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#EU GREEN WEEK

EU Green Week Partner Event

WEFE Nexus Interlinkages of Tsunami-Type Natural Hazards: Case Studies in the Aegean and Marmara Sea, and Baffin Bay

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THE WATER-ENERGY-FOOD NEXUS: BUILDING RESILIENCE TO GLOBAL CHALLENGES

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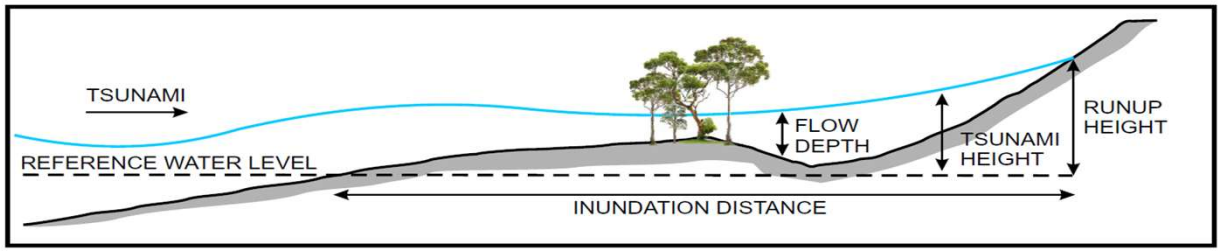
Introduction



- 津(Tsu): Harbour　波(nami): Wave
- A long, high sea wave caused by an earthquake or other disturbance.
- Reasons of Tsunamis:
  - ❖ Earthquake (Mainly in Mediterranean and Black Sea)
  - ❖ Terrestrial Landslide (Mainly occured in Norway and in some areas of Europe)
  - ❖ Submarine Landslide (Mainly occured in Norway and in some areas of Europe)
  - ❖ Underwater Volcanic Eruption (Mainly in Aegean and Mediteranean Sea Region)

İzmit Tsunami, 1999

https://www.britannica.com/event/Izmit-earthquake-of-1999

İzmit Tsunami, 1999

- Date and Time: 17 August 1999
- Location: Marmara Sea
  İzmit (Türkiye)
- Reason: *Earthquake and submarine landslide*
- Magnitude (Mw): 7.4
- Run-up Height: 2.6 - 2.9 m
- Inundation: 200 - 300 m

Kuran, U. and A.C.Yalciner (1999)

- Loss and damage: Unknown; damaged infrastructure: roads, ports, costs, buildings, cars, yatchs.

Short-term NI Matrix

İzmit Tsunami, 1999

0S	The tsunami waves eroded soil in the Marmara Seabed.
0W	The tsunami event initiated water rise and inundation.
WE2	The buildings inundated with sea water due to the tsunami lost electricity.
WF1	Due to the tsunami, restaurants and cafes were inundated with seawater, disrupting the food supply.
SEc	Marmara Sea is contaminated with sediment transport.
WS	The sediment transport and debris flow occurred into the sea due to the tsunami wave at the coast.

Short-term NI Matrix

İzmit Tsunami, 1999

WT1	Road networks are inundated with tsunami and road transportation is disrupted.
WE1	The energy related infrastructure (electric transmission line) in the inundated region is damaged.
WL	Many people living in houses near the coast lost their homes because of the inundation and sea water rise.
WH	There were life casualties due to the earthquake and tsunami. The tsunami waves reached the coast right after the earthquake.
TF	The food supply was disrupted due to the disruption in transportation because of the damaged roads.
TH	Due to the disruption in transportation, there was disruption in medic supply.

Mid-term NI Matrix

İzmit Tsunami, 1999

0Ec	The disturbance caused by a tsunami can devastate benthic (sea bottom) ecosystems, which include invertebrates like crustaceans, worms, and snails.
0ICT	Due to the tsunami and earthquake, the communication network is disrupted.
WEc1	Due to the inundation, some mussels were observed in the inundation area and therefore ecosystem is negatively affected.
WF2	Due to the inundation, dead fishes were observed in the inundation area and therefore food is negatively affected.
WT2	Tsunami waves flooded the Yachting Club and Seaport and damaged motor yachts and boats. Therefore, sea transportation is disrupted.

Mid-term NI Matrix

İzmit Tsunami, 1999

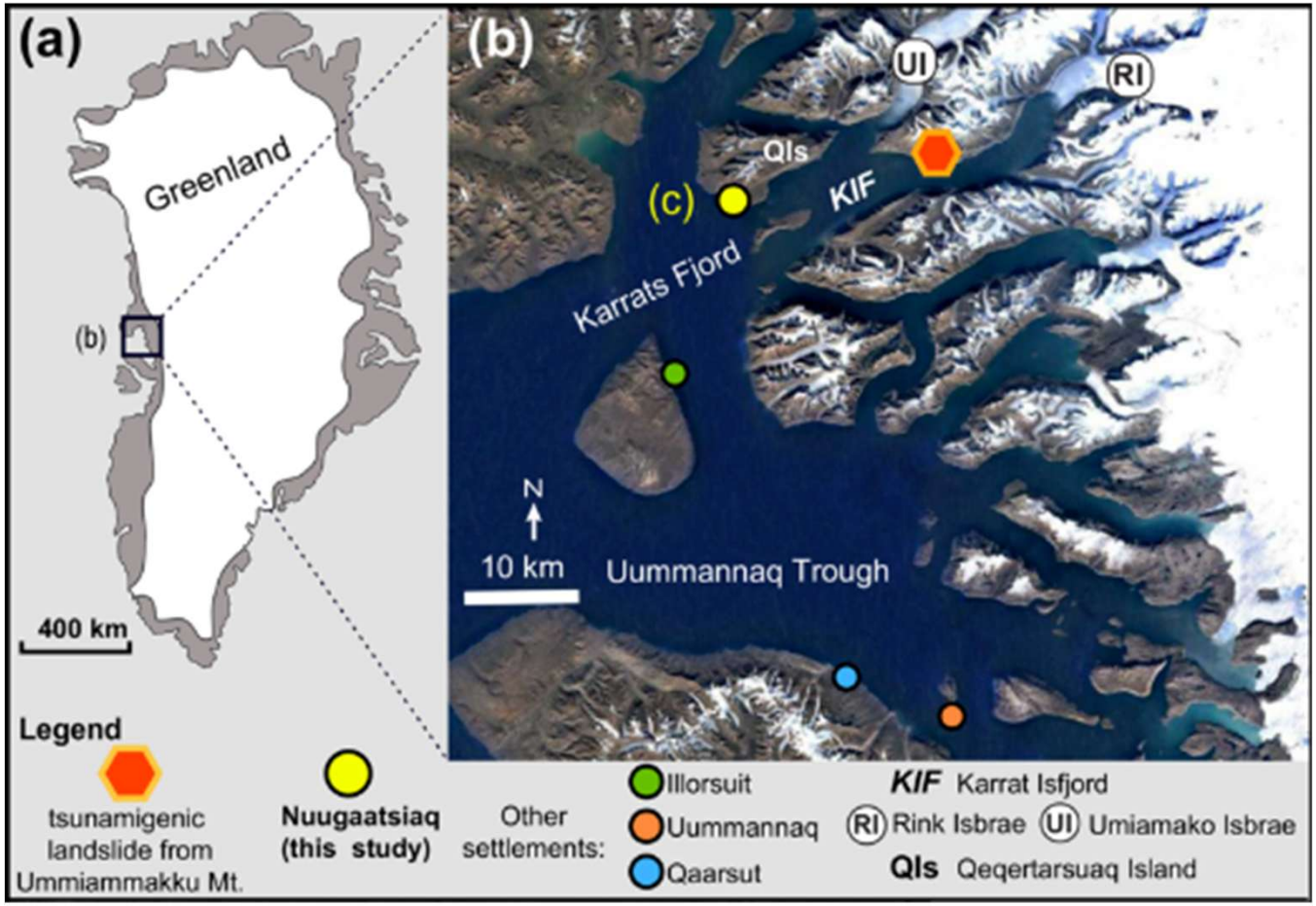
WEc2	Due to the inundation, moss and jelly fish were observed in the inland area and therefore ecosystem is negatively affected.
0T	Due to the tsunami, a gross ton tanker and other large ships first fell down and then uplifted. Therefore, sea transport is negatively affected.
WE1	The damaged infrastructure (electric transmision line) related to energy is not renewed.
SEc1	The sediment transported into the seawater affected ecosystem (health of biodiversity).

Long-term NI Matrix

İzmit Tsunami, 1999

WL1	The land use changed permanently because part of the land is under water.
WL2	Many people living in houses near the cost lost their homes because of the tsunami.
WT1	The coastal road is under water permanently.
WEc1	The natural coastline is affected and reshaped permanently.

Karrat Fjord Tsunami, 2017

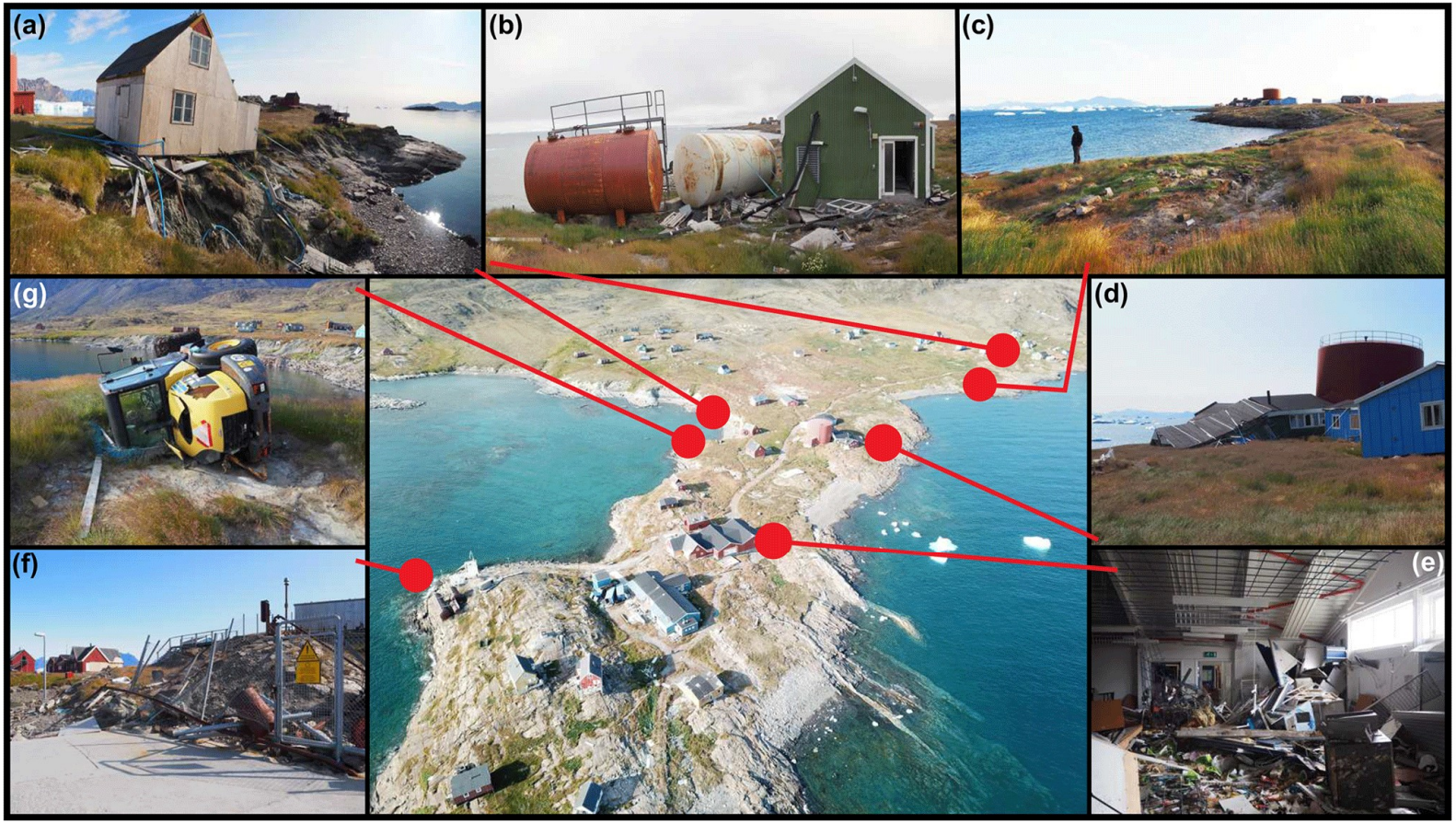


Strzelecki and Jaskólski (2020)

Karrat Fjord Tsunami, 2017

- Date: 17 June 2017
- Location: Karrat Fjord (Greenland - Kingdom of Denmark)
- Reason: Terrestrial Landslide 58×10^6 m^3 of rock and colluvium was mobilized and 45×10^6 m^3 entered Karrat Fjord
- Run-up Height: (50 m – 90 m), flow depth 9 m.
- Tsunami traveled 32 km along the fjord.
- Loss and damage: 4 lives, 48% of infrastructure objects including houses and administration buildings (The entire village was permanently resettled).

Karrat Fjord Tsunami, 2017



Strzelecki and Jaskólski (2020)

Short-term NI Matrix

Karrat Fjord Tsunami, 2017

0W	Nuugaatsiaq located ca. 32 km from the landslide was hit by three 1–1.5 m high waves, inundating the settlement over a period of ca. 3 min. The wave inundated terrain up to 9 m.a.s.l.
WH	Tsunami waves were powerful enough to cause four deaths and injure nine inhabitants.
WEc1	The wave tore blocks of tundra (shrubs, mosses, grass) off the coastal slope and deposited them on land. We noted a significant removal of tundra cover.
WS1	We noted soil erosion, and associated formation of rills or small gullies (0.2–0.6 m deep) concentrated on surfaces exposed after the washing away of buildings.
WL	Tsunami wave washed away buildings; the wave overwashed the section of settlement through a saddle between the middle beach and local harbour and modified the relief of cliffs in the harbour. The wave destroyed 45 buildings (48% of the original infrastructure): 22 buildings were fully swept away from land, 23 buildings were partly damaged, and 11 were moved between 2 and over 100 m from the original location.
WS2	Soil was also eroded along the cliffed coast of the harbour.
WEc2	Tundra was also eroded along the cliffed coast of the harbour.
WEc3	We assume that some parts of the grass cover were compressed by the fragments of icebergs or ice floes washed on shore by the tsunami.
WT	Sand and gravel washed from narrow and thin beaches were deposited along the main road (ca. 30–50m from the shore), where the thickness of deposits exceeds 8–10cm.

Mid-term NI Matrix

Karrat Fjord Tsunami, 2017

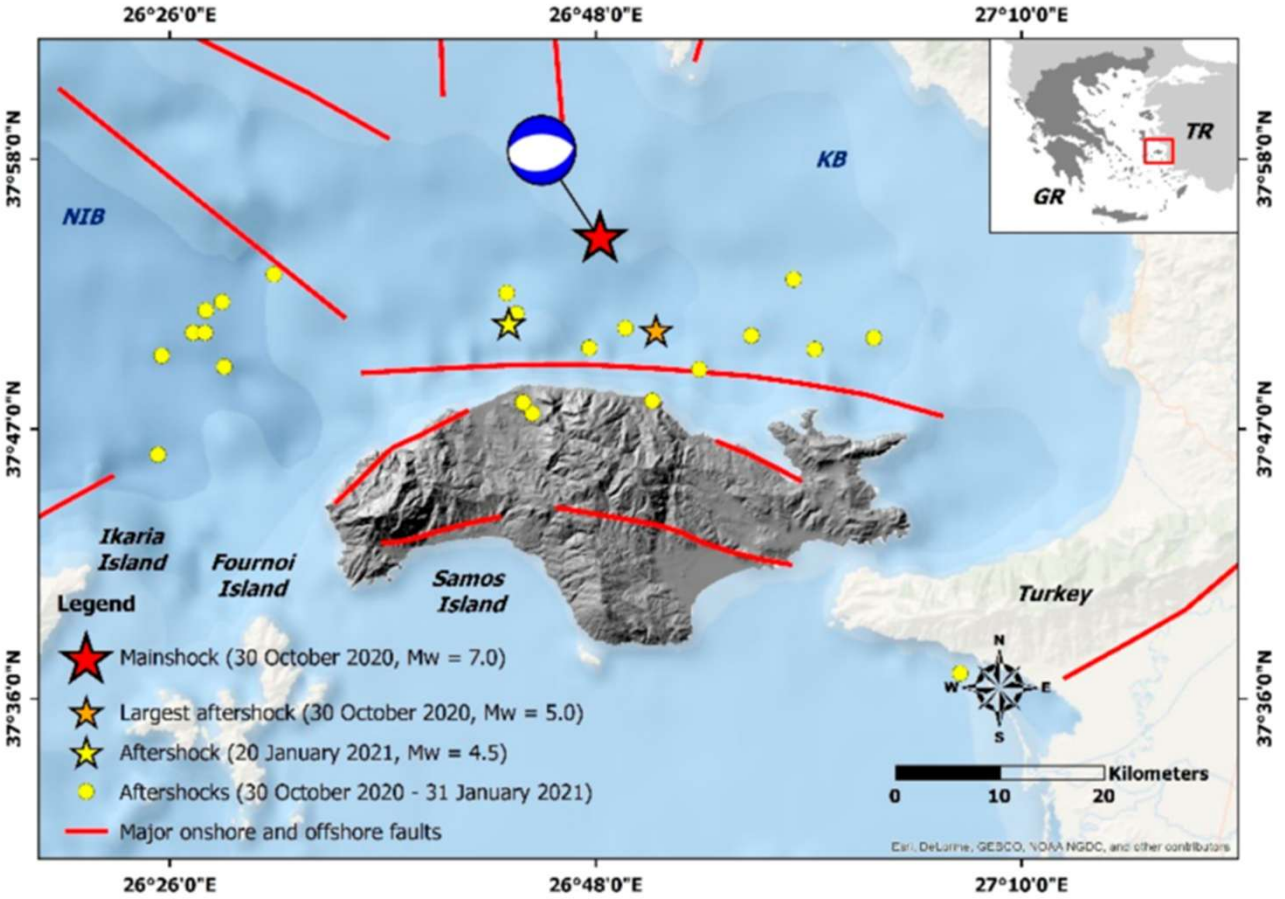
WL	Thirty-nine people were evacuated and separated into the settlements of Uummannaq and Qaarsut.
WS3	In sites where icebergs or floes were deposited and melted away, grasses were weighted down and melt-out sediment (gravel, sand, mud) was observed between grass blades.
WEc4	Tundra was also compressed by tsunami-derived boulders both eroded from beaches and melted out of icebergs.
EcL	During our fieldwork we noticed very dense and relatively high (0.4–0.6 m) grassy meadows covering coastal lowlands and recolonized abandoned playgrounds, roads, and backyards. The observed post-event vegetation cover in the study area was significantly denser and higher than in other settlements visited in the region in the same season.

Long-term NI Matrix

Karrat Fjord Tsunami, 2017

WL	Thirty-nine people were evacuated and separated into the settlements of Uummannaq and Qaarsut.
WH	The remaining material and waste in the settlement area still constitute a serious hazard.
WEc	A total of 2 years after the event, normal coastal processes (wave and tidal action) had not yet removed or redistributed the eroded blocks of tundra and litter from the slopes and bases of the cliffs.
EcS	About 2 years after the event most of the blocks of eroded soil, rafts of tundra, boulders, or litter that were found were almost entirely hidden in a high grass cover.

Samos Tsunami, 2020



Mavroulis, S, et al. (2021)

Samos Tsunami, 2020

- Date: 30 October 2020
- Location: Aegean Sea
  Offshore İzmir Province (Türkiye)
  Samos Island (Greece)
- Reason: *Earthquake*
- Magnitude (Mw): 7.0
- Run-up Height: 3.8 m
- Inundation: 2490 m (in Alaçatı, Türkiye)
- Loss and damage: 1 life; damaged infrastructure: coasts, yacht marines, roads, houses, cars, yachts.

Kalligeris, N, et al. (2021)

Short-term NI Matrix

Samos Tsunami, 2020

0W	The tsunami event is initiating apparently with water rise and inundation
WH	There were life casualties due to tsunami
WF	The tsunami affected fisheries and fish farms, leading to a reduced supply of seafood in the immediate aftermath.
WT	The tsunami caused significant damage to the coastal infrastructure, which includes transportation systems, roads, and storage facilities.
TF	Import and export routes, especially in coastal regions like Samos and Izmir, were disrupted, causing immediate shortages of fresh produce, fish, and other essentials.
ICT0	The Greek Civil Protection sent a tsunami warning via SMS to the residents of the eastern Aegean Greek islands through the European emergency number 112.
WE	The tsunami resulted in an electricity distribution problem right after the event.
WS	Tsunami waves may change the sediment with sand from a sea.

Mid-term NI Matrix

Samos Tsunami, 2020

WL	Many people who has restaurants in Sığacık had intensive damage in their restaurants because of tsunami
WT	Ports, roads, and other transportation infrastructure needed time to recover, affecting food imports and exports.
WF	The recovery of the local fishing industry could take several months to years, especially if fishing equipment, boats, or fish farms were damaged.

Synthesis and Recommendations

Label	Interlinkage Short Description	Term (S/M/L)	Recommendations
0W	The tsunami event initiated water rise and inundation.	S	**Operational:** Pumping out flood waters from inundated areas such as basements and first floors **Tactical:** Construction of barrier structures to block the tsunami such as breakwaters and seawalls, coastal dike, water gates **Strategic:** Generation of tsunami hazard and risk maps; restrictions of new residentials based on the maps
WS	The sediment transport and debris flow occurred into the sea due to the tsunami wave at the coast.	S	**Operational:** Removal of sediment and debris out of residentials and critical places **Tactical:** Construction of debris flow structures such as dikes **Strategic**: Implementation of coastal forest to control tsunami sediment movement
WT	Road networks are inundated with tsunami and road transportation is disrupted. Ports and ships are damaged.	S	**Operational:** cleanup the debris deposition on the roads **Tactical:** repair the washout road sections **Strategic:** constructing tsunami resilient infrastructure

Synthesis and Recommendations

Label	Interlinkage Short Description	Term (S/M/L)	Recommendations
WH	There were casualties due to the earthquake and tsunami.	S	**Operational:** Determining and improving evacuation routes **Tactical:** building tsunami evacuation structures **Strategic:** implementing tsunami early warning system
WE	The energy related infrastructure in the inundated region is damaged.	S	**Operational:** Using flashlights until power is on. **Tactical:** Repairment of power lines; the microgrids can mitigate the acceleration of the restoration of power system **Strategic**: Put powerlines underground, making them less vulnerable to tsunami
WF	Seafood and local fishing industry are affected	S/M	**Operational:** removing fish from food supply **Tactical:** Replacement of local fish farms to less vulnerable places against tsunami **Strategic:** The seawater reservoirs separated by the Tsunami barriers should be used for fish/tuna and seafood production
WEc	Tsunami waves harm marine life and cause significant removal of tundra cover.	S/M/L	**Tactical**: location-specific, appropriate green-belt protection alternatives should be defined. **Strategic**: Coastal Regulation Zone requirement of a 200–500-m as 'no development' zone should be implemented. Natural barriers such as coastal vegetation (e.g. mangroves) should be implemented.

Elaboration of Results-Conclusion

- **Water-Transport:** Both the ports and coastal roads are severely damaged and inundated with flood waters resulting in major disruptions in sea and ground transportation.
- **Water-Soil:** Enormous amounts of debris flow and sediment transport are observed during tsunamis, disturbing the soil cover and causing erosion and deposition in the seabed, which negatively affect biodiversity and the ecosystem.
- **Water-Food**: The seafood is severely affected by tsunami waves damaging fisheries and fish farms and resulting in dead fishes.
- **Water-Ecosystem:** Observations of dead fishes, mussels, moss and jelly fishes inundated regions are indicators of ecosystem degradation.
- **Water-Energy:** The power outages are inevitable due to damages on electric power lines and functionality cut-off of electric outlets in inundated areas.
- **Water-Health:** Casualties and injured lives are observed after tsunamis.


THANK YOU FOR YOUR ATTENTION !