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The Impacts of Natural Disasters on Educational Attainment: Cross-Country Evidence from Macro Data

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Abstract

Do natural disasters impact educational attainment? Education as a paramount factor of economic development suffers from the uncontrollable effects of these increasing events from storms to floods, earthquakes to wildfires. Globally, educational resources are destroyed, directly and indirectly, students and teachers are displaced or killed, parents' income is affected because of natural disasters. Investments in human capital for rich- and low-income countries are exposed to the uneven impact of natural disasters that adjusts household and country-level decisions, leaving them to short and long-run losses. Exploring the influence of natural disasters on secondary school attainment across a sample of 85 countries from 1960 to 1990, we employ a panel data set from the Emergency Events dataset and Barro-Lee dataset. Using year and country fixed effects, the data shows that the intensity of deaths from natural disasters has a greater effect on secondary school attainment than the intensity of damages from these disasters. Data also suggests that damages per capita have a slightly significant effect on the secondary school repetition rate. Psychological and behavioral effects caused by deaths from disasters lead to disinvestments from human capital and these degenerates into long-term effects on economic development. Consequently, while natural disasters cannot be averted, its damages can be curtailed, therefore, it is crucial to inform policies that drive countries to a conscientious effort for high-performance social intervention programs; and motivate an urgency for climate change conversation.

Keywords: *Educational attainment, Natural Disasters, Economic Development, Education, Human Capital, Disinvestments.*

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Content

1. Introduction

The impact of natural disasters around the world has left nations with a significant amount of economic damages and deaths. According to the Food and Agriculture Organization (FAO), between 2003 and 2013 alone, the damages from disasters add up to about $1.5 trillion dollars, 1.15 million people killed and over 2 billion people affected.

These trigger the broad discussion of the devastating impacts of disasters on elements of economic and social development for present and future generations (Kousky, 2012, 2016). These impacts could be directly (Skidmore and Toya, 2007; Noy, 2009), indirectly (Gitter and Braham, 2007), or due to geographic variation, vulnerability and short and long run losses (Skidmore and Toya, 2007). Studies have also looked at the impacts of disasters on micro and macro outcomes; micro outcomes such as, education (Gitter and Braham, 2006), household income and expenditures (Anttila-Hughes and Hsiang, 2013), human capital productivity (Shah and Steinberg, 2017) and macro outcomes such as, long-run economic growth and GDP effects (Hsiang and Jina, 2014; UNDP report, 2005), positive and negative effects on foreign direct investment (Escaleras and Register, 2011).

Therefore, it is pertinent to fully understand the competing effects of disaster intensities and its disinvestment effects on these elements of economic and social development, especially on education. The knowledge of these impacts should help inform the policies that guide these elements economic and social development. Disinvestment, in this context, represents the withdrawal of investments or expenditure in any of these elements and diverting this expenditure into other seemingly profitable ventures or sectors of the economy.

Several studies report that the gravity of disasters is defined by the economic development factors such as the size of the government or public sector, level of educational attainment, openness, financial markets, and so on (Skidmore and Toya, 2007; Noy 2009). They show that high levels of education, openness, etc., exhibit readiness in the event of a disaster. Other authors have investigated the effect of natural disasters on economic growth such as the Hsiang and Jina (2014) global study of cyclones. They suggest that the long-term disaster costs set an average country back by two years of growth for every one standard deviation in a year's cyclone exposure and this lowers GDP by 3.6 percentage points twenty years later. They go further to predict that by 2090, damages from natural disasters would be as high as 9.7 trillion dollars in net present value.

Other studies are concerned with the sensitivity of these contemporaneous and disproportionate effects for poor households in the events of typhoons in the Philippines (Anttila-Hughes and Hsiang,

2013), shocks on child-nutrition (Alderman, 2009; Baez et al, 2010) which leads families close to subsistence level carry out precarious risk management and coping strategies all in the bid for survival while the child suffers hunger and malnutrition.

Furthermore, some authors discuss the natural disaster effects on not just cognitive skills but also future earnings (Hoddinott et al, 2008), where household income cuts that shift children out of schools into the labor market to help them contribute to the family income (Kousky, 2016). The likelihood of natural disasters to affect educational attainment via health has also been widely discussed where in rural households in Central Mexico, children are found to be more susceptible to (self-reported) diseases because of weather-related (flood, drought, and hurricanes) and geological (earthquakes) shocks (De la Fuente and Fuentes, 2008).

Up until to this point, all these studies have largely contributed to studying the impacts of natural disasters on a child's education, at the household level and globally. But very few have explored how the intensity of disaster damages and the number of deaths influence the disinvestment in education across countries. Therefore, the objective of this study is to fully explore that relationship while answering questions like, what are the impacts of damages and deaths per capita on secondary educational attainment and repetition rates? Does the income of a household show variation in the impacts of these disasters?

We contribute to this literature by analyzing the gap in human capital created by natural disasters. Particularly, we look at the micro-level effects of natural disasters on educational attainment using macro-level data.

This study tries to motivate policy implications for better risk management and coping strategies and fortifying the conversation about how much these risks as a subject of climate change can contribute to the loss of educational opportunity for developing countries.

The rest of this paper is organized as follows; Section 2 reviews disasters and relevant literature. Section 3 covers the methodology: hypothesis, model specification, and data sources. Section 4 discusses the results and Section 5 reviews the conclusion.

2. Literature Review

2.1 Natural Disasters

Natural disasters are natural events resulting from the natural processes of the earth such as floods, earthquakes, or hurricane leading to great damage or loss of life. For this paper, 8 major disasters will be explored from the Emergency Events Database (EM-DAT) which is maintained by the Centre for Epidemiology of Disasters (CRED) at the University of Louvalin, Belgium. Particularly, the number of

deaths and the value of economic losses (damages in USD '000) per capita will be the two major measures of disasters. These include geophysical disasters such as earthquake, mass movement (dry), volcanic activity, landslides; hydro-meteorological and climatological such as storms, floods, droughts, and wildfires. Each disaster is recorded as a disaster in the database if only at least: 10 or more people are reported killed; 100 or more people are reported affected, injured and/or homeless; a declaration of a state of emergency; and the case where the country calls for international assistance.

Figure 1, according to the CRED International Disaster Database, shows that natural disasters events from 1960 to 1990 has increased from about 40 events to 296 events and as highs as 400 events in the 2000s. Worldwide economic losses from natural disasters between 2003 and 2013 totals to about 1.5 trillion US dollars in damages. Subsequently, in 2015 and 2016, economic losses were about $92 billion and $108 billion respectively. For the 1960 to 1990 period, about 218 million people were affected by natural disasters per annum.

Floods have been ranked as the most frequent natural disaster, with 3,062 (about 43% of all events) flood events recorded between 1995 and 2015 by CRED. Storms and earthquakes account for about 28% and 8% (2,018 and 562 events) respectively. Landslide and Droughts are at 5%, that is 387 and 334 events. Wildfire and Volcanic activities are 4% and 2% (251 and 111 events) of total recorded natural disasters between 1995 and 2015 (World Economic Forum, 2016). From Figure 2, the data for this paper shows that USA, India, China and Indonesia had the highest number of disasters at 231(7.9%), 201 (6.9%), 148 (5.1%) and 133 (4.59%) events respectively. Japan and Bangladesh have 116 (4.0%) and 102 (3.5%) occurrences recorded from 1960 to 1990. Figure 3 presents the number of occurrences for 1960 to 1990 in percentages for 85 countries. Figures 4-11 gives the distribution of disaster incidences around the world by type.

2.2 Natural Disasters and Human Capital

There has been a wide debate about the effects of natural disasters shocks which could either have positive (Skidmore and Toya, 2002) or negative (Raddatz, 2007) effects on GDP. Both sides consider how the destruction of capital (both physical and human) by natural disaster shocks could either affect productivity in the long-run or encourage replacement of outdated capital with newer technologies.

Parts of literature discuss the potential effect of natural disaster risks on mortality which lowers education investment in disaster-prone countries (Cuaresma, 2010). According to the Asian Development Bank and the World Bank, the 2005 Earthquake in Pakistan led to the death of 853 teachers and 18,095

students, and the destruction of more than 7,500 schools and reconstruction efforts are unable to restore capacity and education infrastructure after a disaster.

Another part of literature considers the inequalities in risk exposure, access to resources, opportunities, and capabilities that put certain groups in a disadvantaged position raises questions about the heterogeneous effects of these risks for these groups (Baez et al, 2010). The gravity of a disaster is dependent on the complex interplay of socioeconomic and environmental factors (Thomalla, 2006) such as the population density, the level of development, etc. This is sensitive for how people can prepare and cope when disasters hit. Poor households, especially women and children, due to limited resources are forced to live in disaster-prone areas and are easily exposed to natural disaster shocks that leave large impacts to their human capital. The damaging consequences of disasters do not only affect education but also nutrition, health, and income generating processes and the magnitude and intensity of these effects could be long-lasting and colossal, leading to evacuation or permanent migration as in the Hurricane Katrina and Rita cases (Sacerdote, 2008). Furthermore, the frequency of being affected by the climate shock depends on their economic behavior (Baez et al, 2010; World Bank. 2000, Noy, 2009) which might keep these poor families from investing in human capital therefore partly justifying the slow rate of education attainment in low-income countries. Economic behavior, here, implies that the level of economic standing which determines preparedness in the event of disasters.

Studies have shown that disaster-prone areas tend to have declining levels of growth. Cyclone-prone climates affect the level of long-term growth and income for a country such that, cumulative effects of cyclones depress a country's per capita income by 7.4% two decades after the event (Hsiang and Jina, 2014). Tendencies for repeated incidences in these countries, such as small island states, affect growth. Most of these island states are prone to tropical cyclones due to the comparatively extensive coastline. The more the natural disasters, the higher it leads to high levels of damages for these states (Rasmussen, 2004).

Research also investigates that the after-effects of disaster shocks, such as destruction of durable assets and reduction of income, lead to large cuts in expenditure and indirectly disinvestments in health and human capital. For example, children in Cote D'Ivoire who experienced adverse weather shocks and households affected by typhoons in the Philippines had lower investments in education and health (Jensen, 2000; Anttila-Hughes and Hsiang, 2013) where poor households have limited ability to mitigate post-disaster losses and they tend to transfer investment to other ventures.

In addition, the elements connected to the creation and use of human capital, such as school performance, cognitive development, and then earnings and productivity are affected by the direct effects

of natural disasters (loss of lives, destruction of properties) which decomposes into indirect effects such as, macro impacts (general disequilibrium effects on prices and earnings, fiscal constraints) and micro impacts (household level effects like inability to invest in human capital, high probability of disability and mortality). The resulting outcomes of these effects such as temporary poor health and child malnutrition, unavailability of school resources, among many other factors, all degenerate the processes of human capital accumulation. To fully connect how inconsistencies caused by disaster shocks are a threat to future productivity and welfare through educational attainment, we must understand the theme supporting educational attainment.

2.3 Human Capital and Educational Attainment

Education has been described as a major contributor to growth. Human capital accumulation which is explained with investments in education is a strong determinant of economic progress as seen in labor productivity and social outcomes (Barro and Lee, 2013) and an abundance of well-educated human resources can be hampered by various natural disaster shocks.

Educational attainment, as reflected in the enrollment of school-aged population, is indicative of past inflows of schooling and the cumulative of these flows create future stocks of educational attainment (Lee and Lee, 2016, Barro and Lee, 1993, 2001). Secondary school attainment, therefore, represents the level of secondary attained, that is the percentage of an age-group that have completed their secondary education and have some form of secondary schooling.

Schools represent repositories for the formation of educational human capital by building positive externalities for society and instilling skills, attitudes, and values (Baez et al, 2010). Therefore, the role of schools, in addition to other tremendously crucial factors, are all equally important in the formation of human capital. But the role of schools surpasses not only the formation of human capital and goes further to ensure the reconstruction and returns on children to help the government rebuild the social contract (United Nations Development Programme (UNDP) report, 2005).

It is notable to stress the importance of time versus income in human capital development and the opportunity costs of schooling as an important factor for determining overall human capital investment. Time, in the sense that, early-life investment in human capital increases not just the level of human capital but also the return to additional human capital investments. Income, in the sense that, if low-education jobs offer higher wages, especially in poor countries then the opportunity cost of staying in school increases. Overall, this causes inequality and slows long-term growth (Shah and Steinberg, 2017; Baez et al, 2010).

Relatedly, recent research discusses how education outcomes face a substitution effect between children's capacity and the adult's labor on or off the farm. This takes from or eliminates the time and energy they have for school (Kousky, 2016, Kim, 2010, Shah and Steinberg, 2017), thereby demeaning the quality of education drops and human capital accumulation.

The availability of educational resources is another pertinent factor where the availability of both physical (schools, teachers, teaching and learning materials, etc.) and complementary resources (clean environment, accessibility, instruction time, etc.) bolster the accumulation of human capital. For example, in many developing countries, a Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) study showed that the average child was in a school with 8.7 of the twenty-two desirable school resource items; the range was from 4.3 items in Malawi to 16.7 in Seychelles, with wide urban-rural variation within countries (UNDP, 2005).

The level of attainment has also been connected to the ample or lack of supply of affordable educational opportunities where the UNDP report in 2005 discovered that children who live close to a secondary school had higher educational attainment. Furthermore, this report showed that children from higher socio-economic backgrounds – where parents had more education and households had more material possessions, including more books – tended to perform better than those from poorer homes. Children who lived in a household headed by a more educated person had higher SAGE (the ratio of the total number of years of school completed to the age of the child minus the age that a child starts school) scores (Gitter and Barham, 2008). This suggests that children of parents with higher human capital stock attain higher levels of human capital themselves. In other words, that increasing the educational outcome of the current generation will likely increase the educational attainment of future generations.

Nevertheless, one of the burdens that the human capital accumulation faces is the impact of risks such as disaster shocks on household's income, demography, and policy change, etc., on education outcomes. These outcomes are measured by school enrolment and attainment, grade advancement, performance at school, etc., (UNDP, 2005) which hamper the decision of the households and government to invest in the human capital.

2.3.1 *THE INTUITION OF EDUCATIONAL ATTAINMENT IN HUMAN CAPITAL*

The Barro-Lee (2011) study has successfully connected the importance of human capital attained through education to economic growth. The higher the level and distribution of education people receive, the higher the productivity. Lucas (1990) discusses that the growth rate of per capita income depends on

the growth rate of human capital accumulation and this consequently depends on the time allocation of the individuals for acquiring the skill. This goes further to express that increased investments or subsidies to education would have potentially large effects on human capital accumulation and long-term growth rate (Lucas, 1990) making it an easy link between human capital, productivity, and investments in human capital accumulation.

Likewise, the Barro-Lee study (2010, 2016) in tandem with Lucas (1988) stress "the way an individual allocates his time over various activities in the current period and how it affects his productivity or his average skill level" in the formation of human capital. Therefore, the level and quality of human capital affect current production and the allocation of an individual's current time is of the essence to the accumulation of human capital (Lucas, 1988).

Therefore, using survey/census data gathered from United Nations Educational, Scientific and Cultural Organization (UNESCO), Eurostat, national statistics agencies and other sources, the study creates a 5-year interval of educational attainment measure for over 58 countries from 1960 to 1990. These measures cover the distribution of educational attainment for the adult population over the age of 15 and over the age of 25 by gender for seven levels of schooling. Therefore, to prevent measurement error, the authors utilize observations by 5-year age intervals rather than the 5-year periods applied in their previous studies. Furthermore, the forward and backward extrapolation strategy is advanced by constructing estimates for survival rates by age and by education; and completion ratios by educational attainment and by age group. This structure ensures that the available aggregate stock of human capital is satisfactorily and concurrently measured as an input to production.

2.4 Natural Disasters and Educational Attainment

The heterogeneous and likely disproportionate nature of disasters makes the relationship between natural disasters and school attainment quite ambiguous.

Theoretical evidence shows that the direct effects of these shocks such as the destruction of critical educational centers and related infrastructure and complementary resources (roads and teachers) degenerate into indirect effects. Empirically, the effects of these events have proven largely negative where natural shocks leave households with tighter budgets causing them to cut down on basic investments in health, education and productive physical capital. In Jensen (2000), the enrolment rates in regions in Ivory Coast declined by approximately 20 percent for regions that experienced extreme weather shocks between 1986 and 1987 as compared to non-shock regions. Also, a study by Stein et al (2003) showed that the 1976

earthquake in eastern Guatemala had a negative impact on the number of grades attained by adults born in four villages of the country.

Furthermore, another link for the disaster-human-capital study is the shifts in parental investments in children due to cuts in expenditure that seem to be temporary adjustments to shocks now become permanent shifts (Baez et al, 2010). Past literature on shocks and human capital describe educational attainment as "path-dependent[1]", which is a behavioral effect of experiencing a shock (Kousky, 2016; Baez et al, 2010). Also, in addition to behavioral responses, the underlying effects of the disaster shocks goes further to effect changes in the use of children's time. These studies show that disasters, economic downturns, idiosyncratic shocks and risky environments are strongly correlated with the several responses. These include the effects of changes in the incidence of child labor or substitution effects in the aftermath of these disasters (Gitter and Braham, 2007), psychological effects like Post Traumatic Stress Disorder and depression (Kousky, 2016), which affect academic grades, attendance and subsequently, educational attainment.

Empirically, these shocks thereby affect the allocation of time in the formation of human capital. This empirical discussion of the importance of the years of schooling in human capital formation (Barro-Lee, 1993) gives the paper its foundation. The likelihood of positive productivity shocks has been seen to lower levels of educational attainment, just by a move from regular rainfall to a positive rainfall shock. Such that wages increase by 2 percent math test scores decrease by 2–7 percent of a standard deviation; school attendance decreases by 2 percentage points; and the probability that a child is enrolled in school decreases by 1 percentage point (Shah and Steinberg, 2017). On the other hand, the impact of extreme rainfall shocks in the early life of women shows a higher 0.22 grade of schooling (Maccini and Yang, 2008).

The long-term impacts of rainfall shocks in India show that more rainfall during school years (particularly ages 11–13) lowers total years of schooling. For this age group (which is the age group that transitions from primary to secondary school), the likelihood to drop out significantly increases with positive rainfall shocks. Thus, positive employment shocks are particularly detrimental to human capital investment during this period (Shah and Steinberg, 2017).

An important issue in discussing the effects of disasters on educational attainment is the interplay of the demand and supply effects of education in the period of the disaster. Several works of literature

[1] Baez et al (2010) describe the path dependency theory in the sense that the stock of human capital for a child is very dependent on the accumulated years of education. Therefore, any shock to these accumulated years of schooling creates a path that might affect the stock of human capital in the long-run. Such that, once a child drops out of school due to a shock, that child is less likely to return to school.

suggest that investment in education may result in serious and instant damages on health, mortality rate, and the supply of education resources inclusive. But when the disrupted supply of education resources is met with an inelastic demand for education where parents decide to move their children to other schools in less-prone areas of disaster, then cases like this resolve in no significant amount of damages from disasters on educational attainment. That is, combining both demand and supply effects, damages from disasters may not have a contemporaneous effect on attainment (Halliday, 2006; Rush, 2014).

An important concern in the disaster-human-capital literature is the death effects of disasters on educational attainment. Loss of a parent or guardian is one of the most traumatic events a child can face. Several studies show that if the loss of a parent reduces investments in children, it can also have other long-lasting implications. Using Indonesia's survey data during 1994-1996, Gertler et al (2004) empirically show that the demographic change caused by the death of a parent can affect the investment in children's education. The rate at which one human capital investment factor, school enrollment, is largely affected by a parent's recent death. In addition, Kousky (2016) reports that disaster shocks indirectly lead to high infant mortality due to malnutrition. Additionally, there were records of a high likelihood of depression and post-traumatic stress disorder for adolescents who lived in the most-damaged cities and those who experienced the death of a family member six months after Hurricane Mitch hit Nicaragua. After the 2004 tsunami, about 14 to 39 percent of the 264 children (aged 8 to 14 years) observed in affected areas of Sri Lanka had Post Traumatic Stress Disorder symptoms (Kousky, 2016; Lonigan, 1994; Neuner, 2006).

Moreover, the authors find that the intensity of disasters (measured by the ratio of casualties to population) is positively correlated with a larger differential effect on women's life expectancy. These effects, however, are reduced the higher the socio-economic status of women (Maccini and Yang (2013). This goes alongside with studies that have shown that a higher level of female attainment stimulates the acquisition of human capital by children while male educational attainment is more important in terms of the direct effects on GDP growth and non-human investment. (Barro and Lee, 1993, 2001).

Overall, this study tries to contribute to the disaster-human capital study by investigating the effects of natural disaster shocks on educational attainment for a broad group of countries.

2.4.1 Repetition Rate

Although repetition rates could be classified as a measure of school performance, it is a crucial way to investigate the efficiency of school systems in the face of natural disasters (UNESCO, 1993). Barro-Lee (1993) describe repeaters as students who are admitted to the same level as the previous year. In compiling data for this rate, differences in promotion standards must have been taken into consideration. This study

will be using the proportion of repeaters in the secondary level of education. UNESCO records that out of the 17 countries with the highest rates of secondary school repetition, 15 are in Sub-Saharan Africa and the other 2 are in the Middle East and North Africa. The highest levels of secondary repetition rates are recorded in Congo (30.8%), Iraq (27.5) and Algeria (27.2%) (UNESCO, UIS 2004). The presence of psychological, social or health factors from natural disasters causes lower attendance, lower performance, substitution effects of a child's time in school and working to earn household income. These factors create gaps in schooling, lower a child's grade and lead to higher drop-out rates in the long run.

3. METHODOLOGY

3.1 Overview of Data and Data Sources

Empirically, this study aims to analyze the impact of economic damages and deaths from natural disasters on educational attainment on all population and by gender for 85 countries from 1960 to 1990. Therefore, following the works of Barro-Lee (2001, 2010) and Escaleras et al (2011), this study combines data from the Emergency Events Database[2], Barro-Lee Educational Attainment (1993)[3] data set and the World-Bank[4] database to carry out this analysis.

Primarily, we limit analysis to only 8 of the most frequently occurring natural disasters; Floods, Storms, Earthquakes, Landslides, Drought, Wildfire, Volcanic activity and Mass movement (Dry). All 8 disasters are categorized into two groups; geophysical and hydro-meteorological. This study considers the total economic damages of these disasters in dollars (total damages) and the total deaths from these disasters (total deaths) as the major predictor variables. With the goal of measuring the long-term effects of natural disaster shocks, we use the intensity of deaths and damages as measures for disasters for the current and a period after that. This will cover 5 and 10 years after the event has occurred. Despite the misreporting or systematic reporting differences across countries and regimes, the CRED database is the most advantageous available.

The Barro-Lee dataset, as earlier discussed, provides data set for the educational attainment data of 85 countries by sex and by 5-year age intervals. We use the 15-24 population at the secondary school

[2] The Emergency Events Database is the International Disasters Database maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the University of Louvalin, Belgium. The data can be downloaded from www.emdat.be/

[3] The Barro-Lee Dataset provides educational attainment for 5-year intervals. The dataset can be downloaded from http://www.barrolee.com

[4] The World Bank Open Databank provides an extensive collation of data and can be downloaded from https://data.worldbank.org

attainment and repetition rates as main dependent variables. We use the empirical foundation of the Barro-Lee (1993, 2001) study specified;

$$Q = Q(F, R) + \varepsilon,$$

to control for other factors that influence educational attainment. F represents family resources (which include parents' income and education) and R represents school resources (such as government expenditure per student and pupil-teacher ratio). Therefore, we use the World Bank database to provide data on constant Gross Domestic Product per capita (GDPpc) per capita as a proxy for parents' income and aggregate country population. The Barro-Lee (1993) dataset provides data on the repetition rate and secondary school attainment, government spending per student, pupil-teacher ratio and parents' education.

According to the World Bank's country classification, all countries in my sample are grouped by region into East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, the Middle East and North Africa, North America, South Asia and Sub-Saharan Africa. Countries are also grouped by income into Low-income, Lower-middle-income, Upper-middle-income and High-income economies. All variables are measured in percentages which allow for consistency of empirical estimation of this study.

3.2 Model Specification and Hypothesis

The main question for this study;

- Do natural disasters impact human capital formation by reducing educational attainment?

The baseline model is;

$$Edu_{it} = \alpha + \beta_1 ND_{it} + \beta_2 ND_{it-1} + \beta_3 \ln\_gdppc_{it} + \beta_4 TEASEC_{it} + \beta_5 GEESEC_{it} + \beta_6 SEC25_{it} + \lambda_i + \lambda_t + \varepsilon_{it}$$

This model consists of the following:

Edu_{it} = represents the dependent variables which are;

- the percentage of secondary school attained in the total 15+ population for country i at time t (SEC15)
- the rate of repetition at the secondary school level (REPSEC)

ND_{it}= represents the natural disaster predictor variables which are;

- the ratio of the total number of deaths caused by natural disasters to the aggregate country population (deaths per capita)

- the ratio of the total value of economic losses caused by natural disasters to the aggregate country population (damages per capita)

ND_{it-1} = the lag measure of the natural disaster predictor variables

$\ln\_gdppc_{it}$ = the log value of constant gross domestic product as a proxy for parents' income

$TEASEC_{it}$= the ratio of students to teacher at the secondary school level

$GEESEC_{it}$= the real government current education educational expenditure per pupil at the secondary school level

$SEC25_{it}$= the percentage of secondary school attained in the total 25+ population

λ_i = country fixed effects

λ_t = year fixed effects

We test the hypothesis that disasters (damages and deaths per capita) cause a decline in educational attainment.

3.3 Empirical Strategy

The study applies the fixed effects model to measure the impacts of natural disasters on educational attainment following the results of a Durbin-Wu Hausman test. The results from the test show that the fixed effect is more aligned to yield consistent efficient estimates as compared to the random effects model. Specifically, we employ a year and country fixed effects model to account for time- and country-specific factors, clustered at the country level. The time-specific fixed effects account for any movement in the educational attainment variable for all countries while the country-specific fixed effects control for unobserved country variation that remains unchanged over time. Each regression was estimated with robust standard errors to check for issues of error variation (heteroscedasticity). Therefore, conditional on the country and year fixed effects, we assume that natural disasters are exogenously determined. Variation is identified by a within-country variation over time.

Since approximately all countries in the dataset have many disasters across the same year such that many countries appeared with repeated time values, data collected for natural disasters is collapsed to match the 5-year age interval educational attainment data. This ensures that a panel data set is available for analysis.

4. Results

4.1 Summary Statistics

Tables 2A to 2J in Appendix 2 provides a description of statistics for the full sample of 85 countries, 21 developed countries and 64 developing countries, and across regions. Secondary education attainment contains the value of those who have attained any form of secondary education and drop-out rate inclusive (Barro-Lee, 1993). This explains the average of the 15+ and 25+ population secondary school attainment at 22.74% and 17.6% for the developing countries and 21.55% and 16.6% for developed countries. Including the high drop-out rates, which at maximum 80% in developing countries as compared to 68.8% in developing countries, would make secondary attainment rates higher than it seems. Figure 3 gives a very detailed description of the secondary school attainment across countries. The repetition rates, on average, are highest in sub-Saharan and South Asia at 10% and 13% respectively. Barro-Lee (1993) point out that the promotion standard of schools in a country reflects the quality of schools in that country. Data shows as the teacher to student ratio go as high as 42 students per class in developing as compared to 37 students in developed countries. Public spending per student suggests that developed countries spend about $772 per student and developing countries. Gross Domestic Product per capita is at its lowest for South Asia at about $400 and $1777 for Sub-Saharan Africa. Deaths are on average 11,464 people in 85 countries with damages of over $500,000 on average for the entire sample.

4.2 Regression Results

4.2.1 Deaths and Secondary School Attainment

The regression results from columns 1 and 2 of Table 3 (see Appendix) estimate the effects of the intensity of deaths on secondary school attainment using both country and year fixed effects. We see that in the current period of the disasters, there is a negative and significant association with deaths per capita and secondary school attainment. This result is consistent with both columns 1 and 2 whether or not parents' income is controlled for. Secondary school attainment reduces by 10.3% and 12.8% at a 5% level of significance for a 1% increase in deaths per capita. At deaths per 1000, the 1% increase in deaths per capita will cause a decrease in attainment by 0.0103 percentage points. Although parents' income is not significant for both columns, results show a positive and highly significant of parents' education on a child's secondary school attainment. Holding all other factors constant, the attainment of secondary education increases by 90% and 92.6% for a 1% increase in parents' education.

These results are consistent with the literature which describes how the effects of deaths affected the attainment of the child. The loss of a parent or guardian leads to substitution effects, psychological and behavioral responses such as the likelihood of the child being pulled out of school to work on the farm instead of going to school, posttraumatic stress and depression (Kousky, 2016). These affect the

academic performance and attendance of the child. These effects are more significant for older children who were most likely to be pulled out of school to earn family income. For example, in India, weather shocks did not affect the level of school attainment for younger children but since older children were made to work for family income, their years of schooling reduced over time as seen in our results (Shah and Steinberg, 2017). Therefore, studies broadly discuss the relevance of a stronger economy via higher income, better government stability and investment climate in reducing death rates (Raschky, 2008 qtd. in Kousky, 2013).

These results also portray the importance of parents' education for children's education (Gitter and Braham, 2006; Barro-Lee, 1993). The outcome of a child's education is reflective that of the parent and this relevant for the human capital accumulation of that child. In the event of a disaster, the more withdrawal of investment is reduced, the higher the educational attainment of the current generation which translates into higher educational attainment for future generations.

4.2.2 Damages and Secondary School Attainment

For Table 4, we use the same model specification with the intensity of economic damages as the two main predictor variables with country and year fixed effects. Columns 1 and 2 show a negative and no significant relationship between damages per capita and secondary school attainment. Data suggests that the damages per capita have no significant impact on secondary educational attainment. We see the consistent significance of parents' education for secondary school attainment which remains positive and highly significant. The results show that a 1% increase in parents' education leads to an 89.6% and 91.5% increase in secondary school attainment, holding all other factors constant.

These findings are in line with previous literature which describes the supply and demand factors of education in the event of a disaster. Halliday (2006) and Rush (2014) discuss the likelihood of current effects of damages on educational attainment to fade away when the distorted supply of educational resources is met with an inelastic demand of education by parents. This is mostly seen in the migration effects caused by natural disasters. We see that the direction of damages per capita on educational attainment is consistent with the effects of deaths, but this is not statistically significant.

Educational attainment serves as a long-term element of education. We see the effects of both disaster measures on the highest number of years of schooling in the long run.

The use of damages as a measure somewhat poses a potential threat to validity. This is hard to ignore when considering the scales with which economic losses are recorded. The magnitude of a

disaster depends on the size of the country in terms of per capita income[5] (Cavallo et al, 2009). Cyclical fluctuations in relation to a country's gross domestic product (GDP) affects the over-estimation or under-estimation of economic damages that may occur. From Figure 1 (see Appendix), we see that a clear representation of the cyclical fluctuation across many countries over many years. The effect of these fluctuations reflects the systematic differences and misreporting of damages as a measure. This poses a threat of endogeneity in our analysis of natural disasters using economic damages.

4.2.3 Disasters and Repetition Rate

Repetition rate provides a short-run outcome of education where we look at the effect of the shock on the rate at which children repeat grades in school. Table 5 represents the same model specification with secondary school repetition rates as the dependent variable. From columns 1 and 2, data suggests that a positive association between repetition rates and natural disasters, with higher and significant effects from damages per capita in the current period of the disaster. Secondary educational attainment decreases by 19.6% for a 1% increase in damages per capita. We see consistency in the direction of the effects of these disaster measures with deaths per capita not statistically significant.

Data also suggest a negative association of repetition rates with variables like the parents' income, the ratio of teachers to students, government spending per student and parents' education. But we see a statistically significant impact of government expenditure per student such that a 1% increase in government spending decreases secondary repetition rates by 26.4%, holding all other factors constant. The negative and consistent direction of these variables for both columns 1 and 2 are in line with literature that discusses the importance of an increase in parent and school resources on student performance (Hanushek, 1997; Barro-Lee, 1993, 2001, 2010). Although household may form an inelastic demand for education, the likelihood of a child to repeat a grade is more influenced by the economic damages from disasters.

After controlling for country and year specific characteristics and socioeconomic determinants, we find that deaths per capita affect the stock of educational attainment at a 5% level of significance while damages per capita influence the flows of educational attainment.

[5] Cavallo et al (2009) discuss the issue of poorer countries facing higher effects of disaster because they take on more pro-cyclical fiscal policies rather than counter-cyclical policies that are relevant for reconstruction. Where advanced countries adopt counter-cyclical fiscal policies, they increase spending and reduce taxes to adopt recuperative measures.

Disasters lead to direct and indirect impacts such as poorer attendance, direct impacts of disasters on health, cuts in family expenditure and likely opportunity cost of the demand for education and the demand for household labor. These create distractions that reduce performance, difficulties in school work and in the long-run could lead to dropping out of school.

5. Conclusion

It is eminent to say that the distribution of a child's time in building human capital is important and any deviations or shock to this leads to long-term detriments to human capital accumulation and economic development. The pulling costs of disaster shocks cause a strain on investments in human capital and lead to a rather more pressing investment in other sectors of the economy. Direct and indirect impacts of disasters that lead to income loss and cuts in expenditure still stand as a challenge for developing countries. Developed countries have built stable mechanisms to reduce death effects and the after-effects of disaster shocks but human capital is still at risk where we see still a wide range of underperforming intervention policies and low commitment to education.

This study concludes that while the intensity of damages still shows negative influences on secondary schooling attainment, it does not significantly affect attainment. Rather, the intensity of deaths to secondary schooling attainment poses a significant threat for secondary school attainment. It is also important to note the significance of parents' education in increasing educational attainment across all specifications. This explains the current and contrasting educational attainment across regions and is consistent with the path-dependency theory. In cases where shocks have hindered attainment for children in the 60s-90s, this may spill over to their own children in the 21st century (Baez et al, 2010). The literature on repetition rates and likely external shocks that affect these rates has not been widely discussed but data here shows some evidence that the intensity of damages increases repetition rates in secondary schools.

This study provides insight into crucial factors that create gaps in educational levels for countries that are well-prepared to handle disasters and countries that are not. This informs the need for country-specific coping and risk management strategies to tailor plans for countries to prevent degradation of elements of economic development. It is also relevant in motivating policies that cater to the psychological and behavioral responses of disadvantaged groups mostly in developing countries. Humanitarian efforts and conditional transfer programs have been slowly rising but governments have to ensure that the right

channels are provided for these aids and programs to reach the disadvantaged and vulnerable groups. Undeniably, we see that the importance of education for past, present, and future cannot be underrated before, during and after a disaster (Gitter and Braham, 2006). Research shows that higher levels of past educational attainment determine the gravity of a disaster (Skidmore and Toya, 2006). Therefore, guarding education for the present generation is indicative of how good or bad effects from disasters would be.

With this knowledge of the impacts of disasters and the path dependency of education on policies, should this affect the urgency of acting on climate change? This would be a possible area for further research in addition to exploring the impact of these shocks on the quality of education at all levels which will strengthen country-specific policy interventions and place a stronger emphasis on the dangers education faces during natural disaster events, especially for developing countries.

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Appendix 1

TABLE 1: TABLE OF COUNTRIES

Afghanistan	Fiji	Mexico	Swaziland
Algeria	France	Morocco	Sweden
Argentina	Germany	Mozambique	Switzerland
Australia	Ghana	Myanmar	Syrian Arab Republic
Bangladesh	Greece	Nepal	Taiwan
Barbados	Guatemala	Netherlands	Thailand
Belgium	Haiti	New Zealand	Togo
Benin	Honduras	Nicaragua	Trinidad and Tobago
Bolivia	Hong Kong	Niger	Tunisia
Brazil	Hungary	Pakistan	Turkey
Canada	Iceland	Panama	Uganda
Chile	India	Paraguay	United Kingdom
China	Indonesia	Peru	United States of America
Colombia	Iran	Philippines	Uruguay
Congo D. R.	Iraq	Poland	Venezuela
Costa Rica	Italy	Portugal	Zambia
Cuba	Jamaica	Romania	
Cyprus	Japan	Senegal	
Denmark	Jordan	Sierra Leone	
Dominican Republic	Kenya	South Africa	
Ecuador	Malawi	Spain	
Egypt	Malaysia	Sri Lanka	
El Salvador	Mauritius	Sudan	

Appendix 2

Table 2: Summary Statistics

Table 2A: Full Sample

Variable	count	mean	sd	min	max
Total deaths	442	11464.81	120819.8	0	2006430
Total damages	442	598377.4	2031634	0	23795000
SEC15	434	22.47	15.76	0.7	73
SEC25	439	17.42	14.24	0.2	64
REPSEC	225	10.22	7.88	0	45
GDPpc	442	7311.39	10808.4	0	62159
GEESEC	442	686.8	897.28	0	4910
TEASEC	442	17.91	7.75	0	42
Agg Country Pop	442	51791963	145000000	0	1160000000

Table 2B: Developed Countries

Variable	count	mean	sd	min	max
Total deaths	101	378.09	1122.74	0	9008
Total damages	101	1575249	3539369	0	23795000
SEC15	101	21.55	13.98	1.6	50
SEC25	101	16.6	12.86	1.1	48
REPSEC	48	11.21	8.78	1	45
GDPpc	101	23174.34	12473.56	0	62159
GEESEC	101	772.52	957.77	0	3811
TEASEC	101	17.07	6.66	0	37
Agg Country Pop	101	42828735	57396615	221840.8	256000000

Table 2C: Developing Countries

Variable	count	mean	sd	min	max
Total deaths	341	14748.56	137426.4	0	2006430
Total damages	341	309040.1	1140950	0	13206237
SEC15	333	22.74	16.27	0.7	73
SEC25	338	17.66	14.64	0.2	64
REPSEC	177	9.95	7.62	0	44
GDPpc	341	2612.98	2978.74	0	20079
GEESEC	341	661.41	878.44	0	4910
TEASEC	341	18.16	8.04	0	42
Agg Country Pop	341	54446761	162000000	0	1160000000

Table 2D: East Asia and Pacific

Variable	count	mean	sd	min	max
Total deaths	74	32273.55	234433.9	0	2006430
Total damages	74	751308.3	2044178	0	13206237
SEC15	74	16.94	13.42	2.3	48
SEC25	74	13.07	12.72	1.8	48
REPSEC	30	8.17	6.94	1	23
GDPpc	74	7431.35	10885.36	0	38979
GEESEC	74	737.03	734.24	0	3811
TEASEC	74	18.73	5.09	8.4	35
Agg Country Pop	74	1.25E+08	270000000	0	1160000000

Table 2E: Europe and Central Asia					
Variable	count	mean	sd	min	max
Total deaths	81	339.2	974.41	0	5666
Total damages	81	890088.9	2977440	0	23795000
SEC15	81	23.95	14.24	1.6	50
SEC25	81	17.91	12.43	1.1	45
REPSEC	47	11.55	8.74	1	45
GDPpc	81	18988.74	14346.72	0	62159
GEESEC	81	823.36	1011.57	0	3639
TEASEC	81	17.31	7.15	0	37
Agg Country Pop	81	25377801	20330408	221840.8	58871460

Table 2F: Latin America and the Caribbean					
Variable	count	mean	sd	min	max
Total deaths	130	1530.29	6657.08	0	67132
Total damages	130	270872	657171.3	0	4454000
SEC15	122	23.26	15.98	1	73
SEC25	127	17.89	14.28	0.3	64
REPSEC	55	8.98	9.25	1	44
GDPpc	130	4125.46	3091.96	0	14232
GEESEC	130	464.75	642.72	0	3297
TEASEC	130	17.84	8.64	0	42
Agg Country Pop	130	17314102	28503905	232667.4	1.55E+08

Table 2G: The Middle East and North Africa					
Variable	count	mean	sd	min	max
Total deaths	32	3849.75	8927.6	0	41366
Total damages	32	520528.1	1967422	0	10029400
SEC15	32	31.14	16.24	1.6	62
SEC25	32	25.75	13.97	0.9	54
REPSEC	20	8.9	5.03	0	19
GDPpc	32	2269.22	1826.07	0	7174
GEESEC	32	1328.1	1112.64	0	3757
TEASEC	32	14.44	9.47	0	39
Agg Country Pop	32	23245249	15688593	1385881	59994296

Table 2H: North America

Variable	count	mean	sd	min	max
Total deaths	14	687.29	745.46	0	1676
Total damages	14	4236041	5104798	0	15824650
SEC15	14	23.12	9.32	7.5	34
SEC25	14	18.44	8	4.8	27
REPSEC	7	9.14	2.41	7	12
GDPpc	14	28076.71	6356.29	17950.3	36773
GEESEC	14	729.57	459.81	0	1533
TEASEC	14	16.23	2.84	9.1	20
Agg Country Pop	14	122000000	104000000	18616602	256000000

Table 2I: South Asia

Variable	count	mean	sd	min	max
Total deaths	41	50394.24	237736.6	0	1504474
Total damages	41	450493.1	1062211	0	5131743
SEC15	41	15.68	15.59	0.7	47
SEC25	41	12	13.34	0.2	44
REPSEC	24	13.96	7.73	4	32
GDPpc	41	419.81	298.06	0	1303
GEESEC	41	412.1	758.24	0	2834
TEASEC	41	19.22	8.72	0	33
Agg Country Pop	41	147000000	249000000	9354860	906000000

Table 2J: Sub-Saharan Africa

Variable	count	mean	sd	min	max
Total deaths	70	3625.88	21401.72	0	150000
Total damages	70	102053.2	541433.4	0	4400000
SEC15	70	25.08	17.42	1.5	66
SEC25	70	19.75	16.91	0.6	63
REPSEC	42	10.48	6.62	1	26
GDPpc	70	1777.34	4221.39	0	33616
GEESEC	70	747.23	1153.36	0	4910
TEASEC	70	19.03	7.87	0	38
Agg Country Pop	70	12567082	12531457	699139.8	80533248

Appendix 3: Regression Results for the Full Sample

Table 3: Deaths per capita on Secondary School Attainment

	(1)	(2)
VARIABLES	Secondary Attainment	Secondary Attainment
ln_deaths_per_capita	-0.103**	-0.128**
	(0.050)	(0.060)
ln_l1_deaths_per_capitas	0.035	-0.012
	(0.071)	(0.063)
ln_gdppc		-0.124
		(1.257)
TEASEC	0.026	0.018
	(0.033)	(0.041)
GEESEC		
	0.020	-0.011
	(0.043)	(0.034)
SEC25		
	0.900***	0.926***
	(0.059)	(0.052)
Constant	3.225	3.096
	(2.047)	(9.888)
Observations	312	293
R-squared	0.847	0.866
Number of Country	76	72
Country FE	YES	YES
Year FE	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Damages per capita in Secondary School Attainment

	(1)	(2)
VARIABLES	Secondary Attainment	Secondary Attainment
ln_damages_per_capita	-0.011	-0.024
	(0.030)	(0.029)
ln_l1_damages_per_capita	0.011	-0.017
	(0.033)	(0.029)
ln_gdppc		0.164
		(1.256)
TEASEC	0.023	0.014
	(0.034)	(0.042)
GEESEC		
	0.022	-0.011
	(0.043)	(0.034)
SEC25		
	0.896***	0.915***
	(0.058)	(0.052)
Constant	4.261**	2.200
	(1.664)	(10.015)
Observations	312	293
R-squared	0.845	0.864
Number of Country	76	72
Country FE	YES	YES
Year FE	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

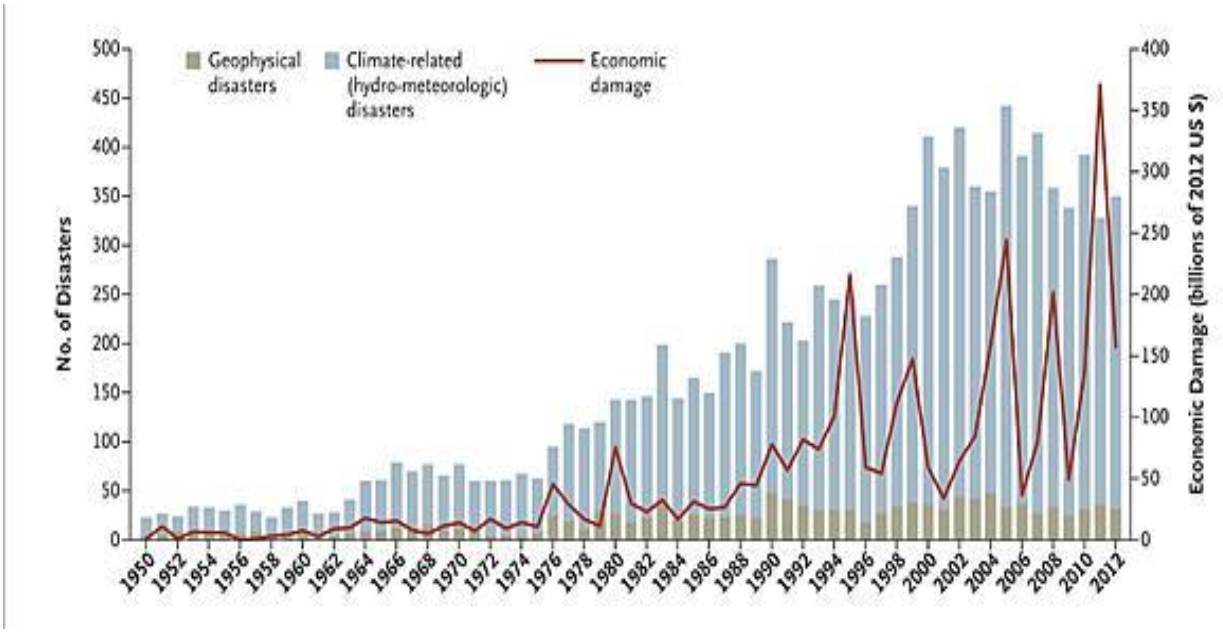
Table 5: Disasters per capita on Secondary School Repetition rate

	(1)	(2)
VARIABLES	Secondary Repetition	Secondary Repetition
ln_damages_per_capita		0.196*
		(0.103)
ln_l1_damages_per_capita		0.032
		(0.063)
ln_deaths_per_capita	0.122	
	(0.267)	
ln_l1_deaths_per_capitas	0.053	
	(0.164)	
ln_gdppc	-0.624	-0.999
	(3.644)	(3.728)
TEASEC	-0.027	-0.052
	(0.109)	(0.101)
GEESEC		
	-0.245	-0.264*
	(0.151)	(0.144)
SEC25	-0.047	-0.077
	(0.079)	(0.056)
Constant	19.778	23.715
	(29.971)	(29.661)
Observations	172	172
R-squared	0.118	0.175
Number of Country	60	60
Country FE	YES	YES
Year FE	YES	YES

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Appendix 4:

Figure 1



Source: EM-DAT: OFDA/CRED International Disaster Database, University of Louvain, Brussels – Belgium.

Figure 2

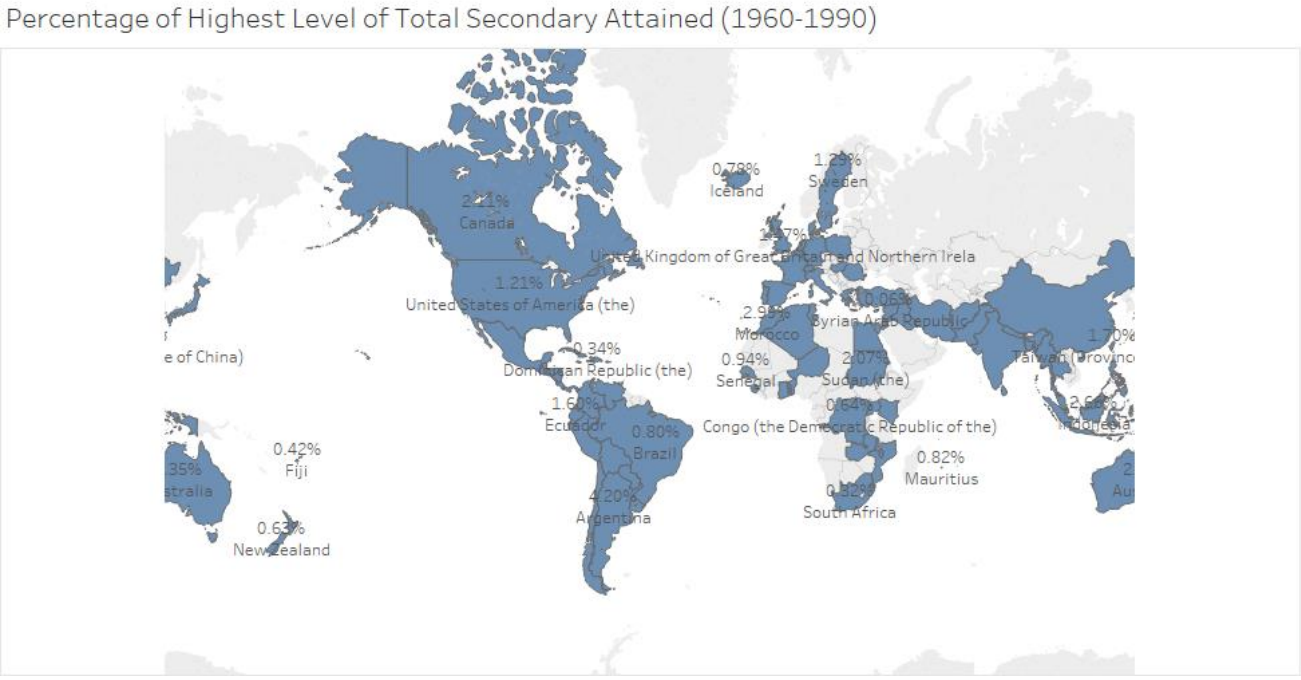


Figure 3

Percentage of Occurrences of Natural Disasters from 1960-1990.

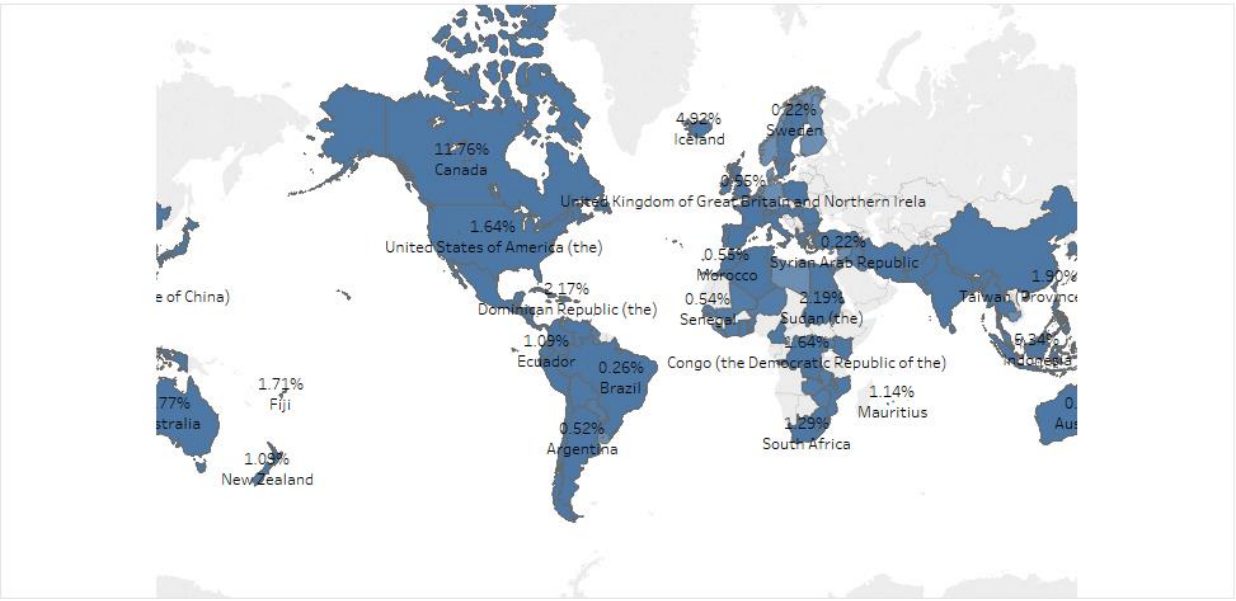


Figure 4

Incidence of Volcanic Activity between 1960-1990 (percentage of the total number of occurrences)

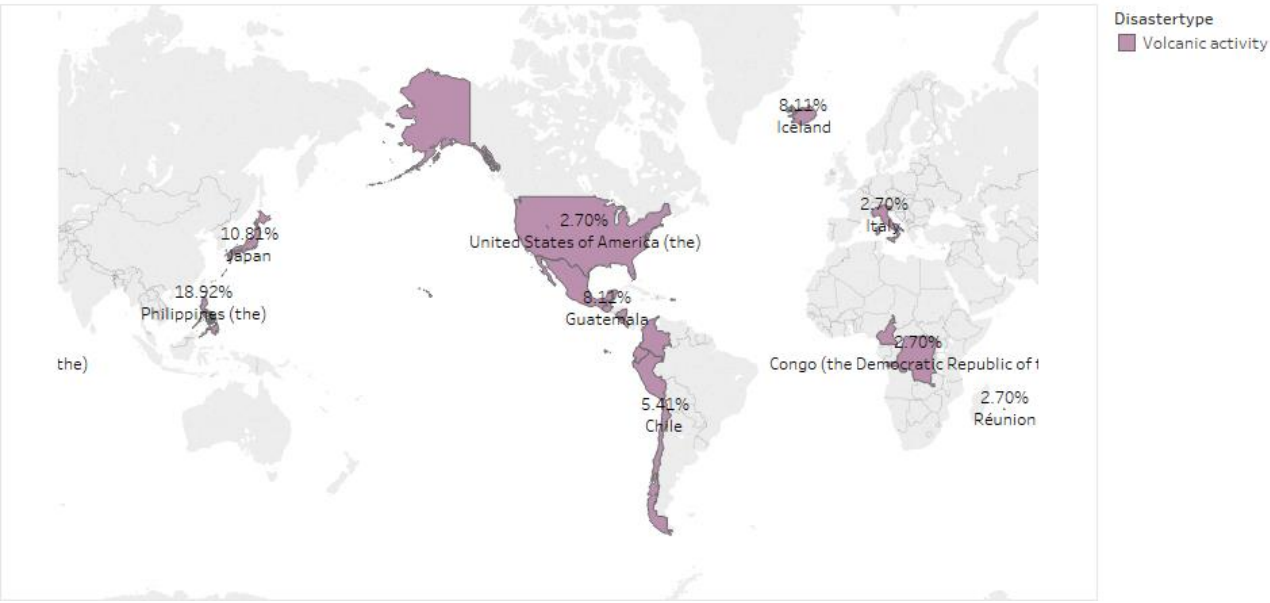


Figure 5

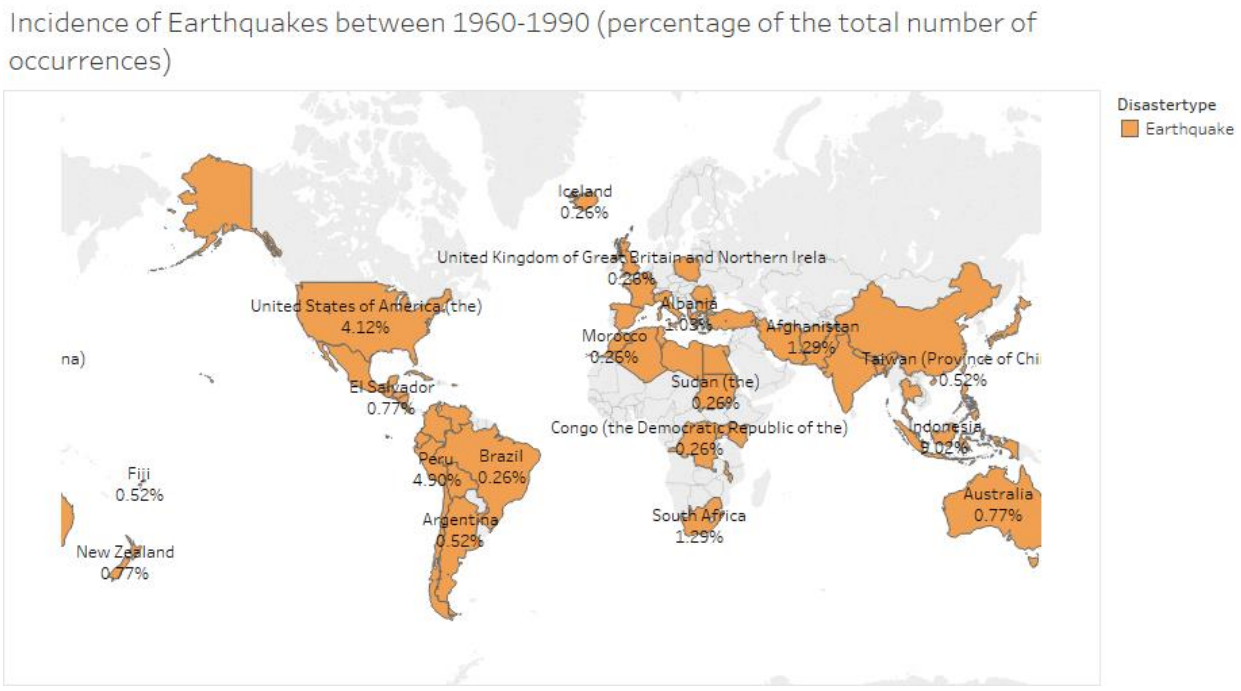


Figure 6

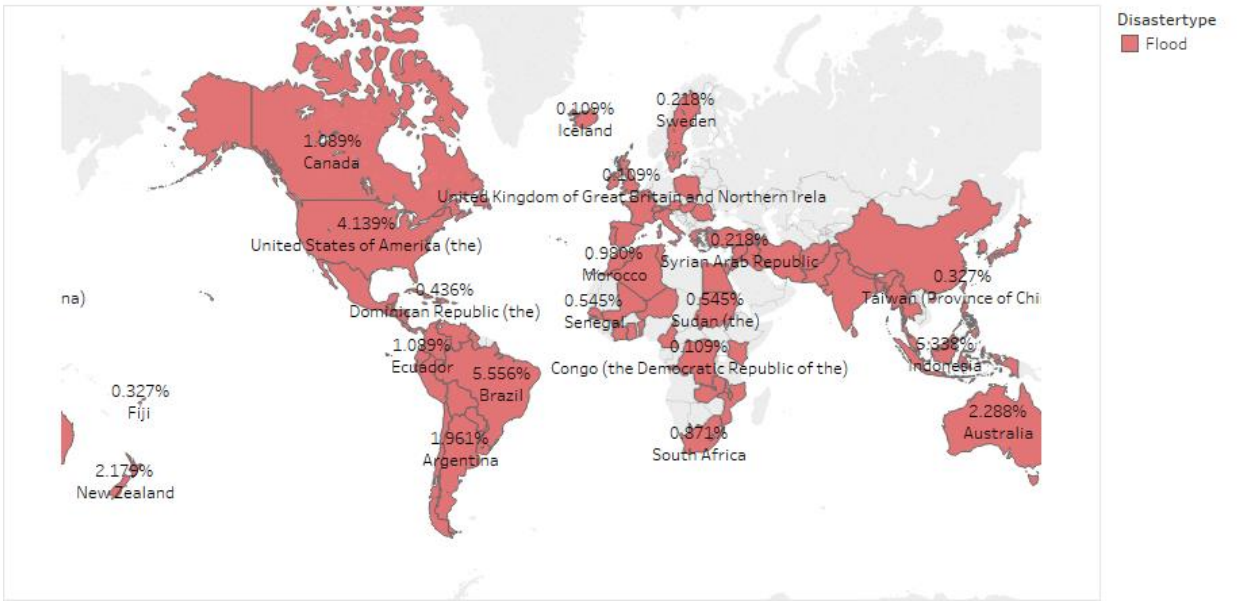


Figure 7

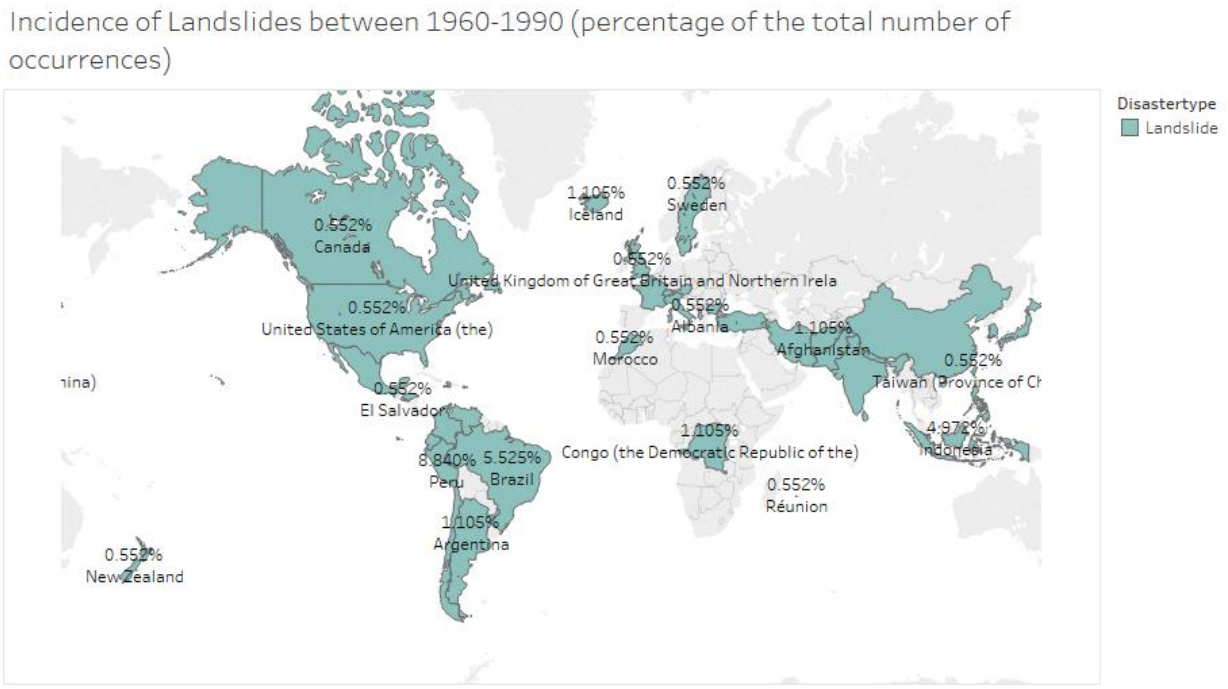


Figure 8

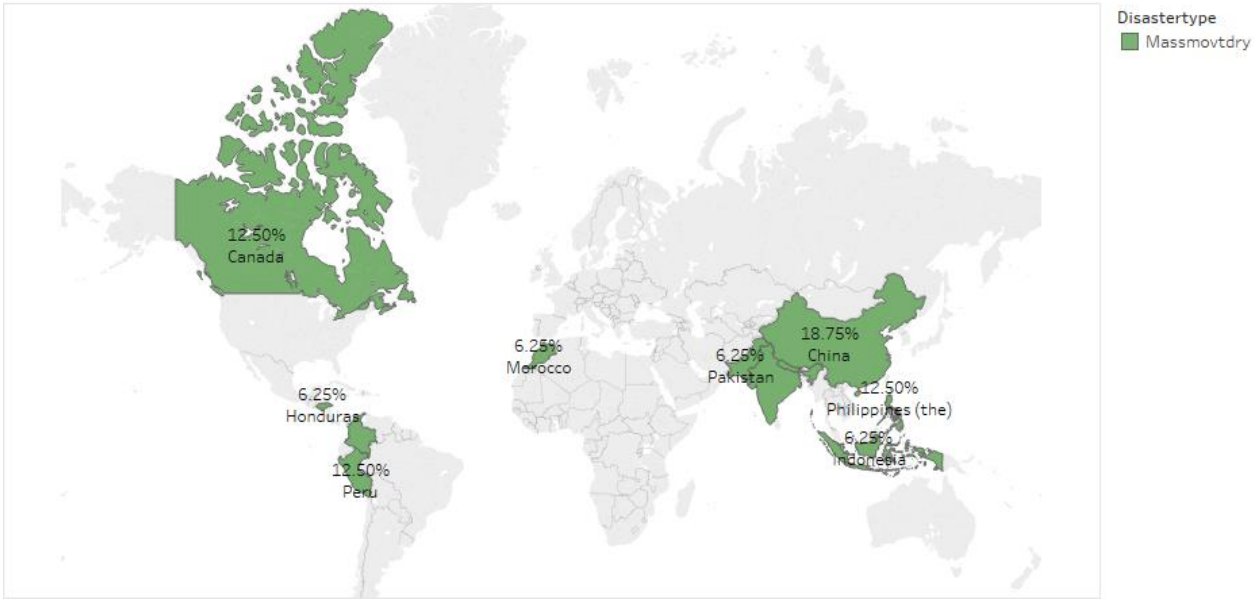


Figure 9

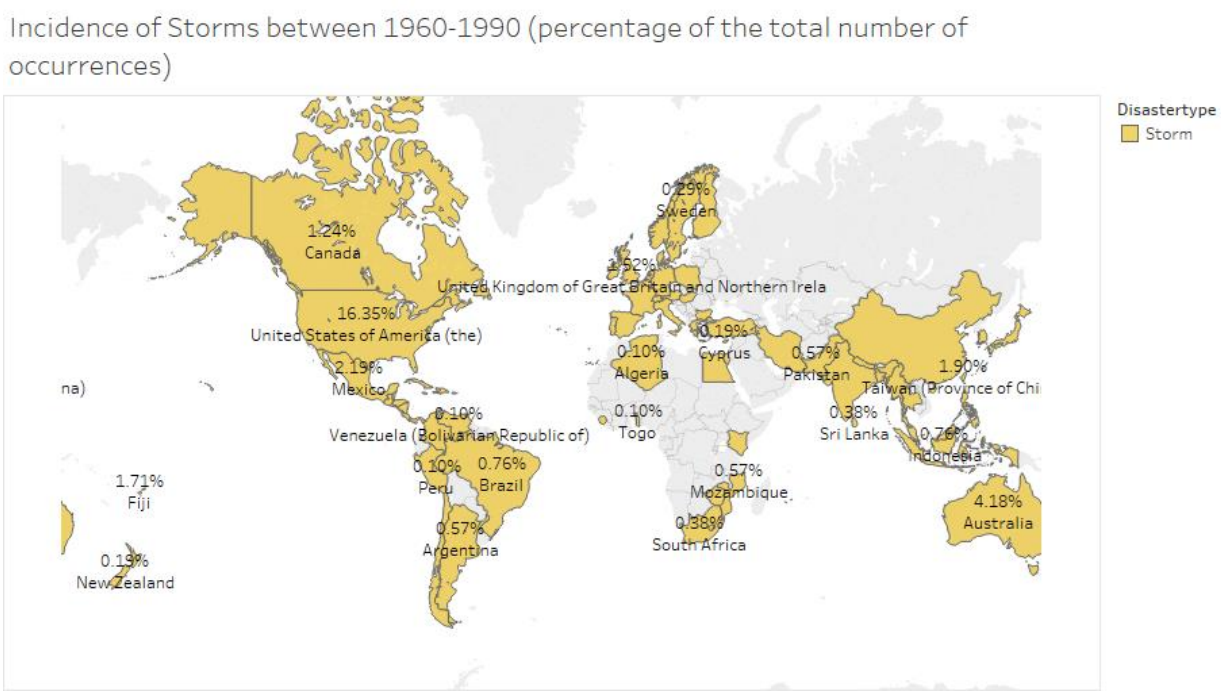


Figure 10

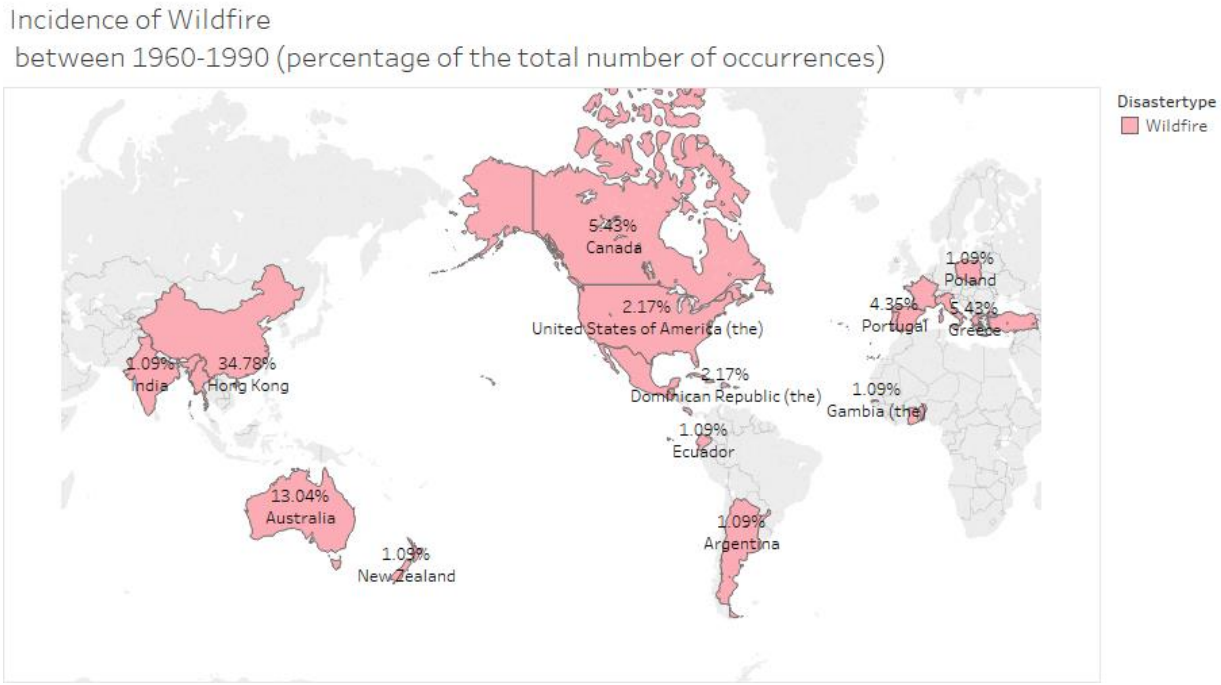
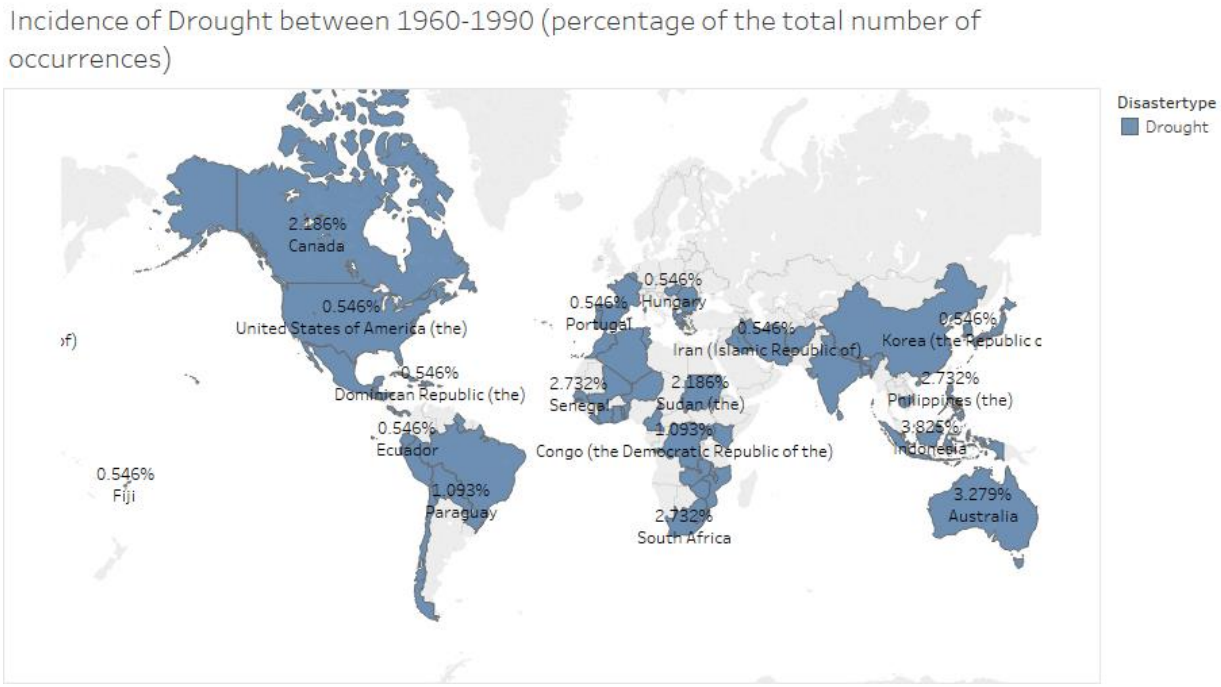


Figure 11



All maps were generated from the dataset of the study by the author using Tableau.