Carbon dioxide Emission from Cereal Food Production

Faith Oyewale OLABISI

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Introduction

Background of the Study

Agricultural practices significantly contribute to the global greenhouse gas emissions particularly through crop production. According to Ricthie (2021), deforestation for agriculture emits approximately 2.6 billion tonnes of (CO_2) each year, accounting for about 6.5% of global emissions. This phenomenon predominately occurs in tropical regions, where Brazil and Indonesia are the major players in both cereal food production and deforesation. This study utilizes data extracted from Ritchie (2021), which highlights the emission of carbon-dioxide (CO_2) from cereal food production across forty-four different countries. The data-set includes crucial variables such as country names, cereal products, total carbon-dioxide emissions in tonnes and per capital emissions. The study aims to analyse the carbon-dioxide (CO_2) emissions associated with cereal food production and assess their environmental impact.

Figure 1: Rice Farmers- source: linkedln.com

Objectives of the Study

General Objective of the Study

1. The major objective of the study is to analyse the Carbon-dioxide emissions emitted from cereal food production across forty-four countries.

Specific Objectives of the Study

1. Convert Carbon-dioxide emissions from tonnes to kilo-tonnes for a clearer understanding of emission across all cereal food products. This conversion will facilitate comparisons and enhance the interpretation of the data.
2. Perform exploratory data analysis to examine the relationships, trends and insights across all variables such as per capital emission, cereal with the highest range of carbon-dioxide emission and the level of emission from various countries.
3. Perform inferential analysis to determine if there are significant difference in carbon-dioxide emission across all the various cereal food products.

Methodology

Data Collection and Importation

1. The data The cereal data was accessed using the read_csv function from the tidyverse package for data wrangling and manipulation.

```
library(tidyverse) #data wranging and analysis
library(car) #anova & posthoc test
library(janitor) #data cleaning
library(knitr) #table formatting

cereal_emission <- read_csv('data/emission_data.csv')
cereal_emission |>
  colnames()
```

```
[1] "entity"              "code"                "products"
[4] "emission"            "per_capital_emission"
```

```
cereal_emission |>
  head() |>
  kable(
    caption = 'Cereal Food Production'
  )
```

Table 1: Cereal Food Production

entity	code	products	emission	per_capital_emission
Australia	AUS	Rice	879389.07	0.5242982
Australia	AUS	Wheat	41496.59	0.5242982
Australia	AUS	Other Cereals	89034.21	0.5242982
Austria	AUT	Rice	184118.42	0.3532005
Austria	AUT	Wheat	15495.06	0.3532005
Austria	AUT	Other Cereals	30146.20	0.3532005

Conversion of Emissions from Tonnes to Kilo-tonne.

1. The emission column under the cereal data was converted from tonnes to kilo-tonnes using the mutate function.

```
cereal_emission <-  cereal_emission |>
  mutate(
    emission = emission / 1000
  )

cereal_emission |>
  head() |>
  kable(
    caption = 'Cereal Food Production data in Kilotonne'
  )
```

Table 2: Cereal Food Production data in Kilotonne

entity	code	products	emission	per_capital_emission
Australia	AUS	Rice	879.38907	0.5242982
Australia	AUS	Wheat	41.49659	0.5242982
Australia	AUS	Other Cereals	89.03421	0.5242982
Austria	AUT	Rice	184.11842	0.3532005
Austria	AUT	Wheat	15.49506	0.3532005
Austria	AUT	Other Cereals	30.14620	0.3532005

```
cereal_emission |>
  summary() |>
  kable(
```

```
  caption = 'Summary of the Cereal Food Production'
)
```

Table 3: Summary of the Cereal Food Production

entity	code	products	emission	per_capital_emission
Length:132	Length:132	Length:132	Min. : 1.31	Min. :0.06882
Class :character	Class :character	Class :character	1st Qu.: 17.53	1st Qu.:0.20271
Mode :character	Mode :character	Mode :character	Median : 79.84	Median :0.38503
NA	NA	NA	Mean : 933.25	Mean :0.50759
NA	NA	NA	3rd Qu.: 316.46	3rd Qu.:0.50162
NA	NA	NA	Max. :62291.32	Max. :2.77977

```
cereal_emission |>
  car::some() |>
  kable(
    caption = 'Section of the Cereal Food Production'
  )
```

Table 4: Section of the Cereal Food Production

entity	code	products	emission	per_capital_emission
Australia	AUS	Other Cereals	89.034207	0.5242982
China	CHN	Other Cereals	460.586305	0.1387806
Czechia	CZE	Other Cereals	17.658683	0.1964134
Japan	JPN	Rice	2324.960378	0.3801927
Japan	JPN	Wheat	115.227108	0.3801927
Malta	MLT	Other Cereals	2.580518	0.3198645
Portugal	PRT	Rice	169.930569	0.3080427
Sweden	SWE	Wheat	18.330836	0.4097284
Switzerland	CHE	Wheat	27.841843	0.6448465
United States	USA	Other Cereals	1027.923640	0.3465427

Exploratory Data Analysis (EDA).

1. Exploratory data analysis such as **Univariate Analysis Bivariate Analysis** and **Multivariate Analysis** were conducted on the data to prepare the data for visualization. The following research questions where asked from the cereal data set.
2. Total Number of Countries engaged in the cereal production
3. check the distribution of carbon-dioxide emission and per capital emission
4. Visualize the emission of individual cereal Production between Australia and Austria
5. Visualize the emissions generated by each products

Inferential Statistical Analysis

1. Inferential statistical analysis was used to determine the difference in emission between products using the anova function from the car package.
2. Null Hypothesis: There is no significant difference in the emission between products
3. Alternative Hypothesis: There is significant difference in the emission between products

Results

View and Summary of the Data

```
tibble [132 x 5] (S3: tbl_df/tbl/data.frame)
 $ entity             : chr [1:132] "Australia" "Australia" "Australia" "Austria" ...
 $ code               : chr [1:132] "AUS" "AUS" "AUS" "AUT" ...
 $ products           : chr [1:132] "Rice" "Wheat" "Other Cereals" "Rice" ...
 $ emission           : num [1:132] 879.4 41.5 89 184.1 15.5 ...
 $ per_capital_emission: num [1:132] 0.524 0.524 0.524 0.353 0.353 ...
```

Table 5: Descriptive Summary of the Cereal Emission Production

entity	code	products	emission	per_capital_emission
Length:132	Length:132	Length:132	Min. : 1.31	Min. :0.06882
Class :character	Class :character	Class :character	1st Qu.: 17.53	1st Qu.:0.20271
Mode :character	Mode :character	Mode :character	Median : 79.84	Median :0.38503
NA	NA	NA	Mean : 933.25	Mean :0.50759

entity	code	products	emission	per_capital_emission
NA	NA	NA	3rd Qu.: 316.46	3rd Qu.:0.50162
NA	NA	NA	Max. :62291.32	Max. :2.77977

Descriptive Statistics for Emission

```
cereal_emission$emission |>
  summary()
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
   1.31   17.53   79.84  933.25  316.46 62291.32 
```

Descriptive Statistics for per_capital_emission

```
cereal_emission|>
  summarise(
    mean_capital = mean(per_capital_emission),
    median_capital = median(per_capital_emission),
    Minimum_capital = min(per_capital_emission),
    Maximum_capital = max(per_capital_emission)
  )|>
  kable(
    col.names = c('Mean', 'Median', 'Min', 'Max'),
    align = 'lccr',
    caption = 'Measure of Central Tendency for Capital Emission'
  )
```

Table 6: Measure of Central Tendency for Capital Emission

Mean	Median	Min	Max
0.5075854	0.3850314	0.0688176	2.779767

Convert emission from tonnes to kilotonne.

Table 7: First Six Rows from the Cereal Food Production Dataset

entity	code	products	emission	per_capital_emission
Australia	AUS	Rice	879.38907	0.5242982
Australia	AUS	Wheat	41.49659	0.5242982
Australia	AUS	Other Cereals	89.03421	0.5242982
Austria	AUT	Rice	184.11842	0.3532005
Austria	AUT	Wheat	15.49506	0.3532005
Austria	AUT	Other Cereals	30.14620	0.3532005

Exploratory Data Analysis (EDA).

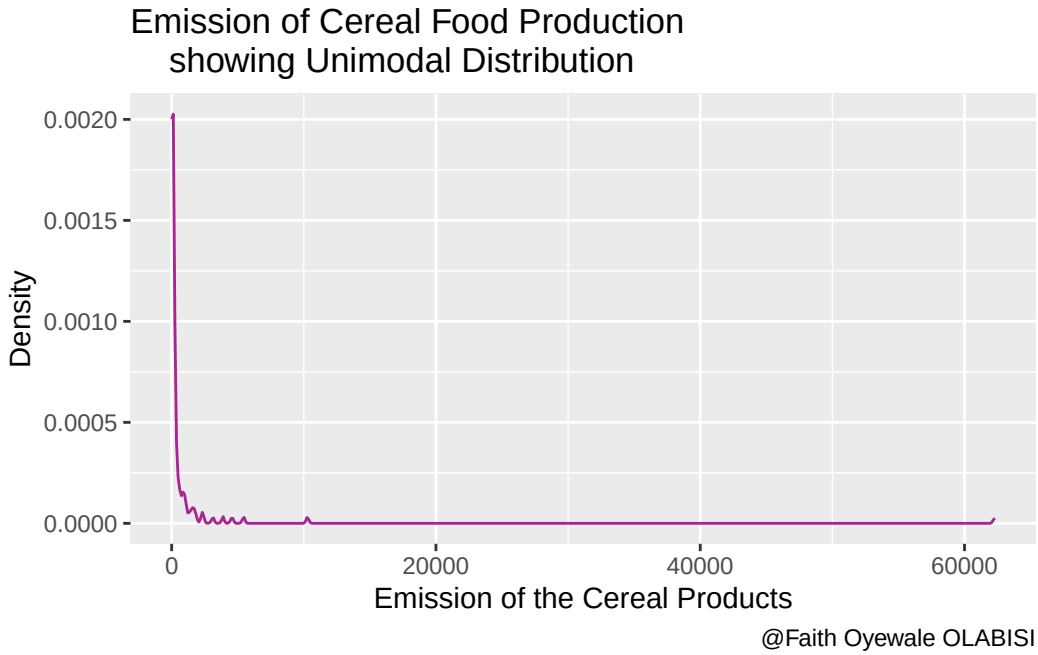
Univariate Analysis

Total Number of Countries engaged in the cereal production

[1] 44

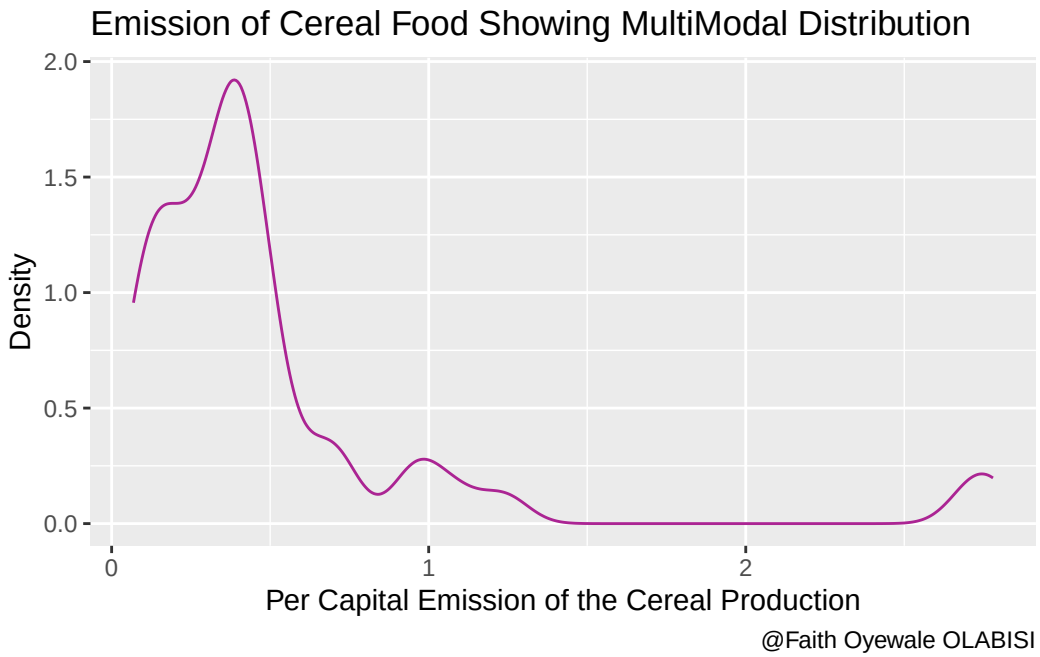
Distribution of Emission

```
cereal_emission |>
  ggplot(aes(emission))+
  geom_density(
    color = '#ab2493'
  )+
  labs(
    x = 'Emission of the Cereal Products',
    y = 'Density',
    caption = '@Faith Oyewale OLABISI',
    title = 'Emission of Cereal Food Production
    showing Unimodal Distribution'
  )+
  theme_gray()
```



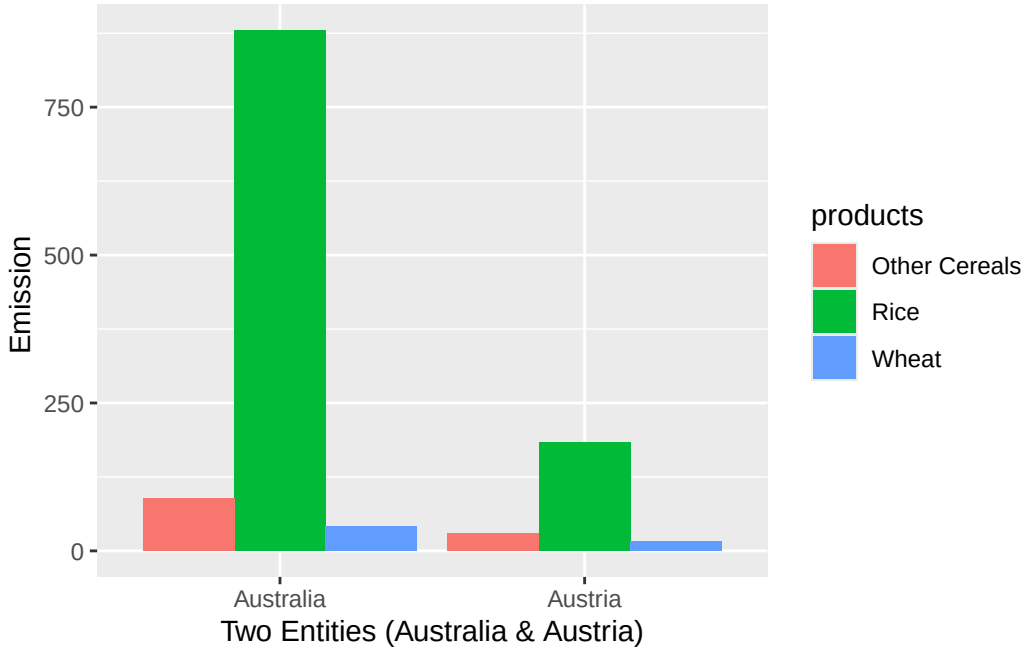

```
cereal_emission |>
  ggplot(aes(per_capital_emission))+
  geom_density(
    color = '#ab2493',
    alpha = 0.5
  )+
  labs(
    x = 'Per Capital Emission of the Cereal Production',
    y = 'Density',
    title = 'Emission of Cereal Food Showing MultiModal Distribution',
    caption = '@Faith Oyewale OLABISI'

  )+
  theme_gray()
```

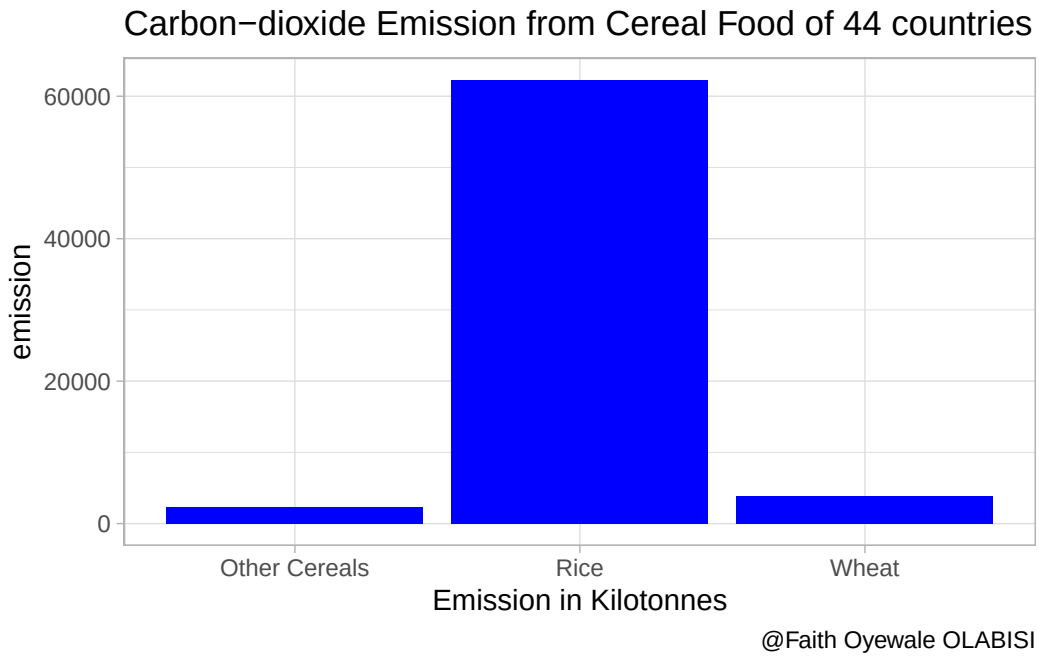


Bivariate Analysis

```
cereal_emission |>
  select(entity, products, emission) |>
  filter(entity == 'Australia' | entity == 'Austria') |>
  ggplot(aes(entity, emission, fill = products))+
  geom_bar(
    stat = 'identity',
    position = 'dodge'
  )+
  labs(
    x = 'Two Entities (Australia & Austria)',
    y = 'Emission '
  )
```

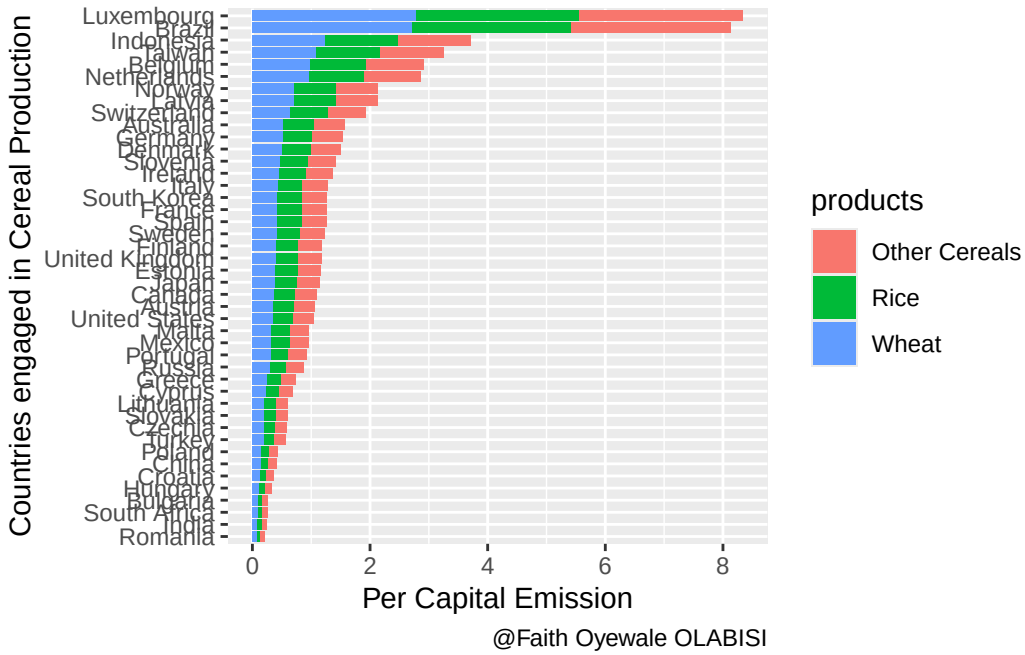



```
cereal_emission |>
  ggplot(aes(emission, products))+
  geom_bar(
    stat = 'identity',
    position = 'dodge',
    fill = 'blue'
  )+
  labs(
    X = 'Cereal Food Products',
    y = 'Emission in Kilotonnes',
    title = 'Carbon-dioxide Emission from Cereal Food of 44 countries',
    caption = '@Faith Oyewale OLABISI'
  )+
  theme_light()+
  coord_flip()
```

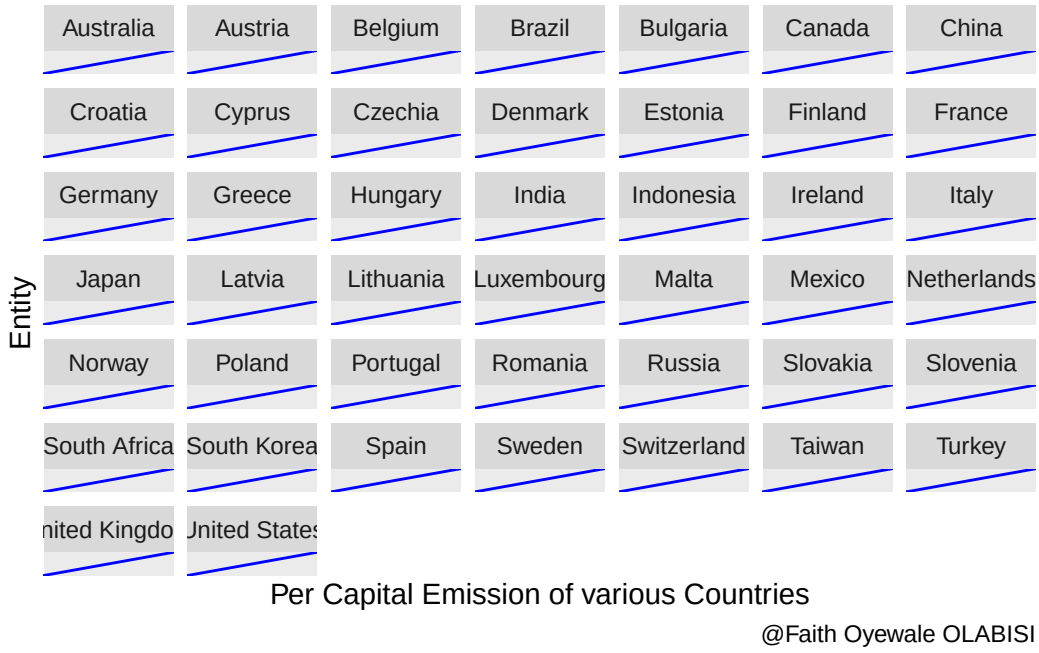


Multivariate Analysis

```
cereal_emission |>
  ggplot(aes(per_capital_emission, fct_reorder(entity, per_capital_emission), fill = products))+
  geom_bar(
    stat = 'identity'
  )+
  labs(
    x = 'Per Capital Emission',
    y = 'Countries engaged in Cereal Production',
    caption = '@Faith Oyewale OLABISI'
  )+
  theme(
    plot.title = element_text(face = 'bold', hjust = 9)
    )
```




```
cereal_emission |>
  ggplot(aes(per_capital_emission, entity, fill = products))+
  geom_abline(
    color = 'blue'
  )+
  labs(
    x = 'Per Capital Emission of various Countries',
    y = 'Entity',
    caption = '@Faith Oyewale OLABISI',
    Title = 'Trend of Capital Emission across various Countries'
  )+
  facet_wrap(~entity)
```



Inferential Statistical Analysis

```
anova_table <- aov(emission ~ products -1, data = cereal_emission) |>
  anova()

anova_table |>
  kable(
    caption = 'Anova Result showing the difference in Emission across all Products'
  )
```

Table 8: Anova Result showing the difference in Emission across all Products

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
products	3	241388075	80462692	2.691907	0.0489268
Residuals	129	3855885914	29890588	NA	NA

```
p_value <- anova_table$`Pr(>F)`
p_value
```

```
[1] 0.04892676       NA
```

Conclusion

- The result of the inferential analysis showed there is a significant difference in the emission of carbon-dioxide between the cereal food production ($p<0.05$), from the exploratory data analysis it can also be inferred that rice production as the highest range of emission compared to other products. Therefore, rice production emitted the highest range of carbon-dioxide across all countries while wheat and other cereals production had a low carbon-dioxide emission.
- The exploratory data analysis also showed us that Luxembourg, Brazil and Indonesia generated the highest levels of carbon-dioxide emission from cereal food production.
- Further analysis is needed to evaluate if the production levels of various products across all countries are the same so as to validate our analysis result which inferred that there is a significant difference in the emission across all products.

References

1. Ritchie, Hannah. (2021). "Carbon Emissions from Deforestation: Are They Driven by Domestic Demand or International Trade?" Our World in Data.