Floating Community

Designing a floating module for a resilient community in Manila, Philippines
Megatrends

The increasing frequency of climatic disasters, especially water related, coupled with the megatrend of urbanization, leads to a sense of urgency to offer long-term resilient solutions in the urban context.
Cycle of Vulnerability

1. Slums
2. No Means
3. No Rights
4. Disaster
5. Eviction
6. No Land

Diagram by author
To address the problem, the areas which are at **most risk** and which are the most populated should be examined.

Out of the top 10 countries on the WRI (World Risk Index), **HALF** are in the Southeast Asia region.

“In Asia, for example, more than 18 percent of the urban population lives in the Low Elevation Coastal Zone... “

“...around 3 million people in Manila live in areas threatened by flooding.... “

Quotes and risk locations according to World Risk Index (WRI) reports
World Risk Index (WRI) top 10:

<table>
<thead>
<tr>
<th>Country</th>
<th>% risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vanuatu</td>
<td>36.28</td>
</tr>
<tr>
<td>Tonga</td>
<td>29.33</td>
</tr>
<tr>
<td>Philippines</td>
<td>26.70</td>
</tr>
<tr>
<td>Guatemala</td>
<td>19.88</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>19.17</td>
</tr>
<tr>
<td>Solomon Islands</td>
<td>19.14</td>
</tr>
<tr>
<td>Brunei Darussalam</td>
<td>17.00</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>17.00</td>
</tr>
<tr>
<td>Cambodia</td>
<td>16.58</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>16.43</td>
</tr>
</tbody>
</table>

“[...] urbanization pressure leads to urban growth rates that exceed the capacity of government authorities to adequately develop and operate urban infrastructure e.g. for healthcare, flood protection, storm evacuation... “

World Risk Index Report 2014 - City as a Risk Area
Research process

How can sustainable interventions in **dense coastal vulnerable communities** help improve urban and environmental resilience?

Urbanization and climate risks → Urban communities → Research Question → Case Studies

- Manila, Philippines
- Dhaka, Bangladesh
- Phnom Penh, Cambodia

→ Defining resilience in urban context

→ Proposal Floating modular unit as alternative habitation → Framework for assessment
Informal housing inhabitants

Age: 28
Previous Occupation: Rice farmer
Current occupation: Rubbish collector
Highest education: none
Family size: 6
Housing location: Canal slum
House size: 22 m2
Shared with: 6
Running water: no
Toilet: no
Stove: no
Flooring: yes

Age: 23
Previous Occupation: Midwife
Current occupation: Food vendor
Highest education: secondary
Family size: 5
Housing location: Coast slum
House size: 14 m2
Shared with: 5
Running water: yes
Toilet: yes
Stove: no
Flooring: yes

Based on data from the Philippine Institute for Development Studies, Asian Development Bank 2000 and 2009 reports
Adaptive design for urban risk

RESILIENCE

Water Management
- Drainage
- Flooding
- Sea level
- Storage

Multifunctionality
- Mixed use
- Spatial stacking
- Biodiversity

Connectivity
- Transportation
- Linkage

Redundancy
- Risk spreading
- Safe-to-fail
- Modularity

Transferability
- Assessment
- Monitoring
- Experimentation
Assessment of Resilience

Water Management

Transferability

Redundancy

Connectivity

Multifunctionality
Manila, Philippines

ACTIONS
- 2011 declogging of 39,436 linear meters of waterways to improve flood drainage.
- Relocation project for informal settlers for a 5-year plan costing €1 billion. About 10% were relocated.
- Long term (until 2035) master plan of dams and river improvements at cost of €6.5 Billion.

Dhaka, Bangladesh

ACTIONS
- Failed “Action Plan” of 1990 to embank rivers in Bangladesh. Cost is €140 Billion.
- United Nations Development Programme’s Early Recovery Facility (ERF) innovation of dismantable housing units from wood and metal sheets for relocation during disaster and flooding. 200 units so far.
- ERF and UNDP program to raise housing above flood levels. 2,250 houses raised so far.

Phnom Penh, Cambodia

ACTIONS
No effective action has been implemented or properly organized to deal with flood-risk and climate change in the Phnom Penh urban context.
- Ineffective or partially successful drainage improvement projects by Japan International Cooperation Agency (JICA) since the early 2000’s totalling €300 million.
- Habitat For Humanity (HFH) conducted 600 house improvements since 2004.
“Urban Land that does not Flood”
Site Selection
One of the major metropolises in Southeast Asia, Manila has a water network which includes both coast and river, which offers opportunities to analyze and address the needs of vulnerable urban populations from multiple aspects and can inform future contexts.
Manila, Philippines

Avg. elevation - 16m
Metropolitan population 12,877,253
Density 42,000 / km² (1st)

Tropical region
High humidity

24 - 32 °C
Comfort temperature
10% too hot
3% too cold

July - October
5-10 storms / year
30% of rainfall

Typhoon Haiyan
November 2013
6,300 dead
2 Billion USD

Poor population
4 million
Approach to existing urban fabric

Rural populations in need of land arrive to the city in search of new economic opportunities.

They would benefit from a location only in the proximity of the existing city center.

Therefore the module is not created as a separate entity but new land in connection to the existing fabric.
Elements of the Design
Elements of Value

City scale
- Modularity
- Stability
- Storm Break
- Wave Height
- Module Size
- Tsunami
- Weight
- Cost
- Energy
- Monsoon
- # of People

Module scale
- Transport
- Education
- Health
- Energy
- Monsoon
- # of People

Family scale
- Food
- Materials
- Demographics
- Climate
How will it float?
If the structure is **more than twice the wavelength** in extent, its response will tend to zero.

- Seasteading engineering report (2011)
A platform with very high width to depth ratio will have a very large **metacentric height**, adding to its stability.
Modularity = Value

Multifunctionality

Risk-spreading

Efficiency
Functional stacking

- Pedestrian / Greenery
- Soil
- Utilities
- Water Storage
Decentralization of utilities

Centralized

Decentralized

Distributed
Volume to Surface ratio

Storage capacity
Material efficiency
Bouyancy

1.166 → 0.833 → 0.56
Community
Barangay
Administrative urban unit
> 2000 people

Human social unit
Dunbar’s number
~150 people

Density of Manila City
300 people / ~7000 m²

Area of stable module
6500 m²
General types of Modules

- Large public space
- Medium spaces
- Small spaces
- Dense housing
General types of Modules

- Large public space
- Medium spaces
- Small spaces
- Dense housing
Requirements for selection

- Number of Units
- Courtyard Access
- Public Space
- Water Collection
- Accessibility
- Quality of Views
Adaptation of Manila

<table>
<thead>
<tr>
<th>Number of Units</th>
<th>Courtyard Access</th>
<th>Public Space</th>
<th>Water Collection</th>
<th>Accessibility</th>
<th>Quality of Views</th>
<th>Score</th>
<th>Weight</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

- **Number of Units**: 1
- **Courtyard Access**: 1
- **Public Space**: 1
- **Water Collection**: 1
- **Accessibility**: 1
- **Quality of Views**: 1

**Score**: 5

**Weight**: 3

**Quality of Views**: 0

**Adaptation of Manila**: 2.583

**Quality of Views**: 1.667

**Water Collection**: 1.667

**Accessibility**: 1.667

**Public Space**: 2

**Courtyard Access**: 3

**Number of Units**: 5

**Score**: 2.25

**Weight**: 2
Evolutionary Variations
Size of prototype community

6500 m²

100 m

50 m
Infrastructure
Distribution of urban services

Schools

Hospitals
The average distance from slum to work is 2.5 km.

The intervention in Manila should therefore be kept at a close distance to shore, adapting to the local patterns.
Manila - W / m² / Day
~1800

Solar Panel Tilt (Avg.)
20 degrees from Horizontal

Typical Solar Panel
1.64 m² - 17% efficiency

Output / Day
~1 Kwh

<table>
<thead>
<tr>
<th></th>
<th>w/hour MIN</th>
<th>w/hour MAX</th>
<th>Hours / day</th>
<th>Kwh/day MIN</th>
<th>Kwh/day MAX</th>
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<tr>
<td>Ventilation Fan</td>
<td>10</td>
<td>25</td>
<td>6</td>
<td>0.06</td>
<td>0.15</td>
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<tr>
<td>Lightbulb</td>
<td>25</td>
<td>100</td>
<td>6</td>
<td>0.15</td>
<td>0.6</td>
</tr>
<tr>
<td>TV</td>
<td>80</td>
<td>400</td>
<td>6</td>
<td>0.48</td>
<td>2.4</td>
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<tr>
<td>Refrigerator</td>
<td>100</td>
<td>400</td>
<td>24</td>
<td>2.4</td>
<td>9.6</td>
</tr>
<tr>
<td>Electric Stove</td>
<td>1000</td>
<td>1500</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td><strong>4.09</strong></td>
<td><strong>14.25</strong></td>
</tr>
</tbody>
</table>
Power to the people

Roof area : 2508 m2
Families : 257
Solar panels : 1529
Kwh / Family : 5.95
Water from the sky

Storage
325m³ / Pod

Sectors

Pipes

Liter storage over time

<table>
<thead>
<tr>
<th></th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>...</th>
<th>...</th>
<th>June</th>
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<tbody>
<tr>
<td>1 Pod</td>
<td>23010</td>
<td>30810</td>
<td>26065</td>
<td>11830</td>
<td>...</td>
<td>...</td>
<td>18655</td>
</tr>
<tr>
<td>2 Pod</td>
<td>28020</td>
<td>71640</td>
<td>105770</td>
<td>111430</td>
<td></td>
<td></td>
<td>51930</td>
</tr>
</tbody>
</table>
Common Gardens

Grey Water

Black Water

Pipes

20cm Sand

40cm Gravel

Native Reed “Phragmites Karka”

Grey Water
How to make a “module”?
Employment
Local materials
Circular usage
## Choosing a material for modular pod

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight</th>
<th>Durability</th>
<th>Sustainability</th>
<th>Strength</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDPE (plastic)</td>
<td><img src="Green.png" alt="Green" /></td>
<td><img src="Green.png" alt="Good" /></td>
<td><img src="Green.png" alt="Good" /></td>
<td><img src="Green.png" alt="Good" /></td>
<td><img src="Green.png" alt="Good" /></td>
</tr>
<tr>
<td>Concrete</td>
<td><img src="Red.png" alt="Red" /></td>
<td><img src="Red.png" alt="Bad" /></td>
<td><img src="Red.png" alt="Bad" /></td>
<td><img src="Green.png" alt="Good" /></td>
<td><img src="Green.png" alt="Good" /></td>
</tr>
<tr>
<td>Wood</td>
<td><img src="Green.png" alt="Green" /></td>
<td><img src="Green.png" alt="Good" /></td>
<td><img src="Green.png" alt="Good" /></td>
<td><img src="Green.png" alt="Good" /></td>
<td><img src="Green.png" alt="Good" /></td>
</tr>
<tr>
<td>Steel</td>
<td><img src="Red.png" alt="Red" /></td>
<td><img src="Red.png" alt="Bad" /></td>
<td><img src="Red.png" alt="Bad" /></td>
<td><img src="Green.png" alt="Good" /></td>
<td><img src="Green.png" alt="Good" /></td>
</tr>
</tbody>
</table>

- **Green**: Good
- **Yellow**: OK
- **Red**: Bad

### Notes
- **Weight**:
  - HDPE is good
  - Concrete is bad
  - Wood and Steel are OK
- **Durability**:
  - HDPE and Wood are good
  - Concrete and Steel are bad
- **Sustainability**:
  - HDPE and Wood are good
  - Concrete and Steel are bad
- **Strength**:
  - HDPE, Wood, and Concrete are good
  - Steel is OK
- **Cost**:
  - HDPE and Wood are good
  - Concrete and Steel are OK
Pods and Caps

Street Pod
1% slope IN
Bouyancy chamber

Wetland Pod
Wetland soil
Rainwater tank
Septic tank

Family Pod
1% slope OUT
Bouyancy chamber
Multiple uses

- Low green
- Trees
- Trees + Street
- Public bathroom
- Socializing
- Water feature
- Small deck
- Large deck
Bouyancy chamber - Pod

1. 2cm HDPE panel
2. Water and waste service tunnel
3. Zigzag connection between panels
4. HDPE 2cm bolts
5. 2cm inner HDPE panel with reinforcing ribs
6. 2cm corner HDPE panel for rigidity - 1m cavity chamber
Pod layers

25cm thick reinforced concrete cap modules

50cm thick 2cm HDPE service modules

Center HDPE holding ring (optional)
Assembly package

X 8

X 82
Housing for the Urban Poor
Vernacular huts / Vernacular slums

- Coco Lumber
- Nipa Hut
- Nipa Palm
- Bamboo
- Wood Scraps
- Plastics
- Metal Sheet
- Slum
Lightweight
Cheap
Simple to maintain
Flexible
35 m² core

Kitchen

Shower

Solar Heating

Toilet
STRUCTURE

Living
Kitchen / Dining
WC
Sleeping
Living
Kitchen / Dining
WC
35 m² / floor
5-7 people
Prefab elements
Local materials
Prefab Columns & Bamboo Roof

1. 15cm bamboo beam
2. 10cm bamboo beam
3. 6cm bamboo purlin
4. 20x20cm reinforced concrete beam
5. 20 degree angle corrugated steel roof
6. Potential DIY hollow brick wall

Bamboo truss and purlins

Column section and hollow concrete brick

Column steel pin and roof connection
Bamboo truss and purlins

Column to Cap connection

1. 8mm holes for connections
2. Bent reinforcing bar for column

2cm thick top steel pin

Bottom insert column hole
Basic plan
Climate section

Section A-A

Section B-B

0 1 5m
INFILL
DIY extension
Appropriation and Improvement
Exploring other house typologies
Hexagonal options

- 27 m² with 2m between houses
- 38 m² with 0.8m between houses
- 38 m² with 1.7m between houses
- 38 m² with 0.7m between houses
Hexagonal floorplan

- Living
- Kitchen / Dining
- WC
- Sleeping

Scale: 0 to 5m
Hexagonal volume
Comparison of hexagonal and rectangular houses

<table>
<thead>
<tr>
<th>Feature</th>
<th>Hexagonal</th>
<th>Rectangular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor area</td>
<td>![Red Circle]</td>
<td>![Green Circle]</td>
</tr>
<tr>
<td>Structural complexity</td>
<td>![Green Circle]</td>
<td>![Red Circle]</td>
</tr>
<tr>
<td>Maintenance</td>
<td>![Green Circle]</td>
<td>![Red Circle]</td>
</tr>
<tr>
<td>Durability</td>
<td>![Green Circle]</td>
<td>![Red Circle]</td>
</tr>
<tr>
<td>Flexibility</td>
<td>![Red Circle]</td>
<td>![Green Circle]</td>
</tr>
<tr>
<td>Accessibility</td>
<td>![Green Circle]</td>
<td>![Red Circle]</td>
</tr>
<tr>
<td>Cost</td>
<td>![Green Circle]</td>
<td>![Red Circle]</td>
</tr>
<tr>
<td>Material use</td>
<td>![Red Circle]</td>
<td>![Green Circle]</td>
</tr>
<tr>
<td>Waterproofing</td>
<td>![Green Circle]</td>
<td>![Red Circle]</td>
</tr>
</tbody>
</table>
Collective informal
House extensions
Collective extensions
Street life
Components in Time

Base pod
30 years

Modular elements
10 years

Daily life
3 years
Life on the water
Relation with water
Biodiversity

Nutrient Exchange

Food source

Biodiverse zone

Dark zone
A  Couple with 4 children
   Home shop

B  3 generation home
   Fishermen

C  Young couple with relatives
   Street vendors

D  Young couple with children
   Scavenging trash

E  Young couple with children
   Construction worker
Types of movement
Transportation types
Street hierarchy
### Urban section

<table>
<thead>
<tr>
<th>Perimeter Street</th>
<th>House / Street</th>
<th>Canopy</th>
<th>House</th>
<th>Canopy</th>
<th>House</th>
<th>Canopy</th>
<th>House</th>
<th>Canopy</th>
<th>House / Street</th>
<th>Perimeter Street</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

0 —— 20 m
Urban Scenarios

Scenario 1 - Housing

Scenario 2 - Industry & Commerce

Scenario 3 - Housing & Commerce

Placement of the development in **proximity** to current habitation and economic activities creates an **extension of the city fabric**.
Urban Scenario
Year 3

10 communities
1000 pods

400 housing units
3000 inhabitants

65,000 m²

3 wavebreakers
45 IMTA units
Wave Breaker
A floating wave breaker which integrates nutrient remediation with economic opportunity could prove resilient on many scales.
Integrated multi-trophic aquaculture [IMTA]

Per m²:
- 3 kg of fish
- 5 kg of shellfish
- 3 kg of seaweed

“Bangus” Fish

Native Eucheuma or Kappaphycus Seaweed

Mussels / Shellfish

Nitrogen & Phosphorus

Nitrogen
Working at sea
IMTA

Milkfish Cages

Shellfish Nets

Seaweed Lines
Large scale defensive strategy
Connecting modules

A

B

A-B
Connecting modules

- Gap covers
- 1m gap

Flexible joint
- Socket
- 1m steel rod
Seabed anchoring - suction caissons
Development Sequence

1st Pod
Development Sequence

Attached Pods
Development Sequence
Complete Assembly
Development Sequence

Infill
APPENDIX
Utility schematic for House and Courtyard

F  Filter
OF  Tank Overflow
WT  Water Tank
P  Pump
S  Sink
SH  Solar Heater
SW  Shower
WC  Toilet
ST  Septic Tank
WL  Wetland
Safety measures

- Evacuation path [max 50 m]
- Hydrant and Ladder locations
## Pod weight calculations

<table>
<thead>
<tr>
<th>Material</th>
<th>m³</th>
<th>m³ × (Kg/m³)</th>
<th>Kg / 325 m³</th>
<th>% submerged</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDPE plastic</td>
<td>6.5</td>
<td>6240</td>
<td>19.20</td>
<td>1.92</td>
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<tr>
<td>Concrete</td>
<td>17</td>
<td>40800</td>
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<td>Seawater</td>
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<td>111000</td>
<td>341.54</td>
<td>34.15</td>
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<tr>
<td>Bamboo</td>
<td>0.25</td>
<td>125</td>
<td>0.38</td>
<td>0.04</td>
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<tr>
<td>Other</td>
<td>x</td>
<td>~5000</td>
<td>15.38</td>
<td>1.54</td>
</tr>
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</table>

Total: 163165 Kg / 325 m³ (50%)