: Predicting Climate Change Risks For Pacific Coastal and Maritime Supply Chain Infrastructure

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Overview

- **Defining A Pacific Coastal/ Maritime Supply Chain**
- **Climate Change Risks and Projections**
- **Climate Change Impact Costs**
- **Risk-Vulnerability Matrix**
- **Risk Impact Cost Event Tree**
- **Predicting Climate Change Probability Methods**
- **Stakeholder Criteria To Assess Climate Change Risk**
- **-Opportunities**

Defining A Pacific Coastal/ 'Maritime' Supply Chain

Import/Export/Transhipment/Transit

Resource Extractor/Producer

Value adding/beneficiation

Port.

Port authority/customs/state

Consumer

Retail/Wholesale

Transport and Distribution

Shipping

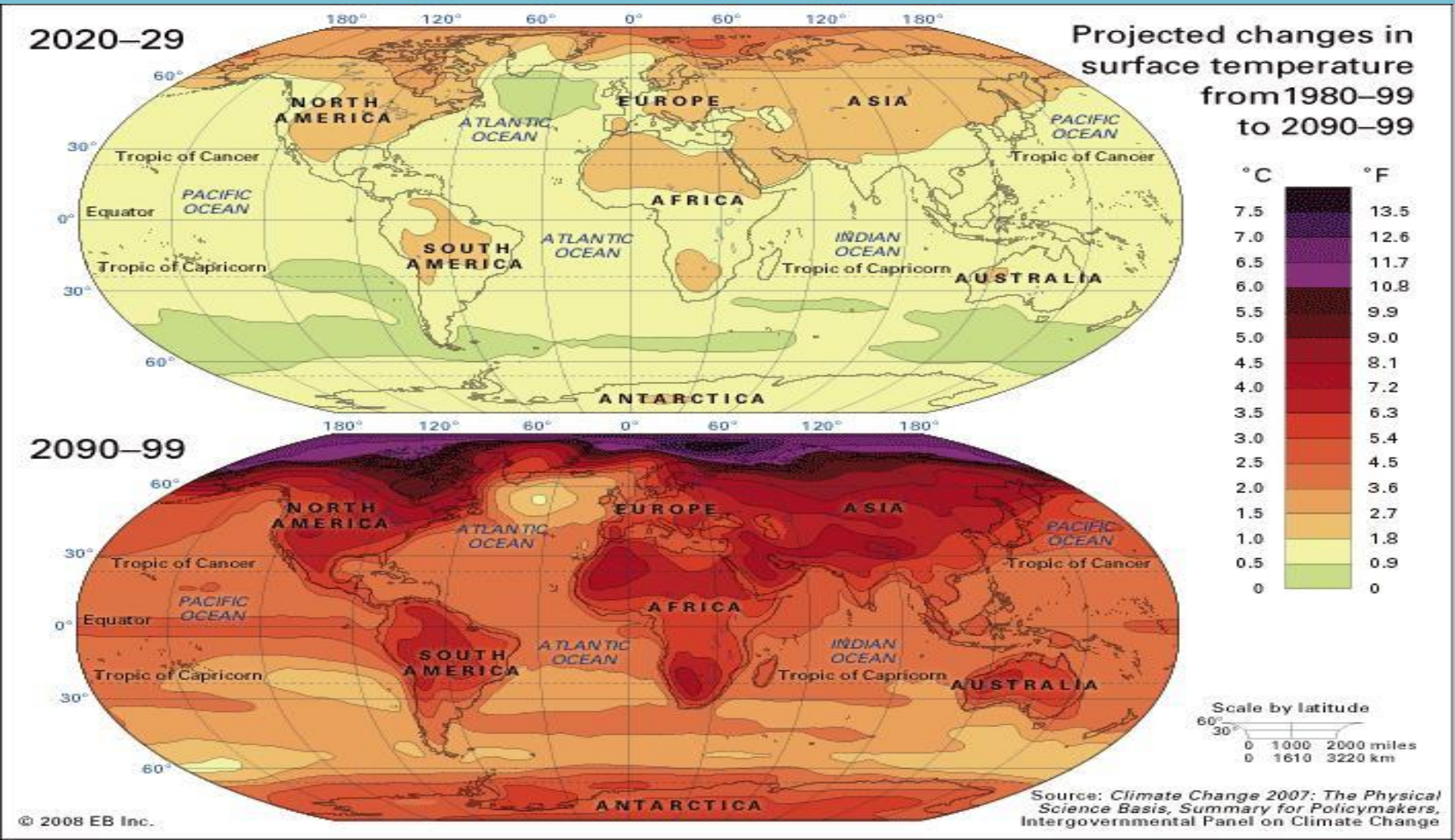
Banking/Insurance

Marketing/Publicity

Maritime Resources/Ecosystem

Seafood/Pearls

Global Mean Surface Temperature, Climate Change Projections



CLIMATE CHANGE VULNERABLE LOCATIONS

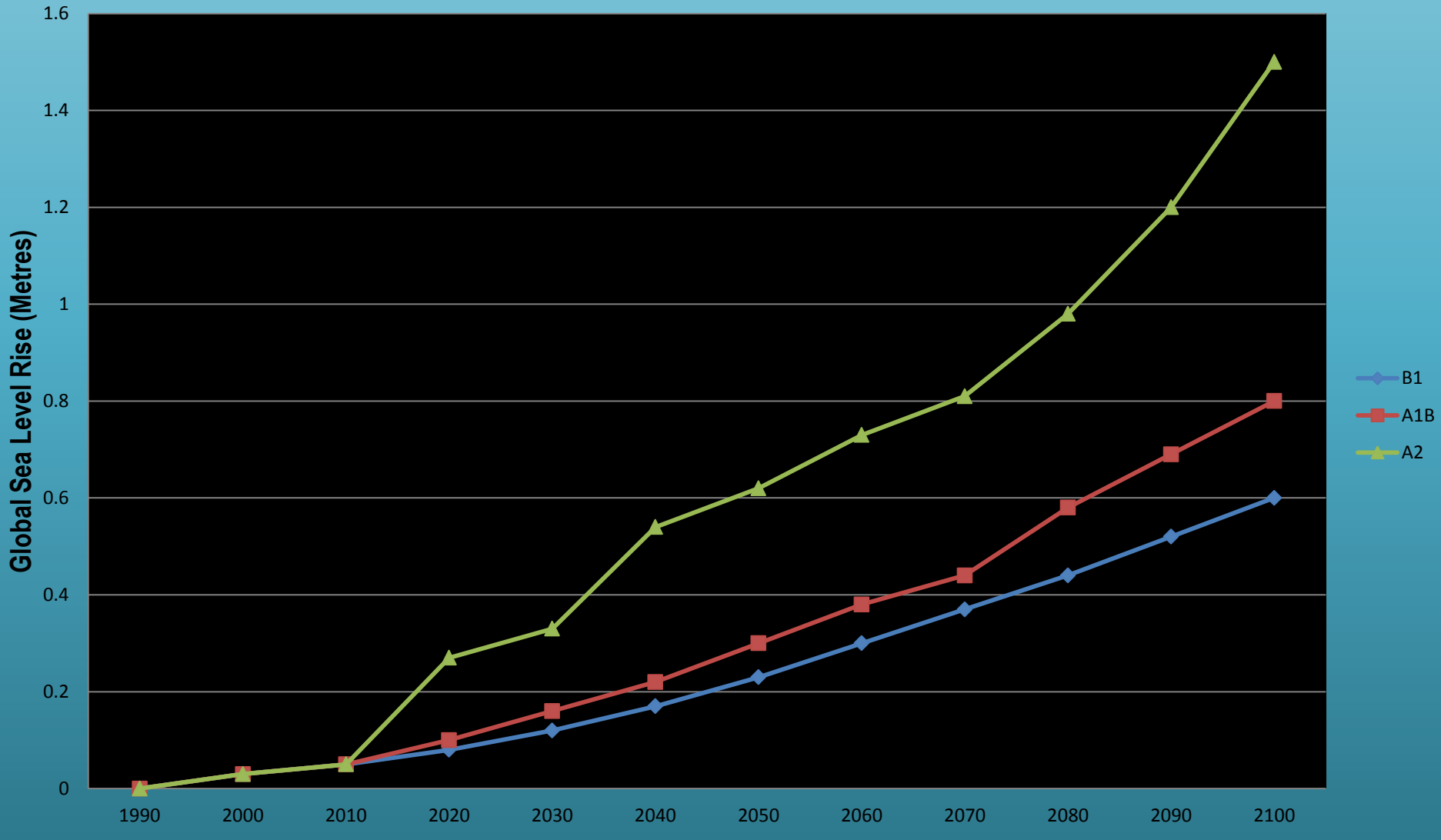
CLIMATE CHANGE LONG TERM RISKS

- SEA LEVEL RISE
- AIR, LAND AND OCEAN SURFACE TEMPERATURE
- CHANGES IN PRECIPITATION
- CHANGES IN WIND VELOCITY
- CHANGES IN CURRENTS, WAVE ENERGY AND SEDIMENTATION
- CHANGES IN SPECIES MIGRATION AND BIODIVERSITY

CLIMATE CHANGE SUDDEN, SHORT TERM RISKS

- STORMS/SUPERSTORM SURGES AND FLOODS
- HURRICANES/CYCLONES,
- DROUGHTS
- HEATWAVES
- LANDSLIDES
- TSUNAMIS

Global Sea Level Rise, Climate Change Risk Projections



CLIMATE CHANGE PROJECTIONS RISK EVENT IMPACT COSTS

- Loss of life
- Physical Damage to assets, cargo commodity, infrastructure to operations and performance, to other supply chains
- Threat to Navigation/Physical Accessibility
- Financial Cost –Adaptation, Repair, Lost Profits, Storage, Taxes, Insurance, Chartering Costs –vessels –fixed and operating,
- Health/Safety
- Environmental
- Communication, Information and Warning Systems
- Delay To Throughput/Productivity
- Opportunity Cost
- Reputational Cost, Administrative, Marketing, Legal; Policy
- Changes in Competitiveness
- Potential Trade Diversion/Intermodal Shift

CLIMATE CHANGE RISK-VULNERABILITY MATRIX

- **I: DEFINE RISK AND VULNERABILITY:**

- **II: RISK IDENTIFICATION**
  Identify General and Specific Projected Climate Change Risk Types (Long and Short Term), calculating the probabilities of risk event occurrences where possible

- **III: RISK-VULNERABILITY ANALYSIS:**
  Establish Climate Change Risk Projections; Scenario Assumptions and Time Horizons:
  -Identify current vulnerabilities, risks and resilience of supply chain assets, stakeholders, functions, infrastructure, ecosystems and systems plus future risks presented by projected climate change, competitors and interdependent supply chains.

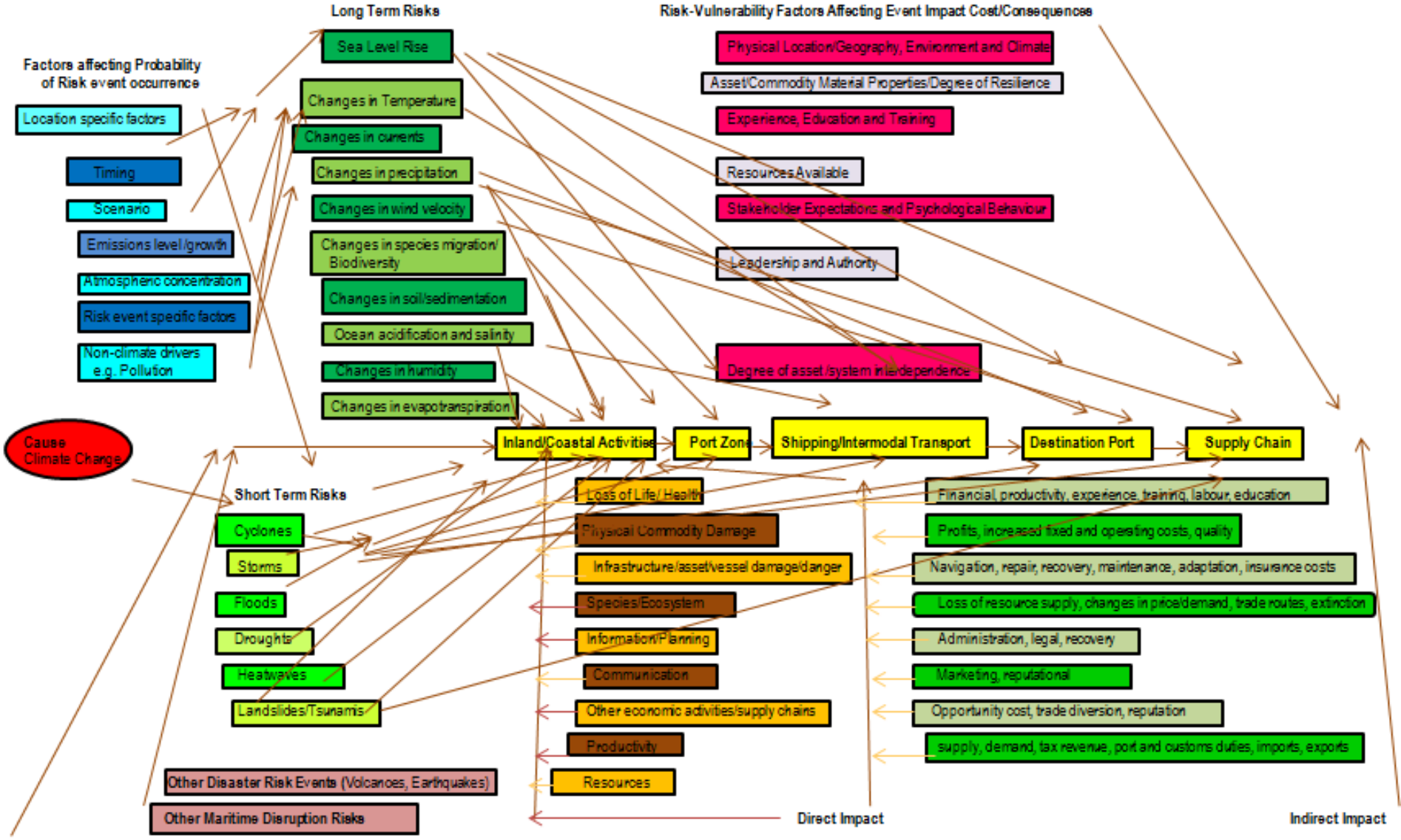
- **IV: RISK EVALUATION:**
  To identify climate and non-climate change related factors which might affect the rate of risk growth and impact costs.
  To describe each risk event's intensity, duration, frequency and probability, its likelihood and consequences

- **V: RISK PRIORITISATION:**
  To rank risks by urgency/risk probability and magnitude of climate change impact costs

- **VI: RISK ADAPTATION/TREATMENT:**
  (This stage is addressed separately to resolve KRQC through identifying risk adaptation strategies, aimed at minimising supply chain impact costs from associated risks), to manage, transfer, reduce or avoid risk.

- **VII: MONITORING AND REVIEW:**
  To evaluate proposed adaptation strategies' effectiveness to reduce disruption risk impact costs through reducing vulnerability and increasing resilience across a maritime supply chain and its stakeholders.

CLIMATE CHANGE RISK-IMPACT EVENT TREE



Predicting Climate Change Probability Methods

- **A climate change risk event probability =**

P (Historic Climate Change Risk) = Lim $\frac{n!}{n\ X!\ (n-X)}\ p^F\ q^{(n-F)}$ = **P (F)** = $\frac{e^{-\lambda}\lambda^X}{X!}$ for X =0, 1, 2 $\lambda > 0$

- + Cumulative Probability $\sum(P(1_iF) + P(1i_iF) + P(1_{iii}F)\ \Delta t\text{-}\Delta t\text{-}1) +$ P(1iS)P(1iF) Joint Probability + Factors affecting the Probability of a risk occurrence.

- **Probability of P Future/Current Climate Change Specific Risk Event/P(CCRisk)**
- P (Future Climate Change Risk) = Lim $\frac{n!}{n\ F!\ (n-x)}\ p^x\ q^{(n-x)}$ = **P (x)** = $\frac{e^{-\lambda}\lambda^x}{x!}$ for X =0, 1, 2 $\lambda > 0$

- + Cumulative Probability $\sum(P(1_iF) + P(1_iF) + P(1_iF)\ \Delta t\text{-}\Delta t\text{-}1)$ (Climate Change Scenario Probability) + P(1iS)P(1iF) Joint Probability + Factors affecting the Climate/Non Climate change Probability of a risk occurrence

- **The conditional probability of an asset failure given a climate change related event =**

- **P(X Y) =$\frac{P(X,Y)}{P(X)}$ =** P (Climate Change Risk P(Asset Failure =$\frac{P(AssetFailure)}{P\ (Climate\ Change\ Risk)}$

Predicting Climate Change Probability Methods

The conditional probability of an asset failure given a climate change related event =

- **P(X Y) =$\frac{P(X,Y)}{P(X)}$** = P (Climate Change Risk P(Asset Failure =$\frac{P(AssetFailure)}{P(Climate\ Change\ Risk)}$
- For the Poisson distribution, assuming N = sample number of stakeholders which can be individually calculated for each individual maritime supply chain stakeholder, stage, system, location and commodity and probability of failure of 1 = FT where F = failure rate and T = interval size, the failure number during the interval is provided by the binomial distribution:

- $\frac{dP}{dT}$ = (1-P(t)F with initial condition P(0) =0

- $\frac{N!}{(N-n)!}$ = N^n and $(1-FT)^N = e^{NFT}$ ln (1-FT) = -(FT)

- Pn = $\frac{(N!)}{(n!(N-n)!)(FT^n)(1-FT)^{N-n}}$
-
- = $e^{-NFT}\frac{(NFT)^n}{n!}$ + P(aNFT)P(bNFT) + ∑Pn + (p(Vulnerability –Resilience-Adaptive Capacity) (Total sample time period (Δt-Δt-1))

- = $\frac{e^{-q}q^n}{n!}$ + P(aNFT)P(bNFT) + ∑Pn + (p(Vulnerability –Resilience-Adaptive Capacity)
- (Total sample time period (Δt-Δt-1))

Stakeholder Criteria To Assess Climate Change Risk

Figure 3.3 Thesis Criteria to Evaluate Stakeholder Asset Condition for Probability of Risk Failure

- Physical location/risk exposure/vulnerability
- Recovery Time To Disruption Risk Event
- Performance, productivity and output metrics
- Efficiency –through cost minimisation and optimal resource allocation
- Frequency of Maintenance
- Asset age
- Asset Materials/Properties
- Technical Standards
- Ecological Sustainability

Stakeholder Criteria In Identifying Where To Prioritise Risks

- Historic Experience
- Current and Future Risk exposure
- Demographics
- Existing Resources
- Capacity
- Funding Priorities
- Stakeholder Requirements
- Location/Accessibility of information/communication
- The asset's physical location –Altitude, Latitude, coastal erosion, Proximity to water/floodplain Adaptive Gradient/Slope, Aridity, Isolation –hinterland connectivity and congestion access points

Stakeholder Criteria To Assess Climate Change Risk

Stakeholder Criteria In Determining Which Risks To Prioritise And Why?

- Probability of Climate Change Risk Occurrence/Conditional Probability of Asset Failure.
- Size of Impact Costs/Consequences
- Resources available
- Historic, Current and Future Risk
- Factors affecting asset condition
- Factors affecting asset resilience
- Factors affecting asset vulnerability
- Constraints to climate change risk adaptation
- Physical Location
- Time Horizon
- Climate Change Scenario
- Stakeholder Requirements
- Other Supply Chain Stakeholders
- Competitors
- Capacity For Redundancy
- Extent of supply chain interdependent and exposure
- Contractual obligations
- Legislation/policy guidelines
- Fiscal/donor funding incentives/disincentives
- Potential for research innovation/technical progress

Stakeholder Criteria In Identifying When To Prioritise Risks

- Climate Change Scenarios, Assumptions, time horizons and quality of climate/climate change projections information
- Probability of Climate Change Risk Occurrence/Conditional Probability of an Asset Failure
- Probability of Other Risks Occurring/Asset Failure
- Changes in demographics/migration, tax and legislative policy
- Identify Physical environment and risk factors
- Identifying accumulative impacts from past and current climate change events
- Updated communication/information systems and sources
- Physical changes in species/ecosystems/climate
- Resources available and other adaptation constraints
- The extent and effectiveness of climate change mitigation/adaptation as factors potentially affecting the extent/probability of risk

CLIMATE CHANGE LITERATURE RESPONSE STRATEGIES

- Mitigation
- Ecological Rehabilitation
- Retreat/Surrender
- Elevation
- Migration
- Adaptation

FUTURE RESEARCH

PREPARE FIELD RESEARCH…..

APPLY METHODOLOGY TO PACIFIC CASE STUDIES

IDENTIFY CONSTRAINTS TO ADAPTATION

ADAPTATION STRATEGIES

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Any questions
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Please also feel free to contact me via email at: Jack.Dyer@utas.edu.au