Ghana Living Standard Survey 4

Final Group Project

Renato Albolea, Andrew Cardillo, Huy Le, Shuai Ma

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Executive Summary - Ghana Living Standard Survey 4

The following is a summary of our recommendations for ACME's business exploration into agricultural inputs in Ghana.

Our hypotheses were that education would have a positive impact on profit and that regional differences would have both positive and negative impacts on profit. After analyzing the data, our conclusion is that agricultural profit does not equal higher profit per acre. Additionally, we conclude that farmers who work small- to normal-size farms in the Western, Greater Accra, Volta and Brong Ahafo regions experience higher profit per acre (*Exhibits A, B, and C*).

To increase the effectiveness of our analysis, we divided our dataset into three sections to account for differences between small farms (less than 2 acres), normal farms (2-10 acres) and large farms (10+ acres). Finally, we examined profit per acre to equalize the difference in scale between each farm.

On small- and normal-sized farms, a basic education in the form of a BECE has minimal impact and an advanced education has either no effect or a negative effect on profit *(Exhibits D and E).* On large farms, a BECE is not a significant factor and an advanced education has a negligible positive effect on profitability *(Exhibit F).* We believe that, at 20 households, our sample size of advanced degrees is too small to determine the true impact and that people with higher education are most likely not employed as farmers.

Our results determined that regions have a large impact on profitability per acre for small and normal farms, but no impact on large farms. This is likely because most large farms are in Ashanti, Western and Brong Ahafo, so regional data is limited. For small farms, the most profitable regions are Northern, Western, Greater Accra, Volta and Brong Ahafo. For normal farms, the most profitable regions are Brong Ahafo, Western, Ashanti, Volta, and Greater Accra. Please note that this conclusion does not account for fishing, as fishing is conducted along the coastline and does not contribute to profit per acre.

Other interesting variables we examined include the proximity of motorways, the presence of a bank in the community and the farmer's quality of life as determined by the quality of

materials/construction of their home (e.g. walls and strength of building materials). We assumed that these variables would increase profits per acre as farmers would be able to transport their goods more effectively, utilize financial services and be in better health, respectively. However, our results indicate that these variables either affect profit per acre negatively or we lack evidence that they affect profit per acre in any significant way.

Exhibit A

Profit per Acre per Region for Small Farms

Exhibit B

Profit per Acre per Region for Normal Farms
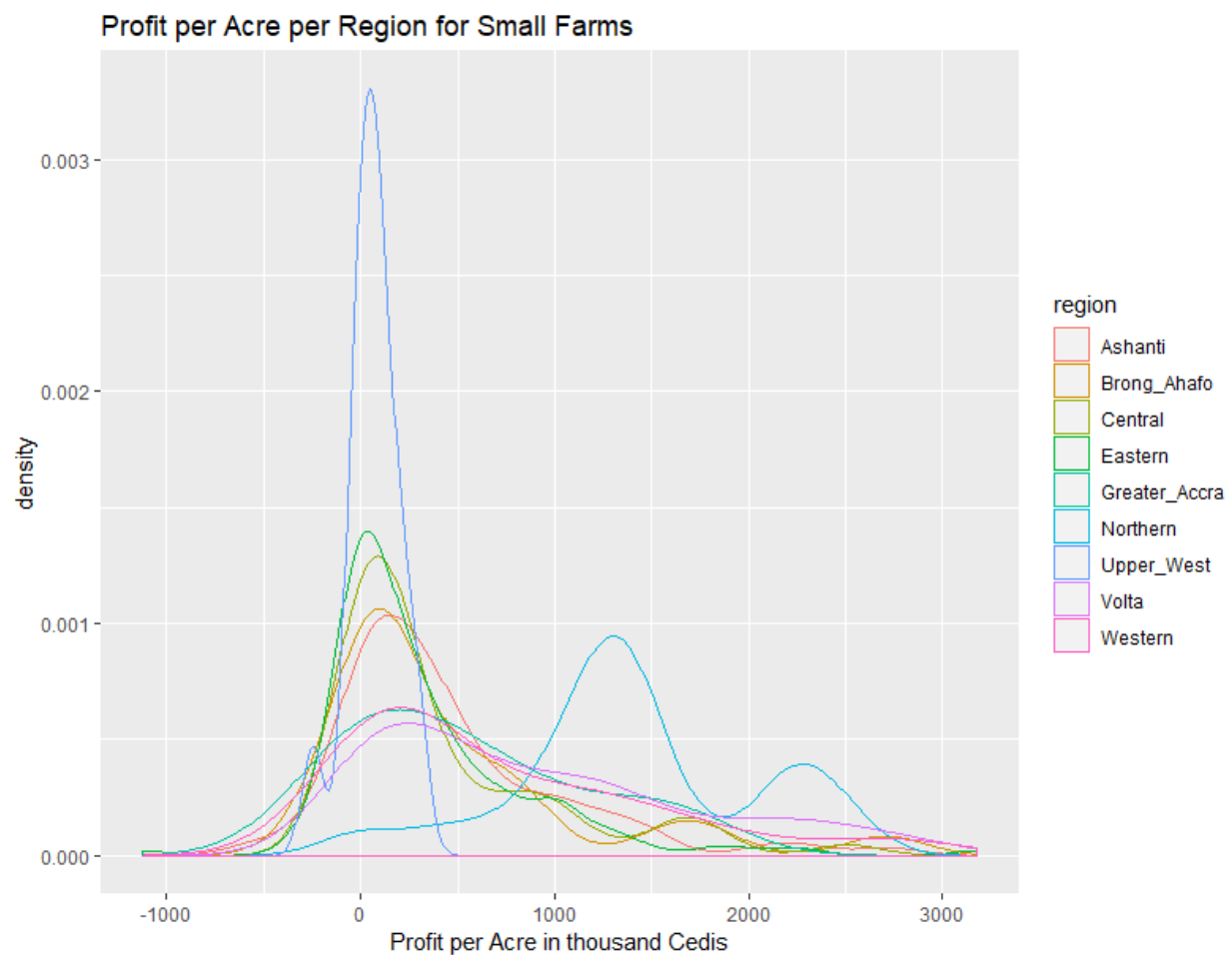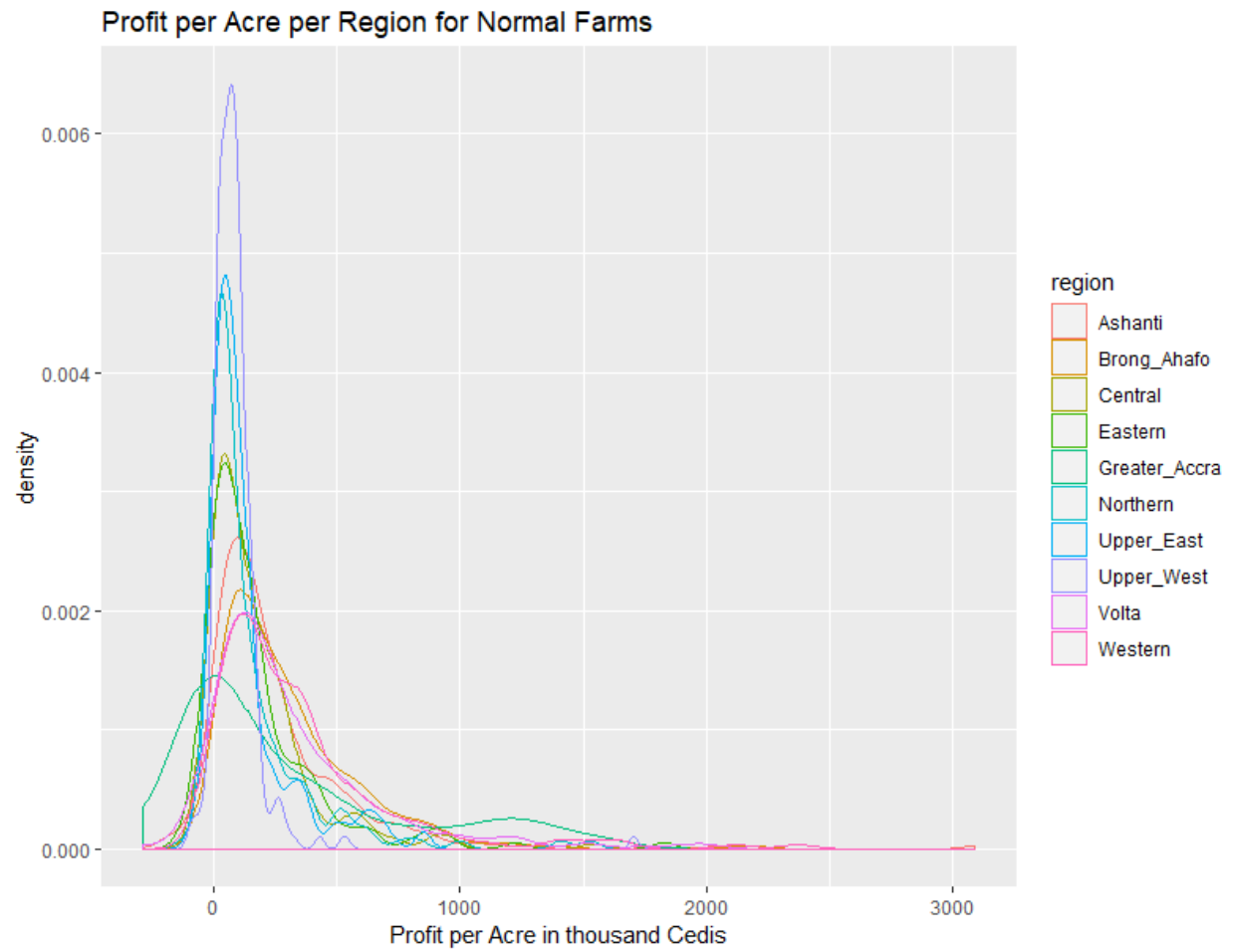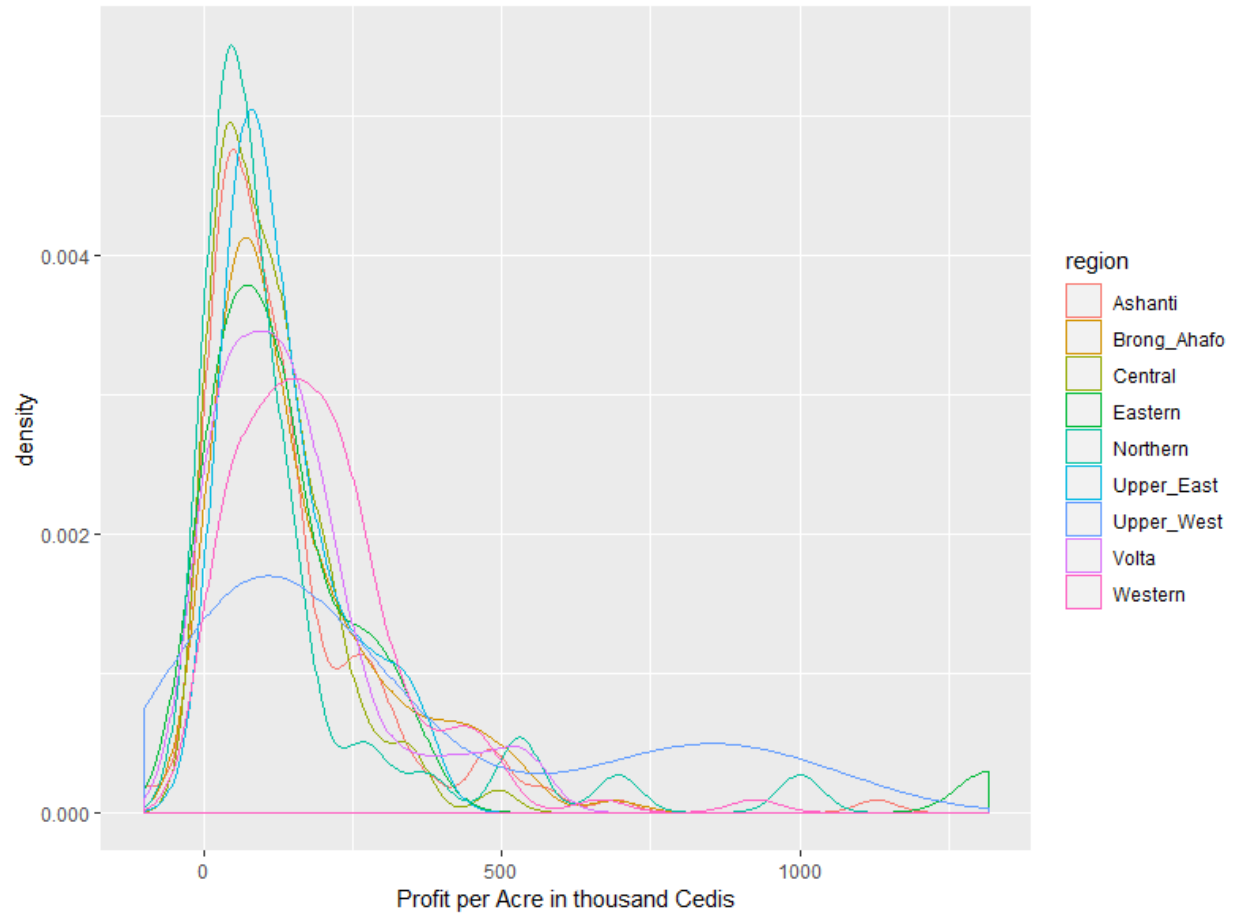
Exhibit C

Profit per Acre per Region for Large Farms

Exhibit D

Profit per Acre per Education for Small Farms

Exhibit E

Profit per Acre per Education for Normal Farms

Exhibit F

Profit per Acre per Education for Normal Farms
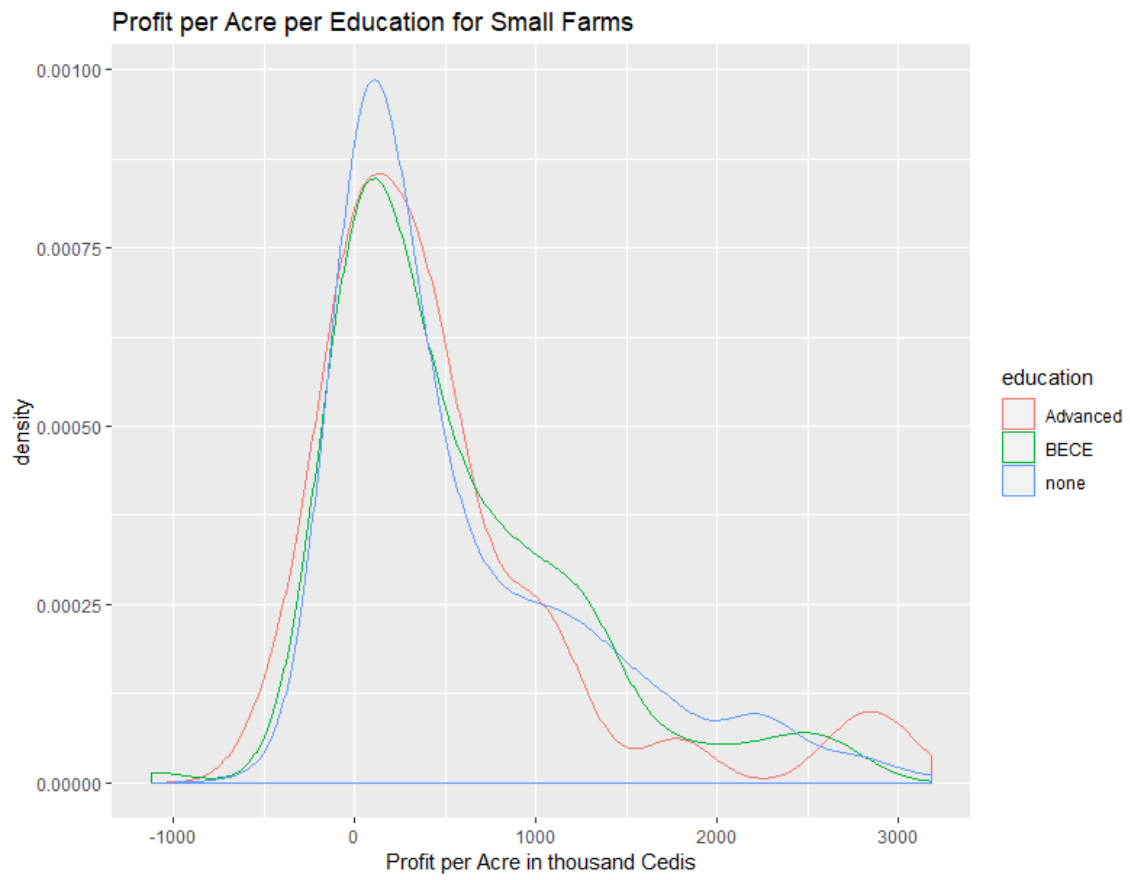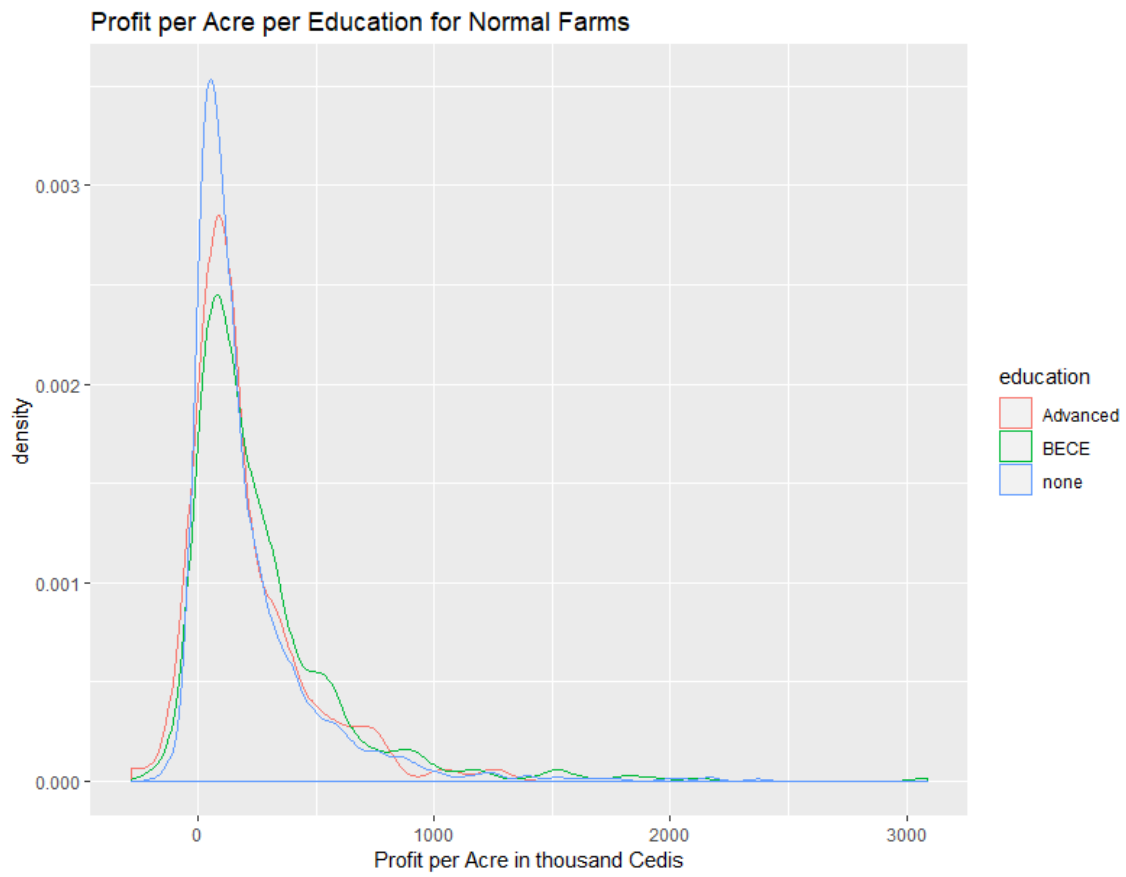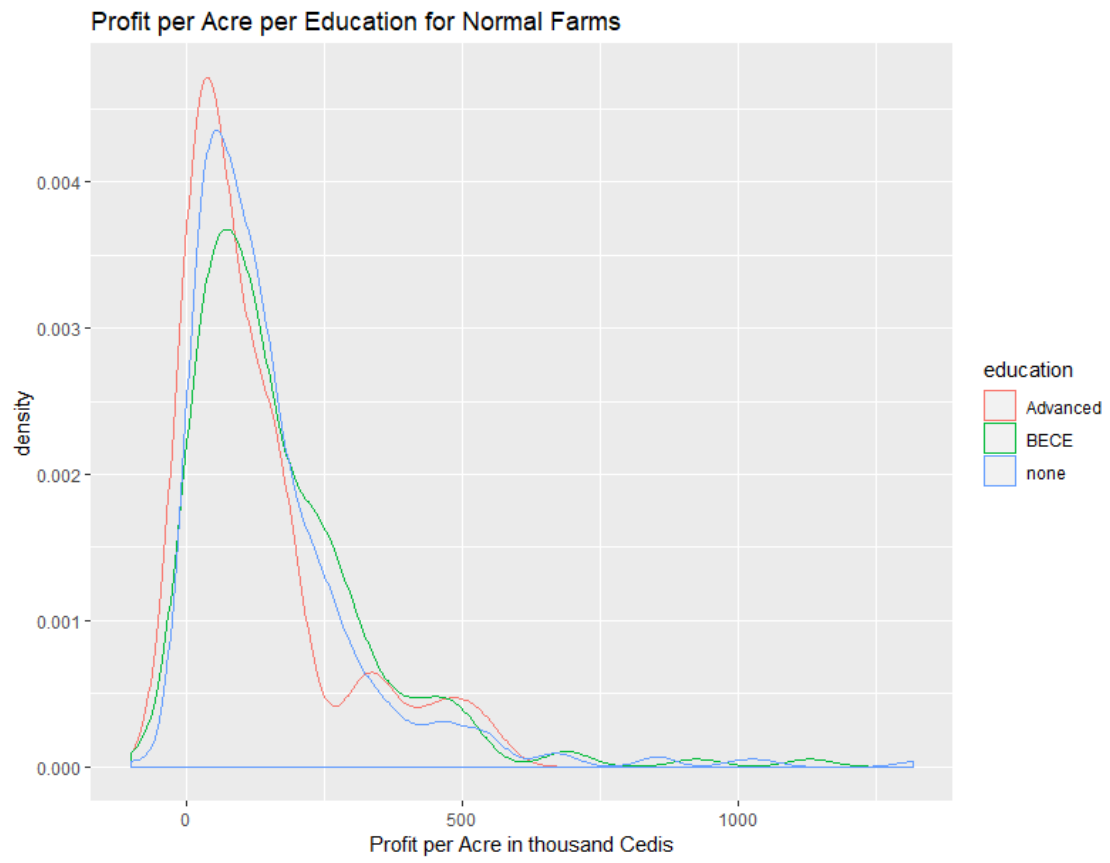
Statistical Analysis – Ghana Living Standard Survey 4

Introduction

At the start of our work, we set out to answer two questions: first, what variables were most relevant for determining ACME's potential agricultural profit? Secondly, how did the data/ chosen variables support or discount our hypothesis?

We will now present a walkthrough of the steps we took to evaluate our methods and findings.

Step 1: Setup HO & Brainstorm Significant Variables

The first step in our analysis was to import the data, read its associated paperwork and begin brainstorming what variables we believed would be important factors for profit per acre to create our null hypothesis.

Our hypothesis was that 5 factors would have a positive effect on profit: education, region, the presence of motorways, the existence of a bank in the community and the quality of the farmer's life as determined by the quality of the materials used to build their home. We decided to measure profit per acre to equalize the differences in scale between farm sizes.

Step 2: Clean & Organize the Dataset

To clean the data, we began by eliminating outliers (*Appendix A*) and excluding two factors from the dataset – depreciation from profit and instances where profit was equal to 0. This gave us a profit model that we could join our explanatory variables to. We then imported data about household information, land size, farmers, family information, education, workforce and community information and joined these together, excluding certain factors of each category to ensure we would achieve a 97.5% level of significance.

For clarity, we converted Ghanaian units of measurement (poles and ropes) into acres and evaluated each acre according to US dollars. We excluded information about non-farmers, people who own their own businesses, observations that do not have information about education, and communities where fishing accounted for the majority of revenue.

Step 2: Build Data Model & Identify Significant Variables

To run our initial analysis, we built a data model to evaluate 55 variables from the Ghana Living Standard Survey 4 that we believed would be significant to profit per acre (*Appendix B*). The first models Standardized Residuals Plot (*Appendix* C) showed a somewhat normally distributed curve with a slight right tail and outliers on the left side, while the Residual vs. Fitted Value scatterplot (*Appendix D*) showed a lot of heteroskedasticity, demonstrating that the variability of our chosen variables was unequal across the range of secondary predictive variables.

We decided to break our data model into three categories to better explain the data. Since the explanatory variables will have different effects across farms of different sizes, we divided our general model to account for three farm sizes: small farms defined as less than 2 acres (*Appendix E*), normal farms defined as 2 – 10 acres (*Appendix H*) and large farms defined as 10+ acres (*Appendix K*) and ran linear regressions of our original variables against them.

Step 3: Evaluate the Results

After transforming our data models, we saw immediate improvements in our results. Our new graphs (*Appendixes F, G, I, J, L, and M*) have more normally distributed curves and are closer to homoscedasticity than the first general model, signaling that they are more significant for our profit per acre model. Running linear regression for the 5 variables in our hypothesis produced surprising results – a full table of results for the 58 variables we examined is available for reference as *Appendix*

I.   **Education**

We expected that higher levels of education would have a positive effect on farmer's profit per acre, but the results demonstrate that education has a negligible or even negative effect. From the table below, we can see that having a basic education negatively impacts the profit per acre of a small farm and an advanced education negatively impacts the profit per acre of a normal farm, while each level only marginally affects the profit per acre for all other categories.

All effects are not statistically significant at a level of 95%, so we cannot reject that the variable may have a zero effect on profit.

Education	Large Farms		Normal Farms		Small Farms	
	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
BECE	*0.09*	*.083*	*0.02*	*.298*	***(0.01)***	*.584*
Advanced	*0.02*	*0.829*	***(0.05)***	*.081*	*0.00*	*.971*

II.   Region

As expected, region had a wide variety of effects on the profit per acre for each size of farm. Surprisingly, large farms typically see a negative impact of region on their profit per acre. The Western, Greater Accra, Volta and Brong Ahafo regions typically had the most positive effect on profit per margin for normal and small farms, albeit at varying levels of statistical significance.

Region	Large Farms		Normal Farms		Small Farms	
	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
Ashanti	***(0.20)***	*0.148*	*0.23*	*2.75E-11*	*0.12*	*0.045*
Brong Ahafo	***(0.11)***	*0.420*	*0.28*	*1.05E-15*	*0.14*	*0.036*
Central	***(0.32)***	*0.020*	*0.13*	*0.000119*	*0.10*	*0.109*
Eastern	*0.05*	*0.740*	*0.15*	*3.80E-06*	*0.05*	*0.391*
Greater Accra	*NA*	*NA*	*0.20*	*0.000126*	*0.16*	*0.041*
Northern	***(0.29)***	*0.029*	*0.07*	*0.016942*	*0.31*	*1.44E-06*
Upper East	***(0.33)***	*0.050*	*0.02*	*0.603646*	*NA*	*NA*
Volta	***(0.12)***	*0.380*	*0.21*	*3.70E-10*	*0.16*	*0.01*
Western	***(0.01)***	*0.960*	*0.28*	*3.66E-14*	*0.21*	*0.00*

III.   Presence of Motorways

In our hypothesis, we assumed that the presence of a motorway would have a positive impact on profit per acre as it would allow farmers to transport their goods to market more efficiently. However, our linear regression shows that there is a negative effect on all three sizes of farms and negligible statistical significance for large and normal farms. This may indicate that

motorways are only present in more urban areas where farms are non-existent. As we have no way of determining the exact reason at this time, we suggest exploring the connection in a future analysis.

	Large Farms		Normal Farms		Small Farms	
Motorway	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
	(0.24)	*0.0003*	*(0.06)*	*0.008*	*(0.02)*	*0.65*

IV.   Bank in the Community

In our hypothesis, we assumed that the presence of a bank in the community would also provide an advantage for farmers thanks to the availability of financial services, loans, and checking/savings accounts. However, we were again surprised to find that this variable had a negative and statistically insignificant effect on all three farm sizes' profit per acre. Our reasoning was that farmers in Ghana may not make enough money to justify utilizing a bank, their business does not utilize loans, checking/savings accounts or other types of financial services, or banks are in more urban areas where farms are scarce.

	Large Farms		Normal Farms		Small Farms	
Local Bank	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
	(0.19)	*0.151*	*(0.12)*	*0.0008*	*(0.07)*	*0.046*

V.   Farmer's Quality of Life Determined by Quality of Home

The fifth variable in our hypothesis was the farmer's quality of life, which we determined by evaluating the presence of walls and the strength of materials used to build their home (e.g. stone, wood, etc.) and the presence of cooking gas, electricity, a generator, and a flush toilet. For this explanation, we will focus on the materials used to construct the farmer's house – other variables can be assessed in *Appendix N.*

We were surprised to find that stronger materials such as iron or cement had a negative or negligible effect on profit per acre, and we lack evidence to suggestion that the household construction level bears significance on profit. We conclude that the materials used to build a

farmer's home are not related to how much revenue a farm is generating, perhaps because the materials used during construction are scavenged, donated or otherwise acquired without the need to invest profits from agricultural yields.

Wall Material	Large Farms		Normal Farms		Small Farms	
	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
Cement	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
Iron	*NA*	*NA*	*(0.24)*	*0.319*	*(0.10)*	*0.395*
Mud	*(0.02)*	*0.599*	*(0.02)*	*0.284*	*0.02*	*0.445*
Stone	*0.17*	*.436*	*2.767e03*	*0.962*	*0.06*	*0.494*
Wood	*(0.18)*	*0.35*	*0.02*	*0.85*	*(0.06)*	*0.71*

VI. Farm Sizes and Age

The only two continuous variables we used on the model were the age of the head of the household in years and the size of the farm. The best model we found was using a quadratic polynomial regression for both variables.

For the variable "age", our hypothesis was that the linear factor would show a positive effect and the quadratic component would result in a negative effect, given that young people have less experience but more energy to work and the opposite is true for older people. However, given that both factors (capacity of work and experience) should not change the same amount at the same time, an inflection point should occur. The results of the regression show us that age have almost no effect at all in the profit per acre in cases where it is statistically significant.

For farm size, we anticipated that we should observe an increase in the profitability of the farm with the increase of the land due to scale gains. However, we expected that this would diminish with the increase of the farm because new challenges start to appear with bigger land and due to the exhaustion of some resources with a larger increase.

The model contradicts our hypotheses, showing that the increase of the land has a linear effect of diminishing profitability that is compensated in a small amount by the quadratic increase of

the land size. One assumption that may explain this is that farmers probably already work with less resources than the ideal for the size of the farm, so increases of land only make the problem worst.

Age & Farm Variables	Large Farms		Normal Farms		Small Farms	
	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
agey	*0.00*	*0.88*	*0.00*	*0.071*	*0.01*	*0.003*
farm_size	*(0.04)*	*<2.0E-16*	*(0.40)*	*<2.0E-16*	*(2.40)*	*<2.0E-16*
I(agey^2)	*(0.00)*	*0.99*	*(0.00)*	*0.049*	*(0.00)*	*0.005*
I(farm_size^2)	*0.00*	*2.46E-10*	*0.02*	*<2.0E-16*	*0.65*	*<2.0E-16*

Appendix

A. Assumptions

To eliminate outliers, we:

- Excluded farms smaller than .2 acres (16 observations/0.55%)
- Excluded farms larger than 150 acres (10 observations/0.34%)
- Analyzed profit_per_acre only inside 97.5% of confidence interval (62 observations/2.1%)
- Predicted LN of profit_per_acre after scaling up by the minimum observation +10,000
- Excluded communities where fishing is the main activity

B. General Model Variables & Coefficients

```
## Coefficients:
##                                  Estimate Estimate Error t value Pr(>|t|)

## (Intercept)                      1.458e+01  1.270e-01 114.783   < 2e-16 ***
01 most_impor_farmingTRUE          -1.327e-01  1.028e-01  -1.290 0.197117
02 moto_roadTRUE                   -3.693e-02  3.732e-02  -0.990 0.322415
03 moto_road_impassableTRUE        -3.690e-02  2.257e-02  -1.635 0.102129
04 have_barTRUE                    -8.494e-03  2.602e-02  -0.326 0.744125
05 have_post_of_pub_telephoneTRUE  -6.985e-02  4.305e-02  -1.623 0.104773
06 have_bankTRUE                    6.729e-02  5.648e-02   1.191 0.233633
07 have_daily_mktTRUE              -6.123e-03  3.710e-02  -0.165 0.868898
08 have_week_mktTRUE               -2.744e-02  2.921e-02  -0.939 0.347570
09 public_transpTRUE               -4.232e-02  2.723e-02  -1.555 0.120173
10 people_come_for_job_farmingTRUE  4.417e-02  2.577e-02   1.714 0.086616 .
11 have_hospitalTRUE               -4.363e-02  9.331e-02  -0.468 0.640158
12 have_agric_ext_centerTRUE        1.727e-02  3.386e-02   0.510 0.610049
13 have_cooperativeTRUE            -8.121e-02  2.381e-02  -3.411 0.000657 ***
14 any_farm_use_fertTRUE           -1.085e-01  2.442e-02  -4.442 9.28e-06 ***
15 any_farm_use_inset_herbTRUE     -1.446e-02  2.799e-02  -0.516 0.605562
16 any_farm_use_irrigateTRUE       -3.588e-02  3.939e-02  -0.911 0.362440
```

```
17 mutual_aid_farmTRUE            7.658e-02  3.377e-02   2.268 0.023432 *
18 farm_size                     -1.197e-01  2.121e-03 -56.438  < 2e-16 ***
19 I(farm_size^2)                 9.426e-04  2.851e-05  33.067  < 2e-16 ***
20 agey                          -1.510e-03  7.611e-04  -1.984 0.047353 *
21 spouse_live_hhTRUE             1.303e-02  2.977e-02   0.438 0.661679
22 sex_maleTRUE                  -1.087e-01  3.294e-02  -3.298 0.000984 ***
23 fishingTRUE                    6.041e-02  2.952e-02   2.046 0.040805 *
24 own_businessTRUE              -2.840e-02  2.174e-02  -1.306 0.191504
25 educ_beceTRUE                 -4.255e-02  3.201e-02  -1.329 0.183912
26 educ_advancedTRUE              1.589e-02  4.901e-02   0.324 0.745827
27 do_mathTRUE                   -1.741e-02  3.204e-02  -0.543 0.586899
28 region_Western                3.895e-01  6.474e-02   6.017 2.01e-09 ***
29 region_Central                1.823e-01  6.189e-02   2.946 0.003244 **
30 region_Greater_Accra          3.102e-01  9.812e-02   3.161 0.001587 **
31 region_Eastern                5.406e-01  5.600e-02   9.654  < 2e-16 ***
32 region_Volta                  5.145e-01  5.876e-02   8.756  < 2e-16 ***
33 region_Ashanti                2.819e-01  6.075e-02   4.641 3.63e-06 ***
34 region_Brong_Ahafo            2.566e-01  6.330e-02   4.053 5.19e-05 ***
35 region_Northern               8.274e-02  5.432e-02   1.523 0.127801
36 region_Upper_East            -1.448e-01  6.676e-02  -2.170 0.030125 *
37 light_eletricityTRUE          6.133e-03  3.811e-02   0.161 0.872158
38 light_generatorTRUE          -1.643e-01  1.337e-01  -1.229 0.219210
39 cooking_full_gasTRUE         -5.689e-01  2.863e-01  -1.987 0.047035 *
40 toilet_flushTRUE             -2.945e-01  1.378e-01  -2.137 0.032684 *
41 toilet_latrineTRUE           -3.768e-02  2.610e-02  -1.444 0.148947
42 wall_mudTRUE                   2.723e-03  2.751e-02   0.099 0.921156
43 wall_woodTRUE                 -2.709e-02  1.626e-01  -0.167 0.867674
44 wall_ironTRUE                  2.543e-01  3.089e-01   0.823 0.410430
45 wall_stoneTRUE               -1.860e-01  1.059e-01  -1.757 0.079065 .
46 harvest_sold_gateTRUE         1.688e-02  3.961e-02   0.426 0.670039
47 harvest_sold_marketTRUE      -7.949e-02  2.243e-02  -3.544 0.000401 ***
48 harvest_sold_consumerTRUE     3.073e-02  3.764e-02   0.817 0.414241
49 harvest_sold_state_orgTRUE    3.600e-02  2.945e-02   1.223 0.221560
50 harvest_sold_coopTRUE         1.850e-01  1.086e-01   1.704 0.088438 .
```

```
51 paid_at_saleTRUE                    -3.419e-02  2.211e-01  -0.155 0.877121
52 paid_at_weekTRUE                    -2.862e-01  2.229e-01  -1.284 0.199390
53 paid_at_monthTRUE                   -1.264e-01  1.912e-01  -0.661 0.508608
54 males_on_farme                       1.412e-03  1.393e-03   1.014 0.310810
55 females_on_farme                    -1.081e-03  2.598e-03  -0.416 0.677203
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.528 on 2813 degrees of freedom
## Multiple R-squared:  0.6869, Adjusted R-squared:  0.6808
## F-statistic: 112.2 on 55 and 2813 DF,  p-value: < 2.2e-16
```
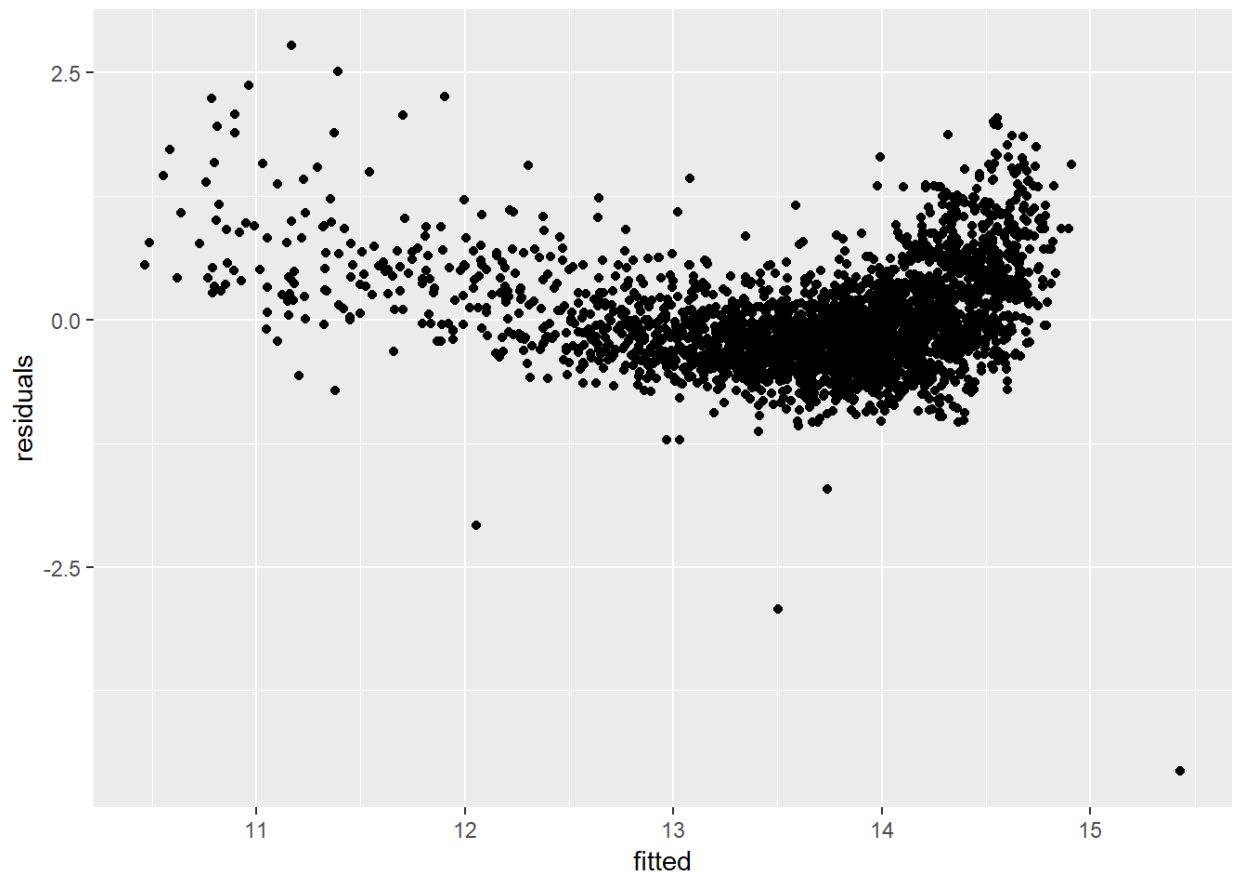
C. Standardized Residuals Plot (General Model)
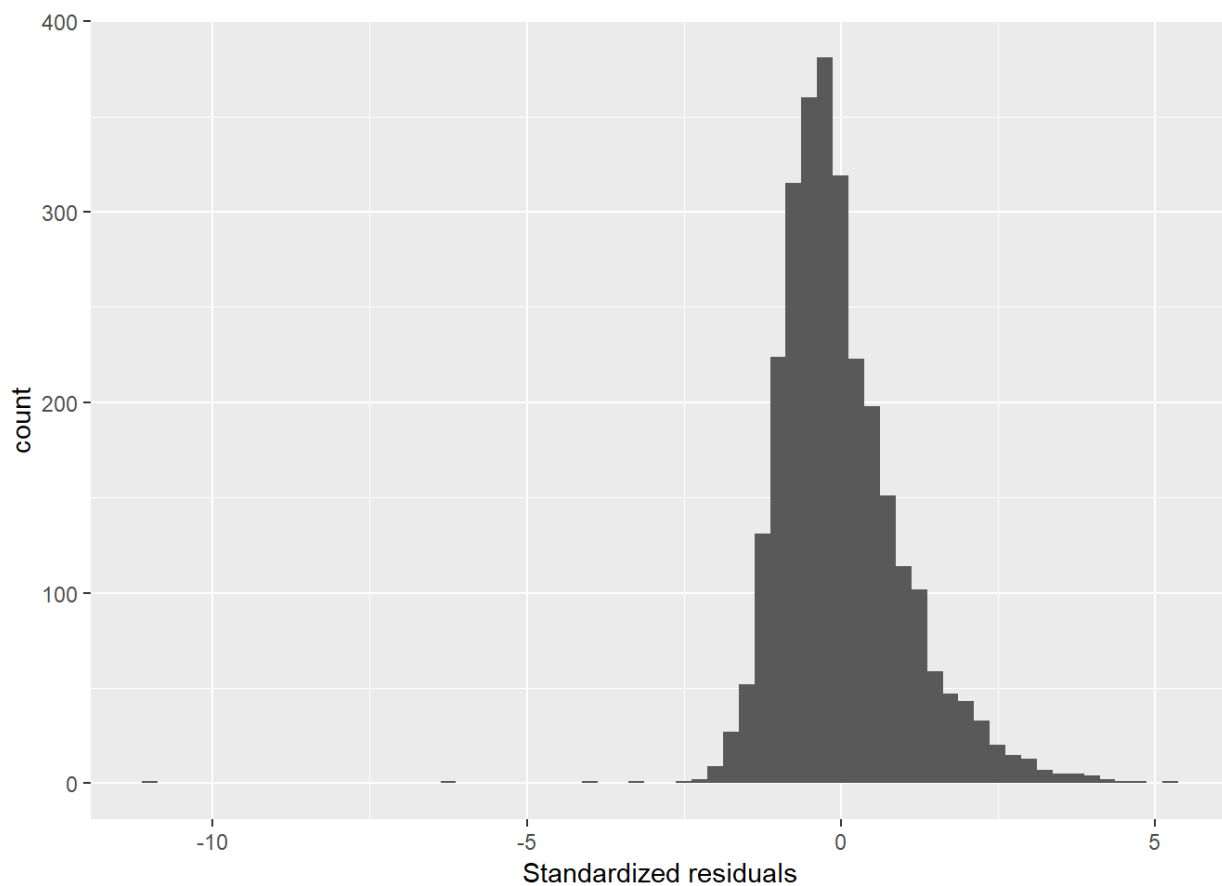
D. Residual vs. Fitted Value (General Model)

E. Small Farm Model Variables & Coefficients (<2 Acres – 496 Observations)

```
## Coefficients: (8 not defined because of singularities)
##                                Estimate Estimate Error t value Pr(>|t|)

## (Intercept)                    1.643e+01  1.182e-01 139.017  < 2e-16 ***
1 most_impor_farmingTRUE         -1.922e-02  5.616e-02  -0.342 0.732301
2 most_impor_fishingTRUE               NA         NA      NA       NA
3 moto_roadTRUE                  -1.843e-02  4.009e-02  -0.460 0.645898
4 moto_road_impassableTRUE        2.408e-02  1.994e-02   1.207 0.227940
5 have_barTRUE                   -1.398e-02  2.113e-02  -0.661 0.508652
6 have_post_of_pub_telephoneTRUE  1.331e-03  3.515e-02   0.038 0.969822
7 have_bankTRUE                  -7.120e-02  3.556e-02  -2.003 0.045834 *
8 have_daily_mktTRUE             -1.269e-03  3.207e-02  -0.040 0.968446
```

```
9  have_week_mktTRUE                 2.166e-03  2.470e-02   0.088 0.930169
10 public_transpTRUE                -1.756e-02  2.154e-02  -0.815 0.415399
11 people_come_for_job_farmingTRUE   4.258e-03  1.840e-02   0.231 0.817140
12 have_hospitalTRUE                 6.383e-02  8.009e-02   0.797 0.425893
13 have_agric_ext_centerTRUE         6.734e-03  2.699e-02   0.249 0.803106
14 have_cooperativeTRUE             -2.553e-02  1.975e-02  -1.293 0.196765
15 any_farm_use_fertTRUE            -3.114e-02  1.955e-02  -1.593 0.111802
16 any_farm_use_inset_herbTRUE      -7.986e-03  2.238e-02  -0.357 0.721410
17 any_farm_use_irrigateTRUE        -2.337e-02  2.741e-02  -0.853 0.394230
18 mutual_aid_farmTRUE               1.736e-02  2.585e-02   0.672 0.502177
19 farm_size                        -2.399e+00  8.467e-02 -28.337  < 2e-16 ***
20 I(farm_size^2)                    6.474e-01  4.026e-02  16.079  < 2e-16 ***
21 agey                             8.013e-03  2.723e-03   2.943 0.003421 **
22 I(agey^2)                        -7.544e-05  2.673e-05  -2.822 0.004980 **
23 spouse_live_hhTRUE                5.832e-02  2.197e-02   2.655 0.008219 **
24 sex_maleTRUE                     -2.977e-02  2.260e-02  -1.317 0.188464
25 fishingTRUE                       4.360e-02  2.454e-02   1.776 0.076340 .
26 own_businessTRUE                 -3.655e-03  1.590e-02  -0.230 0.818314
27 educ_beceTRUE                    -1.319e-02  2.407e-02  -0.548 0.583985
28 educ_advancedTRUE                 1.290e-03  3.496e-02   0.037 0.970578
29 do_mathTRUE                       2.139e-02  2.269e-02   0.943 0.346209
30 region_Western                    2.131e-01  6.117e-02   3.483 0.000545 ***
31 region_Central                    9.732e-02  6.064e-02   1.605 0.109220
32 region_Greater_Accra              1.567e-01  7.644e-02   2.050 0.040930 *
33 region_Eastern                    4.551e-02  5.306e-02   0.858 0.391493
34 region_Volta                      1.557e-01  5.651e-02   2.754 0.006122 **
35 region_Ashanti                    1.217e-01  6.070e-02   2.006 0.045498 *
36 region_Brong_Ahafo                1.444e-01  6.859e-02   2.106 0.035793 *
37 region_Northern                   3.075e-01  6.294e-02   4.886 1.44e-06 ***
38 region_Upper_East                        NA        NA      NA       NA
39 light_eletricityTRUE             -6.210e-03  2.728e-02  -0.228 0.820061
40 light_generatorTRUE                      NA        NA      NA       NA
41 cooking_full_gasTRUE                     NA        NA      NA       NA
42 toilet_flushTRUE                  2.244e-02  1.005e-01   0.223 0.823423
```

```
43 toilet_latrineTRUE            1.997e-02 1.835e-02   1.088 0.277171
44 wall_mudTRUE                  1.657e-02 2.167e-02   0.765 0.444936
45 wall_woodTRUE                -6.315e-02 1.695e-01  -0.373 0.709646
46 wall_ironTRUE                -1.046e-01 1.229e-01  -0.851 0.395225
47 wall_stoneTRUE                5.897e-02 8.606e-02   0.685 0.493541
48 wall_cementTRUE                      NA        NA      NA        NA
49 harvest_sold_gateTRUE         7.818e-02 3.357e-02   2.329 0.020328 *
50 harvest_sold_marketTRUE       6.186e-02 1.771e-02   3.493 0.000526 ***
51 harvest_sold_consumerTRUE     1.378e-02 3.068e-02   0.449 0.653583
52 harvest_sold_state_orgTRUE    9.857e-02 2.747e-02   3.588 0.000370 ***
53 harvest_sold_coopTRUE                NA        NA      NA        NA
54 paid_at_saleTRUE                     NA        NA      NA        NA
55 paid_at_weekTRUE                     NA        NA      NA        NA
56 paid_at_monthTRUE             1.723e-01 1.712e-01   1.007 0.314681
57 males_on_farme               -6.061e-04 3.144e-03  -0.193 0.847217
58 females_on_farme              4.739e-03 2.296e-03   2.064 0.039552 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1608 on 445 degrees of freedom
## Multiple R-squared:  0.9055, Adjusted R-squared:  0.8948
## F-statistic: 85.24 on 50 and 445 DF,  p-value: < 2.2e-16
```

F. Standardized Residuals Plot (Small Farm Model)
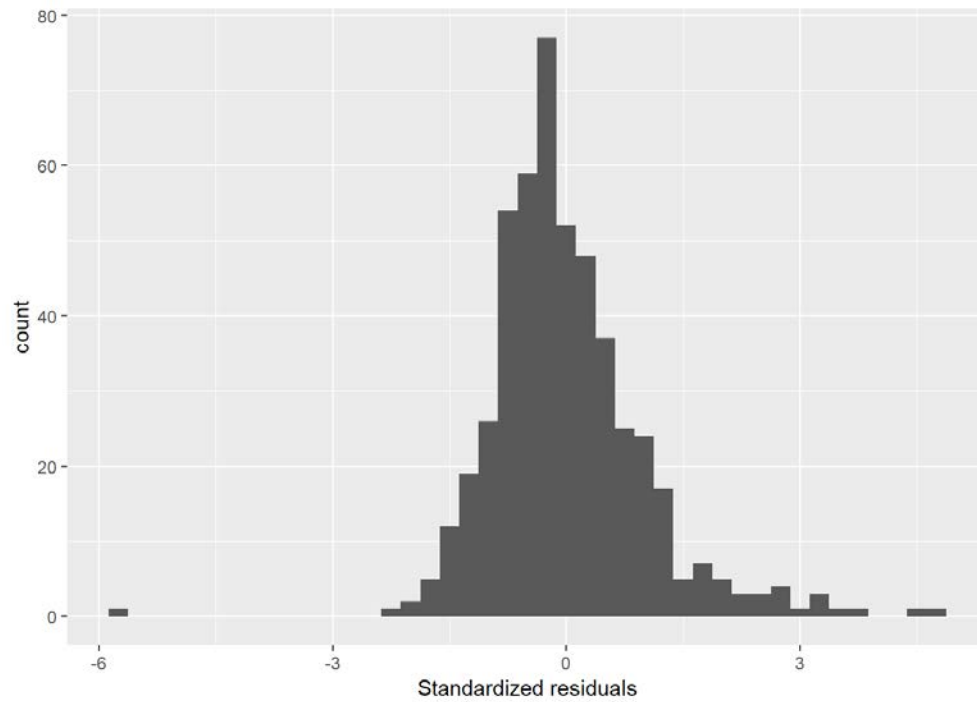
G. Residuals vs. Fitted Values Plot (Small Farm Model)
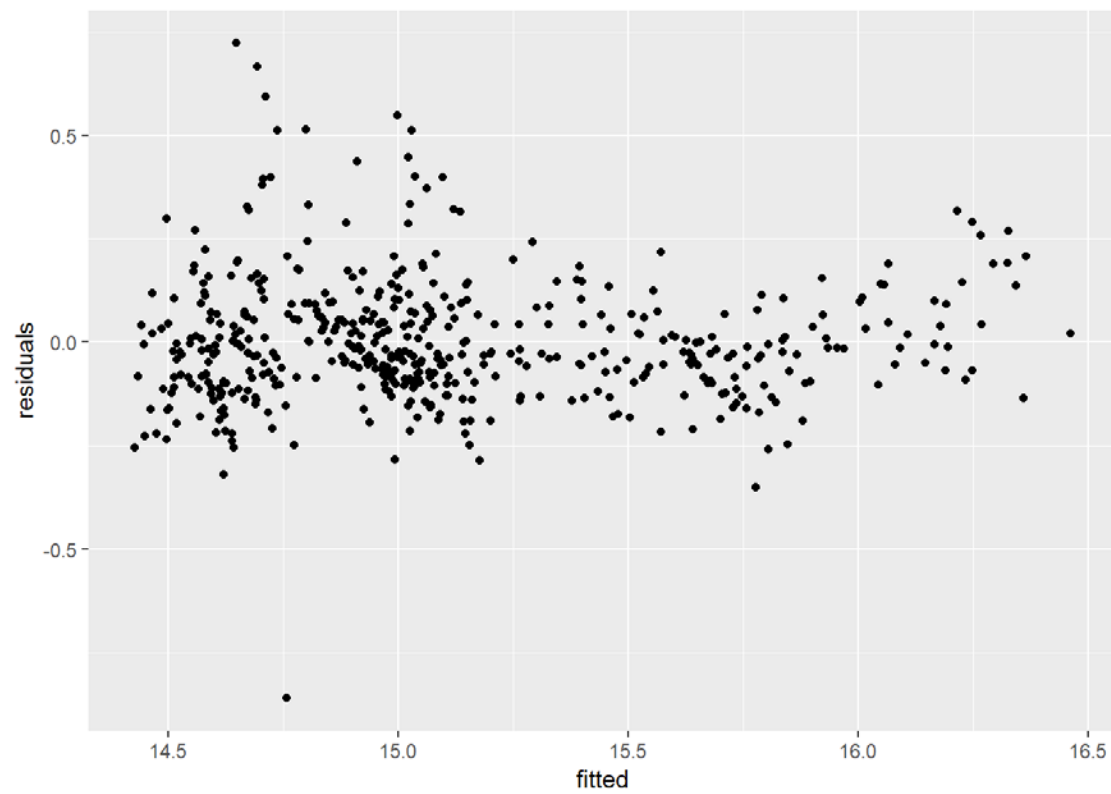
H. Model for Normal Farm Variables & Coefficients (2 – 10 Acres, 1787 Observations)

```
## Coefficients: (2 not defined because of singularities)
##                               Estimate Estimate Error t value Pr(>|t|)

## (Intercept)                   1.481e+01  9.719e-02 152.341  < 2e-16 ***
1 most_impor_farmingTRUE        -1.834e-02  6.633e-02  -0.277 0.782168
2 most_impor_fishingTRUE              NA         NA       NA       NA
3 moto_roadTRUE                 -5.503e-02  2.081e-02  -2.645 0.008249 **
04 moto_road_impassableTRUE     -1.915e-02  1.283e-02  -1.493 0.135696
05 have_barTRUE                  1.898e-03  1.539e-02   0.123 0.901855
06 have_post_of_pub_telephoneTRUE 4.779e-02 2.409e-02  1.983 0.047481 *
07 have_bankTRUE                -1.160e-01  3.459e-02  -3.353 0.000817 ***
08 have_daily_mktTRUE           -3.135e-02  2.088e-02  -1.501 0.133533
09 have_week_mktTRUE            -7.948e-03  1.639e-02  -0.485 0.627768
10 public_transpTRUE            -2.801e-02  1.597e-02  -1.754 0.079616 .
11 people_come_for_job_farmingTRUE -9.357e-03 1.513e-02 -0.619 0.536325
12 have_hospitalTRUE             5.969e-02  5.504e-02   1.085 0.278254
13 have_agric_ext_centerTRUE     2.745e-02  1.937e-02   1.417 0.156605
14 have_cooperativeTRUE         -3.433e-02  1.378e-02  -2.491 0.012844 *
15 any_farm_use_fertTRUE        -3.969e-02  1.444e-02  -2.749 0.006048 **
16 any_farm_use_inset_herbTRUE   7.205e-03  1.606e-02   0.449 0.653773
17 any_farm_use_irrigateTRUE    -2.466e-02  2.309e-02  -1.068 0.285661
18 mutual_aid_farmTRUE           3.942e-02  2.025e-02   1.947 0.051702 .
19 farm_size                    -4.016e-01  1.221e-02 -32.904  < 2e-16 ***
20 I(farm_size^2)                1.965e-02  1.056e-03  18.608  < 2e-16 ***
21 agey                          4.210e-03  2.330e-03   1.807 0.070965 .
22 I(agey^2)                    -4.549e-05  2.313e-05  -1.967 0.049400 *
23 spouse_live_hhTRUE            7.370e-02  1.732e-02   4.255 2.20e-05 ***
24 sex_maleTRUE                 -2.935e-02  1.930e-02  -1.521 0.128534
25 fishingTRUE                   5.045e-02  1.704e-02   2.960 0.003113 **
26 own_businessTRUE             -2.604e-02  1.256e-02  -2.074 0.038267 *
27 educ_beceTRUE                 1.974e-02  1.898e-02   1.040 0.298551
28 educ_advancedTRUE            -5.130e-02  2.940e-02  -1.745 0.081192 .
29 do_mathTRUE                  -1.644e-02  1.917e-02  -0.858 0.391111
```

```
30 region_Western              2.846e-01 3.726e-02  7.637 3.66e-14 ***
31 region_Central              1.337e-01 3.466e-02  3.857 0.000119 ***
32 region_Greater_Accra        2.011e-01 5.232e-02  3.843 0.000126 ***
33 region_Eastern              1.504e-01 3.243e-02  4.637 3.80e-06 ***
34 region_Volta                2.094e-01 3.322e-02  6.303 3.70e-10 ***
35 region_Ashanti              2.289e-01 3.414e-02  6.704 2.75e-11 ***
36 region_Brong_Ahafo          2.849e-01 3.519e-02  8.098 1.05e-15 ***
37 region_Northern             6.859e-02 2.870e-02  2.390 0.016942 *
38 region_Upper_East           1.707e-02 3.288e-02  0.519 0.603646
39 light_eletricityTRUE       -1.580e-02 2.222e-02 -0.711 0.477008
40 light_generatorTRUE         4.669e-02 6.999e-02  0.667 0.504776
41 cooking_full_gasTRUE       -2.527e-01 1.497e-01 -1.688 0.091573 .
42 toilet_flushTRUE           -1.908e-02 7.971e-02 -0.239 0.810818
43 toilet_latrineTRUE         -5.051e-03 1.543e-02 -0.327 0.743402
44 wall_mudTRUE               -1.725e-02 1.611e-02 -1.071 0.284334
45 wall_woodTRUE               2.060e-02 1.088e-01  0.189 0.849832
46 wall_ironTRUE              -2.399e-01 2.406e-01 -0.997 0.318865
47 wall_stoneTRUE              2.767e-03 5.853e-02  0.047 0.962297
48 wall_cementTRUE                    NA        NA     NA       NA
49 harvest_sold_gateTRUE       8.066e-02 2.301e-02  3.505 0.000469 ***
50 harvest_sold_marketTRUE     7.487e-02 1.310e-02  5.715 1.29e-08 ***
51 harvest_sold_consumerTRUE   5.514e-02 2.261e-02  2.439 0.014840 *
52 harvest_sold_state_orgTRUE  1.327e-01 1.818e-02  7.300 4.37e-13 ***
53 harvest_sold_coopTRUE       1.034e-01 8.251e-02  1.253 0.210410
54 paid_at_saleTRUE            1.646e-01 1.104e-01  1.490 0.136306
55 paid_at_weekTRUE           -8.284e-02 1.027e-01 -0.807 0.419871
56 paid_at_monthTRUE          -2.874e-02 1.243e-01 -0.231 0.817122
57 males_on_farme              7.361e-04 1.429e-03  0.515 0.606611
58 females_on_farme            8.106e-04 2.036e-03  0.398 0.690648
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2383 on 1730 degrees of freedom
## Multiple R-squared:  0.7669, Adjusted R-squared:  0.7594
## F-statistic: 101.7 on 56 and 1730 DF,  p-value: < 2.2e-16
```
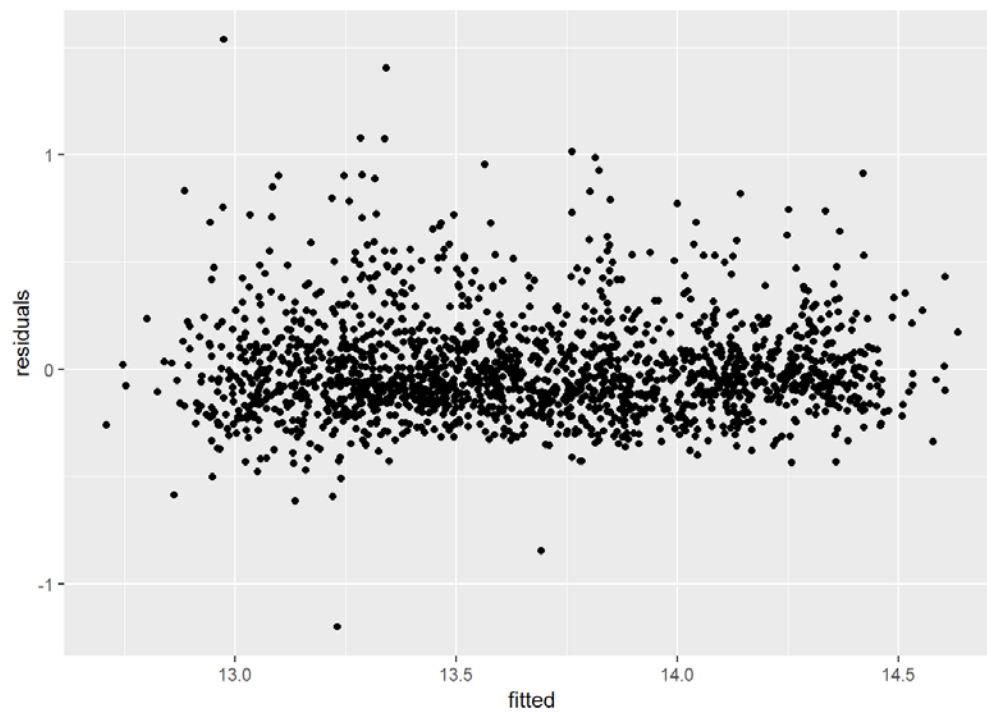
I. **Standardized Residuals Plot (Normal Farm Model)**
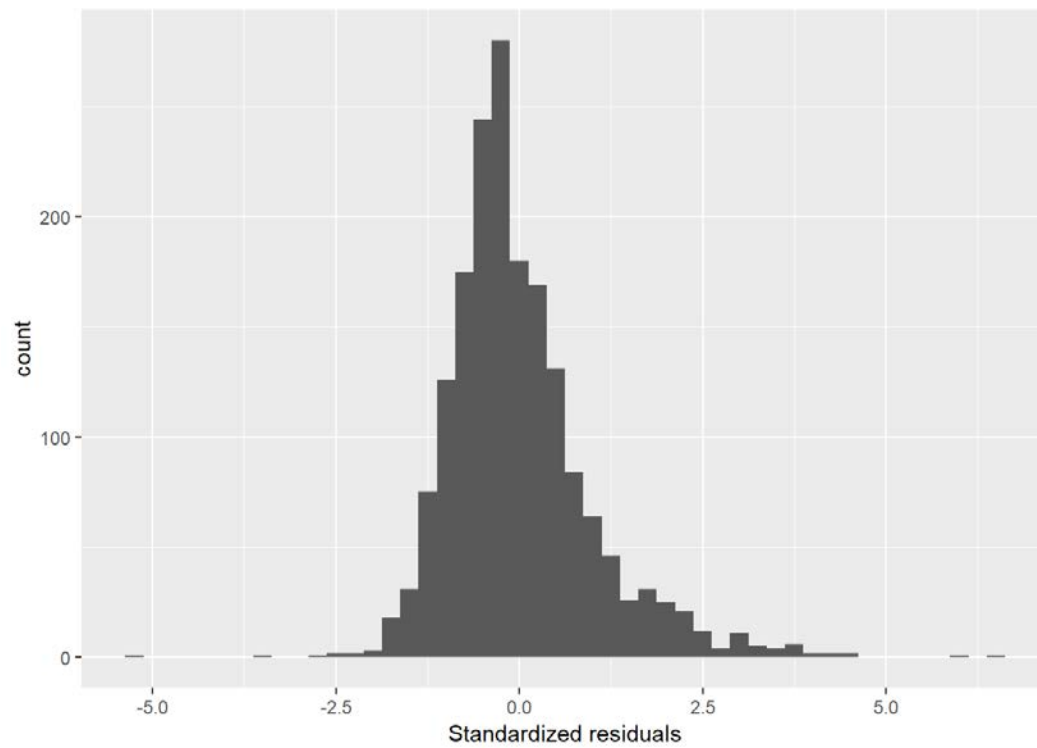
J. **Residual vs. Fitted Value Plot (Normal Farm Model)**

K. Large Farm Model Variables & Coefficients (10+ Acres – 496 Observations)

```
## Coefficients: (5 not defined because of singularities)
##                              Estimate Estimate Error t value Pr(>|t|)

## (Intercept)                   1.336e+01  3.148e-01   42.441  < 2e-16 ***
01 most_impor_farmingTRUE        8.398e-02  2.217e-01    0.379 0.705038
02 most_impor_fishingTRUE             NA         NA       NA       NA
03 moto_roadTRUE                 -2.400e-01  6.596e-02   -3.638 0.000301 ***
04 moto_road_impassableTRUE      -1.469e-01  4.216e-02   -3.485 0.000534 ***
05 have_barTRUE                  -5.318e-02  4.555e-02   -1.167 0.243567
06 have_post_of_pub_telephoneTRUE 6.455e-02  9.483e-02    0.681 0.496381
07 have_bankTRUE                 -1.869e-01  1.300e-01   -1.437 0.151212
08 have_daily_mktTRUE             5.518e-02  6.988e-02    0.790 0.430100
09 have_week_mktTRUE             -1.289e-01  5.897e-02   -2.185 0.029308 *
10 public_transpTRUE             1.193e-03  5.125e-02    0.023 0.981437
11 people_come_for_job_farmingTRUE 9.096e-02 5.081e-02   1.790 0.073997 .
12 have_hospitalTRUE             -1.661e-01  1.562e-01   -1.063 0.288154
13 have_agric_ext_centerTRUE     -5.371e-02  6.499e-02   -0.826 0.408958
14 have_cooperativeTRUE          -1.193e-01  4.034e-02   -2.958 0.003232 **
15 any_farm_use_fertTRUE         -1.373e-02  4.254e-02   -0.323 0.746903
16 any_farm_use_inset_herbTRUE    2.506e-02  5.477e-02    0.457 0.647535
17 any_farm_use_irrigateTRUE     -1.395e-01  8.654e-02   -1.611 0.107664
18 mutual_aid_farmTRUE            1.554e-01  6.098e-02    2.548 0.011111 *
19 farm_size                     -4.350e-02  3.197e-03  -13.609  < 2e-16 ***
20 I(farm_size^2)                 2.097e-04  3.249e-05    6.453 2.46e-10 ***
21 agey                          1.087e-03  7.186e-03    0.151 0.879785
22 I(agey^2)                     -8.232e-07  6.768e-05   -0.012 0.990300
23 spouse_live_hhTRUE             7.013e-02  5.479e-02    1.280 0.201159
24 sex_maleTRUE                  -6.617e-03  6.505e-02   -0.102 0.919020
25 fishingTRUE                    8.599e-02  5.127e-02    1.677 0.094106 .
26 own_businessTRUE               4.701e-02  3.930e-02    1.196 0.232122
27 educ_beceTRUE                  9.002e-02  5.193e-02    1.734 0.083568 .
28 educ_advancedTRUE              1.717e-02  7.955e-02    0.216 0.829174
29 do_mathTRUE                   -5.596e-02  5.242e-02   -1.068 0.286200
```

```
30 region_Western                 -6.960e-03  1.378e-01  -0.050 0.959748
31 region_Central                 -3.242e-01  1.394e-01  -2.325 0.020430 *
32 region_Greater_Accra                   NA         NA      NA       NA
33 region_Eastern                  4.823e-02  1.454e-01   0.332 0.740281
34 region_Volta                   -1.199e-01  1.365e-01  -0.878 0.380189
35 region_Ashanti                 -1.957e-01  1.351e-01  -1.449 0.147980
36 region_Brong_Ahafo             -1.089e-01  1.349e-01  -0.807 0.419900
37 region_Northern                -2.854e-01  1.302e-01  -2.192 0.028845 *
38 region_Upper_East              -3.290e-01  1.671e-01  -1.969 0.049512 *
39 light_eletricityTRUE           -2.157e-02  7.286e-02  -0.296 0.767352
40 light_generatorTRUE             1.302e-02  2.106e-01   0.062 0.950723
41 cooking_full_gasTRUE           -1.841e-01  4.791e-01  -0.384 0.700927
42 toilet_flushTRUE               -2.392e-01  2.495e-01  -0.959 0.338134
43 toilet_latrineTRUE             -1.491e-01  4.784e-02  -3.117 0.001924 **
44 wall_mudTRUE                   -2.406e-02  4.572e-02  -0.526 0.598958
45 wall_woodTRUE                  -1.761e-01  1.882e-01  -0.935 0.349999
46 wall_ironTRUE                          NA         NA      NA       NA
47 wall_stoneTRUE                  1.659e-01  2.126e-01   0.780 0.435525
48 wall_cementTRUE                        NA         NA      NA       NA
49 harvest_sold_gateTRUE           1.429e-01  7.190e-02   1.987 0.047385 *
50 harvest_sold_marketTRUE         1.031e-01  3.983e-02   2.589 0.009877 **
51 harvest_sold_consumerTRUE       1.511e-01  5.668e-02   2.666 0.007911 **
52 harvest_sold_state_orgTRUE      1.626e-01  4.300e-02   3.781 0.000174 ***
53 harvest_sold_coopTRUE           2.475e-01  1.154e-01   2.145 0.032413 *
54 paid_at_saleTRUE               -6.229e-01  4.121e-01  -1.512 0.131243
55 paid_at_weekTRUE                       NA         NA      NA       NA
56 paid_at_monthTRUE              -1.794e-01  2.373e-01  -0.756 0.450013
57 males_on_farme                  1.271e-03  1.232e-03   1.032 0.302515
58 females_on_farme               -5.420e-04  2.870e-03  -0.189 0.850267
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3981 on 532 degrees of freedom
## Multiple R-squared:  0.5629, Adjusted R-squared:  0.5193
## F-statistic: 12.93 on 53 and 532 DF,  p-value: < 2.2e-16
```
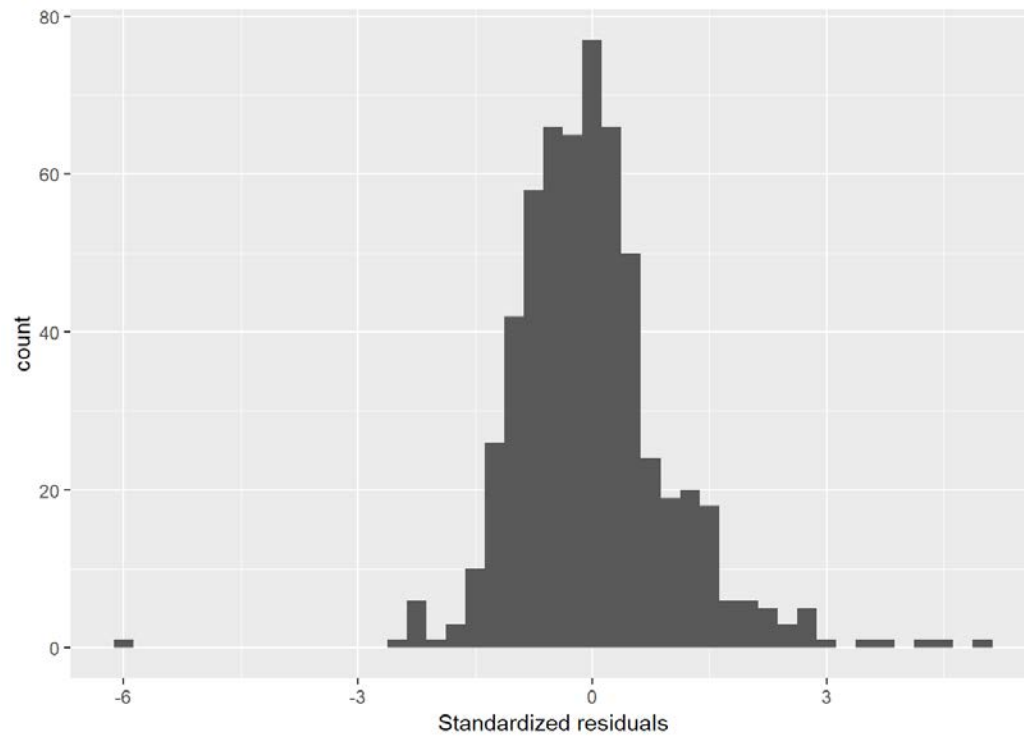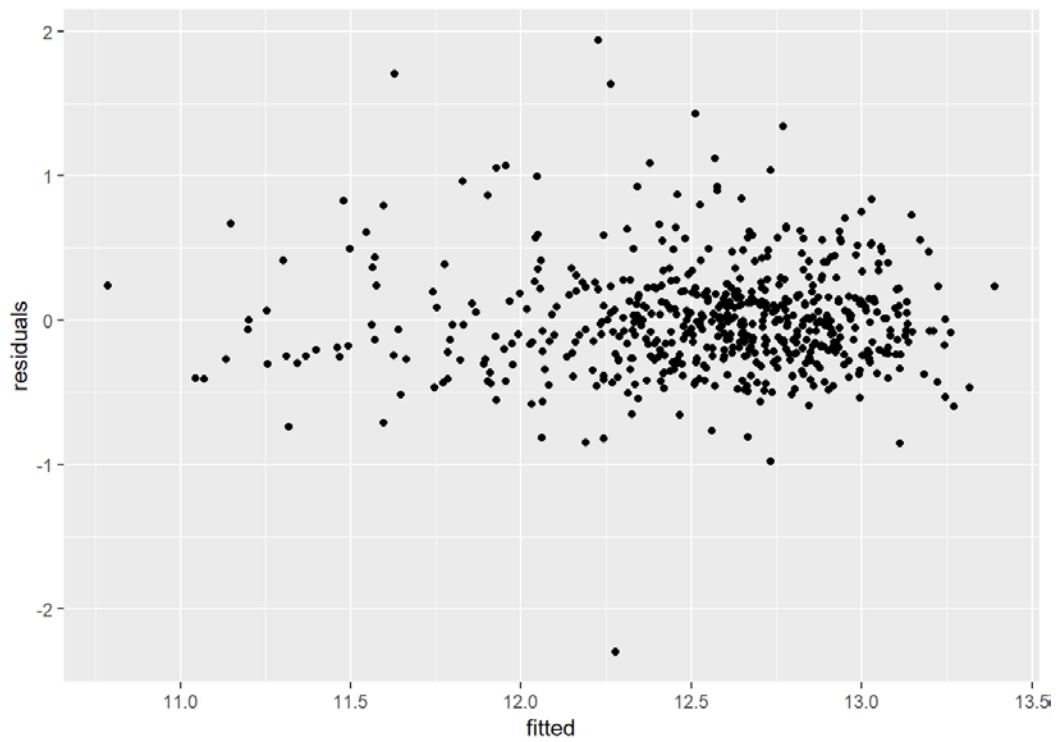
L. Standardized Residuals Plot (Large Farm Model)

M. Residuals vs. Fitted Values Plot (Large Farm Model)

N. Linear Regression Results for All 58 Variables

	Large Farms		Normal Farms		Small Farms	
	Estimate	Pr(>|t|)	Estimate	Pr(<|t|)	Estimate	Pr(>|t|)
(Intercept)	13.36	<	14.81	<	16.43	<
agey	0.00	0.879785	0.00	0.070965	0.01	0.003421
any_farm_use_fertTRUE	(0.01)	0.746903	(0.04)	0.006048	(0.03)	0.111802
any_farm_use_inset_herbTRUE	0.03	0.647535	0.01	0.653773	(0.01)	0.72141
any_farm_use_irrigateTRUE	(0.14)	0.107664	(0.02)	0.285661	(0.02)	0.39423
cooking_full_gasTRUE	(0.18)	0.700927	(0.25)	0.091573	NA	NA
do_mathTRUE	(0.06)	0.2862	(0.02)	0.391111	0.02	0.346209
educ_advancedTRUE	0.02	0.829174	(0.05)	0.081192	0.00	0.970578
educ_beceTRUE	0.09	0.083568	0.02	0.298551	(0.01)	0.583985
farm_size	(0.04)	<2.00E-16	(0.40)	<2.00E-16	(2.40)	<2.00E-16
females_on_farme	(0.00)	0.850267	0.00	0.690648	0.00	0.039552
fishingTRUE	0.09	0.094106	0.05	0.003113	0.04	0.07634
harvest_sold_consumerTRUE	0.15	0.007911	0.06	0.01484	0.01	0.653583
harvest_sold_coopTRUE	0.25	0.032413	0.10	0.21041	NA	NA
harvest_sold_gateTRUE	0.14	0.047385	0.08	0.000469	0.08	0.020328
harvest_sold_marketTRUE	0.10	0.009877	0.07	1.29E-08	0.06	0.000526
harvest_sold_state_orgTRUE	0.16	0.000174	0.13	4.37E-13	0.10	0.00037
have_agric_ext_centerTRUE	(0.05)	0.408958	0.03	0.156605	0.01	0.803106
have_bankTRUE	(0.19)	0.151212	(0.12)	0.000817	(0.07)	0.045834
have_barTRUE	(0.05)	0.243567	0.00	0.901855	(0.01)	0.508652
have_cooperativeTRUE	(0.12)	0.003232	(0.03)	0.012844	(0.03)	0.196765

have_daily_mktTRUE	0.06	0.4301	(0.03)	0.133533	(0.00)	0.968446
have_hospitalTRUE	(0.17)	0.288154	0.06	0.278254	0.06	0.425893
have_post_of_pub_telephoneTRUE	0.06	0.496381	0.05	0.047481	0.00	0.969822
have_week_mktTRUE	(0.13)	0.029308	(0.01)	0.627768	0.00	0.930169
I(agey^2)	(0.00)	0.9903	(0.00)	0.0494	(0.00)	0.00498
I(farm_size^2)	0.00	2.46E-10	0.02	<	0.65	<
light_eletricityTRUE	(0.02)	0.767352	(0.02)	0.477008	(0.01)	0.820061
light_generatorTRUE	0.01	0.950723	0.05	0.504776	NA	NA
males_on_farme	0.00	0.302515	0.00	0.606611	(0.00)	0.847217
most_impor_farmingTRUE	0.08	0.705038	(0.02)	0.782168	(0.02)	0.732301
most_impor_fishingTRUE	NA	NA	NA	NA	NA	NA
moto_road_impassableTRUE	(0.15)	0.000534	(0.02)	0.135696	0.02	0.22794
moto_roadTRUE	(0.24)	0.000301	(0.06)	0.008249	(0.02)	0.645898
mutual_aid_farmTRUE	0.16	0.011111	0.04	0.051702	0.02	0.502177
own_businessTRUE	0.05	0.232122	(0.03)	0.038267	(0.00)	0.818314
paid_at_monthTRUE	(0.18)	0.450013	(0.03)	0.817122	0.17	0.314681
paid_at_saleTRUE	(0.62)	0.131243	0.16	0.136306	NA	NA
paid_at_weekTRUE	NA	NA	(0.08)	0.419871	NA	NA
people_come_for_job_farmingTRUE	0.09	0.073997	(0.01)	0.536325	0.00	0.81714
public_transpTRUE	0.00	0.981437	(0.03)	0.079616	(0.02)	0.415399
region_Ashanti	(0.20)	0.14798	0.23	2.75E-11	0.12	0.045498
region_Brong_Ahafo	(0.11)	0.4199	0.28	1.05E-15	0.14	0.035793
region_Central	(0.32)	0.02043	0.13	0.000119	0.10	0.10922
region_Eastern	0.05	0.740281	0.15	3.80E-06	0.05	0.391493

region_Greater_Accra	NA	NA	0.20	0.000126	0.16	0.04093
region_Northern	(0.29)	0.028845	0.07	0.016942	0.31	1.44E-06
region_Upper_East	(0.33)	0.049512	0.02	0.603646	NA	NA
region_Volta	(0.12)	0.380189	0.21	3.70E-10	0.16	0.006122
region_Western	(0.01)	0.959748	0.28	3.66E-14	0.21	0.000545
sex_maleTRUE	(0.01)	0.91902	(0.03)	0.128534	(0.03)	0.188464
spouse_live_hhTRUE	0.07	0.201159	0.07	2.20E-05	0.06	0.008219
toilet_flushTRUE	(0.24)	0.338134	(0.02)	0.810818	0.02	0.823423
toilet_latrineTRUE	(0.15)	0.001924	(0.01)	0.743402	0.02	0.277171
wall_cementTRUE	NA	NA	NA	NA	NA	NA
wall_ironTRUE	NA	NA	(0.24)	0.318865	(0.10)	0.395225
wall_mudTRUE	(0.02)	0.598958	(0.02)	0.284334	0.02	0.444936
wall_stoneTRUE	0.17	0.435525	0.00	0.962297	0.06	0.493541
wall_woodTRUE	(0.18)	0.349999	0.02	0.849832	(0.06)	0.709646