

## **To what extent could natural hazards pose a risk to the end of humanity, and what has been or could be done to mitigate their impacts?**

On our planet we, as a species, face a myriad of natural hazards including: tropical storms and wildfires, both of which are becoming increasingly frequent and severe due to enhanced climate change. However, the end of humanity does not fully lie within the realm of natural hazards; non-anthropogenic risks such as supervolcanoes and tsunamis, both of which are uncontrollable existential events, also pose a significant threat to our species. Each of these hazards are deadly and do pose a risk to us, but the threat of tropical storms and wildfires ending all of humanity is highly improbable, in comparison to the severity of a supervolcano eruption or a tsunami as the latter two are capable of causing global damage whilst the natural hazards' impacts are more concentrated geographically. In this essay I will assess each of the four listed hazards individually on their scale, neglectedness and solvability by linking to case studies and evidence to evaluate their potential as an existential threat, and finish with a conclusion comparing the 4 hazards' ability to end all of humanity.

### **Tropical Storms:**

'Tropical storms' is the overarching term for cyclones, hurricanes and typhoons; these only form between 8-20 degrees north or south of the Equator due to the convergence of the Trade Winds which creates a uniform wind direction with low pressure that tropical storms thrive off of. In order for a sufficient amount of water to evaporate and reach the atmosphere to feed the storm, the sea surface temperatures must be at a minimum of 27 degrees Celsius to a depth of 70 metres. As the water condenses, latent heat is released allowing it to reach higher into the atmosphere which causes a lower pressure system and atmospheric instability that directly lead to high wind speeds. During the development of a tropical storm, the Coriolis effect begins to turn the lower pressure system anti-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere eventually creating the easily recognisable spiral of clouds. The most favourable conditions for a tropical storm also have a weak vertical wind shear, as the developing low pressure system does not get undercut by high speed pockets of wind thereby allowing the tropical storm to grow to its maximum vertical height and absorb higher levels of water vapour to strengthen itself.

### **Typhoon Haiyan- Philippines Case Study**

This tropical storm began to develop as a tropical depression over Micronesia 8 days before it hit the east coast of the Philippines on November 8th 2013. There was an unusually thick band of deep, hot water of 30 degrees Celsius at a depth of 90 metres with ideal atmospheric conditions that led to the lowest atmospheric pressure ever recorded in the eye of the storm and subsequent high winds which peaked at 200mph for 2 hours upon landfall. This tropical storm killed 6000 people, left 4 million left homeless and damaged \$14 billion of infrastructure in the Philippines. Although, this storm had immense repercussions for this nation's economy and was a deeply saddening natural event, the scale of deaths caused by this tropical storm is nowhere near enough to end all of humanity as there are 7.9 billion people. This individual tropical storm killed 0.0000759494% of the current human population, showing it's minimal impact on the human population even for a typhoon with the highest ever wind speeds and lowest ever atmospheric conditions. Therefore the scale of the tropical storm, although it had an intense impact on this nation's economy and subsequent international financial troubles, is not a hazard with a fatality scale anywhere near to ending all of humanity.

As the Philippines is a multi-hazardous location with volcanoes, earthquakes and faces upto 10 tropical storms annually, the population across 7640 islands have adapted by building their homes from nipa palm. This is a sturdy but light material that does not kill people when structures collapse

above them, demonstrating the innovative ways people have mitigated risk by preparing their homes. However, only rural areas continue to use such mitigating practices, therefore highly urbanised areas like Manila had higher fatalities from people trapped under collapsed concrete buildings in the aftermath of Typhoon Haiyan. Another way people mitigate the impact of typhoons in the Philippines, is by growing yams as the vegetable can survive in saline water for up to 2 weeks, thereby minimising malnutrition in the wake of the tragedy. Therefore, Filipinos have adapted their lifestyles to minimise the impacts of typhoons, due to their regularity in the area showing tropical storms' limited neglectedness and high level of solvability through various means.

Although Hawaii's Joint Typhoon Warning Centre and the Philippines Weather Service predicted Haiyan well in advance of landfall, nobody predicted the 6 metre storm surge in cities like Tacloban as storm surge modelling is still not advanced enough due to multiple factors that influence the wave including tides, rivers or locations of low lying deltas. Therefore, there is some neglectedness with regards to the secondary impacts of the hazard, so there needs to be more research and funding into this type of modelling to allow people to hide and understand the threats they face. This makes tropical storms relatively solvable as although we cannot completely stop them from occurring we can minimise the scale of fatalities and damage to property.

Tropical storms are unable to kill all of humanity but do destroy huge expanses of land and they are becoming more frequent as sea temperatures are increasing so they are no longer constrained to being 8-20 degrees north or south of the Equator but do still remain reasonably localised. Also, the Philippines have disproportionately felt the destructive nature of enhanced climate change by receiving a sea level rise of 8 inches in the last 20 years so they have had more intense tropical storms but they don't appear to be an existential threat to humanity currently as they don't affect the entire globe.

### **Hurricane Sandy**

On 29th of October 2012 New York City was hit by a tropical storm which caused \$63 billion in damage and 44 deaths. Sandy began in the Caribbean as the Gulf stream was 3 degrees hotter than usual due to climate change therefore there was more evaporation of sea water causing an unusual low pressure system. Furthermore there was no Bermuda high to repel the hurricane away from the east coast of America to the colder northern Atlantic. To prepare for this immense tropical storm, that had merged with a Nor'Easter which only requires high altitude winds to survive, the New York Subway was shut for the first time in 108 years and filled with inflatable water blockers but this didn't help much considering the Hudson river flooded an electrical substation which exploded and meant half of Manhattan lost their power. Therefore, the scale of fatalities from tropical storms is minimal but it can have a significant impact on individuals fiscally through massive property damage. So, tropical storms cannot kill all of humanity but indirectly through intense economic devastation they could severely stunt economic development of regions, however this is still not enough to end all of humanity.

As a result of the devastation across 16 states from Hurricane Sandy, areas like New Orleans have begun social programs to build up their natural marshlands with old Christmas trees<sup>1</sup> to slow down tropical storms onset thanks to a natural buffer. This demonstrates the limited neglectedness of tropical storms as entire cities are working together to mitigate the destructiveness of tropical storms, as well as the reasonably easy way to solve this hazard.

### **Tropical Storm Conclusion:**

Tropical storms' scale is far less than other natural hazards as they are predominantly trapped between 8-20 degrees above or below the equator and although enhanced climate change is

---

<sup>1</sup> <https://mississippiriverdelta.org/old-christmas-tree-new-marsh-habitat/>

broadening their area of impact through warmer water and higher sea levels their scale isn't large enough to end all of humanity. Even with the highest wind speeds and inadequate preparation in the Philippines only 6000 died, which is still a huge sum but in comparison to the global population of 7.753 billion the scale is not big enough to end humanity.

According to the UNs Ocean Conference in 2017, more than 600 million people (around 10 percent of the world's population) live in coastal areas that are less than 10 metres above sea level, whilst nearly 2.4 billion people (about 40 percent of the world's population) live within 100 km of the coast<sup>2</sup>. These areas are most vulnerable to tropical storms however one must take into account that not all coastal areas are between 8-20 degrees above or below sea level, further limiting the maximum number of people affected by tropical storms. Even though the climate emergency is increasing water levels and putting these highly populated coastal cities at a higher risk of destruction from tropical storms, this hazard cannot be classified as a risk to end humanity, as it doesn't affect everyone. The maximum number of people who could be vulnerable to tropical storms would be less than 3 billion (if one uses the UN's data), which leaves the 4.9 billion other people to be safer inland, at higher altitudes or different latitudes. Tropical storms are not all encompassing, more than half the human population would survive if every coastal area was destroyed by a tropical storm, thereby limiting their ability to end all of humanity completely.

In addition, tropical storms are not a neglected issue for example the USA has a Hurricane Awareness week from May 25th to May 31st and there are multiple typhoon warning centres across the Pacific such as the Hawaii's Joint Typhoon Warning Centre. Although, there needs to be more investment in storm surge modelling and populations in low lying coastal areas must be educated further, there are plenty already of ways to protect oneself against this natural hazard in comparison to others. Unfortunately, there is no artificial way to stop a tropical storm but actions to reduce global warming may have positive effects on reducing the intensity and severity of tropical storms and there are many ways to protect people from tropical storms so they are reasonably solvable issues; therefore, tropical storms are incapable of ending humanity.

## **Wildfires**

Wildfires are the unpredictable and uncontrollable burning of large areas of land which is dependent on weather, topography and fuel availability. This natural hazard requires 3 things: oxygen, a heat source and fuel, known as the 'Fire Triangle'. Most wildfires start from natural causes due to the warmer climate and different weather patterns like El Nino, but '90% of wildfires are caused by human activity'<sup>3</sup> such as arson. Although wildfires cause extreme damage to regions like California, USA and Victoria, Australia these natural hazards do not directly pose a threat to the complete elimination of humanity. However, wildfires do drive climate change as they release huge quantities of greenhouse gases into the atmosphere, thereby contributing to the detrimental feedback loop through their consequent creation of warmer, drier conditions that enhance the intensity of wildfires. Therefore, wildfires indirectly could contribute to the extinction of humanity but the hazard in isolation could not kill everyone.

Wildfires are on every continent except Antarctica making their scale international and this hazard's impact is only getting worse due to climate change. According to CNN, parts of Siberia and Canada usually had an extreme 'fire every 100 to 150 years' so the forest could completely regenerate but now in those same areas 'fires are happening every 10 to 30 years'<sup>4</sup>. Interestingly, due to the adverse effects of enhanced climate change, wildfires are becoming less frequent but more intense.

---

<sup>2</sup> <https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/05/Ocean-fact-sheet-package.pdf>

<sup>3</sup> <https://www.nationalgeographic.com/environment/article/wildfires>

<sup>4</sup> <https://edition.cnn.com/2021/07/22/world/wildfires-siberia-us-canada-climate-intl/index.html>

For example, in 2011 there was an average of 62,805 fires annually in America which have burnt an average of 7.5 million acres, whilst in 2020 there were 58,980 fires which burned more than 10.1 million acres. Therefore, even though there has been a significant decrease in wildfires their risk level is actually increasing due to their higher intensity. The extreme water shortages and depletion of groundwater in California is partly to blame for the intensifying wildfires in the state as they are creating an unstable environment which could be seen as a microcosm of the future of our planet.

The largest ever wildfire burnt down 8,400,000 acres of the Northwest Territories of Canada in 2014, costing \$55 million Canadian dollars (8 times the annual amount of money spent on the Northwestern Territory's Department of Environment and Natural Resources)<sup>5</sup>. Whilst the deadliest wildfire in human history was the Peshtigo Fire of 1871 which killed 1500 people (85% of the town's population)<sup>6</sup> is testament to wildfires' limited capacity to end the entirety of humanity directly. Even though extreme forest fires may not directly kill all of humanity, their intense scale is 'reducing biodiversity of soil organisms flora and fauna' which 'disrupts the cycle of nutrients' thereby putting the 'sustainability of forest biomes'<sup>7</sup> into jeopardy. This makes the theoretical scale of impact immense as forests are natural carbon sinks which help remove CO<sub>2</sub> from the atmosphere. If wildfires are limiting the long term absorption of pollutants, humanity could be made even more vulnerable to the adverse effects of enhanced climate change.

Wildfires can occur naturally from droughts which makes flora flammable, but most wildfires are man made (e.g. the gender reveal fireworks in California that started a wildfire across the east of Los Angeles in 2020<sup>8</sup>) which is why many national parks ban campfires in case of an accident. There are easy ways to solve the occurrence of wildfires, Australian Aboriginals have been using traditional management techniques for thousands of years. They light fires in 'targeted areas during early dry seasons between March and July'<sup>9</sup> which removes fuel for larger fires later in the hotter seasons which protects the land from degradation and animals from losing their habitats. Wildfires spread incredibly quickly so it is hard for people to escape; Rob Gazzard, who works with the Forestry Commission stated that a slope going upwards at a '10% gradient of the fire, if it's 20% it would quadruple the speed of the fire'<sup>10</sup> so firefighters need to remove anything that could fuel the fire (fuel break) thereby suppressing it. The California Chaparral Institute also recommends wetting roofs of homes; to shut off natural gas supplies and to leave immediately if a wildfire is headed towards your home.

Wildfires are a reasonably neglected issue, according Bill Tieleman the Canadian British Columbia government is under estimating the danger this hazard poses. 'Between 2006 and 2015 the BC government spent only \$8 million a year to remove fuels from just 80,000 of a total 685,000 hectares of high risk forest land'<sup>11</sup> whilst 'it cost the B.C. government an average \$182 million a year to fight forest fires'<sup>12</sup>. Had they protected the 685,000 hectares of forest, it would have cost \$68 million, still less than half of the overall cost to fight forest fires. Hazard mitigation schemes are cheaper than all the direct, indirect and additional costs of wildfires, which include the social

<sup>5</sup> <https://www.cbc.ca/news/canada/north/worst-forest-fires-in-30-years-cost-n-w-t-55m-1.2770136>

<sup>6</sup> <https://www.alltopeverything.com/deadliest-wildfires/>

<sup>7</sup> <https://www.sciencedirect.com/science/article/abs/pii/S0929139315301050> Andrey S. Zaitsev, Konstantin B. Gongalsky, Anna Malmström, Tryggve Persson, Jan Bengtsson, 'Why are forest fires generally neglected in soil fauna research?' Applied Soil Ecology, Volume 98, 2016, Pages 261-271,

<sup>8</sup> <https://www.nytimes.com/2020/09/07/us/gender-reveal-party-wildfire.html#:~:text=An%20elaborate%20plan%20to%20reveal,during%20a%20gender%20reveal%20party.>

<sup>9</sup> <https://www.klc.org.au/indigenous-protected-areas>

<sup>10</sup> <https://www.bbc.co.uk/news/newsbeat-41608281>

<sup>11</sup> <https://www.ctif.org/news/government-neglect-blame-wildfire-chaos-not-just-heat-waves-and-climate-change>

<sup>12</sup> <https://www.ctif.org/news/government-neglect-blame-wildfire-chaos-not-just-heat-waves-and-climate-change>

(respiratory issues), economic (lost tourism and property damage) and environmental impacts (damage to watershed and degraded carbon sink). Governments need to take wildfires far more seriously, especially as they are intensifying in areas that aren't used to them like Greece.

Wildfires are driven by climate change, therefore we must reduce our carbon footprint and emissions to mitigate the warmer conditions which they thrive in, or this hazard will continue releasing intense quantities of greenhouse gases creating a feedback loop that could potentially kill all humanity if left unchecked. This is because climate change will leave vast areas uninhabitable from extreme weather, air pollution, rising sea levels, ocean acidification, mass extinction of animals and insects necessary for food production like bees, and infertile land. Wildfires directly contribute to climate change therefore making them able to end all of humanity indirectly.

### **Tsunamis**

Tsunamis occur after an earthquake on a convergent (destructive) plate boundary as the sudden displacement in the ocean floor causes a slight change in water height. As the wave gets closer to the shoreline the beach becomes steeper and shallower causing the wave to slow down but as it contains the same amount of energy the wave height increases in a process called wave shoaling. This process was witnessed during the 30 metre Boxing Day Tsunami 2004 caused by a 9.1 Richter earthquake where 275,000 people died across 14 countries in 2 continents, demonstrating the intense and widespread scale of devastation thanks to tsunamis. The most powerful earthquake ever recorded (1960 Valdivia, Chile) was a 9.5 on the Richter scale caused 6000 deaths and a 25 metres tsunami all the way in Japan as well as causing the Cordon Caulle volcano to explode, showing the immense are of damage this non-anthropogenic hazard can create.

Each increase of one on the Richter scale represents a 10 fold increase in the magnitude of the earthquake as it is logarithmic, but also represents the release of 31 times more energy but the impact of the subsequent tsunami varies upon multiple factors such as the depth of the epicentre, the size of the coastal population and the geological formation of the nearby coastlines. Rockfalls can also cause tsunamis and although they are more localised than their marine counterparts they produce far larger waves for example the 1958 Lituya Bay earthquake and subsequent rockfall in Alaska caused a 541 metre wave, which is 100m taller than the Empire State building. However, this tsunami was a rare occurrence due to the natural geography that amplified its effects, and thanks to its remote location the human impacts were minimised.

Geologists believe that currently a tsunami capable of ending the world won't be a consequence of an earthquake or rockfall but rather an asteroid. Around 66 million years ago, the asteroid which killed the dinosaurs hit the Yucatan and caused a megatsunami with an initial wave height of 1.5 kilometres, which led to waves around 100 metres in the Gulf of Mexico and 16 metres in Louisiana<sup>13</sup>. Had the asteroid hit a deeper ocean the megatsunami would be 4.6 km tall with speeds of 500mph and cause earthquakes above a magnitude of 11 on the Richter scale causing far beyond the highest ever measured earthquake of 9.5. If a similar hazard occurred now, the scale of destruction would be immense not only from primary impacts like entire cities being swept away but also massive nuclear reactors releasing radioactive isotopes into the ocean similar to that of the 2011 Fukushima nuclear disaster. Although asteroids are continuously occurring, around '80 to 100 tons of material falls upon Earth from space in the form of dust and small meteorites'<sup>14</sup>. Larger asteroids are much less frequent with scales ranging from centuries to millennia therefore making mega tsunamis extremely unlikely to occur, but NASA acknowledges it's own catalogue's incompleteness and knows

---

<sup>13</sup><https://www.iflscience.com/environment/dinosaurkilling-asteroid-created-a-milehigh-tsunami-that-swept-through-the-worlds-oceans/>

<sup>14</sup> <https://www.nasa.gov/planetarydefense/faq>

that if an asteroid were to impact earth no weapon system could stop it as they travel at 'an average of 12 miles per second'<sup>15</sup>, so megatsunamis are still possible.

There have been steps taken such as World Tsunami Awareness day (5th November) set up by the UN to enhance international cooperation when facing tsunamis as well as increasing awareness and resilience of communities across the globe so it is not a neglected issue. This shows that tsunamis are not a neglected issue within the global community. However, a megatsunami from an asteroid would hypothetically cause so much damage that it is a substantial risk factor in causing the end of humanity. A crux of this argument is that a megatsunami of 4.6km tall would not reach every place on the planet such as the town of La Rinconada which is 5km above sea level, in addition to this there are people who live in the International Space Station who would be unharmed so the possibility of ending humanity isn't as clear cut as it seems as these individuals may be able to restart the population. This being said the International Space Station heavily relies on ground control so the individuals may not survive for long to continue humanity, and the highest town of La Rinconada lies right beneath a glacier which could collapse on them if there was a magnitude of 11 Richter earthquake subsequent to a tsunami. Therefore there is substantial evidence that a megatsunami could end humanity but it isn't definitive.

### **Supervolcanoes:**

What makes supervolcanoes incredibly harmful to the world is their ability to erupt a minimum of 1000km cubed of material into the air which has negative knock on effects everywhere. The most well known supervolcano is the Yellowstone caldera in America which is 70km long and 45km wide and according to Jacob B. Lowenstern from the US Geological Survey, if the Yellowstone supereruption occurred 'enough material would be released to bury the state of Texas five feet deep'. The ash short term would suffocate the crops and kill pastoral animals if ingested or inhaled thereby causing food shortages, but long term the soil would be far more fertile as the deposits are enriched with 'magnesium and potassium'<sup>16</sup> which could increase future harvests. Another issue with volcanic ash is that it 'can trigger asthma attacks'<sup>17</sup> and more severe respiratory illnesses which could kill people miles away from the actual epicentre of the eruption. For example the Eyjafjallajökull eruption in March 2010 released ash that covered most of Europe and closed the airspace of 20 countries, even though it was VEI 4. In comparison to this the Yellowstone supervolcano seems extremely destructive, but there have been bigger eruptions like the Wah Wah Springs eruption (Utah) which occurred 2 million years ago and ejected 5500km cubed of debris making it bigger than Yellowstone's past eruptions by a factor of five.

Even more worryingly, the largest mass extinction event (Permian Triassic Mass Extinction) coincided with super volcanic activity, around 252 million years ago it killed 96% of marine species and 73% of terrestrial species. However, this eruption lasted for millions of years as the lava was extremely viscous and the impacts of the higher concentration of volcanic gases in the atmosphere took time to bring about substantial damage. Therefore one supervolcanic event most likely not to wipe out humanity immediately but will definitely cause mass devastation with large expanses of uninhabitable areas, high death tolls and hundreds of millions of people being displaced. A significant impact of a supervolcanic event could be emissions of high concentrations of gases which could lead to multiple scenarios including acid rain or a decreased global temperature due to high levels of sulphur dioxide entering the atmosphere, these two processes could lead to minimal food production

---

<sup>15</sup> <https://www.nasa.gov/planetarydefense/faq>

<sup>16</sup> <https://www.bgs.ac.uk/discovering-geology/earth-hazards/volcanoes/living-with-volcanoes/#:~:text=Volcanic%20deposits%20are%20enriched%20in%20in%20years%20following%20an%20eruption.>

<sup>17</sup> <https://www.lung.org/clean-air/emergencies-and-natural-disasters/volcanic-ash#:~:text=Exposure%20to%20volcanic%20ash%20can,in%20individuals%20with%20sensitive%20airways.>

on a local and global scale. The Icelandic volcano (Hekla) also released high concentrations of fluorine which poisoned and killed 79% of Icelandic sheep, showing the breadth of damage an average volcanic eruption can cause.

There are various ways humanity could survive a supervolcanic eruption which includes NASA's '\$3.46 billion'<sup>18</sup> plan to drill a 10km deep boreholes into the side of the Yellowstone caldera, and then pump cold water creating a giant geothermal power station which would cool the supervolcano to extinction. However, this would take 16,000 years and could even trigger the supereruption through mini earthquakes caused by the fracturing of cooling rock. In contrast, Toby Ord recommended mitigating 'the damage, through building up non-perishable food reserves or developing emergency food production techniques'<sup>19</sup> as the world only has '6 months'<sup>20</sup> of food reserves. By having a surplus of food we could protect humanity from starvation in the wake of the hazard which is why the Svalbard Doomsday vault was built. It ensures the survival of collective agriculture and humanity, but has recently been flooded by thawing glaciers, perhaps showing the unpredictability and vulnerability of stockpiling food or seeds. Stockpiling food is crucial to survival but under the current circumstances of extreme poverty across the world it would be uncaring to prepare tons of food for an event which may never occur when there are people suffering right now.

Instead we could continue high levels of production of masks which have helped during the pandemic as gas and ash masks would help significantly reduce illnesses and fatalities in dangerous areas, alongside goggles could help minimise eye irritation. Another useful way to save lives would be to improve the technology and methods that scientists use to predict eruptions, currently scientists use seismometers, which measure the frequency and intensity of earthquakes prior to an eruption; temperature changes via thermal imaging; tiltmeters, which will help recognise bulges from magma chambers filling; gas chromatography of CO, CO<sub>2</sub> and sulphur dioxide, alongside the research into the history of eruptions to see patterns.

Therefore, supervolcanic eruptions are capable of ending humanity due to their large scale primary and secondary impacts, alongside this they are relatively neglected due to their sheer size which makes their solvability almost minimal.

### **Overall Conclusion:**

In conclusion, natural hazards such as tropical storms and wildfires do not pose a direct threat to the end of humanity due to their localised nature; they only pose an existential risk when they are assessed in conjunction with the detrimental effects of enhanced climate change. Due to global warming these two hazards have been at the forefront of technological innovation with various groups trying to minimise their effects, thereby further limiting their ability to end all of humanity as they are not neglected issues. Non-anthropogenic risks are far more deadly as their scale of impact is international, thereby making them less solvable. Supervolcanoes or extreme tsunamis are far more neglected as they aren't as frequent or common across the globe like wildfires or tropical storms. Therefore tsunamis and supervolcanoes are more likely to end all of humanity than natural risks like wildfires or tropical storms, as their scale of impact is larger, their solvability is minimal and they are more neglected.

---

<sup>18</sup> <https://www.businessinsider.com/nasa-earth-supervolcano-apocalypse-2019-1?r=US&IR=T>

<sup>19</sup> Ord, Toby 'The Precipice'

<sup>20</sup> ibid