Variable Vulnerability

A comparative understanding of different socio-economic systems.
San Francisco bay region
‘Variable’ - not consistent or having a fixed pattern

‘Vulnerability’ - The quality or state of being exposed to possible hazard
Vulnerability is the degree to which a system is susceptible (or sensitive) to, and unable to cope with, adverse effects of climate change... (IPCC 2007)

"the vulnerability of any system (at any scale) is a function of the exposure and sensitivity of that system to hazardous conditions and the ability of the system to cope or recover from the effects of those conditions (Smit & Wandel 2006)"
Exposure + sensitivity + response
Urban resilience = dynamic of socio - ecological interaction

The basin of attraction depends on the tolerable range of the socio-economic state. In case A the range is lower compared to case B. (Liao, 2012).
High adaptive capacity = reduce exposure through higher threshold
Risk equation

\[
\text{Risk} = (\text{hazard probability} \times \text{exposure} \times \text{sensitivity} \times \text{response}) \times \text{adaptability}
\]

Understanding Risk in Urban Environment

The layers approach (Sijmonds, Feddes, & al., 2002)
Understanding Risk in the context of San Francisco Bay area
Historic growth

1900 c.a 1950 c.a 2016 c.a

1900 c.a
- Marsh lands
- Urban occupation

1950 c.a
- Exploited Marsh lands
- Urban occupation

2016 c.a
- Exploited Marsh lands
- Urban occupation

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Occupation

Current urban occupation

Restoration of marsh lands
Low income and high population density

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Urban Occupation

Large Green areas

Internal water bodies/Creeks

Bay waters

Sea Level rise inundation area (1.5m)

Existing salt marsh plains

Areas of high population density

Areas of Low income

Residential land use at risk of inundation

Industrial land use at risk

Commercial land use at risk

Critical infrastructure at risk

Important economic drivers of region (silicon valley)

Airports

Ports

Port related industries

County borders

Interstates and major roads
Urban assets

- Residential land use at risk of inundation
- Industrial land use at risk
- Commercial land use at risk
- Critical infrastructure at risk
- Important economic drivers of the region (silicon valley)
- Airports
- Ports
- Port-related industries

Macro scale vulnerability

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Urban Occupation

Large Green areas

Internal water bodies/Creeks

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Sea Level rise inundation area (1.5m)

Existing salt marsh plains

Areas of high population density

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Residential land use at risk of inundation

Industrial land use at risk

Commercial land use at risk

Critical infrastructure at risk

Important economic drivers of the region (silicon valley)

Airports

Ports

Port-related industries
Variable vulnerability

Martinez
*Economic value*

San Francisco
*High population density, dense built structure*

Oakland
*Low - income communities*

Alviso
*Land elevation*

East Palo Alto
*Low -income communities, population density*

Redwood City
*Population density*

Foster City
*Population density, economic value*
“What we choose to protect and how we pay for it may have a disproportionate impact on low-income neighbourhoods and communities of colour”

San Francisco Bay has a centralised mechanism of managing floods. Shoreline protection structures eliminate natural tidal processes and ecological exchange.
Problem statement

Risk

Flood risk modulation

Re-inventing to face climate change

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Research question

How to integrate flood risk modulation into a specific existing socio-economic development to enhance urban resilience towards climate uncertainties
Comparative study into two different system

Foster City
Avg population density: 15,623 p/sqmi
Avg income: $110,000

East Palo Alto
Avg income: $35,648 29% below US average
Methodology for research

3 step analysis - *defining the methodology*

2 Visions - *specific to the socio economic context*

1 design objective - *increase capacities to build resilience*
spatial structure and relation with bay
Growth towards Bay

- 1850 c.a
  - Gold Rush
  - Agriculture
  - Pre - industrialization
  - Post - Industrialization

- 1950 c.a
  - Post war - development

- 2010 c.a
  - Silicon valley

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<table>
<thead>
<tr>
<th>Social</th>
<th>Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture neighbourhood</td>
<td>Agriculture, salt ponds (mining)</td>
</tr>
<tr>
<td>- poultry Farmers</td>
<td></td>
</tr>
<tr>
<td>Runnymede Community (Farmers)</td>
<td>Light industries, Fertilizer waste industries</td>
</tr>
<tr>
<td>- Residents from nearby towns</td>
<td>- Green house farming</td>
</tr>
<tr>
<td>War veterans, Migrant com-</td>
<td>Commercial centers, Light industries</td>
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<tr>
<td>munities</td>
<td></td>
</tr>
<tr>
<td>Low - income migrant</td>
<td>IKEA - commercial center</td>
</tr>
<tr>
<td>population</td>
<td>Gateway 101 - commercial center</td>
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<tr>
<td>Runnymede farming community</td>
<td>Light industries, salvage yards</td>
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<tr>
<td>High - income communities,</td>
<td>Bio technology, Pharmaceutical companies,</td>
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<td>silicon valley employees</td>
<td>Silicon valley companies, Silicon valley</td>
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<tr>
<td></td>
<td>companies</td>
</tr>
<tr>
<td></td>
<td>Light industries</td>
</tr>
</tbody>
</table>

**East Palo Alto** - Has lost its economic resilience due to change in regional economy and demographic influence. - Urban sprawl

**Foster City** - New town with careful planning. Stable economy
Socioeconomic system to the concept of resilience

Defined by risk equation and understanding capacities

Flood risk from 3 directions
Socioeconomic system to the concept of resilience

- Bay waters
- Administrative boundary
- Inundation due to SLR of 1.5m
- Large open spaces
- City parks and open spaces
- Tidal flats
- Creeks
- Watershed boundaries
- Northern coastal salt marsh

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Level of risk modulation

100 year flood plain

500 year flood plain

East Palo Alto

Foster City
Risk in both cases due to SLR (1.5m)

Fig S.11: Risk Analysis in Foster City and East Palo Alto (maps by author)
Risk = [Hazard probability \times Exposure \times Sensitivity \times Response] \times Adaptability

<table>
<thead>
<tr>
<th>City</th>
<th>Hazard Probability</th>
<th>Exposure</th>
<th>Sensitivity</th>
<th>Response</th>
<th>Adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Palo Alto</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>High probability of flooding due to low level of protection. Fragmented risk protection</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foster City</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Low probability of flooding due to Robust protection measures</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Flood risk modulation + Socio-economic system + Urban system

Threshold capacity + Coping capacity + Recovery capacity

Adaptation

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Urban systems

Built space

Open space

Water infrastructure

Foster City

Mobility infrastructure

Levees and flood control

Subsurface
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Levee
Bay Waters
Urban drainage
ROAD INFRASTRUCTURE
BUILT SPACE
OPEN SPACE
FLOOD AND WATER INFRASTRUCTURE
SYNERGIES
Residents have the lowest level of access to public open spaces. Public open spaces usually include sports field and parking lots.

Fragmented Levee system does not provide enough protection for the residences. Lack of detention basins also may causes vulnerability due to pluvial and fluvial flooding.

Infrastructure does not support different types of mobility. Mainly designed for cars.

Low density with segregated typologies. Less diversity of typologies.
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Diversity of Typologies creates different living conditions and mixed programs. Good road infrastructure with access to different modes of mobility. Flood infrastructure and water system generates water sensitivity and robust protection, creating conditions for new water typologies and recreational synergies. Combination of shared public space and private spaces provides access to all types of communities.
Socio spatial structure

East Palo Alto

Foster City

Street character
Importance to public space and open water
Access to bay edge
Socio spatial culture

space defined by its society

Car oriented community
Walkability

Social structure

Demographic character
cultural landscape
To build on existing quality and identity

Comparison narrative - Understanding the differences in spatial quality
In terms of system evaluation - Foster City

Week ecological sensitivity but good livability aspect
In terms of system evaluation - East Palo Alto

Strong ecological sensitivity but weak flood protection and livability aspect.
Comparing values

Process of learning from each other

Designing for future uncertainties in both cases

Design narrative - Comparitive values + Historic identity + Adaptation design principles
**East Palo Alto**

Revitalize the past agriculture identity of East Palo Alto

**Foster City**

To induce natural processes by introducing more informal land-water gradients.
Operationalizing vision in the context of East Palo Alto

Area under high vulnerability

Important urban function and low income vulnerability
Vision - East Palo Alto

Legend
- Public open space
- Water storage infrastructure
- Vacant plots identified for infill development
- Urban agriculture land
- New infill development with water storage
- Urban nodes with shared facilities
- Riparian vegetation/brackish marsh
- Fresh water/brackish marsh
- Northern coastal Salt marsh
- Inundation due to 1.5 m of SLR
Urban Block scale transformation - East Palo Alto

Urban ‘In-fill development combined with agriculture economy and slow mobility

New urban infill that host several new functions

New streets with water management strategies integrated into them

Storage facilities in farms
Bio-swales on streets
New blocks integrated with water management
Urban Block scale transformation - Edge blocks

Vacant plots towards the edge integrated with wetland park and enhanced levee system.
New slow mobility connections
Operational sections - at the edge of the bay East Palo Alto

Utilizing potential of fresh water marsh and buffer to build recreation and spatial quality
Operationalizing vision in the context of Foster City

Utilizing natural elements to build resilience
Urban Block scale transformation - Edge blocks

Building a new levee network that enhances ecology and robust structures

- Cul-de-sac streets transformed into small retention ponds that adds new neighbourhood green and blue
- Lagoon structures that adds new quality to the existing housing block
- Breakwaters trap sediments that helps to build levee and encourages regrowth of marsh
- Regrowth of marshland also new cultural value and recreation towards its communities.
Urban block scale transformation - Lagoon

Naturalizing embankment of Lagoon, adding new water retention along open spaces at the edge.

Natural embankments add ecological quality and natural water filtration.

Water from inland urban areas can be detained in pond for filtration and let into the lagoon. These detention areas add increased capacity and allow natural process to occur.
Operational section - Foster City

Adding new destination to the edge with ecological functions.

- Existing development
- Lagoon
- New development
- Horizontal levee
- Wooden break waters
- Existing shoreline
- Existing street raised
- Wooden breakwater structure to trap sediments from wave action, this also enhances the growth of new salt marshes.
- Reused dredge material to build levee slope
- New building structures form part of the levee
- New public space

Scenario study

- Design scale - Foster City
Operational section - Foster City

Lagoon system builds diversity and ecological value
scenario study

Designing for uncertainty
WARM scenario

- City Council
- Community
- Farmers
- Vacant plot owners

Encourage collaboration empowering communities
Boost agriculture as primary economy and self sufficient communities
New housing developments with basic facilities

- City Council
- Community
- Farmers
- Vacant plot owners

Protection against flooding and environmental restoration becomes a key goal. Levee enhancement done incrementally based on available resources. Flood plain is restored with possible relocation.

Low impact development along edge, more space for water retention

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Possible outcome

Block transformation of inner city
City Council Community Farmers Vacant plot owners

To encourage establishment of small scale tech industries that generate employment as well as support agriculture economy. Controlling land development with strict policies to risk

Generate employment and self sufficiency, build upon water quality and livability

Build diverse robust typologies that provides new living qualities and facilities.

Build diverse robust typologies that provides new living qualities and facilities.

Generate employment and self sufficiency, build upon water quality and livability
Possible outcome
Block transformation along the edge with wetland park
STEAM scenario

- Initiate building of natural embankments and restore water quality through natural processes
- Improve water storage and living quality by embracing nature
- To boost self-sufficiency and re-use water for non-household purposes to reduce demand
- Integrate high-level protection and bring new quality to the edge
- To respond to new natural conditions by expediting process and development
- Build and facilitate new robust typologies with mixed use to accommodate future demand in housing and employment

City Council
Community
Private real estate
Silicon valley companies

City Council
Community
Private real estate
Silicon valley companies
Possible outcome

*Block transformation along the edge with new marsh land*
Possible outcome

Naturalizing embankments along Lagoon
Towards building a sustainable region system from cross learning
Thank you for listening