Investigation of Systems that Mitigate Adverse Microclimate Effects on Urban Dwellers

Case Study of Central Harlem with Proposed Urban Design Solutions

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PRESENTED 4/07/2010  10-11 AM
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INTRODUCTION:

- Global ambient average temperatures are rising at a rate of 1 degree every 20 years.

- This global climate change is increasing the heat island affect.

- Urban dwellers are most affected by climatic changes at the micro level

- Mankind adapts their cities to adverse environmental change.
LITERATURE REVIEW:

- Street trees
- Green roofs
  1. Hanging Canopy Trussardi café
     Milano, IT
  2. Siam Paragon, (Atrium)
     Bangkok, TH
  3. Pacha, The Driver
     London, UK
- Green walls
  4. Diagram of food production and thermal mitigation

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LITERATURE REVIEW:

Street trees
• Provides shade to buildings, streets and lots,
• Provide natural services such as filter storm water, improving air quality, and noise abatement.
LITERATURE REVIEW:

1. Skyways and Sky bridges
   Minneapolis, MN

2. Underground mall, walkways, and PATH transit system
   Toronto, Canada

3. Enclosed malls
   Eaton Center
   Toronto, Canada

4. Dome: Tensile membrane
   Millennium Dome
   London, England
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LITERATURE REVIEW:

Galleria
Galleria Vittorio Emmanuel II
Milano, IT

Galleria Umberto
Italy

Arcade
Duke Street Arcade
Cardiff, Wales

STRUCTURES

Galleria Umberto

Arcade
Duke Street Arcade
Cardiff, Wales
LITERATURE REVIEW:

Awning
- Private Residence
- California

Canopy
- Fremont Street Experience
- Las Vegas, NV

Geodesic Domes
- Eden Project
- St Blazey, UK

Atrium
- Ford Foundation
- Manhattan, NY
PROPOSAL:

• Identify study area

• Identify mitigations system that enhance the existing urban design.

METHODOLOGY

Criteria: I identified an urban center that experienced adverse microclimates such as frost pockets, heat waves, and severe winter storms. The study area has a vulnerable population that cannot evacuate easily. The study area has a large percentage of impervious surface and thermal mass which are contributing factors to the heat island effect. The study area has poor air quality and other pollution problems related to the heat island effect. The area is an important transportation node and serves as a cultural and civic center.

I studied how humans interacted with each system by modeling the study area. Systems were eliminated from consideration that detracted from the human quality of the existing neighborhood.
PROPOSAL:

• Comparative analysis of the effectiveness of each system.

• Devised an implementation strategy

METHODOLOGY

Criteria: Using proven data I analyzed the effectiveness of each system to mitigate detrimental climatic effects. I compared the results of each system to determine which systems were most effective.

Analyzed combined systems to see if there was a gain in the effectiveness of multiple systems over the individual systems.

I created conceptual drawings and renderings to diagram how the systems functioned and illustrated how the proposed systems addressed the existing urban usage.

I found potential funding sources to pay for the systems and architectural interventions.

A replication strategy was devised.
FINDINGS:

DEFNIED STUDY AREA

• Criteria used to
FINDINGS:

Study area inventory

Buildings with historic and cultural significance
- Apollo Theater
- Hotel St Teresa (Columbia offices)
- Studio Museum in Harlem
- President Clinton’s Harlem office
- Harlem Center w/ AMC Magic Johnson Theater
- Sylvia’s (World famous soul food restaurant)
- Multi-modal collector for bus and subway systems.
FINDINGS:

Study Area attributes
• People
  • Density
  • Diversity
• Vendors
  • Licensed Street vendors
• Businesses
  • Retail sales
  • Harlem Center
• Civic services
  • Harlem Children’s Zone
  • Columbia University offices
  • Adam Clayton Powell state offices
**FINDINGS:**

Vulnerable populations in study area include:

- 15.5% of population is more than 65 years old
- 47.2% of the population is at or below poverty
- 27% of the population is obese and more than 53% of the population is overweight.
- 10-30% live in linguistically isolated households
- Only 11% of the population owns a personal vehicle.

**DEFINED THE STUDY AREA**
FINDINGS:

- Building stock is comprised primarily of buildings of 3 or more stories in height.
- The majority of the buildings are more than 50 years old.
- Most structures are masonry construction.
- Most roofs are made of asphalt with a butyl rubber underlayment.
- The majority of the land cover is impervious surfaces.
FINDINGS:

- The heat island effect causes Harlem to be 5–12 degrees warmer than the surrounding open land.
- There is a direct correlation between the air quality and the heat island effect.
- Non-point source pollution such as vehicles passing through the study area are the main contributors to poor air quality.

STUDY AREA POLLUTION

Asthma Case per 100,000 Population
FINDINGS:

Street trees:
- **Benefits**
  - Energy savings
  - Improve air quality
  - Increase property values
  - Manage storm water
  - Changes with the seasons
- **Detriments**
  - Damage sidewalks
  - Create hazards
  - Debris

![Tree Image]

LIVING SYSTEMS

**Tree Benefits Details (in 000s)**

<table>
<thead>
<tr>
<th>Borough</th>
<th>Energy</th>
<th>CO2</th>
<th>Air Quality</th>
<th>Stormwater</th>
<th>Property Values</th>
<th>Total</th>
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<tbody>
<tr>
<td>Bronx</td>
<td>$2,699</td>
<td>$73</td>
<td>$505</td>
<td>$3,300</td>
<td>$5,339</td>
<td>$11,916</td>
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<td>Brooklyn</td>
<td>$7,352</td>
<td>$195</td>
<td>$1,378</td>
<td>$9,409</td>
<td>$12,697</td>
<td>$31,031</td>
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<tr>
<td>Manhattan</td>
<td>$1,646</td>
<td>$42</td>
<td>$293</td>
<td>$1,804</td>
<td>$4,411</td>
<td>$8,196</td>
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<tr>
<td>Queens</td>
<td>$12,308</td>
<td>$342</td>
<td>$2,375</td>
<td>$16,238</td>
<td>$21,567</td>
<td>$52,830</td>
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<tr>
<td>Staten Island</td>
<td>$3,814</td>
<td>$103</td>
<td>$719</td>
<td>$4,877</td>
<td>$8,478</td>
<td>$17,991</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$27,818</strong></td>
<td><strong>$755</strong></td>
<td><strong>$5,270</strong></td>
<td><strong>$35,628</strong></td>
<td><strong>$52,492</strong></td>
<td><strong>$121,964</strong></td>
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</table>

![Tree Damage Table]

<table>
<thead>
<tr>
<th>Borough</th>
<th>Damaged Sidewalks</th>
<th>Canopy Debris</th>
<th>Choking Wires</th>
<th>Close Paving</th>
<th>Choking Grate</th>
<th>Tree Lights</th>
<th>Electric Outlet</th>
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<tbody>
<tr>
<td>Bronx</td>
<td>8,867</td>
<td>879</td>
<td>1,858</td>
<td>2,232</td>
<td>270</td>
<td>203</td>
<td>353</td>
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<tr>
<td>Brooklyn</td>
<td>28,424</td>
<td>2,625</td>
<td>3,632</td>
<td>17,436</td>
<td>1,070</td>
<td>554</td>
<td>172</td>
</tr>
<tr>
<td>Manhattan</td>
<td>2,984</td>
<td>1,451</td>
<td>772</td>
<td>1,373</td>
<td>1,193</td>
<td>771</td>
<td>929</td>
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<tr>
<td>Queens</td>
<td>49,245</td>
<td>2,034</td>
<td>6,161</td>
<td>18,258</td>
<td>813</td>
<td>702</td>
<td>324</td>
</tr>
<tr>
<td>Staten Island</td>
<td>11,309</td>
<td>352</td>
<td>1,442</td>
<td>4,110</td>
<td>572</td>
<td>296</td>
<td>97</td>
</tr>
<tr>
<td><strong>Citywide Total</strong></td>
<td><strong>100,829</strong></td>
<td><strong>7,341</strong></td>
<td><strong>13,865</strong></td>
<td><strong>43,409</strong></td>
<td><strong>3,918</strong></td>
<td><strong>2,526</strong></td>
<td><strong>1,875</strong></td>
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FINDINGS:

- The tree heights and girths will never be sufficient to fully shade the street and buildings.

- Commercial constraints restricted trees' spacing.

**LIVING SYSTEMS**

**Condition.** Just over 90% of the trees were rated in good to excellent condition.

- Excellent: 23.9%
- Dead: 1.4%
- Poor: 8.3%
- Good: 66.4%

**Size.** Census takers measured the girth of each tree at chest height. One-quarter of all street trees citywide are small, with Manhattan having the highest percentage of small trees (35%). Five percent of trees are extra large (over 30 inches wide), with Queens having the highest percentage of extra large trees (6.3%).

- Small (0-6 in): 25%
- Medium (6-18 in): 50%
- Large (18-30 in): 20%
- X-large (30+ in): 5%

Most (70%) of the City’s largest street trees are comprised of just three species: London planetree, pin oak, and silver maple. By contrast, there is much greater species diversity in the small tree population (14 species in the first 70%).
FINDINGS:

- Green roofs and walls reduce temperatures as much as 90 °F, surfaces measured as high as 180 °F.

- Green roofs reduce the energy consumption of a buildings by 5.4%. Green walls reduce the energy by 4.2%.
FINDINGS:

- Living system provide natural services such as filtering the air and reducing humidity by 30%.
- Living systems can produce as much as 12,000 pounds of food per vertical acre.
FINDINGS:

STREET CANOPY

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FINDINGS:

- The effective range of the shaded area in the summer at midday is 60-95%.
- Thermal sensitive glass reduces the solar heat gain by 20%.
- External louvers can achieve an effective reflection of the solar energy of 95%.
- Daylight controlled by louver systems.
- Street canopies properly manage the solar heat gain across all seasons.

STREET CANOPY

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FINDINGS:

ATRIUM STRATEGY

1.
FINDINGS:

Natural Ventilation
- Heat sinks in the atrium roof are used to drive the ventilation system.
- Cool air is drawn in from underneath the plaza and circulates the air reducing humidity

Thermal controlled louvers
- The louvers open to allow indirect

ATRIUM STRATEGY

ATRIUM SCHEMATIC
1: HEAT SINK - Removes heat generated inside building and powers natural ventilation system.
2: REFLECTED SOLAR ENERGY - Adjustable louvers allow management of solar energy.
3: LIVING SYSTEM - A: Vertical Garden B: Indoor Orchard
4: SAFETY ZONE - A place to gather during severe weather events and power outages.
5: CISTERNS - A: Collects storm water and greywater from the building. B: Radiant heat exchange system.
6: SHADED SIDE - Natural convection heat exchange as air passes through a moistened filtration fabric.
FINDINGS:

- Interior space of the atrium is designed to provide an oasis from inclement weather.

- People can meet in this space with lush plants and ample seating.

- The living system could be used for food production with the south, east and west facing surface of the building serving as vertical garden space.

- The atrium properly constructed would serve as a refuge during heat waves and as a disaster response center during severe storms and acts of terror.
FINDINGS:

COMBINED STRATEGY

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FINDINGS:

- The synergy gained in a combined system is due to the effective coverage area.
- The thermal mass blocked by a combined system ranges from 65 to 90% of the total exposed surfaces.
- The effectiveness depends upon the systems and materials chosen and the ability of the system to adjust to seasonal changes.
<table>
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<th>IMPLEMENTATION:</th>
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<tr>
<td>• Green roofs tax credits</td>
</tr>
<tr>
<td>• Disaster mitigation and technical assistance grants</td>
</tr>
<tr>
<td>• Federal and State Department of Transportation: corridor and transit funding</td>
</tr>
<tr>
<td>• New York City Historical Preservation Grants</td>
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<td>• Magic Johnson Enterprises has actively funded projects in Harlem including the Harlem Center.</td>
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<table>
<thead>
<tr>
<th>FUNDING</th>
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<tr>
<td>In New York City, the average green roof costs around $18-$20 per square foot installed. <strong>New York City green roof installations can receive a tax credit of $4.50 per square foot of green roof area</strong>. Building owners can receive a one-year property tax credit of up to $100,000. Building owners are able to apply for the credit starting Jan. 1, 2009. This is a pilot program that will expire after March 15, 2013, unless it is extended.</td>
</tr>
<tr>
<td>Disaster mitigation funding can pay for the design and construction of disaster relief centers. Atriums may qualify for this funding if they meet the design guidelines and management criteria.</td>
</tr>
<tr>
<td>Historical Preservation Grants are available for funding façade protection up to $15,000 dollars</td>
</tr>
</tbody>
</table>
IMPLEMENTATION:

- Identify area for replication based upon criteria used in this study
- Inventory assets
- Determine which mitigation strategies are best suited for the replication area.
- Observe how people use the space and determine how the replication strategy will enhance their usage.
- Maintain the contextual elements and cultural assets of the replication area.
CONCLUSION:

- Choosing systems that can mitigate the adverse effects of microclimate can enhance the quality of life without detriment to the character of the community.

- Mitigation systems can reduce the energy consumption of the built environment and increase the life cycle of those structures.

- Mitigation system can provide shelter and comfort during severe weather and catastrophic events.