

Measuring Resilience based on Post- earthquake Water Demand

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Outline

- Introduction
- Previous disasters' Impact on Water Supply
- Mechanism of earthquake impact on water system
- Resilience as a New Approach
- Demand-based Resilience
- Conclusion

Introduction

- Human life depends on water
- Water supply is sensitive & vulnerable
- Water system gets damaged in disasters



Disasters' Impact on Water Supply System





Earthquake

- Pipe breaks
- Structure collapse



Flood

- Loss of treatment plant
- Contamination of distribution system



Drought

- Water shortage
- Water quality problem



Wind

- Flood-induced problems
- Structure damage



Severe Weather

- Frozen pipes
- Outage and leaks

Earthquake Impact on Water System



Water supply vulnerability



Personal Shortage

Water Contamination



Air Contamination

Water-well Damage



Pipe Breakage

Structure Damage



Power outage

Communication Disruption

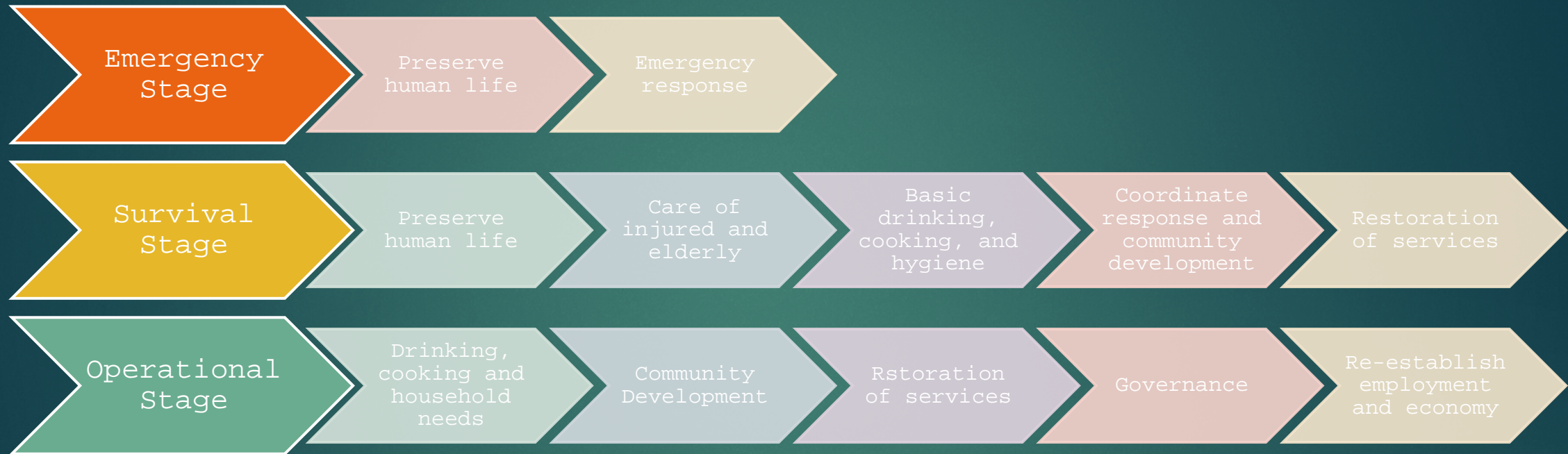


Transport Failure

What happened in Christchurch



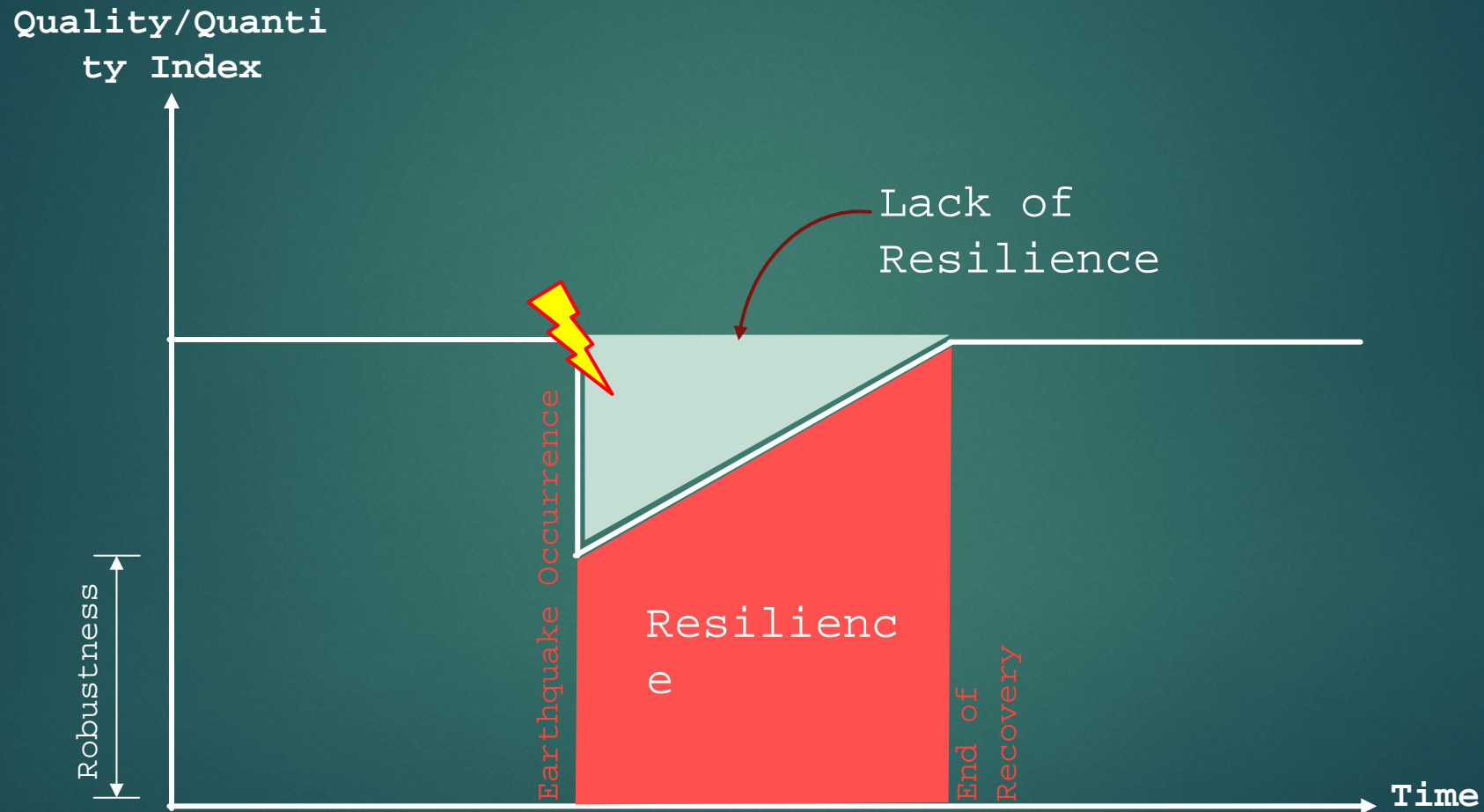
Post-earthquake Water Demand



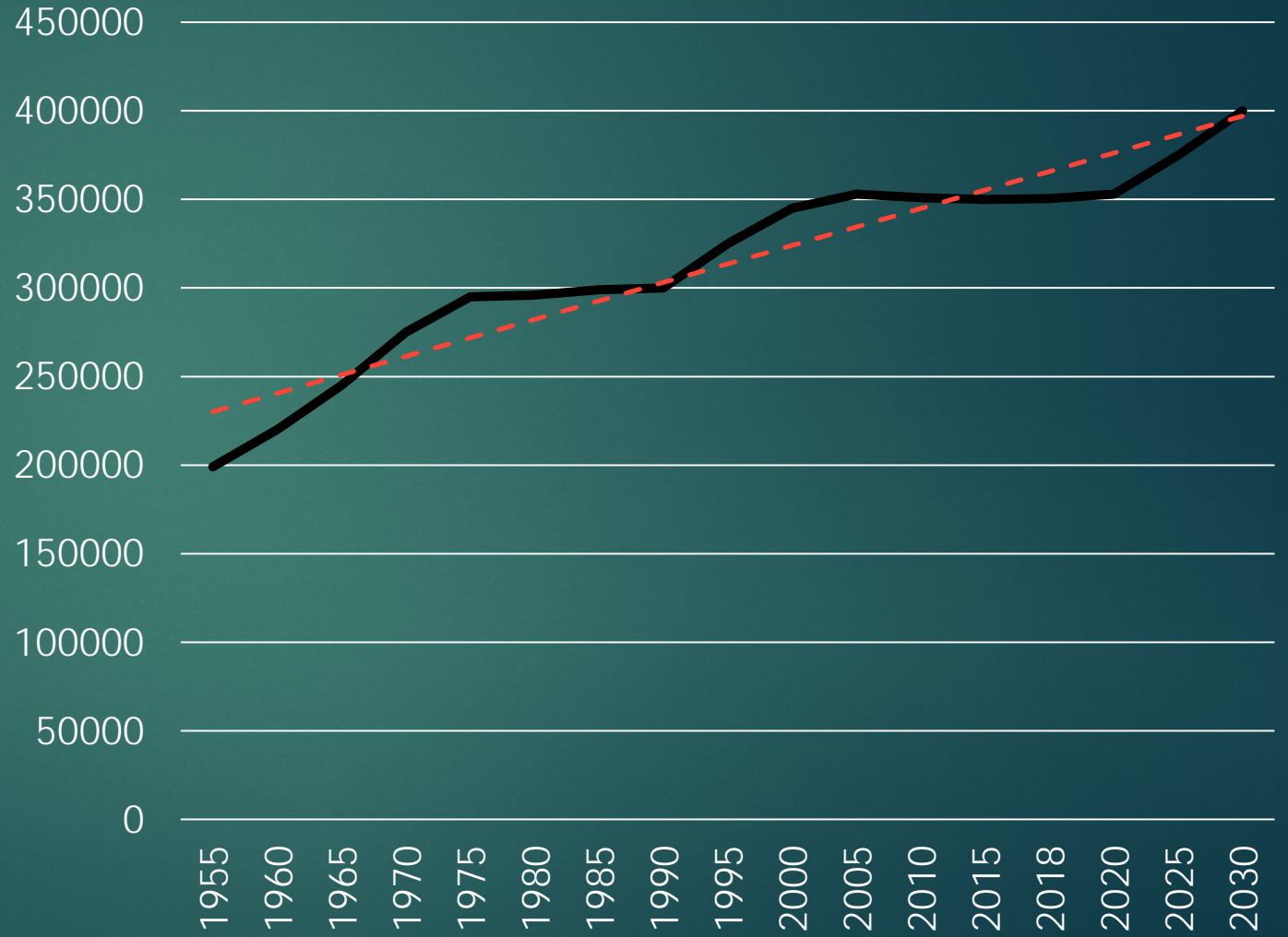
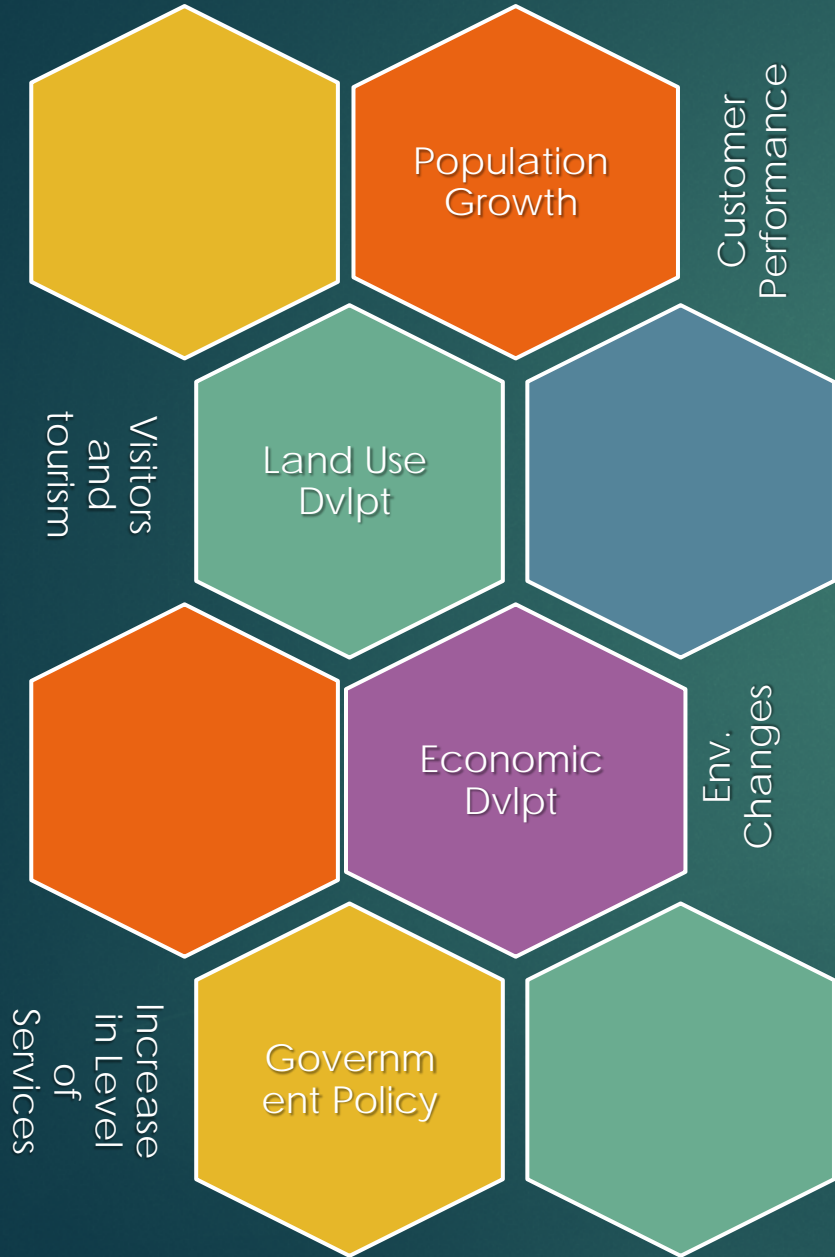
Risk Management



Resilience as a Global Approach



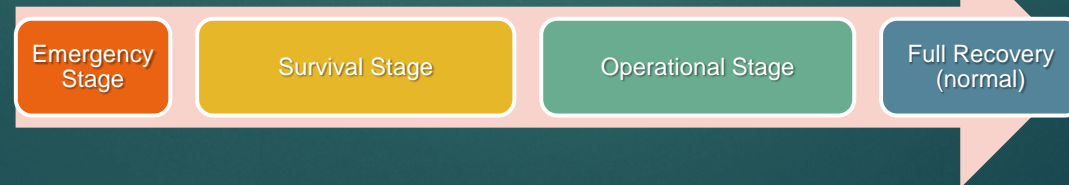
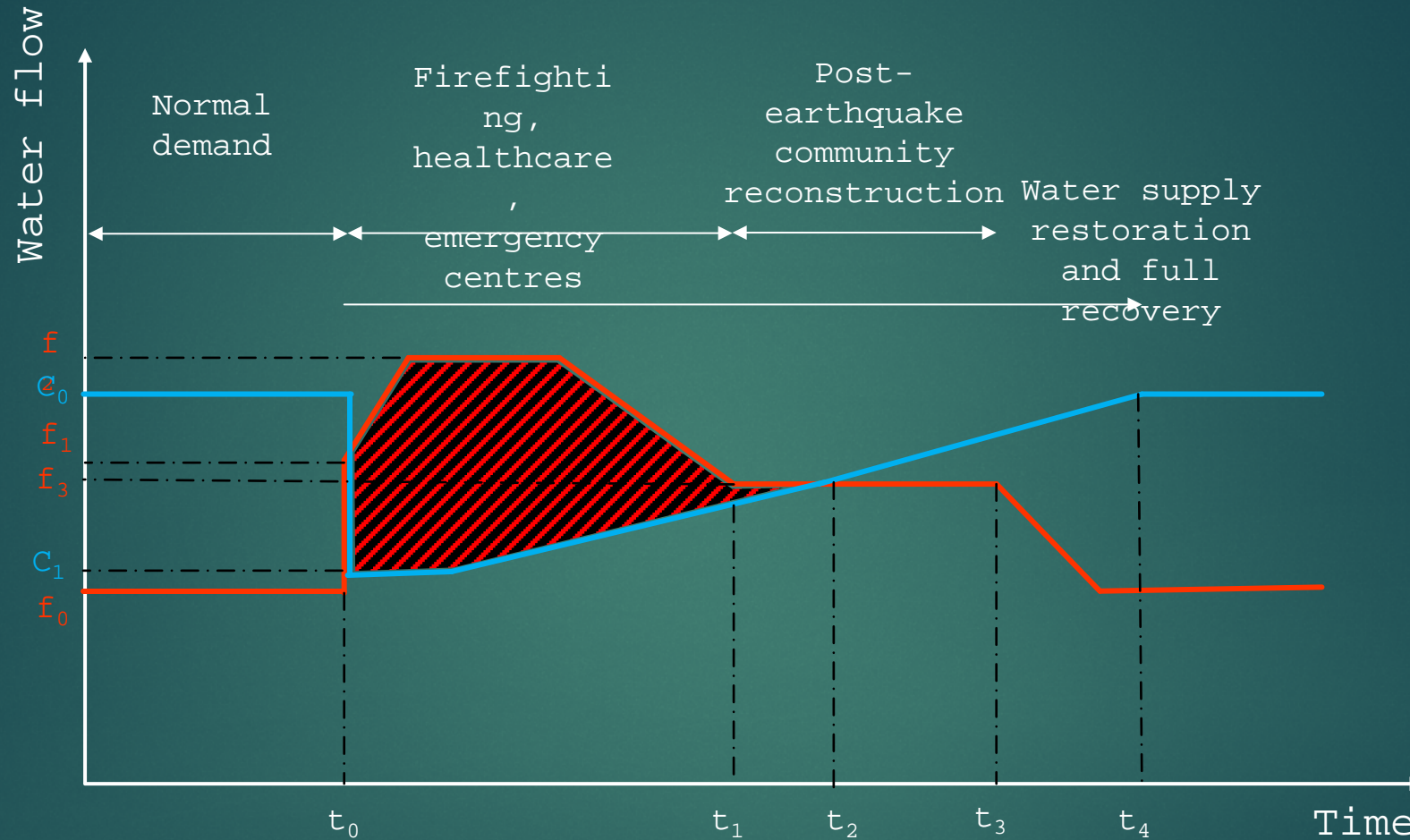
Water Demand Drivers (BAU)



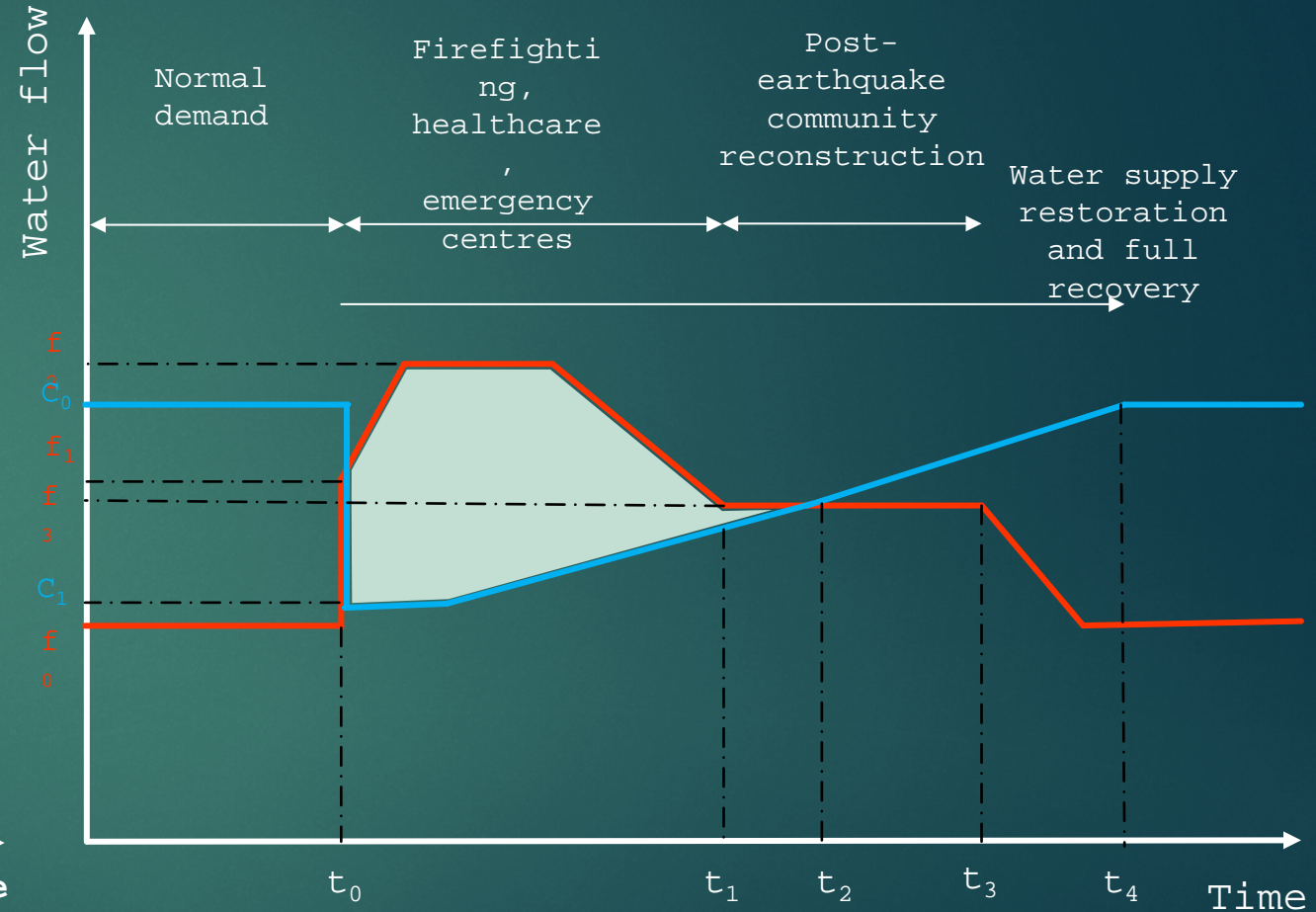
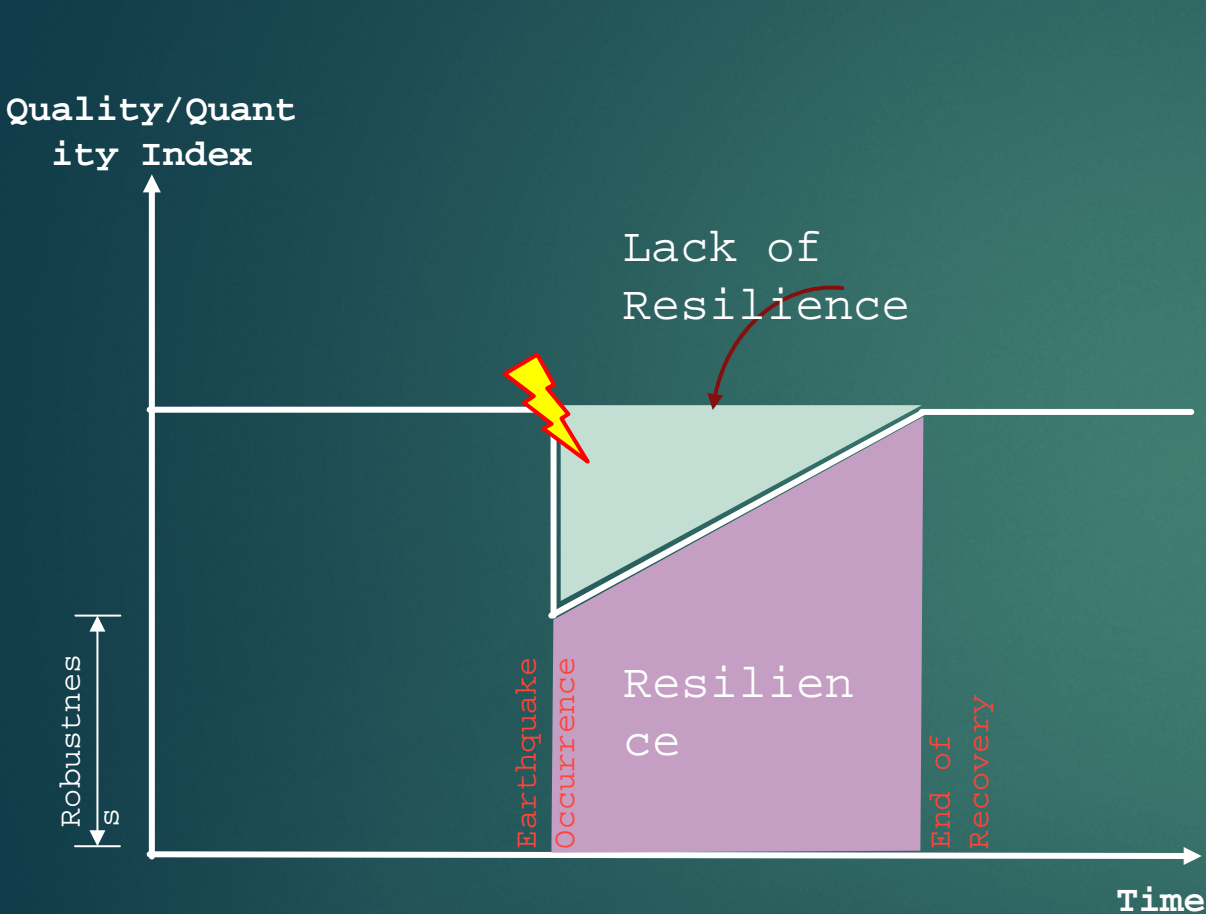
Water Demand Drivers (Emergency)

Purpose of LOS	Location, user supplied	Duration
Firefighting	Priority locations	▪
Emergency Response	Civil defence centres; Emergency operation centres; Ports, airports & other lifelines	2 days
Loss of life, emergency response – fire fighting	Relocation areas; Hospitals; Aged care centres; Prisons; Ports, airports & other lifelines; Civil defence centres; Emergency operation centres	3 days
Care of injured, elderly and others who cannot be moved	Hospitals	3 days
	Aged care centres Prisons	3 days
	Relocation centres	3 days
Drinking, cooking, basic hygiene	Within 500-1000m of households	3 days
	At household	▪
Community development, Education	Schools	▪
	Community meeting places, e.g. cafes, sports centres	▪
Governance	Central & government facilities	▪
Employment	Shopping, business and industrial areas	▪
Housekeeping	Households	▪

Demand-based Resilience



Comparison of Concepts



$$Resilience = \frac{\int_{t_0}^{t_4} C_t dt}{(t_4 - t_0) \cdot C_0}$$

$$Resilience = \begin{cases} \frac{\int_{t_0}^{t_2} C_t dt}{\int_{t_0}^{t_2} f_t dt} & \text{if capacity} < \text{demand} \\ 1 & \text{if capacity} \geq \text{demand} \end{cases}$$

Conclusion

- Water supply system is vulnerable to earthquake
- Some components are damaged more than the others
- Water demand should be considered as the main measurement tool
- The new water supply resilience measurement shows significance difference compared to the traditional one
- Demand-based resilience measurement is a more accurate tool to understand the current condition to enable us to plan for the enhancements.

