Climate Change in Belize

Bah'Inah Rimpel

Community College of Baltimore County

Independent Research, Math 293 Cohort 3

May 21, 2021

Abstract:

Climate is the condition of the atmosphere (rainy or dry) over a long period of time. Climate change therefore refers to the shift in the condition of the atmosphere as a result of changes in the atmospheric composition. (Stennet et al, 2019). Factors such as level of concentration of greenhouse gases that include carbon dioxide, may cause a shift in climate where regions experience extended rainfall patterns or drought. The main causes are use of fossil fuels as a source of energy. Climate change affects the day-to-day activities of people around the world. The study was aimed at understanding how climate change has affected the county of Belize.

A study was conducted in Belize in the years 2016, 2018, and 2019. This study included 137 interviews from a variety of residents residing in Belize. The Interviews provided qualitative data that showed correlations between natural resources, sea-level rise, livelihood location, and changes in the timing of seasons, aquaculture fishing practices, and many more. By implementing this data into the SPSS software, correlations were found between multiple variables using the Chi-Square statistical analysis testing. Where the data concluded that location played a significant role in how the people of Belize were affected by Climate Change.

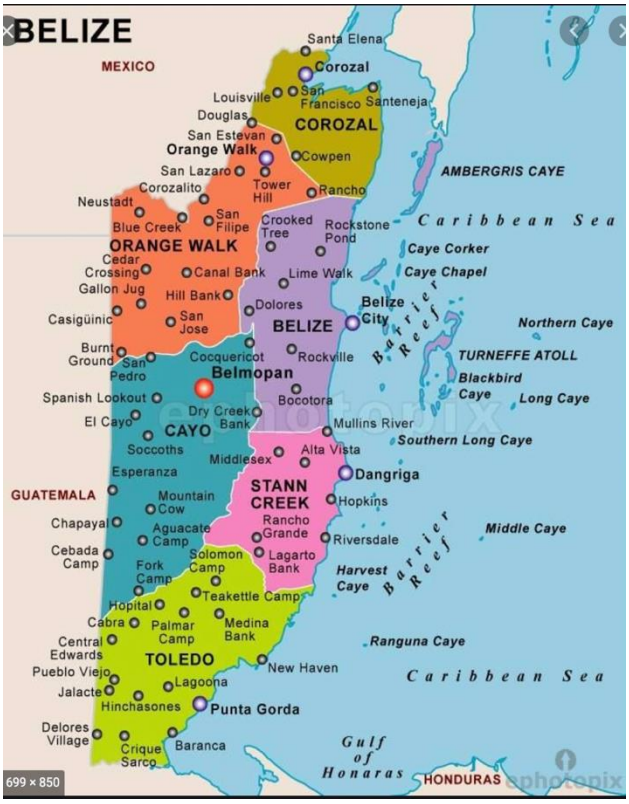
Country Overview:

Climate Change in Belize

Belize is located in Central America, bordered by Mexico in the north, Guatemala in the south, and the Caribbean Sea to its east. Belize is a small country, measuring about 274 km long north to south and 109 km wide east to west. Its total land area is approximately 22,970 km^2, which includes 1,540 km^2 of lagoons and 690 km^2 of approximately 450 small islands (FAO, 2015).

The country is divided into six districts, which include Belize, Cayo, Corozal, Orange Walk, Stann Creek, and Toledo. The Northern region of the country is flat, with swamplands and coastal plains, while the southern region is home to low mountains, hills, and a flat coastline (Sweetman, 2018).

Located near the equator, Belize has a subtropical climate and two primary seasons. The rainy season begins in June and ends in November, while the dry season begins in December and ends in May (FAO, 2015). Belize has a population of about 420,000 people and is one of the least populated countries in Latin America. Belize houses the largest coral barrier reef in the Western hemisphere, only second to the great barrier reef in Australia, which runs almost the entire length of the coastline measuring about 386 km (Karlsson et al, 2020). As of 2015, 63 percent of the country is classified as forest, with 35 percent of that being forest reserves or has protected status by the government (FAO, 2015). Altogether agriculture



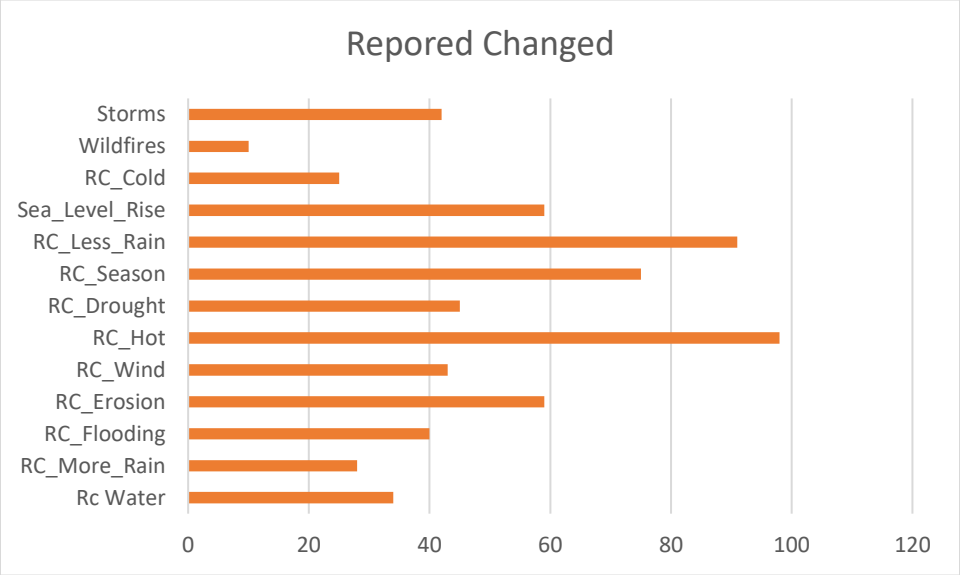
production and fisheries make up 11.7% of GDP, industry accounts for 14.4%, while tourism accounts for almost one-fourth of Belize's GDP (Lindenberg et al, 2006)

Objectives and Methodology

This study was conducted by interviewing residents of Belize. A total of 137 interviews were collected from 2015-2019 mainly during the rainy season. The participants were questions on their age, gender, years lived in the area, sea-level rise, increased rainfall, decreased rainfall, and many other variables related to climate change. The majority of these interviews took place along the coastline of Belize, specifically in the regions of Corozal, Belize, Stann Creek, and Toledo.

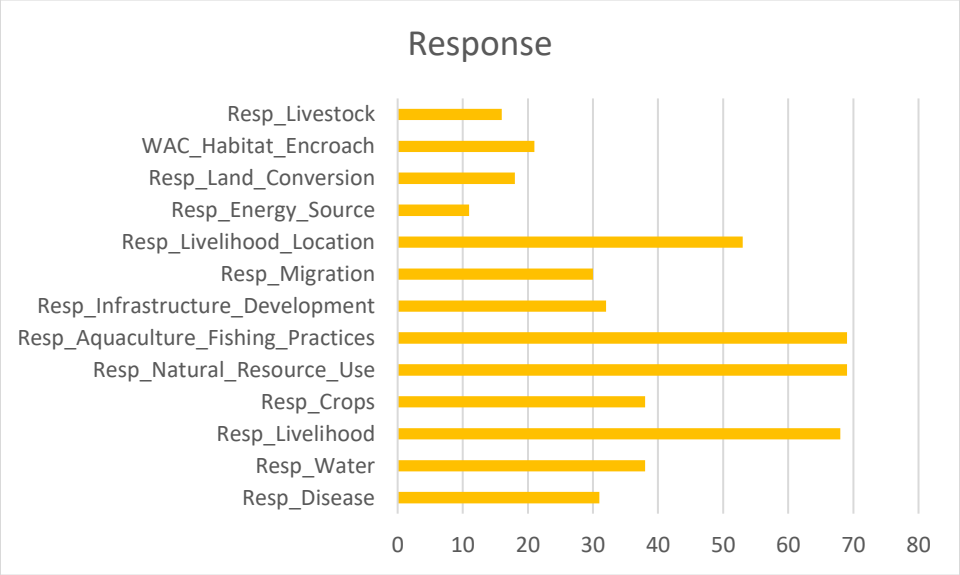
From the interviews, variables were generated that showed either reported changes or responses to those changes. 38 relevant variables were coded into SPSS variable view. Specifics about the state of the variables were included under "Values" in SPSS. For instance, under the variable "decreased rainfall", "reported" or "not reported" were coded as values. Most of these variables were identified and labeled within the interviews by the data analyst. Below shows the frequency of the variables that reported change.

Graph 1: Reported Changes



From the results above it is quite clear that majority of the residents have experienced an increase in temperature and lowered rainfall as compared to the past. Changes in the seasonal pattern has also occurred as indicated in the graph above. An increase in erosion has been observed by the residents. However, a very low number of people have observed changes in wildfires.

Graph 2: Responses to Reported Changes



A majority of the people stated that they changed their fishing practices, natural resources and livelihoods. However, most interviewees indicated that they still depend on the forms of resources that depended on their location. With lower numbers in response to land conversion, encroachment and livestock practices.

The interviews give us an idea of what climate-related issues the residents of Belize are experiencing and how people are acclimating to climate change. Belize is a small whose economy relies heavily on its ability to properly utilize its resources. These Chi-Squared test allowed me to see which variables played a more significant role to how climate change is affecting everyday life. Belizeans rely on the resources within their community to make a living. Location plays a major role in how climate change affects the people of Belize. Below is a graph of the responses to the climate change occurring in Belize? These variables were used to analyze the effect of climate change.

Chi-Square Test:

Chi-Square tests were used to find correlations between several variables. To better understand the variables used to conduct these tests, it is important to define those variables. A list of the variables that were coded into SPSS was used to run the Chi-Square test listed below.

Variables	SPSS Values	What caused it to be reported?
Resp_Energy Source	0= Not Reported 1= Reported	Energy sources
Resp_Natural Resources Use	0= Not Reported 1= Reported	Natural resource use
RC_Sea Level Rise	0= Not Reported 1=Reported	Sea level rise
Resp_Crop	0= Not Reported 1= Reported	Changes in crop practices
Resp_Location	0= Not Reported 1= Belize 2= Toledo 3= Stann Creek 4= Corozal	Location
RC_Storms	0= Not Reported 1= Reported	Change in storms
Resp_Infrastructure Development	0= Not Reported 1= Reported	Infrastructure Development
RC_Cold	0= Not Reported 1= Reported	Cold Spells/Frost
RC_Drought	0= Not Reported 1= Reported	Drought
RC_Water Source	0= Not Reported 1= Reported	Loss of Water Source
Resp_Aquaculture Fishing Practices	0= Not Reported 1= Reported	Change in aquaculture and fishing practices
RC_Erosion/Landslide	0= Not Reported	Erosion/Landslides

	1= Reported	
RC_Hot	0= Not Reported 1= Reported	Hotter Days/Heat Waves
RC_Less Rain	0= Not Reported 1= Reported	Decreased Rainfall
Resp_Land Conversion	0= Not Reported 1= Reported	Land conversions
Gender	0=Not Reported 1=Male 2=Female	**Gender**
Age	0= Not Reported 1= 18-35 2= 36-53 3= 54-71 and greater	Age
Years Lived in Area	0=Not Reported 1= Greater than 10 years 2= 1-10 years	Years lived in an Area
RC_More Rain	0= Not Reported 1= Reported	Increased Rain Fall
Resp_Disease	0= Reported 1= Not Reported	Pest/Disease Management
Resp_Livestock	0= Not Reported 1=Reported	Change in livestock practices

Notes: ---Some variables were left out due to lack of significant correlations

NR= Not Reported

R= Reported

RC= Reported Change

Resp= Response

The Chi-Square Test is used to find significance between two variables, and the strength of the significance between those specific variables. The Chi-Square Test provides two conclusions:

(Null hypothesis) $\boldsymbol{H_0}$: There is no significant association among the variables

(Alternative hypothesis) $\boldsymbol{H_1}$: There is a significant association among the variables

Phi and Cramer's V: analyzes the strength of that association

A Chi-Square test is generated for two variables. Once a table is populated, then we check for any violations, table size, p-value, and then the significance of that correlation. The first step is to analyze whether the generated table from the Chi-Square Test violates the assumptions. If the table is a two-by-two and no cells have an expected count less than five, then the table does not violate the assumptions. Second, if the table is two by two, the Pearson Chi-Square and the asymptotic significance, (p-value) is analyzed for significance. If the p-value is less than 0.05, we accept the H_1 (the alternative hypothesis). If the p-value is more than 0.05, we accept H_0 (the null hypothesis), and the test shows no significance. A p-value of 0.05, tells us that we have a 95% confidence in the Chi-Square test that was generated. Third, if the table is two by two, the Phi value is used to analyze the strength of the associations. If the table is not two by two, there are no violations, and the alternative hypothesis is accepted, then Cramer's V value is used to analyze the strength of the associations.

If a Chi-Square Test violation occurs, then two possible scenarios must be considered. The number of cells in violation and table size must be analyzed to determine which values from the Chi-Square test show any significance. If the table is a two by two then Fisher's exact test and Exact sig (2 sided) is the p-value used to determine significance. If the table is more than

two by two, we will follow the same steps and check the Chi-Square table to ensure that the Chi-Square assumption is not violated. If the assumption is violated, then the Likelihood ratio and asymptotic significance are used. If the table is two by two, the Phi value is used to check the strength of the association. If the table is more than two by two, Cramer's V value is used to check the strength of the association.

Association Level	**No Association**	**Low Association**	**Moderate Association**	**High Association**
Phi	0-0.1	0.1-0.3	0.3-0.5	>0.5
Cramer's V	0-0.1	0.1-0.3	0.3-0.5	>0.5

Example 1:

In this first example, there are no cells that violate the assumptions; all cells have an expected count of five and above. The table is a two by two, so the Pearson Chi-square and the asymptotic significance are used to determine significance. The value was determined to be 0.002, which is below 0.05, so the H_1 (the alternative hypothesis) is accepted. Lastly, the Phi value is used to determine the strength of the association. The Phi value of .268 shows a low association between the variables.

Response: Crop Practices * Reported Change: Changes in timing of seasons Crosstabulation

			Reported Change: Changes in timing of seasons		
			NR	Reported	Total
Response: Crop Practices	NR	Count	53	46	99
		Expected Count	44.8	54.2	99.0
		% within Response: Crop Practices	53.5%	46.5%	100.0%
		% within Reported Change: Changes in timing of seasons	85.5%	61.3%	72.3%
		% of Total	38.7%	33.6%	72.3%
	Reported	Count	9	29	38
		Expected Count	17.2	20.8	38.0
		% within Response: Crop Practices	23.7%	76.3%	100.0%
		% within Reported Change: Changes in timing of seasons	14.5%	38.7%	27.7%
		% of Total	6.6%	21.2%	27.7%
Total		Count	62	75	137
		Expected Count	62.0	75.0	137.0
		% within Response: Crop Practices	45.3%	54.7%	100.0%
		% within Reported Change: Changes in timing of seasons	100.0%	100.0%	100.0%
		% of Total	45.3%	54.7%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.877[a]	1	.002		
Continuity Correction[b]	8.708	1	.003		
Likelihood Ratio	10.336	1	.001		
Fisher's Exact Test				.002	.001
Linear-by-Linear Association	9.805	1	.002		
N of Valid Cases	137				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 17.20.

b. Computed only for a 2x2 table

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.268	.002
	Cramer's V	.268	.002
N of Valid Cases		137	

Example 2:

In this second example, the Chi-Square Test shows that two cells are violating the Chi-Square assumptions; the expected count is less than 5. The table is two by three, so the Likelihood Ratio and Asymptotic significance (2 sided) are used to determine significance. The p-value of 0.003 is less than that of 0.05, therefore the alternative hypothesis H_1 is accepted. The Cramer's V value is 0.287, which shows a low association between the variables.

Years lived in area * Reported Change: Changes in timing of seasons Crosstabulation

			Reported Change: Changes in timing of seasons		
			NR	Reported	Total
Years lived in area	Not Reported	Count	3	2	5
		Expected Count	2.3	2.7	5.0
		% within Years lived in area	60.0%	40.0%	100.0%
		% within Reported Change: Changes in timing of seasons	4.8%	2.7%	3.6%
		% of Total	2.2%	1.5%	3.6%
	Greater than 10	Count	34	61	95
		Expected Count	43.0	52.0	95.0
		% within Years lived in area	35.8%	64.2%	100.0%
		% within Reported Change: Changes in timing of seasons	54.8%	81.3%	69.3%
		% of Total	24.8%	44.5%	69.3%
	1–10 years	Count	25	12	37
		Expected Count	16.7	20.3	37.0
		% within Years lived in area	67.6%	32.4%	100.0%
		% within Reported Change: Changes in timing of seasons	40.3%	16.0%	27.0%
		% of Total	18.2%	8.8%	27.0%
Total		Count	62	75	137
		Expected Count	62.0	75.0	137.0
		% within Years lived in area	45.3%	54.7%	100.0%
		% within Reported Change: Changes in timing of seasons	100.0%	100.0%	100.0%
		% of Total	45.3%	54.7%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.310[a]	2	.004
Likelihood Ratio	11.413	2	.003
Linear-by-Linear Association	6.560	1	.010
N of Valid Cases	137		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 2.26.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.287	.004
	Cramer's V	.287	.004
N of Valid Cases		137	

Tests that accepted the Alternative Hypothesis

The subsequent tables will elaborate on the test that satisfied the requirement and accepted H_1 (the alternative hypothesis). These tables show the tests ran for my hypothesis that show no, low, moderate, and high association.

Table 1: No Significance

```
CROSSTABS
  /TABLES=RC_Hot BY Resp_Livelihood
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ PHI
  /CELLS=COUNT EXPECTED ROW COLUMN TOTAL
  /COUNT ROUND CELL.
```

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Reported Change: Heat waves/ Hotter days * Response: Livelihood Type	137	100.0%	0	0.0%	137	100.0%

Reported Change: Heat waves/ Hotter days * Response: Livelihood Type Crosstabulation

			Response: Livelihood Type		
			NR	Reported	Total
Reported Change: Heat waves/ Hotter days	NR	Count	19	20	39
		Expected Count	19.6	19.4	39.0
		% within Reported Change: Heat waves/ Hotter days	48.7%	51.3%	100.0%
		% within Response: Livelihood Type	27.5%	29.4%	28.5%
		% of Total	13.9%	14.6%	28.5%
	Reported	Count	50	48	98
		Expected Count	49.4	48.6	98.0
		% within Reported Change: Heat waves/ Hotter days	51.0%	49.0%	100.0%
		% within Response: Livelihood Type	72.5%	70.6%	71.5%
		% of Total	36.5%	35.0%	71.5%
Total		Count	69	68	137
		Expected Count	69.0	68.0	137.0
		% within Reported Change: Heat waves/ Hotter days	50.4%	49.6%	100.0%
		% within Response: Livelihood Type	100.0%	100.0%	100.0%
		% of Total	50.4%	49.6%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.059[a]	1	.808		
Continuity Correction[b]	.003	1	.957		
Likelihood Ratio	.059	1	.808		
Fisher's Exact Test				.851	.478
Linear-by-Linear Association	.059	1	.809		
N of Valid Cases	137				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 19.36.

b. Computed only for a 2x2 table

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	-.021	.808
	Cramer's V	.021	.808
N of Valid Cases		137	

Variables	P-Value	Phi or Cramer's V	Significance?
Heat waves/Hotter days and Livelihood type	0.808>0.05	-0.021	No
Heat waves/Hotter Days and Natural Resource use	0.808>0.05	0.21	No

A Chi Square Test was generated using the variables Heat Waves/Hotter Days with Livelihood type and Natural Resource Use. For both test there were zero cells violating the Chi-Square assumptions and the table is a two by two. This means we use the Pearson Chi-Square and the Asymptotic Significance, which is 0.808. The p value of 0.808 is greater than 0.05, so this test shows no significance between the variables.

My original theme was to see whether there was a correlation between high temperatures' effect on livelihood type and natural resource use in Belize. After running the Chi-Squared Test to check for correlation, the math showed that there was no significance between high temperatures on livelihood type and natural resource use. Initially, I was surprised to see the math contradict my original hypothesis, but Belize is a subtropical country. The slight temperature rise would not greatly affect Belizeans, who were accustomed to a warm climate.

Table 2: Low Association

```
CROSSTABS
  /TABLES=RC_Season BY Resp_Livelihood
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ PHI
  /CELLS=COUNT EXPECTED ROW COLUMN TOTAL
  /COUNT ROUND CELL.
```

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Reported Change: Changes in timing of seasons * Response: Livelihood Type	137	100.0%	0	0.0%	137	100.0%

Reported Change: Changes in timing of seasons * Response: Livelihood Type Crosstabulation

			Response: Livelihood Type		
			NR	Reported	Total
Reported Change: Changes in timing of seasons	NR	Count	40	22	62
		Expected Count	31.2	30.8	62.0
		% within Reported Change: Changes in timing of seasons	64.5%	35.5%	100.0%
		% within Response: Livelihood Type	58.0%	32.4%	45.3%
		% of Total	29.2%	16.1%	45.3%
	Reported	Count	29	46	75
		Expected Count	37.8	37.2	75.0
		% within Reported Change: Changes in timing of seasons	38.7%	61.3%	100.0%
		% within Response: Livelihood Type	42.0%	67.6%	54.7%
		% of Total	21.2%	33.6%	54.7%
Total		Count	69	68	137
		Expected Count	69.0	68.0	137.0
		% within Reported Change: Changes in timing of seasons	50.4%	49.6%	100.0%
		% within Response: Livelihood Type	100.0%	100.0%	100.0%
		% of Total	50.4%	49.6%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.072[a]	1	.003		
Continuity Correction[b]	8.068	1	.005		
Likelihood Ratio	9.182	1	.002		
Fisher's Exact Test				.003	.002
Linear-by-Linear Association	9.006	1	.003		
N of Valid Cases	137				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 30.77.

b. Computed only for a 2x2 table

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.257	.003
	Cramer's V	.257	.003
N of Valid Cases		137	

Variables	P-Value	Phi or Cramer's V value	Association Level
Change in Timing of the Seasons and Livelihood type	0.003	0.257	Low

There are zero cells in violation and the table is two by two. We use the Pearson Chi Square and the asymptotic significance to find the p value. The p value of 0.003 is less than 0.05 so we can conclude there is significance between the variables. We then look at Phi value. The Phi value shows 0.257, which means there is a low association between the variables.

Belize relies heavily on its natural resources to support its economy. The data shows that there is currently a low association between Belizeans changing their livelihood types based on the changes in the timing of seasons. As the seasons come earlier or later, there is a slight change

in what kind of livelihood type Belizeans choose to engage in. Banana farmers may choose to become citrus farmers, as the seasons become harder to predict and citrus can better withstand short periods of cold. The government has been slowly changing its focus from tourism to agriculture and fisheries as climate change affects their dependence on their natural resources (Leslie, 2020). This slow change in focus from tourism to agriculture and diversifying its fisheries is reflected in our low association between livelihood type and changes in the timing of seasons. This association may have become stronger due to the effects of the pandemic on the tourism sector.

Table 3: Moderate Association

```
CROSSTABS
  /TABLES=Resp_Natural_Resource_Use BY Resp_Livelihood
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ PHI
  /CELLS=COUNT EXPECTED ROW COLUMN TOTAL
  /COUNT ROUND CELL.
```

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Response: Natural Resource Use * Response: Livelihood Type	137	100.0%	0	0.0%	137	100.0%

Response: Natural Resource Use * Response: Livelihood Type Crosstabulation

			Response: Livelihood Type		
			NR	Reported	Total
Response: Natural Resource Use	NR	Count	47	21	68
		Expected Count	34.2	33.8	68.0
		% within Response: Natural Resource Use	69.1%	30.9%	100.0%
		% within Response: Livelihood Type	68.1%	30.9%	49.6%
		% of Total	34.3%	15.3%	49.6%
	Reported	Count	22	47	69
		Expected Count	34.8	34.2	69.0
		% within Response: Natural Resource Use	31.9%	68.1%	100.0%
		% within Response: Livelihood Type	31.9%	69.1%	50.4%
		% of Total	16.1%	34.3%	50.4%
Total		Count	69	68	137
		Expected Count	69.0	68.0	137.0
		% within Response: Natural Resource Use	50.4%	49.6%	100.0%
		% within Response: Livelihood Type	100.0%	100.0%	100.0%
		% of Total	50.4%	49.6%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	18.993[a]	1	<.001		
Continuity Correction[b]	17.533	1	<.001		
Likelihood Ratio	19.459	1	<.001		
Fisher's Exact Test				<.001	<.001
Linear-by-Linear Association	18.854	1	<.001		
N of Valid Cases	137				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 33.75.

b. Computed only for a 2x2 table

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.372	<.001
	Cramer's V	.372	<.001
N of Valid Cases		137	

Variables	P-value	Phi or Cramer's V value	Association Level
Natural Resource Use and Livelihood Type	<0.001	0.372	Moderate

A Chi-Squared Test was generated on the variables Natural Resource Use and livelihood Type. There are zero cells in violation and the table is two by two. We look at the Pearson Chi-Square and the Asymptotic Significance to find the p value. The p value is <0.001 which is less than 0.05, which means there is a significance between the variables. We than look at Phi value. The Phi value of 0.372 shows a moderate significance between the variables.

```
CROSSTABS
  /TABLES=Resp_Natural_Resource_Use BY Location
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ PHI
  /CELLS=COUNT EXPECTED ROW COLUMN TOTAL
  /COUNT ROUND CELL.
```

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Response: Natural Resource Use * Response: Livelihood Location	137	100.0%	0	0.0%	137	100.0%

Response: Natural Resource Use * Response: Livelihood Location Crosstabulation

			Response: Livelihood Location				
			Belize	Toledo	Stann Creek	Corozal	Total
Response: Natural Resource Use	NR	Count	43	6	12	7	68
		Expected Count	29.3	8.9	15.4	14.4	68.0
		% within Response: Natural Resource Use	63.2%	8.8%	17.6%	10.3%	100.0%
		% within Response: Livelihood Location	72.9%	33.3%	38.7%	24.1%	49.6%
		% of Total	31.4%	4.4%	8.8%	5.1%	49.6%
	Reported	Count	16	12	19	22	69
		Expected Count	29.7	9.1	15.6	14.6	69.0
		% within Response: Natural Resource Use	23.2%	17.4%	27.5%	31.9%	100.0%
		% within Response: Livelihood Location	27.1%	66.7%	61.3%	75.9%	50.4%
		% of Total	11.7%	8.8%	13.9%	16.1%	50.4%
Total		Count	59	18	31	29	137
		Expected Count	59.0	18.0	31.0	29.0	137.0
		% within Response: Natural Resource Use	43.1%	13.1%	22.6%	21.2%	100.0%
		% within Response: Livelihood Location	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	43.1%	13.1%	22.6%	21.2%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	23.689[a]	3	<.001
Likelihood Ratio	24.602	3	<.001
Linear-by-Linear Association	20.250	1	<.001
N of Valid Cases	137		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.93.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.416	<.001
	Cramer's V	.416	<.001
N of Valid Cases		137	

Variables	P-value	Phi or Cramer's V value	Association Level
Natural Resource use and Location	<0.001	0.416	Moderate

A Chi-Square Test was generated for the variables Natural Resource use and Location. There are no cells in violation and the table is two by four. We look at the Pearson Chi-Square and Asymptotic Significance to find the p value. The p value of <0.001 is less than 0.05, which shows their significance between the variables. Since the table is two by four, we look at Cramer's V value of 0.416 which shows a moderate association between the variables.

The Chi-Square test shows that there is a moderate association between natural resources use and livelihood type. Belize is a small country that is very dependent on its natural resources, with citizens basing their livelihoods on the resources available. For example, dams along

several rivers produce electricity to help power the country. In addition, the four main sources of revenue in Belize rely heavily on its natural resources: the timber industry, agricultural productions, fisheries, and tourism. Residents are often employed in these industries or trades that service these industries.

Table 4: Moderately High to High Association

```
CROSSTABS
  /TABLES=Location BY RC_Water_Source
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ PHI
  /CELLS=COUNT EXPECTED ROW COLUMN TOTAL
  /COUNT ROUND CELL.
```

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Response: Livelihood Location * Reported Change: Loss of Water Source	137	100.0%	0	0.0%	137	100.0%

Response: Livelihood Location * Reported Change: Loss of Water Source Crosstabulation

			Reported Change: Loss of Water Source		
			NR	Reported	Total
Response: Livelihood Location	Belize	Count	55	4	59
		Expected Count	44.4	14.6	59.0
		% within Response: Livelihood Location	93.2%	6.8%	100.0%
		% within Reported Change: Loss of Water Source	53.4%	11.8%	43.1%
		% of Total	40.1%	2.9%	43.1%
	Toledo	Count	13	5	18
		Expected Count	13.5	4.5	18.0
		% within Response: Livelihood Location	72.2%	27.8%	100.0%
		% within Reported Change: Loss of Water Source	12.6%	14.7%	13.1%
		% of Total	9.5%	3.6%	13.1%
	Stann Creek	Count	23	8	31
		Expected Count	23.3	7.7	31.0
		% within Response: Livelihood Location	74.2%	25.8%	100.0%
		% within Reported Change: Loss of Water Source	22.3%	23.5%	22.6%
		% of Total	16.8%	5.8%	22.6%
	Corozal	Count	12	17	29
		Expected Count	21.8	7.2	29.0
		% within Response: Livelihood Location	41.4%	58.6%	100.0%
		% within Reported Change: Loss of Water Source	11.7%	50.0%	21.2%
		% of Total	8.8%	12.4%	21.2%
Total		Count	103	34	137
		Expected Count	103.0	34.0	137.0
		% within Response: Livelihood Location	75.2%	24.8%	100.0%
		% within Reported Change: Loss of Water Source	100.0%	100.0%	100.0%
		% of Total	75.2%	24.8%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	28.149[a]	3	<.001
Likelihood Ratio	28.266	3	<.001
Linear-by-Linear Association	24.906	1	<.001
N of Valid Cases	137		

a. 1 cells (12.5%) have expected count less than 5. The minimum expected count is 4.47.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.453	<.001
	Cramer's V	.453	<.001
N of Valid Cases		137	

Variables	P-value	Phi or Cramer's V value	Association Level
Location and Loss of Water Source	<0.001	0.453	Moderately High

A Chi-Square Test was generated with the variables Location and Loss of Water Source. One Cell was in violation and the table is two by four. The likelihood Ratio and the Asymptotic Significance p value is used to check for significance. The p value of <0.001 is less than 0.05, meaning there is significance between the variables. We check the Cramer's V value of 0.453, which shows a moderately high association between the variables.

```
CROSSTABS
  /TABLES=Location BY Resp_Crops
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ PHI
  /CELLS=COUNT EXPECTED ROW COLUMN TOTAL
  /COUNT ROUND CELL.
```

Crosstabs

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Response: Livelihood Location * Response: Crop Practices	137	100.0%	0	0.0%	137	100.0%

Response: Livelihood Location * Response: Crop Practices Crosstabulation

			Response: Crop Practices		
			NR	Reported	Total
Response: Livelihood Location	Belize	Count	55	4	59
		Expected Count	42.6	16.4	59.0
		% within Response: Livelihood Location	93.2%	6.8%	100.0%
		% within Response: Crop Practices	55.6%	10.5%	43.1%
		% of Total	40.1%	2.9%	43.1%
	Toledo	Count	11	7	18
		Expected Count	13.0	5.0	18.0
		% within Response: Livelihood Location	61.1%	38.9%	100.0%
		% within Response: Crop Practices	11.1%	18.4%	13.1%
		% of Total	8.0%	5.1%	13.1%
	Stann Creek	Count	25	6	31
		Expected Count	22.4	8.6	31.0
		% within Response: Livelihood Location	80.6%	19.4%	100.0%
		% within Response: Crop Practices	25.3%	15.8%	22.6%
		% of Total	18.2%	4.4%	22.6%
	Corozal	Count	8	21	29
		Expected Count	21.0	8.0	29.0
		% within Response: Livelihood Location	27.6%	72.4%	100.0%
		% within Response: Crop Practices	8.1%	55.3%	21.2%
		% of Total	5.8%	15.3%	21.2%
Total		Count	99	38	137
		Expected Count	99.0	38.0	137.0
		% within Response: Livelihood Location	72.3%	27.7%	100.0%
		% within Response: Crop Practices	100.0%	100.0%	100.0%
		% of Total	72.3%	27.7%	100.0%

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	44.011[a]	3	<.001
Likelihood Ratio	43.851	3	<.001
Linear-by-Linear Association	31.613	1	<.001
N of Valid Cases	137		

a. 1 cells (12.5%) have expected count less than 5. The minimum expected count is 4.99.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.567	<.001
	Cramer's V	.567	<.001
N of Valid Cases		137	

Variables	P-value	Phi or Cramer's V value	Association Level
Location and Crop Practices	<0.001	0.567	High

A Chi-Square Test was generated with the variables Location and Crop Practices. One Cell was in violation and the table is two by four. The likelihood Ratio and the Asymptotic Significance p value is used to check for significance. The p value of <0.001 is less than 0.05, meaning there is significance between the variables. We check the Cramer's V value of 0.567, which shows a high association between the variables.

Running Chi-Square test based on location produced several tests that accepted the alternative hypothesis. The location had an exceptionally high association with loss of water source and crop practices. Belize has very acidic soil which drains very poorly, with only 16% of the land available for farming without skilled management. Its low mountains are incapable of being used for agriculture due to their siliceous soils. (White, 2016). Crop practices are heavily dependent on the location of the farm. Chi-Square Test for the loss of water source in certain locations indicts that that water sources are drying up and becoming contaminated with seawater. When loss of water and drought was tested, it showed a moderately high association. Loss of water source and sea-level rise also showed a low to moderate association.

Conclusion:

Location plays a major factor in how the residents of Belize are affected by climate change. In Belize, location affects livelihood type, the resources available, the kinds of crops that should be planted, the water sources available, drought, and much more. When the location was tested with multiple variables, most Chi-Squared tests accepted the alternative hypothesis. Being a small country, residents are reliant on the resources at their disposal within their location.

Limitations:

The biggest limitation I encountered was that the variables Ages and Years Lived in an Area were grouped and not specific numerical values. These values needed to be more specific to properly group values into SPSS. If the specific ages, and years lived were presented in the interviews, I would have been able to more effectively reduce the values of the variables, allowing me to run more tests with fewer violations. There were also several areas where information about the resident's age was missing. 35 interviews were missing the ages of the

participants. This also increased the number of values coded for the variables in the variable view, contributing to multiple violations.

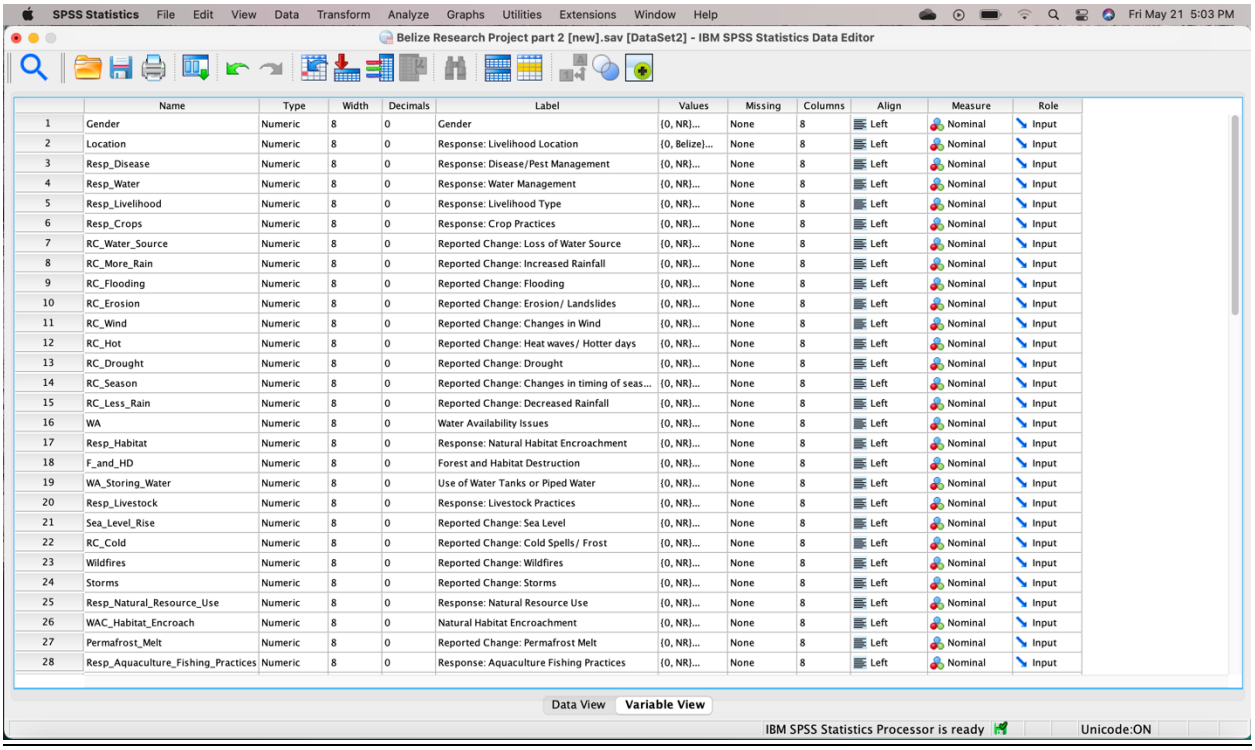
It should also be noted that while these tests show significance and association, they are not evidence of real-world phenomena. They are indicative of interview patterns and may hold no true useful bases in possible climate change patterns.

Future Study:

I believe it would be beneficial to have more questions in future studies about coral health (coral bleaching, the effects of tourism on coastal communities, the amount of energy consumption, the kind of energy sources used, and energy availability. Belize also has a large timber industry, yet there was very little mention of the health of its forest. It would be important to interview residents on the health of the forest and the impact climate change has had on them. There was also little mention of regional animal populations. It would also be important to interview more people who live in the interior of the country, seeing as most participants lived near the coast.

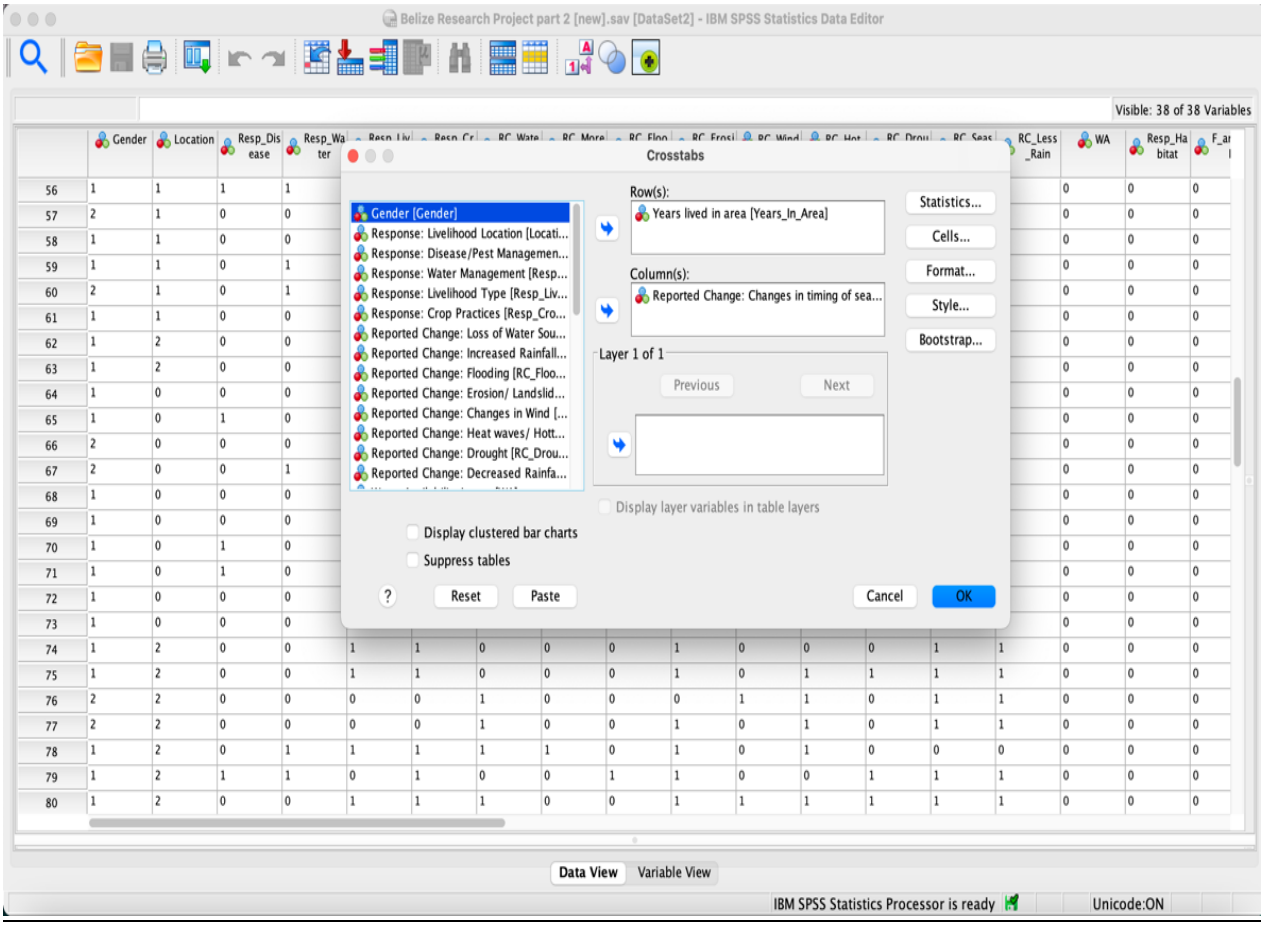
SPSS Screenshots:

This screenshot shows how the variables were labeled and coded for SPSS software. A list of the variables used to run the Chi-Square Test is listed above. Variables were coded with a response label of Resp or a reported change label of RC. There were 38 variables created in the variable view and were later turned into their numerical values in the data view. 137 interviews were numerically coded in the data view to run the Chi-Squared Test.



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	Gender	Numeric	8	0	Gender	{0, NR}...	None	8	Left	Nominal	Input
2	Location	Numeric	8	0	Response: Livelihood Location	{0, Belize}...	None	8	Left	Nominal	Input
3	Resp_Disease	Numeric	8	0	Response: Disease/Pest Management	{0, NR}...	None	8	Left	Nominal	Input
4	Resp_Water	Numeric	8	0	Response: Water Management	{0, NR}...	None	8	Left	Nominal	Input
5	Resp_Livelihood	Numeric	8	0	Response: Livelihood Type	{0, NR}...	None	8	Left	Nominal	Input
6	Resp_Crops	Numeric	8	0	Response: Crop Practices	{0, NR}...	None	8	Left	Nominal	Input
7	RC_Water_Source	Numeric	8	0	Reported Change: Loss of Water Source	{0, NR}...	None	8	Left	Nominal	Input
8	RC_More_Rain	Numeric	8	0	Reported Change: Increased Rainfall	{0, NR}...	None	8	Left	Nominal	Input
9	RC_Flooding	Numeric	8	0	Reported Change: Flooding	{0, NR}...	None	8	Left	Nominal	Input
10	RC_Erosion	Numeric	8	0	Reported Change: Erosion/ Landslides	{0, NR}...	None	8	Left	Nominal	Input
11	RC_Wind	Numeric	8	0	Reported Change: Changes in Wind	{0, NR}...	None	8	Left	Nominal	Input
12	RC_Hot	Numeric	8	0	Reported Change: Heat waves/ Hotter days	{0, NR}...	None	8	Left	Nominal	Input
13	RC_Drought	Numeric	8	0	Reported Change: Drought	{0, NR}...	None	8	Left	Nominal	Input
14	RC_Season	Numeric	8	0	Reported Change: Changes in timing of seas...	{0, NR}...	None	8	Left	Nominal	Input
15	RC_Less_Rain	Numeric	8	0	Reported Change: Decreased Rainfall	{0, NR}...	None	8	Left	Nominal	Input
16	WA	Numeric	8	0	Water Availability Issues	{0, NR}...	None	8	Left	Nominal	Input
17	Resp_Habitat	Numeric	8	0	Response: Natural Habitat Encroachment	{0, NR}...	None	8	Left	Nominal	Input
18	F_and_HD	Numeric	8	0	Forest and Habitat Destruction	{0, NR}...	None	8	Left	Nominal	Input
19	WA_Storing_Water	Numeric	8	0	Use of Water Tanks or Piped Water	{0, NR}...	None	8	Left	Nominal	Input
20	Resp_Livestock	Numeric	8	0	Response: Livestock Practices	{0, NR}...	None	8	Left	Nominal	Input
21	Sea_Level_Rise	Numeric	8	0	Reported Change: Sea Level	{0, NR}...	None	8	Left	Nominal	Input
22	RC_Cold	Numeric	8	0	Reported Change: Cold Spells/ Frost	{0, NR}...	None	8	Left	Nominal	Input
23	Wildfires	Numeric	8	0	Reported Change: Wildfires	{0, NR}...	None	8	Left	Nominal	Input
24	Storms	Numeric	8	0	Reported Change: Storms	{0, NR}...	None	8	Left	Nominal	Input
25	Resp_Natural_Resource_Use	Numeric	8	0	Response: Natural Resource Use	{0, NR}...	None	8	Left	Nominal	Input
26	WAC_Habitat_Encroach	Numeric	8	0	Natural Habitat Encroachment	{0, NR}...	None	8	Left	Nominal	Input
27	Permafrost_Melt	Numeric	8	0	Reported Change: Permafrost Melt	{0, NR}...	None	8	Left	Nominal	Input
28	Resp_Aquaculture_Fishing_Practices	Numeric	8	0	Response: Aquaculture Fishing Practices	{0, NR}...	None	8	Left	Nominal	Input

This screenshot shows a snapshot of variables being selected to run a Chi-Squared Test. To run a Chi-Squared Test in SPSS, we click on analyze, then Descriptive Statistics, and then Crosstabs. Then we click statistics and select Chi-Squared than Phi and Cramer's V and click continue. Then we click cells and select observed, expected, row, column, total, and click continue. Once those setting are selected, any variable can be selected into each box. Once you click OK, a Chi-Squared test will be generated.


Belize Research Project part 2 [new].sav [DataSet2] - IBM SPSS Statistics Data Editor
Visible: 38 of 38 Variables
Crosstabs
Gender [Gender]
Response: Livelihood Location [Locati...
Response: Disease/Pest Managemen...
Response: Water Management [Resp...
Response: Livelihood Type [Resp_Liv...
Response: Crop Practices [Resp_Cro...
Reported Change: Loss of Water Sou...
Reported Change: Increased Rainfall...
Reported Change: Flooding [RC_Floo...
Reported Change: Erosion/ Landslid...
Reported Change: Changes in Wind [...
Reported Change: Heat waves/ Hott...
Reported Change: Drought [RC_Drou...
Reported Change: Decreased Rainfa...
Row(s):
Years lived in area [Years_In_Area]
Column(s):
Reported Change: Changes in timing of sea...
Layer 1 of 1
Previous
Next
Display layer variables in table layers
Display clustered bar charts
Suppress tables
Statistics...
Cells...
Format...
Style...
Bootstrap...
Reset
Paste
Cancel
OK
Data View
Variable View
IBM SPSS Statistics Processor is ready
Unicode:ON

References

Belize Ag Report. (2020, August 24). *Regeneration Belize & Regeneration International to Host 2nd Annual Tropical Agriculture Conference*. Belize Ag Report. https://agreport.bz/regeneration-international-and-regeneration-belize-to-host-2nd-annual-tropical-agriculture-conference/.

Belize seeks to diversify, add value to seafood exports. UNCTAD. (2019, December 13). https://unctad.org/news/belize-seeks-diversify-add-value-seafood-exports.

FAO Fishery Country Profile - Belize. (2005, August). http://www.fao.org/fi/oldsite/FCP/en/BLZ/profile.htm.

FAO. 2015. AQUASTAT Country Profile- Belize. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

Fugazza, M., Eugui, D. V., & Rosenow, S. (2016). *Evidence-based and policy coherent Oceans Economy and Trade Strategies1. Sector data factsheet2: Belize*. Unctad. https://unctad.org/system/files/non-official-document/ditc-ted-Belize-28112018-Factsheet-1-fisheries.pdf.

Haines, S. (2019). Managing expectations: articulating expertise in climate services for agriculture in Belize. *Climatic Change*, *157*(1), 43–59. https://doi.org/10.1007/s10584-018-2357-1

Karlsson, M., & Mclean, E. L. (2020). Caribbean Small-Scale Fishers' Strategies for Extreme Weather Events: Lessons for Adaptive Capacity from the Dominican Republic and Belize. *Coastal Management*, *48*(5), 456–480. https://doi.org/10.1080/08920753.2020.1795971

Leslie, K. (2020, September 16). *The PUP's plan – a shift from tourism to agriculture*. Amandala Newspaper. https://amandala.com.bz/news/the-pups-plan-a-shift-from-tourism-to-agriculture/.

New Agriculturist. New Agriculturist: Country profile - Belize. (2005, September). http://www.new-ag.info/en/country/profile.php?a=847.

Stennett-Brown, R. K., Stephenson, T. S., & Taylor, M. A. (2019). Caribbean climate change vulnerability: Lessons from an aggregate index approach. *PLOS ONE*, *14*(7). https://doi.org/10.1371/journal.pone.0219250

Sweetman, B. M., Cissell, J. R., Rhine, S., & Steinberg, M. K. (2018). Land Cover Changes on Ambergris Caye, Belize: A Case Study of Unregulated Tourism Development. *The Professional Geographer*, *71*(1), 123–134. https://doi.org/10.1080/00330124.2018.1501710

White, K. (2016, July 1). *The Caribbean Water Problem*. Caribbean Journal. https://www.caribjournal.com/2016/06/30/caribbean-water-problem/.