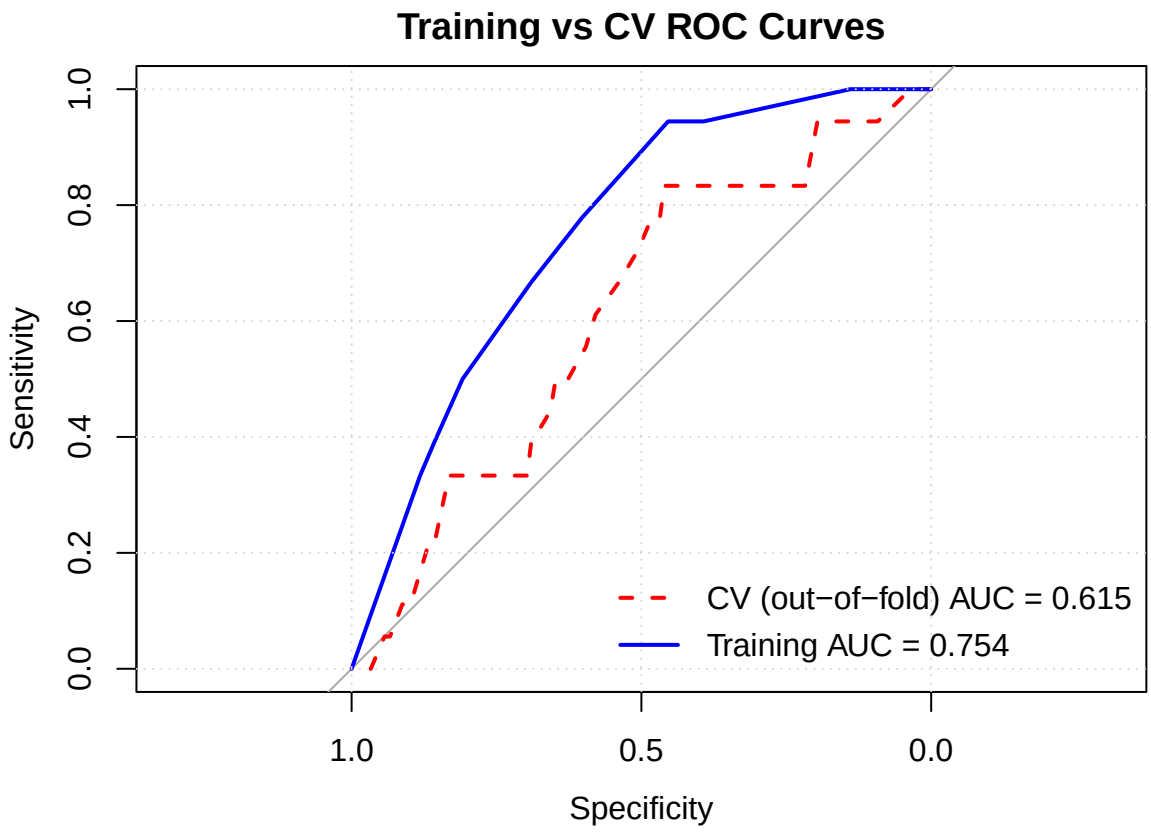
```
##                              OR       2.5 %      97.5 %
## (Intercept)          0.01880342 0.008077381  0.04377268
## L_region_3EuropeAsia 4.45134158 1.519125103 13.04332462
## L_region_3GlobalME   3.95567490 1.096799990 14.26637862
```

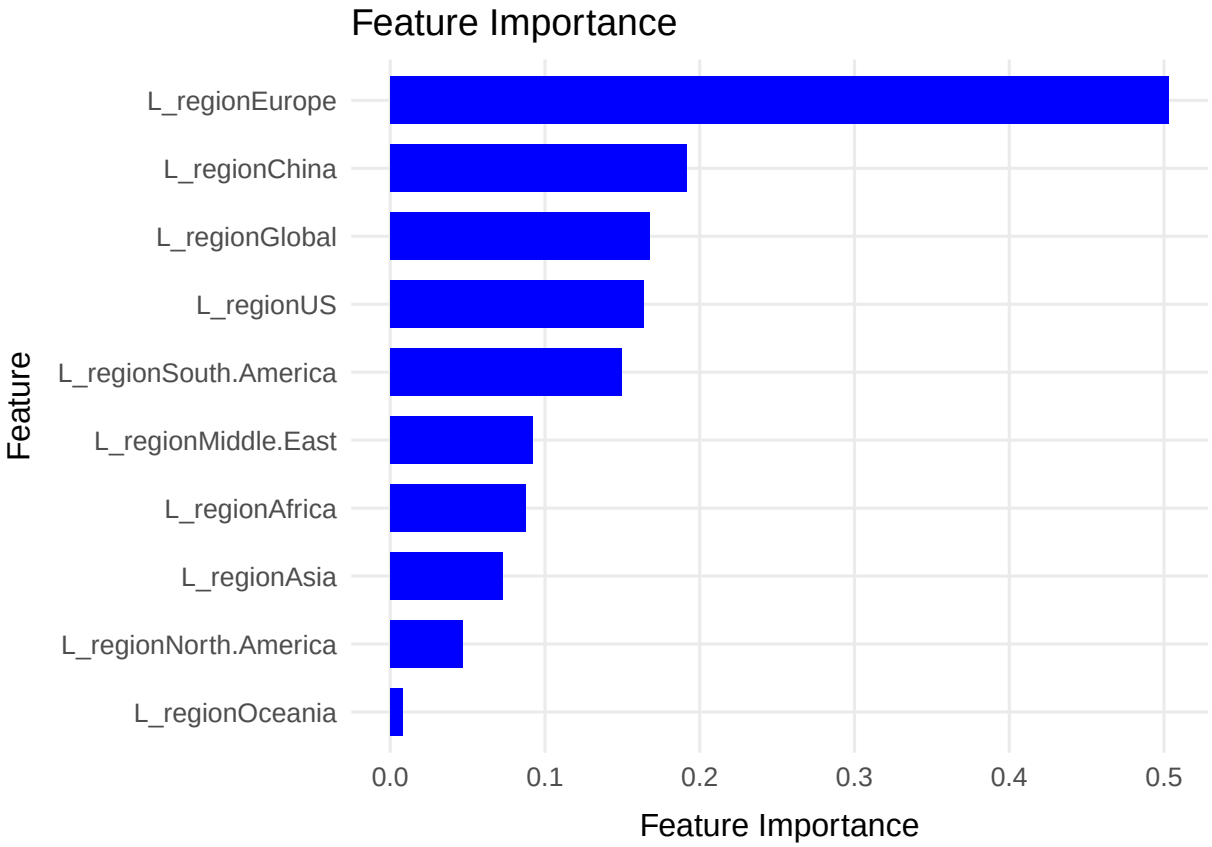
### DECISON TREE: Region area Ensembed Decision Tree - Region area vs solution

## **Random forest (ranger).** 1000 trees; mtry=2; min.node.size=30; 5-fold CV.

## **CV AUC:** 0.635 (SD=0.120).  **n:** 441.  **Class counts:** N=423, Y=18.

## **Top features:** L_regionEurope, L_regionChina, L_regionGlobal.




Feature Importance
L_regionEurope
L_regionChina
L_regionGlobal
L_regionUS
L_regionSouth.America
L_regionMiddle.East
L_regionAfrica
L_regionAsia
L_regionNorth.America
L_regionOceania
Feature
0.0
0.1
0.2
0.3
0.4
0.5
Feature Importance

# 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
```

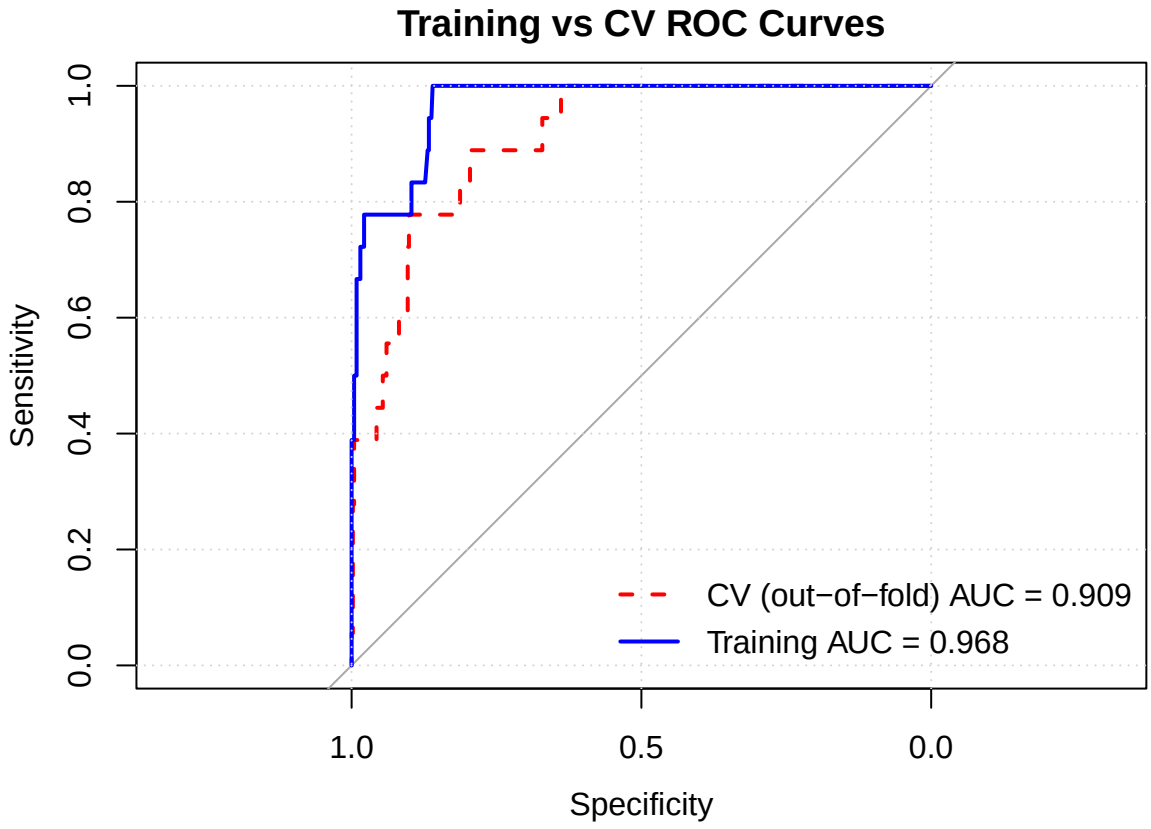
# ADDITIONAL ANALYSIS - ALL VARIABLES

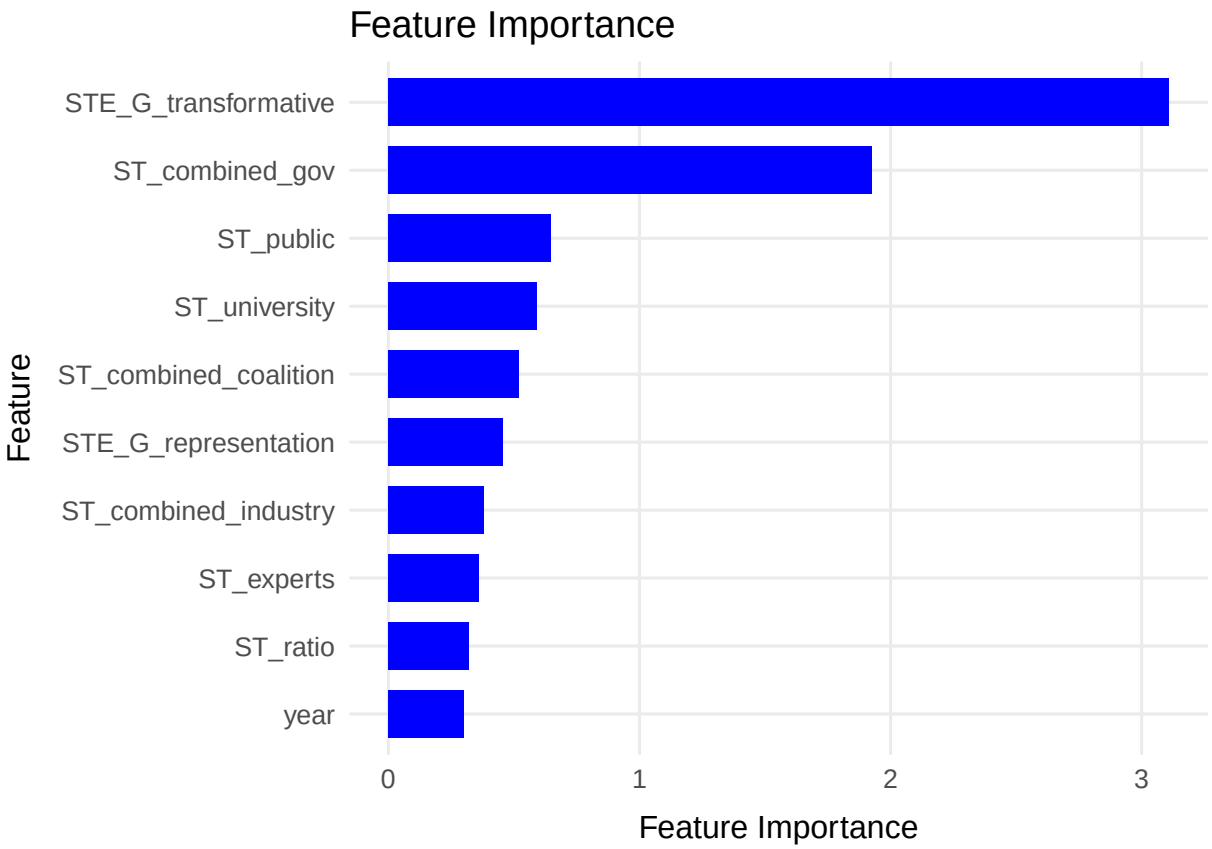
### Looking at Decision Tree for all variables - with Ghodsvali scale - with solution proposed as dependent variable

## **Random forest (ranger).** 1000 trees; mtry=2; min.node.size=40; 5-fold CV.

## **CV AUC:** 0.939 (SD=0.053).  **n:** 483.  **Class counts:** N=465, Y=18.

## **Top features:** STE_G_transformative, ST_combined_gov, ST_public.

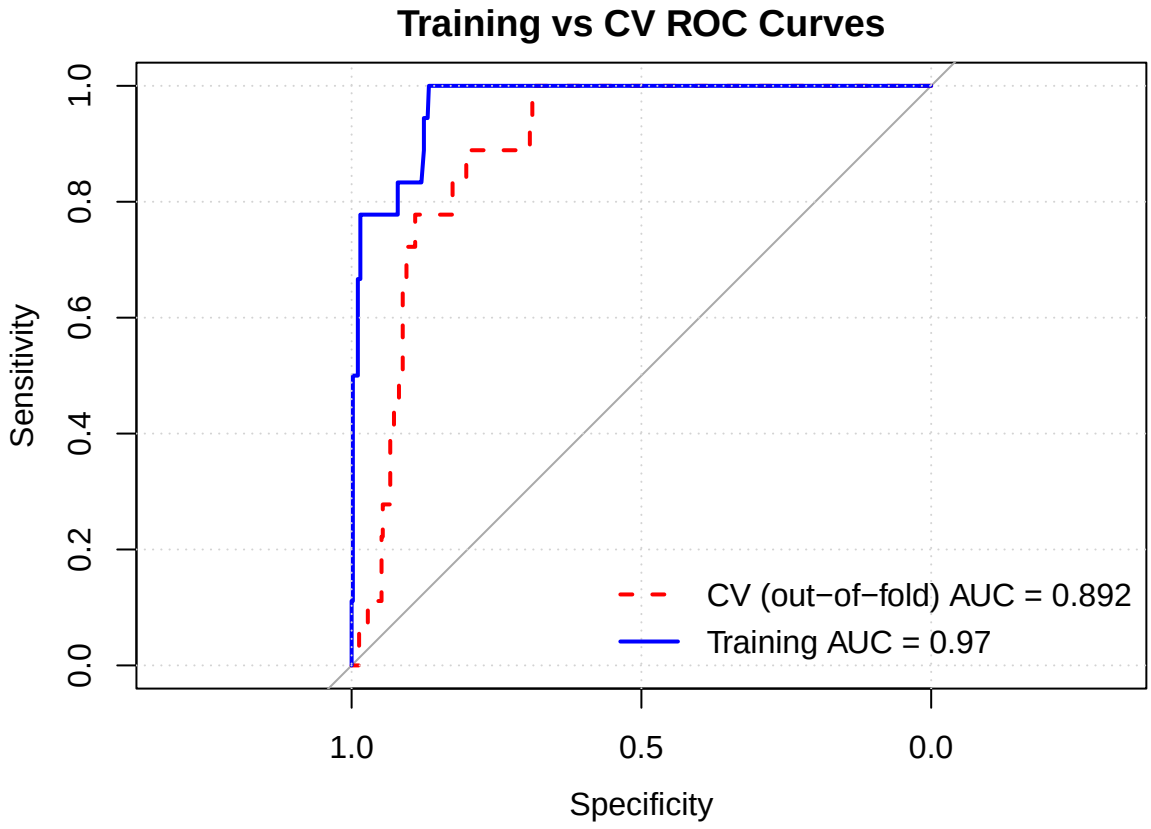


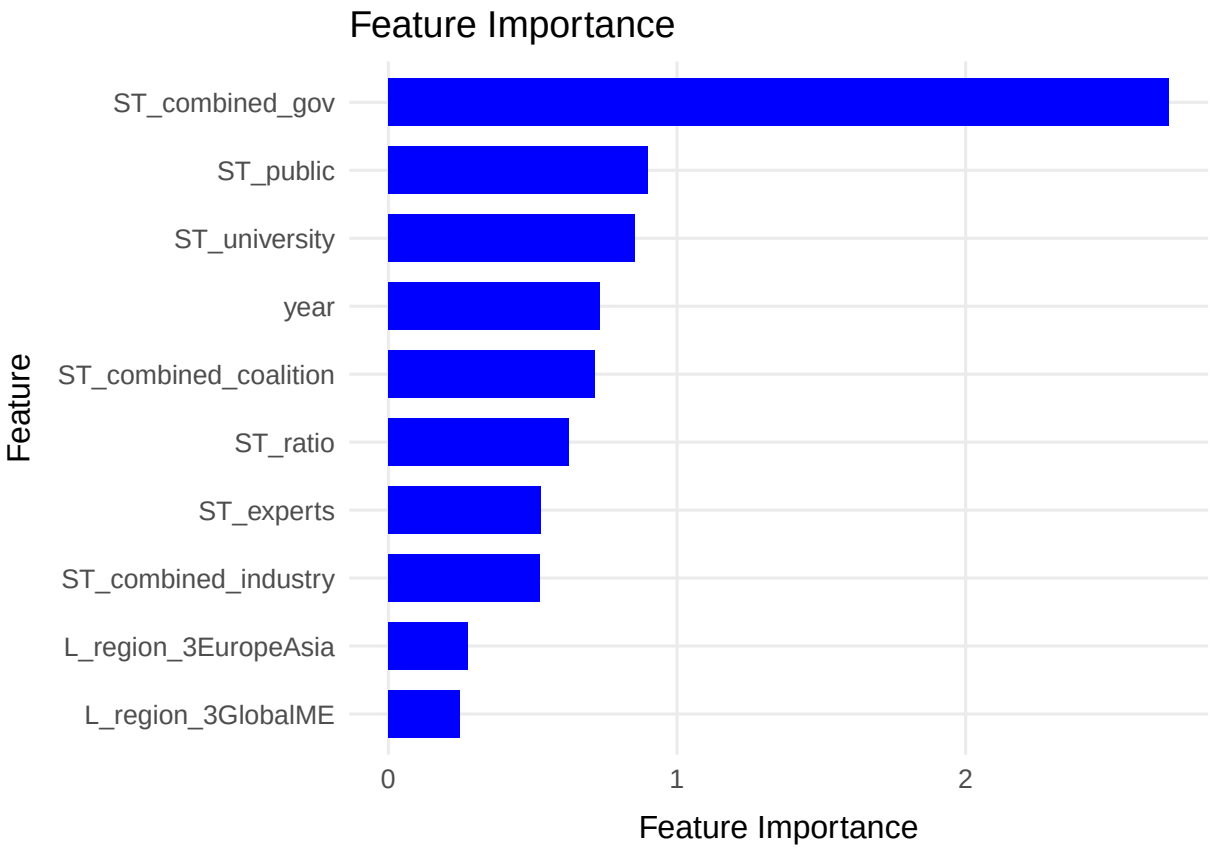

Feature Importance
STE_G_transformative
ST_combined_gov
ST_public
ST_university
ST_combined_coalition
STE_G_representation
ST_combined_industry
ST_experts
ST_ratio
year
Feature
0
1
2
3
Feature Importance

# ADDITIONAL ANALYSIS - ALL VARIABLES - minus scaling

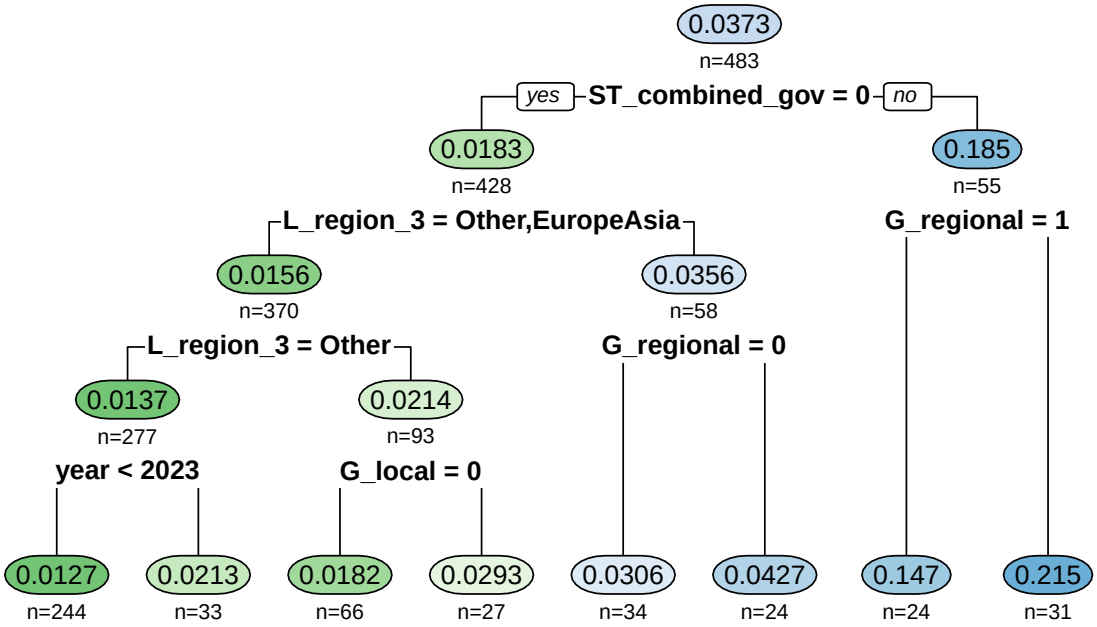
## Looking at Decision Tree for all variables - minus the Ghodsvali scale - with solution proposed as dependent variable

```
## **Random forest (ranger).** 1000 trees; mtry=2; min.node.size=20; 5-fold CV.

## **CV AUC:** 0.909 (SD=0.060).  **n:** 483.  **Class counts:** N=465, Y=18.

## **Top features:** ST_combined_gov, ST_public, ST_university.
```




Feature Importance
ST_combined_gov
ST_public
ST_university
year
ST_combined_coalition
ST_ratio
ST_experts
ST_combined_industry
L_region_3EuropeAsia
L_region_3GlobalME
Feature
0
1
2
Feature Importance

Representative Decision Tree Plot - Balanced Model - Minus Scaling




```
## [1] 0.000514475
```