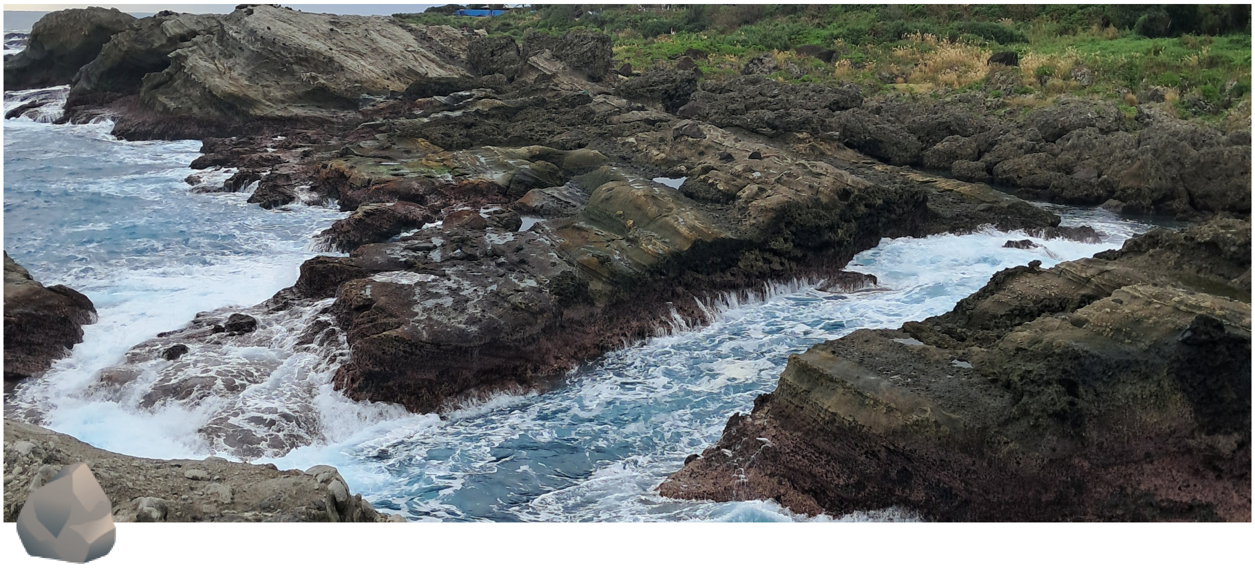

Tectonics

Topic 1.1 Plate Tectonics - Plate Tectonic Theory

1. Tectonic Plate Movement

- Convection currents
  - Mantle gains heat from core > Less dense
    - Rises towards surface
  - Rising mantle spread beneath the plates > Drag them apart (Divergent plate movement)
  - Mantle loses heat and sinks down to core
  - Convection currents collide (Convergent plate movement)
  - Material then gain heat again, rising and sinking movement (Convection currents)
- Slab-pull force
  - When 2 plates converge
    - Denser oceanic crust pulled down by gravity

        - Subducts beneath less dense plate
    - Crust sinks deeper into mantle under it own weight
        - Pulling the rest of plate in
        - Further convergence

Topic 1.2 Tectonics Plates - Seafloor Spreading

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1. Seafloor Spreading

- Plates move away from each other
    - @ Divergent plate boundary
- Magma from deep within Earth rises and forms mid-oceanic ridge
- New oceanic crust is formed

2. Evidence of Seafloor Spreading Support Plate Tectonic Theory

- Age of rocks
    - Nearer to crest of mid-oceanic ridge > Youngest
    - Further away > Older
- Shows that new oceanic crust is created
    - Then moves laterally on both sides of the mid oceanic-ridge
- Little sediment accumulation is found @ oceanic trench as older rocks gets destroyed
    - Oceanic crusts younger than continental

Topic 1.3 Plate Tectonics - Magnetic Stripping

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1. Magnetic Stripping

- Earth has geographic north and south and magnetic north and south
- Magnetic north and south shift
    - Normal polarity: Magnetic north points roughly towards geographic north and likewise for south

    - Reverse polarity: Magnetic north points roughly towards geographic south and likewise for south
- Earth's polarity constantly flipping multiple times

- Magnetic stripping is a zebra-like pattern
    - Strips of normal polarity rocks alternating alongside reverse polarity rocks
    - Symmetrical on both sides of mid-oceanic ridge
- Occurs on
    - Iron-rich lava cools and solidify > Balsamic rocks formed from lava
        - Contain magnetic materials
    - It's magnetic material point towards Earth magnetic North, recording evidence

2. Evidence that supports plate tectonic theory

- Zebra-like patterns symmetrical > Not random occurrence
- O plates move away from each other
- Iron-rich lava erupts from centre of ridge
    - Cools and solidifies > Form new oceanic crust
    - Crust pushed in both directions when process happens again
- Divergence > Overtime, more lava moves away from ridge due to plate divergence

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Topic 1.4 Plate Tectonics - Tectonics Processes at Different Plate Boundaries

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1. Divergent Plate Boundaries

- Oceanic-Oceanic [Mid-oceanic ridge, submarine volcanos]
    - Convection currents > Two O-O plates move apart
    - Decrease overlying pressure > Underlying mantle to melt
        - Magma formed > Rises thru weak areas in crust
            - Fill gaps caused by sea floor spreading

        - Lava cools and solidifies > Basaltic rocks
            - Makes new crust
            - Forms an underwater chain of mountains (mid oceanic ridge)

- Continental-Continental [Rift valley, volcano]
    - Convection currents > 2 C-C plates to move apart
    - Rock fracture > Form parallel faults
        - Rocks between faults collapse > Deep rift valley
    - Decrease overlying pressure > Underlying mantle to melt
        - Magma rises thru weak areas in crust
            - Forms volcanoes
    - EQ occurs due to stress and tension released when plates move

2. Convergent plate boundaries

- Oceanic-Oceanic [Oceanic trench, volcano]
    - Convection currents > 2 O-O plates collide
    - Denser plate subducts beneath less dense plate
        - Forms a deep depression (Oceanic trench)
        - Subducting plate sinks into mantle > High pressure forces water out of crust
            - Lowers MP > Melt > Form magma
        - Magma rises thru weak areas in crust
            - Forms volcanos
        - Friction along oceanic plates collide causes EQ to occur
- Continental-Continental [Fold mountains]
    - Convection currents > 2 C-C plates collide
    - Subduction does not take place
        - Continental plats too buoyant and less dense

    - Huge pressure > Rocks to uplift and buckle
    - EQ occurs due to friction along the convergent plate boundary
- Oceanic-Continental [Oceanic trench, fold mountain, vocalno]
    - Convection currents > Oceanic pate to collide with continental plate
    - Denser oceanic plate subducts beneath less dense continental plate
        - Forms oceanic trench in subduction zone
            - Subducting plate sinks into mantle
            - High pressure forces water put of oceanic crust
                - Lowers MP > Mantle melt > Form magma
    - Magma rises thru weak areas in crust
        - Form volcanos
    - Enormous pressure on C plate > Cause it to buckle and get unlifted
    - EQ occur due to friction between subductions plates

Topic 2.1 Earthquake and Volcanoes - Tectonics Processes Affecting Magnitude of Earthquakes

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1. Earthquakes

- Occurs when...
    - Rock masses on the side of the fault pushed by tectonic forces
        - Due to friction > They get locked > Stress builds up
    - Stress exceeds strength of fault > Rocks snap/ move to new position
        - Seismic waves released > Ground shaking

Focus [Depth]

- Point where seismic waves are released
- Deeper > Weaker , Shallow > Stronger

Epicentre [Distance]

- Point directly above focus on surface
- Closer > Stronger , Further > Weaker

    - Energy lost to surroundings

    - Energy lost to surroundings

2. Measurement of earthquakes

- Using seismometers
    - Richter Scale (ML)
        - Calculated based on the height of largest recorded wave
        - Measured based on maximum seismic intensity (not total seismic energy released)
            - Inaccurate
    - Moment Magnitude Scale (Mw)
        - Calculated based on total energy released instead of a single largest one
            - Accurate

Topic 2.2 Earthquake and Volcanoes - Tectonics processes affecting the magnitude of volcanic eruptions

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1. Volcanoes

- Parts:
    - Crater (Bowl-shaped depression)
    - Vent (Opening)
    - Conduit
    - Magma chamber (Source of magma)

2. Tectonic process resulting in volcanoes

- Divergent plate boundary (O-O)
    - Convection currents > Plates move apart > Crust stretches & fractures develop
    - Decrease in overlying pressure > Underlying mantle to melt > Form magma

        - Magma contain dissolved gases and is less dense > Rises thru weak areas of crust
    - Erupt as lava > Volcanic eruptions
        - Lava cools > Solidify > Accumulate over time
- Convergent plate boundary (O-C)
    - Plates move towards each other > Denser plate subduct beneath less dense plate
        - Sinks into mantle > High pressure > Force water out of oceanic crust
            - Water lowers MP of overlying mantle > Melt > Form magma
    - Magma contains dissolved gases and is less dense
        - Rises thru weak areas of crust
    - Erupt as lava > Volcanic eruptions
        - Lava cools > Solidify > Accumulate over time

3. Explositivity of Volcanoes

<u>High Silica Lava</u>

- <u>More viscous</u> magma
- As magma <u>rises</u>, gases <u>cannot escape</u> easily
    - <u>Pressure builds up</u> until gases <u>escape</u> <u>explosively</u>
    - <u>Violent</u> and <u>explosive</u> eruptions
- Usually <u>stratovolcanoes</u>

<u>Low Silica Lava</u>

- <u>Less viscous</u> magma
- As magma <u>rises</u>, the <u>dissolved</u> <u>gases</u> <u>escape</u> <u>easily</u>
    - <u>Less pressure</u> built up
    - <u>Gentle</u> & <u>effusive</u> eruptions
- Usually <u>shield volcanoes</u>

- Stratovolcanoes
    - <u>High viscosity</u> magma <u>rises</u> thru <u>weak</u> areas of crusts > <u>Erupts explosively</u> as lava, <u>ash</u> and <u>rocks</u>
        - <u>Ash</u> and <u>rocks</u> settle on <u>sides</u>, <u>covered up</u> by <u>lava</u> later

    - Over successive eruptions...
        - Tall volcano with alternating layers of lava and ash develops with steep sides
            - More viscous lava travel a shorter distance before solidifying
- Shield volcanoes
    - Low viscosity magma rises thru weak areas of crusts > Erupts effusively
    - Over successive eruptions...
        - Volcano with layers of lava is developed with gentle slopping sides and broad summit
            - Less viscous lava travel a longer distance before solidifying

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Topic 2.3 Earthquake and Volcanoes - Distribution of Earthquakes, Volcanoes and Tectonic Hazards

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1. Distribution of Earthquakes

- Occur along all type of plate boundaries
- Largely concentrated at the Pacific Ring of Fire
- Occur more commonly along convergent plate boundaries at subduction zones as more stress is built up
- E.g. Common locations of earthquakes
    - Along convergent plate boundary at Pacific Ring of Fire
    - Along divergent plate boundary at Mid-Atlantic Ridge
    - Along transform plate boundary at the San Andreas Fault

2. Pacific Ring of Fire

- Broad belt around the Pacific Ocean where most EQ and active volcanoes occur
- Comprises of all types of plate boundaries
    - Convergent: Pacific and Philippine Plate

- Divergent: Pacific and Cocos Plate
- Transform: Pacific and North American Plate at San Andreas Fault

3. Volcano distribution

- Generally located within convergent and divergent plate boundaries
  - Magma rises up to the surface forming volcanoes
  - Commonly found along
    - Convergent: Along subduction zones on Pacific Ring of Fire
    - Divergent: Between North American and Eurasian Plates
- Volcanoes are not found near...
  - Transform plate boundaries
  - C-C convergent plate boundaries
- Hot spot volcanoes > Located away from plate boundaries
  - E.g. Piton de Fournaise
    - Located on an island in Indian Ocean

Topic 2.4 Earthquake and Volcanoes - Impact of Tectonic Hazards on Natural and Human Systems

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1. Hazards associated with EQs

- Ground shaking, soil liquefaction, landslides and tsunamis
  - GS, SL and Ls are found near plate boundaries
  - Tsunamis beyond geographical locations and travel long distances
- Ground shaking
  - Ecosystems
    - Trees could get uprooted and destroyed
    - Oil & chemical factories > Pollute land & water
  - Destroy properties and infrastructure

        - Weakens structures, buildings, bridges, roads, railways collapse
    - Disrupts services
        - Damage water and gas pipes resulting in disruption in supply
        - Electricity cables may break, affecting electrical supply
    - Causes injuries and fatalities
        - People may get trapped under collapsed buildings and other infrastructure, making it difficult to rescue people result in deaths and injuries
- E.g. [2010] Haiti
    - Surrounding areas of factories were polluted
        - Rivers polluted
    - >250k houses collapsed and 220k people killed
        - Water pipes ruptured > Water shortage
- Soil Liquefaction
    - Destroys ecosystems
        - Soil may enter water > Kill aquatic plants
        - Trees on liquefied soil sink or tips over > Damage natural habitat
        - Sewage pipes may get damaged in the soil > Pollute rivers
    - Properties/Infrastructure
        - Buildings that tip over > Rescue efforts difficult or supply emergency aid
    - Services
        - Roads may sink in liquified soil > Rescue efforts difficult or supply emergency aid
        - Electricity, water and gas pipes may get damaged > Disrupt essential services
    - Injuries/Fatalities

        - People may get trapped in collapsed buildings resulting in injuries/death
    - E.g. [2010-2011] Christchurch, New Zealand
        - Triggered severe liquefaction
            - >60k buildings and infrastructure (1/3 of the city)
            - Liquefied soil and untreated sewage entered waters > Severe pollution and reduction of certain species
- Landslides
    - Ecosystems
        - Fast moving debris may bury huge areas of forests resulting in destruction of natural habitats
        - Debris ends up in water bodies > Affect aquatic life
    - Properties/Infrastructure
        - Debris can bury properties > Destroy them
    - Services
        - Debris may block roads and railways > Difficult for rescue efforts
        - Debris can snap electricity cables and destroy water and gas pipes > Disrupting services
    - Injuries/Fatalities
        - Can get hit or bury people > Injuries/Death
        - Block water and cause flooding > Drown people
    - E.g. [2018] Eastern Iburi Hokkaido, Japan
        - More than 5k landslides triggered
            - Buildings and infrastructure destroyed
                - Nearly 3 million houses lost power
            - Falling debris entered rivers and caused flooding and polluted waters

        - Aquatic life also affected

- Tsunamis
    - Formation of tsunamis
        - Undersea EQ causes seabed to be displaced
        - Large volume of water is lifted
            - Forming waves of great wavelength and low height
            - Travels at high speeds around 800km/h
        - Approaching the coasts > The waves slows down > Friction between shallower seabed
            - Reach up to heights of 15m and speeds of 30-50km/h
                - Inflict huge damage on shorelines
    - Ecosystems
        - Tsunamis can flood huge areas of coastal wetlands and forests > Damaging wildlife and ecosystems
    - Properties/Infrastructure
        - Fast-moving waters carrying debris can damage and sweep away buildings and infrastructure
    - Services
        - Fast-moving waters and the large amount of debris can snap electricity cables, water and gas pipes > Disrupt services
    - Injuries/Fatalities
        - People may drown
        - Get cut by in debris carried by tsunamis
    - E.g. [2011] Tohoku, Japan (Mw 9.0)
        - Tsunamis with up to 40m in height
            - Destroyed buildings, debris carried into land, flooding and polluting the area

            - Sendai greatly affected due to its proximity
        - 70k pine trees were knocked down > Biodiversity loss
        - Tsunamis hit the pacific island > Devastated ecosystems

2. Hazards associated with volcanic eruptions

- Tephra, volcanic gases, lava flows, pyroclastic flows, lahars and volcanic landslides
    - VG, LV, PF, L, VL are often found around volcanoes
    - Volcanic ash may spread beyond geographical regions where volcanoes are found
- Tephra
    - Destroy ecosystems
        - Ash can be carried by winds
            - Pollute huge areas of habitats > Destroy ecosystems
            - Ash can suffocate and kill wildlife, blindness (eyelids gummed together)
    - Destroy properties and infrastructure
        - Volcanic bombs can hit and damage infrastructure
        - Ash can accumulate on roofs
            - Roofs could collapse if saturated with water due to heavy weight
        - Ash can weaken and damage structures of buildings as it is corrosive
    - Disrupt services
        - Ash particles can damage engine of planes > Air transport disrupted
    - Causes injuries and fatalities
        - Volcanic bombs can hit and injure people
        - Ash can cause respiratory problems, eye irritation and suffocate people
    - E.g. [1991] Mt. Pinatubo, Philippines

        - Buried more than 180km² of forests in 25cm of ashes
        - Destroyed 800km² of rice field > Livelihoods affected
        - Airports were closed and planes were damaged
- Volcanic gases
    - Destroy ecosystems (physical)
        - SO_2 > Acid rain > Damage vegetation and kill wildlife
        - Large amount of CO_2 can kill wildlife
            - Especially in valleys where it is denser and exist in high concentrations
    - Destroy properties and wildlife
        - SO_2 > Acid > Damage structure of buildings
    - Causes injuries and fatalities
        - Sulfur dioxide irritates skin, eyes, nose and throat
        - Carbon dioxide
            - 3% > Cause headaches and breathing difficulties
            - >15% > Death
    - E.g. [1979] Mt. Dieng, Indonesia
        - CO_2 released which killed 150+ people
- Lava flows
    - Destroys ecosystems (physical)
        - Hot, low-silica lava > Travel long distance > Destroy habitats, forests and ecosystems
    - Destroys properties and infrastructure
        - Burn thru homes, properties and infrastructure
    - Disrupt services

        - Lava can destroy electricity and communication cables, and water and gas pipes, disrupting supply
    - E.g. [2018] Mt. Kilauea
        - Lava flows destroyed >600 homes
        - Destroyed ecosystems and forests
        - Damaged telephone and power lines
- Pyroclastic flows (Hot cloud of gases, ash and rocks travelling down a volcano at high speeds)
    - Destroys ecosystems
        - Forests destroy > Loss of biodiversity
        - The path of the flows covered with ash > Pollutes huge areas
    - Destroy properties and infrastructure
        - Hot flows burn through buildings in their path
    - Disrupts services
        - Hot flows burn through electricity and communication cables and gas pipes
    - Cause injuries and fatalities
        - High temperatures can burn and kill people in seconds
    - E.g. [2010] Mt. Merapi
        - Blasted a series of pyroclastic flows
            - Devastated villages and killed 350 people
            - Huge areas of forests were burnt
- Lahars
    - Destroy ecosystems
        - Cover and destroys forests and ecosystems with thick mud as it hardens like concrete
        - Pollute water bodies and kill aquatic life

    - Destroy properties and infrastructure
        - Bury buildings and destroy them
        - Cover and destroys farmland with thick mud as it hardens like concrete
    - Disrupt services
        - Debris block roads and railways > Difficult to rescue people
        - Damage electricity and communication cables, and water and gas pipes
    - Cause injuries and fatalities
        - Bury residents > Lost of lives
    - E.g. [1985] Nevado Del Ruiz, Colombia
        - Snow and ice melted due to heat > Water mixed with ash and rocks forming lahar
        - Buried more than 20k people in a nearby town
        - Rivers highly muddied by lahars, killing many fish
- Volcanic landslides
    - Destroy ecosystems
        - Fast-moving debris
            - Pollute water bodies > Kill aquatic life
            - Forests and wetland can be buried
            - Blocks water bodies > Cause floods > Damage ecosystems
    - Destroy infrastructure and properties
        - Debris buries buildings and other infrastructure
    - Disrupt services
        - Debris snap electricity and communication cables, and water and gas pipers
        - Debris block railways and road > Difficult to rescuer people

    - Cause injuries and fatalities
        - Bury or hit people
        - Block water bodies > Flood > Drown people
    - E.g. [1980] Mt. St. Helens, USA
        - North face of volcanic cone collapsed
            - Landslides that travelled >20km
        - Destroyed huge areas and killed many wildlife

3. Benefits of living next to a volcano

- Farming with fertile soil
    - Volcanic rocks and ash break down & undergo weathering
    - Suitable for agriculture > Produce high crop yield
        - Benefit from growing a variety crops and earning more from high crop yield
    - E.g. Bali, Indonesia
        - Best rice-growing region despite continuous use of soil in the region
- Extracting precious minerals and fossil fuels
    - Some magma > Cool and solidify > Form precious materials like copper, silver and gold
        - Employment opportunities to mine minerals > Provide income
        - Sell minerals for revenue > Provide social services (edu and healthcare) to citizens
        - Ash and sand > Used for construction
    - E.g. Mt. Merapi, Indonesia
        - Locals living near are employed to mine volcanic sand for construction
- Harnessing geothermal energy
    - Energy that come from heat in earth's crust

        - Hot rocks heat up groundwater > Forms steam > Harnessed to produce electricity
        - Local get cheaper electricity as produced locally and have employment opportunities
    - E.g. Iceland
        - Most of the country's energy is from geothermal power due to large number volcanoes

- Tourism activities
    - Different volcanic features like the craters > Attract tourists
        - Engage in different activities like hiking and sightseeing
    - Locals have employment opportunities such as tour guides, tourists accommodation and selling goods
        - Boost local economy
    - E.g. Iceland
        - Popular among tourists for their volcanoes and scenic beauty
            - Tourism contributes to about 10% of GDP

Topic 3.1 Disaster Risk Management - Achieving Sustainable Development Through Disaster Risk Management

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1. Disaster Risk

- Potential damage to properties, injuries and loss of life from a disaster

2. Disaster Risk Management

- Prevent disaster risks before the occurrence of tectonic hazards
    - Designing hazard-resistant buildings > Structures do not collapse easily
    - E.g. Taipei 101
        - Weighted damper > Balance out ground shaking > Reduce threat of collapse
- Reduce disaster risks as tectonic hazards occur

    - Tsunami and EQ early monitoring and warning systems > Timely evacuation > Reduce casualties
- Manage disaster risks after the occurrence of tectonic hazards
    - Insurance coverage > Financial payout > Rebuild destroyed buildings
        - Quick recovery from hazard

3. Hinderance of development due to disaster risks

- **Environmental consequences**
    - Tectonic hazards (landslides) > Bury huge areas > Destroy ecosystems and biodiversity
        - Debris
            - Pollute rivers and kill aquatic life
            - Block rivers > Floods > Damage ecosystems
- **Social consequences**
    - Lead to the loss of lives
        - Drown due to flooding
        - Get hit by debris
    - Homes destroyed > Homeless > Temp housing > Poor standard of living
    - Sea water (tsunami) > Contaminate drinking water > Spread of diseases (cholera)
    - Constant threat of losing their lives and being harmed > Psychological trauma > Affect mental well-being
- **Economic consequences**
    - Destruction of buildings
        - Individuals suffer financially > $$ to repair damaged buildings
        - Business owners lose income due to damage
        - Gvt need to spend $$ to repair and rebuild
- Hinder overall development of countries

- Countries need to channel $$ to rebuild
  - Less $$ to be invested in education and healthcare > Development and economic growth slows down
  - People could lose their source of income and driven to poverty
    - Education, healthcare and agriculture affected
      - School and healthcare facilities damaged > Social services disrupted > Decrease in SOL
      - Farmers unable to grow crops (water contamination) and fishmen unable to fish (loss of boats)

4. Importance of reducing disaster risk

- Very important in disaster-prone in developing countries
  - Social, economic and environmental consequences can be severe > Hinder development
  - Developing countries are disproportionately affected as they often lack the capacity to reduce and manage disaster risk
    - E.g. [2010] 7.0 Haiti EQ
      - Lacked finances to invest in EQ-resistant buildings
        - Buildings collapsed and city was destroyed
        - 220k deaths
- Developing countries can also invest and plan to reduce disaster risk
  - Cost-effective investment to prevent future losses
    - Investments usually smaller as compared to costs incurred from disasters
    - Minimise costs of rebuilding and lessen threat
  - E.g. [2010] 8.8 Chile EQ
    - One of the strongest earthquakes detected but with only about 500 casualties

        - Buildings could withstand the shaking due to modern earthquake resistant investments

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Topic 3.2 Disaster Risk Management - Variations in Disaster Risks Caused by Earthquakes and Volcanic Eruptions across Places

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1. Nature of hazards influences disaster risks

- Duration of shaking
    - Longer > More damaging
        - Structures subjected to long periods of stress may collapse
        - People more likely to be trapped in collapsed infrastructure > More injuries and loss of lives
        - E.g. [2011] 9.0 Tohoku EQ
            - Lasted for 6 mins which caused massive damage to buildings
- Time of shaking
    - Time of day influences types of activities carried out by people and how they respond
        - At night > Asleep > Less alert > Unable to evacuate quickly
        - Day time > More alert > Evacuate quickly
            - Less likely to get trapped > Less fatalities
        - E.g. [1995] 6.9 Kobe EQ
            - Occured around 6am
                - People asleep > Trapped at home > >5k lives lost

2. Vulnerable conditions influences disaster risks

- Quality of building design and construction
    - EQs do not kill people, buildings and their content do
        - Poorer quality of building design > More vulnerable to collapse > More trapped people > Injuries and loss of lives

        - Poor build quality > Materials that are rigid and unable to withstand shaking
        - Building codes not followed
        - Lack EQ-resistant features (reinforced steel walls)
    - E.g. [2010] 7.0 Haiti EQ
        - Many buildings and infrastructure collapsed
            - Made of poor-quality material and concrete poorly reinforced
            - 90% of buildings near epicentre was destroyed
- Soil and rock properties
    - It can open up areas for other EQ hazards like liquefaction
        - It occurs when soil is saturated and loose
            - Buildings more vulnerable as they may sink or collapse > People trapped in buildings > More injuries and loss of life
    - Softer soil > Higher risk
        - Seismic waves travel from hard to soft soil > Waves get amplified
            - Waves slow down but become larger
            - Soft soil shakes more intensely > Likely that buildings may collapse > More injuries and death
    - E.g. [2010] 7.0 Haiti EQ
        - Haiti lie along areas with soft soil
            - Seismic waves were amplified > Collapse of many buildings and >220k people lost their lives

3. Exposure to earthquakes influences disaster risk

- Population density
    - No. of people per unit area
        - Higher density > Greater no. of people exposed to EQs

            - Large no. of people in buildings > More people trapped > Increase in injuries and loss of life
    - E.g. [1995] 6.9 Kobe EQ
        - Industrial city with density of 3k people per km^2
            - >5k people killed, 40k injured
- Distance from epicentre
    - Nearer, greater no. of people exposed to hazards > Greater risk
        - Less energy is absorbed by rocks before waves reach the city
            - Waves reaching the city will be stronger > Violent shaking
                - Buildings more likely to collapse > People trapped in> More injuries and loss of life
    - E.g. [2010] 7.0 Haiti EQ
        - >220k deaths recorded as epicentre on 25km west of city

4. Nature of volcanic eruptions influences disaster risk

Low Silica Lava

- Lava flow far before cooling
    - Damage buildings over large areas within geographical location
    - Rarely kill people as people may avoid the path of flows
- E.g. [2018] Kilauea, Hawaii
    - 20+ injured
    - 600+ homes destroyed
    - $800M in damages

High Silica Lava

- Can form highly destructive pyroclastic flows
    - Widespread damage
- Volcanic bomb may strike people/buildings
- E.g. [2010] Mt. Merapi
    - Pyroclastic flows travelled down 3km to heavily populated areas
    - Volcanic bombs travelled up to 10km and hit people
    - 350 killed and 350k people evacuated

5. Vulnerability of volcanic eruptions influences disaster risk

- Avaliability of surface and groundwater
    - Greater availability > Lahars likely developed
        - Increases likelihood of people and buildings getting buried > Destructions of properties, injuries and loss of lives
    - Sources of water: Melting snow/ ice on summit, groundwater, water bodies nearby and rainfall
    - E.g. [1991] Mt. Pinatubo
        - Monsoon season > Triggered rainfall > Lahars destroyed 100k homes
- Prevailing wind conditions
    - Strength and direction of wind > Affect distribution of ash and tephra
        - Carried to human areas
        - Heavier particles deposited near volcanos and finer ash particles are carried thousands of kilometres away due to light weight
    - Larger no. of people exposure > Increased vulnerability
        - People experiences health problems > Respiratory issues
        - Weight of ash > Causes buildings to collapse
        - Farmlands destroyed
    - E.g. [1991] Mt. Pinatubo
        - Ash fall spread over vast distances due to strong winds
        - 800km^2 of farmland destroyed

6. Exposure to volcanic eruptions influences disaster risk

- Presence of human settlements due to benefits > Increases exposure of people to hazards > Greater risks
    - Volcanic soil > Fertile > Suits agriculture
    - Geothermal energy > electricity
    - Mining of precious minerals such as sulphur

- E.g. Mt Sinabung
    - Several explosive eruptions > Restricted zone put in place
        - People still work despite the dangers due to fertile soil

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Topic 3.3 Disaster Risk Management - Effectiveness of Strategies in Building Communities' Resilience to Earthquake and Volcanic Eruptions

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1. Building community resilience to minimise disaster risk

- Strategies are put in place to reduce exposure and vulnerability of hazards
    - Increase the ability of communities living in hazard-prone areas to resist, adapt, and recover from impacts of disasters in a timely and efficient manner

2. Reduce exposure through land use planning

- Reduce community's exposure by controlling and minimise development high-risk areas
    - Potential lives lost and damage to properties
        - Hazards maps and strict guidelines > Control development
        - Identify areas at risk using data from past EQ
            - Suggest level of risk based on likelihood of disaster occurring
    - E.g. Japan
        - [1933] Land-use planning implemented
            - Coastal areas > Shift to higher ground
            - 2011 Tohoku EQ > Tsunami > Houses at higher ground not destroyed

3. Reduce vulnerability through hazard-resistant building designs

- EQ-resistant buildings design > Withstand ground shaking
    - Shock absorbers to absorb vibrations
    - Reinforce buildings using diagonal cross braces > Retain building shape

- Prevents buildings from swaying too much > Reduce vulnerability of it collapsing
    - Reduce injuries and loss of lives
- E.g. Taipei 101, Taiwan
    - EQ-prone zone
        - Weighted damper balances out building > Reduce sway of building > Decreases threat of it collapsing

4. Reduce vulnerability through monitoring and warning systems

- Monitoring and warning systems > Devices to detect waves
    - Make predictions and send warnings
- Early Earthquake Warning (EEW) system which is a network of monitors
    - Waves are detected
        - Alerts are sent out to smart devices to inform people
        - Gives time and information to people and authorities to evacuate quickly > Less prone to risks
        - Sensors to detect areas which require aid
- E.g. [2011] Tohoku, Japan
    - Warning system detected EQ > Sent signal to bullet trains to stop > Saved many lives

5. Building community resilience by increasing preparedness for response and recovery

- Being prepared means knowing what to do in a hazard
    - Raising public awareness through education
        - Educate people on hazards and response
            - E.g. Taking shelter or closing off any opening at home during volcanic eruptions
    - First-aid training

        - Enables people to administer basic medical care to the injured so that they are mobile to evacuate
    - Conducting evacuation drills
        - Enables people to familiarise themselves with routes > Reduce likelihood of getting trapped
            - Volcanic eruption: Avoid areas downwind of volcano
            - Tsunami: Move themselves away from tsunami and make their way to safe areas
        - E.g. [2011] Tohoku, Japan EQ
            - 3k students in Kamashi City survived the tsunami and earthquake as they had extensive evacuation drills
- Preparedness also includes developing plans to ensure that people go back to their normal lives as quick as possible

6. Challenges in building community resilience

- Extent of community resources
    - Financial and technological
        - Influences ability of community to reduce vulnerability and exposure of hazards and to recover from the impacts of disasters
    - Developing countries > Lack the resources to build community resilience
        - Gvt may choose to prioritise for economic development instead of focusing on prevention measures
    - E.g. Haiti
        - Many Haitians (80%) lived below the poverty line, earning less than $2 per day
        - Buildings did not followed building codes and were poorly constructed
        - The government was also corrupt and provide little assistance
- The capability of the community to organise themselves for disasters
    - Limit community's ability to respond and recover from hazards

        - Lack of efforts to educate and train the community
        - Political instability > Civil unrest
        - Corruption > Loss of funding to build community preparedness
    - E.g. Haiti
        - Resulted in 220k deaths
            - Unable to reorganisation themselves as many were uneducated
            - No network of healthcare works > Limited medical and emergency repsonse
            - Poor law-enforcement
                - Looting
                - Chaos and unrest unfolded

Topic 3.4 Disaster Risk Management - Effectiveness of Disaster Management Strategies Affect an Earthquake or a Volcanic Eruption

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1. Disaster Risk Management

- How communities adopt strategies to respond and recover from diasasters
    - Would need various stakeholders (Government and NGOs) to assist with rescue efforts and provide additional aid (NGOs)

2. Strategies to respond to disasters

- Search and rescue efforts
    - Immediate life-saving response > Important
        - Find and save survivors trapped > Aim to rescue as many in shortest time > Minimise risk
    - Skilled rescuers and specialised equipments (heat sensors & listening devices) > Reduce time taken
        - Without rescue > Survivors may die from dehydration, injuries, crush syndrome and other conditions
    - E.g. [2010] Tohoku Earthquake

        - Almost 20k people were saved by search and rescue teams from the various defence forces in Japan

- Timely Evacuation
  - Move people away from areas that have hazards quickly > Reduce loss of life
    - Earthquakes
      - Building and infrastructure may collapse
        - Evacuate quickly to open space to avoid getting trapped
      - Powerful aftershocks
        - Buildings collapse due to aftershocks after already weakened by main EQ
      - Basic services disrupted
        - Evacuated to temp shelters where food, water and medical aid provided
    - Tsunami
      - Evacuated to higher ground away from coastlines
        - E.g. [2011] Tohoku, Japan
          - 3k students in Kamaishi City survived as the sought for higher grounds after EQ
    - Volcanic eruption
      - Volcanic gases, tephra, lahar, landslides, pyroclastic flows > Loss of life
        - Evacuate from danger zones
      - E.g. Mt. Merapi
        - More than 350k people evacuated and 700 evacuation centres set up
- Provision of basic and psychosocial services to affected areas
  - Water shortage

    - Water pipes destroyed, cutting off supply
    - Ash and rocks contaminated waters > May carry water-borne diseases when drinking
    - Clean drinking water needed > Prevent dehydration
  - E.g. [2010] Haiti Earthquake
    - Water supply disrupted
      - International Association of Red Cross supported by stationing water trucks at the capital
  - Food shortage
    - Food may not be available as shops are closed and crops may be destroyed
    - Frozen food available may turn bad as electricity to fridges disrupted
    - Providing food > Prevent starvation
      - E.g. [2010] Haiti Earthquake
        - United Naitons World Food Programme provided ready to eat meals to areas that were heavily affected
  - Healthcare services disrupted
    - Hospital facilities may be destroyed
    - Injured civilians may require healthcare assistance
      - Providing access to medicine, doctors and hospitals > Reduce spread of diseases and death due to injuries
    - E.g. [2010] Mt. Merapi
      - Temporary 24h helathcare shelters set up to attend to the medical needs of civilians
  - Psychosocial services
    - Loss of lives and homelessness > Emotional distress
      - Need counselling from mental health experts to come to terms of disaster and rebuilding their lives

        - Services can also help survivors cope with trauma
    - E.g. Tohoku, Japan
        - The government along with volunteers to provide care and mental support to survivors

3. Strategies to recover from disasters

- Disaster recovery strategies including restoration and improving facilities and living conditions
  - Constructing hazard-resistant buildings
    - Retrofit surviving buildings with resistant features
  - Survivors to return to original homes > Communities kept intact
  - Providing housing assistance > Better quality
- Enable affected communities to rebuild their lives after disasters to minimising vulnerability and exposure to hazards
- E.g. Tohoku, Japan
  - 500k displaced
    - [2016] Rehoused settlements with enhanced features
    - Ground level of houses raised by 10 metres and more sea walls to be built

4. Challenges in disaster management

- Lack of domestic resources, including technological and financial resources
  - Unable to respond and recover from disasters
    - Hinder rescue efforts > Delays > More lives lost
  - E.g. Haiti Earthquake
    - Lack of resources > Hinder rescue efforts
      - Shortage of ambulances to care for the injured and heavy machinery to dig out the rubble

            - Rescuers spent many hours digging out rubble manually > Inefficient

- Authorities may face difficulties engaging relevant stakeholders to collaborate and integrate disaster management strategies into their practices
    - Disagreements from other stakeholders on strategies
    - Underestimation or lack of awareness and the need for certain strategies to be implemented
    - High cost of integrating strategies into practices
        - Locals
            - Reluctant to purchase insurance and retrofit their homes with due to high costs
            - Private insurance companies may not be willing to offer due to high commitment
    - E.g. Philippines
        - Only 10% - 20% of buildings are resistant against EQ
            - Due to high insurance cost

!!!Note/Disclaimer: Content is strictly based off textbook. Cover picture is also taken by myself. Notes were previously personalised so there can be some inconsistencies especially with abbreviations (governmental organisations). Hope these notes help! All the best for your exams :D