Climate change mitigation and adaptation in urban areas: towards a research agenda

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November 18, 2015
Outline

• Urban Planning—key for both mitigation and adaptation
• Major urban planning strategies in mitigation and associated research needs
• Major urban planning strategies in adaptation and associated research needs
• Need for integrated strategies
• Research Needs related to the Urban Planning Process
  – Downscaled modeling
  – Vulnerability/Resilience assessments
  – Evaluation/Appraisal needs
  – Implementation Aspects
    • Legal
    • Institutional
    • Financial
• Conclusion
Key role of urban planning

Human population increasingly urban

Today 54 per cent of the world’s population lives in urban areas, and by 2050 urban populations are projected to 66 per cent (World Population Prospects, UNDESA 2014)

Until the 5th assessment, IPCC reports emissions by sector, not urban areas

Most sectors located in urban areas. 5th Assessment estimates that urban areas emit from 53-87% of carbon emissions.

Focus on urban areas essential

To mitigate GHGs

Urban areas heavily impacted by climate change, where adaptation efforts must focus

Through Urban Planning (UP) communities determine:

Land use, densities, character of built environment, parks and open space, public infrastructure and facilities

Through Urban Management, communities:

Administer public services and regulate and provide incentives for private infrastructure providers and land markets
## Research needs on climate change mitigation

<table>
<thead>
<tr>
<th>Sector</th>
<th>Major urban planning strategies</th>
<th>Research Needs</th>
</tr>
</thead>
</table>
| Energy   | Reducing GHGs through the use of renewables  
Zoning codes can ensure access to solar and wind energy, and facilitate district heating  
Higher Densities can reduce building heating requirements and make transit more viable | How does ensuring solar access affect the urban form of cities?  
What are the trade-offs between ZNE-oriented development and more travel efficient development?  
How does a community prepare a solar access regulation? |
| Transport | UP can ensure densities for efficient transport, reducing use of energy  
Regulate streetscape to facilitate non-motorized travel, reducing use of energy  
Mix of uses to reduce motorized travel, reducing use of energy | What are the obstacles to implementing smart growth or growth management?  
Are other models needed? |
| Buildings | Building codes can require green building features to reduce energy use                       | Differential costs of new buildings codes, who bears burden, and implications for affordable housing; implications for health |
| Industry | Performance standards for industrial uses, reducing energy use  
Location of industries                                                                 | How to deal with loss of property rights in rural areas due to limits? |
Example

• California’s goals on ZNE buildings:
  – By 2020, all new buildings
  – By 2030, all new commercial buildings

• With available PV technology, low density development can achieve ZNE while higher density can only achieve a certain percentage
  – It provides an incentive for low-density development
  – Is this a good policy overall?

• Is this a temporary problem for higher density buildings that will be solved by PV transparent glass?

• If so, is such a policy a good one if it creates a generation of low density development that can last for 40+ years?
## Research needs on climate change adaptation

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Major urban planning strategies</th>
<th>Research Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warming temperatures impact on the heat island effect</td>
<td>UP can regulate the streetscape, parkland and open space in urban areas to reduce the heat island effect. UP can change the building codes to regulate construction/materials to enhance cooling. UP can require mixed use zones to reduce travel.</td>
<td>On strategies to increase vegetation in already developed urban areas for maximum effect on the heat island effect, e.g., configuration of urban green spaces. Cost impacts on new construction and effects on affordable housing. What are the right scales for sustainable neighborhood centers given the trends in large-scale or online retailing?</td>
</tr>
<tr>
<td>Warming temperatures impact on fire-prone areas</td>
<td>UP can designate fire hazard zones, limit development in such areas, and change building code for more fire-resistant buildings.</td>
<td>Strategies to address the limitations on property rights. How effective are materials and techniques to make buildings more fire-resistant?</td>
</tr>
<tr>
<td>Warming effect on drought</td>
<td>UP can regulate landscape to conserve water.</td>
<td>What are the trade-offs between the need to increase vegetation to reduce the heat island effect and reduce landscape water consumption in areas subject to increasing drought?</td>
</tr>
</tbody>
</table>
Beyond the urban heat island effect, will some urban areas be habitable by end of century?

Paul and Eltahir article in Nature Climate Change (Oct. 2015): “Future temperatures in southwest Asia projected to exceed a threshold for human adaptability”

Combination of high temperatures on land and proximity to high humidity from warm bodies of water
## Role of urban planning in climate change adaptation

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Major urban planning strategies</th>
<th>Research Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation changes</td>
<td>Can restrict development in flood zones, areas subject to landslides</td>
<td>Institutional requirements for effective policies; distributional effects</td>
</tr>
<tr>
<td>Sea level rise in coastal areas</td>
<td>UP can restrict development in coastal areas; change building codes to reduce impact, e.g., elevating buildings, construction material</td>
<td>Strategies to address the property loss to owners of land in areas compromised by sea level rise? What are the differential costs of changes and building codes, and their impact on affordable housing?</td>
</tr>
<tr>
<td>Extreme events</td>
<td>UP can change building codes to withstand higher winds, greater loads UP can change infrastructure requirements for new development, e.g. increase drainage infrastructure requirements, undergrounding of utilities</td>
<td>Are models of such codes available, what are the differential costs to developers and who will bear the burden? What are the differential costs and who will bear the burden?</td>
</tr>
<tr>
<td>On existing areas subject to extreme events or coastal areas where defense measures not feasible</td>
<td>UP can develop plans for abandonment, deconstruction, and new settlements. Can play a vital role in identifying more suitable areas and plan new towns or resettlement into existing urban areas</td>
<td>Strategies to address community-wide loss of land property, deconstruction of whole settlements, and development of new towns resilient to climate change; also whether shrinking cities can be used to resettle populations displaced by climate change impacts.</td>
</tr>
</tbody>
</table>
Need for Integrated Strategies and Associated Research

Integration of adaptation and mitigation planning with several types of environmental planning already in place:

- Natural hazards mitigation planning
- Coastal areas environmental regulations
- Floodplain and watershed management
- Air pollution mitigation

Integration with sustainable development

- Mitigation efforts could be highly compatible with sustainable development
- Adaptation to impacts may adversely effect progress on sustainable development

Ensure compatible mitigation and adaptation strategies

Focus on linkages:

- Land use-transport-emissions; water-energy-emissions; land use-water, etc.
EXAMPLE: DISTRIBUTIONAL IMPACTS OF MITIGATION AND ADAPTATION EFFORTS
Cap and Trade and Land Use

• Cap and Trade: performance vs. prescriptive policy
  – Part of the policy allows companies (typically largest and most polluting companies) to decide the timing of full compliance through trades
  – Polluting companies pollute at three scales:
    • Global and two local scales
      – There are two local scales:
        » Metropolitan airsheds—ground level pollution
        » Local neighborhoods—most impacted by ground level pollution, and other environmental impacts
  – Cap and Trade aims at reducing CO2e pollutants at global scale
How California's cap-and-trade will work

Rather than having a strict government mandate, like a carbon tax, to reduce pollution, a cap-and-trade system uses market mechanisms to reward companies that figure out ways to reduce pollution below the level the government sets. California's cap-and-trade rules, which will affect oil refineries, power plants and large factories, take effect Jan. 1.

1. Starting in 2013, a statewide cap on greenhouse gases will be put in place. Through 2020, it will drop each year by 2 to 3 percent.

Source: Mercury News reporting

2. Industries must obtain a permit, known as an "allowance," for every ton of carbon dioxide and other greenhouse gases they emit.

3. As the cap goes down, companies must decide each year how they will get enough allowances to cover their emissions. Their choices: Operate more efficiently, burn less fossil fuel, or buy allowances from another company.

CO2e Sources and their Scales of Pollution

• Global and Local
  – Two scales of local pollution
    • Metropolitan airsheds and neighborhood-scale

• Pollution in metro airsheds motivated CA’s climate change policies
  – Also motivating China’s climate change policies especially in the transportation sector—win-win strategy

• Neighborhood-scale—cap and trade is a win-lose strategy unless the neighborhood effects are addressed
How California Learned about Neighborhood-scale Effects

• Neighborhood-scale activists (EJ community) sued the state and delayed cap and trade implementation
  – Association of Irritated Residents v. California Air Resources Board (May 2011)
    • Claimed AB32’s cap-and-trade system would result in substantial adverse effect on minority populations since facilities regulated primarily located in communities of color/low income (hot spots)
    • Presented statistical evidence that such populations are more likely to live within 6 miles of a cap and trade facility regulated under AB 32
    • Such populations would not see benefits and possibly experience an increase in health and environmental effects
  – Court ruled that CARB failed to conduct an adequate analysis of alternatives to cap-and-trade
  – CARB approved an revised analysis of alternatives in August 2011
  – Court accepted new analysis and found cap and trade permissible under AB 32
• But implementation delayed until 2013
Policy Impacts

• A portion of cap and trade proceeds funding dedicated to low-income communities
    • 25% of GGRF to be allocated to programs that benefit disadvantaged communities and 10% to programs located in such communities directly

• Consideration of the neighborhood effects of projects/policies on low-income vulnerable communities through state-wide environmental justice tool, CalEnviro-Screen, administered by Cal EPA
Other California Bills (2014) specify allocations of GGRF

- Identifies revenue made available by cap-and-trade auctions for Fiscal Year 2014-2015
- Four programs to receive set appropriations into the future:
  - High Speed Rail (25%)
  - Transit and Intercity Rail Capital Program (10%)
  - Low Carbon Transit Operations Program (5%)
  - Affordable Housing and Sustainable Communities Program (20%)
### Greenhouse Gas Reduction Fund Programs

<table>
<thead>
<tr>
<th>Appropriations</th>
<th>Potential Projects Identified by Implementing Agencies</th>
<th>2013-14 (M)</th>
<th>2014-15 (M)</th>
<th>2015-16 (%)</th>
<th>% of 2014-15 Funds Benefitting Disadvantaged Communities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Speed Rail (HSRA)</strong></td>
<td>Planning/Design</td>
<td></td>
<td>$39</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Right-of-way acquisition of Initial Operating Segment</td>
<td></td>
<td>$191</td>
<td>25%</td>
<td>0-25%</td>
</tr>
<tr>
<td></td>
<td>Construction of Initial Operating Segment</td>
<td></td>
<td></td>
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<tr>
<td><strong>Transit and Intercity Rail Capital Program (CalSTA)</strong></td>
<td>Connectivity to existing/future rail systems by adding new rail cars/engines</td>
<td></td>
<td>$25</td>
<td>10%</td>
<td>25% (in statute)</td>
</tr>
<tr>
<td></td>
<td>Increase service and reliability of intercity and commuter rail systems</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Encourage multi-modal transit via integrated ticketing / scheduling</td>
<td></td>
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<td></td>
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<tr>
<td><strong>Low Carbon Transit Operations Program (Caltrans to local agencies)</strong></td>
<td>New/expanded bus or rail services or expanded intermodal transit facilities</td>
<td>$25</td>
<td></td>
<td>5%</td>
<td>50% (in statute)</td>
</tr>
<tr>
<td></td>
<td>Service or facility improvements, e.g. equipment, fueling, and maintenance</td>
<td></td>
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<tr>
<td><strong>Affordable Housing and Sustainable Communities (SGC and member agencies)</strong></td>
<td>Intermodal affordable housing</td>
<td></td>
<td></td>
<td></td>
<td>50% (in statute)</td>
</tr>
<tr>
<td></td>
<td>Transit capital projects</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td>Active transportation/complete streets</td>
<td></td>
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<tr>
<td></td>
<td>Transit-oriented development</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Agricultural land preservation</td>
<td></td>
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<tr>
<td></td>
<td>Local planning and implementation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low Carbon Transportation (ARB)</strong></td>
<td>Passenger ZEV rebates</td>
<td></td>
<td></td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Heavy duty hybrid/ZEV trucks and buses</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Freight demonstration projects</td>
<td>$30</td>
<td>$200</td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Pilot programs (car sharing, financing, etc.) in disadvantaged communities</td>
<td></td>
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</tr>
</tbody>
</table>
CalEnviroScreen

Pollution Burden

- Ozone concentrations
- PM2.5 concentrations
- Diesel PM emissions
- Pesticide use
- Drinking water contaminants
- Toxic releases from facilities
- Traffic density
- Cleanup sites (½)
- Groundwater threats (½)
- Hazardous waste (½)
- Impaired water bodies (½)
- Solid waste sites and facilities (½)

Population Characteristics

- Children and elderly
- Low birth-weight births
- Asthma emergency department visits
- Educational attainment
- Linguistic isolation
- Poverty
- Unemployment

CalEnviroScreen Score

EXAMPLE CENSUS TRACT: INDICATOR RESULTS AND CALENIROSCREEN SCORE

One example census tract in San Bernardino was selected to illustrate how an overall CalEnviroScreen score is calculated using the California Communities Environmental Health Screening Tool. Shown below are:

- An area map for the census tract and surrounding tracts.
- Tables for the indicators of Pollution Burden and Population Characteristics with percentile scores for each of the indicators.
- A table showing how a CalEnviroScreen score was calculated for the example area, using CalEnviroScreen 2.0.

Source: California EPA and Office of Environmental Health Hazard Assessment, Oct. 2014, p. 14
### Exposure Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Ozone (conc.)</th>
<th>PM2.5 (conc.)</th>
<th>DieselPM (emissions)</th>
<th>Pesticide Use (lbs/sq. mi.)</th>
<th>Toxic Releases (RSEI toxicity-weighted releases)</th>
<th>Traffic (density)</th>
<th>Drinking Water (index)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Value</td>
<td>0.79</td>
<td>12.31</td>
<td>23.35</td>
<td>0</td>
<td>851.4</td>
<td>1484.8</td>
<td>533.17</td>
</tr>
<tr>
<td>Percentile</td>
<td>98.47</td>
<td>74.24</td>
<td>71.47</td>
<td>0</td>
<td>63.31</td>
<td>73.41</td>
<td>83.86</td>
</tr>
</tbody>
</table>

### Environmental Effects Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Cleanup Sites (weighted sites)</th>
<th>Groundwater Threats (weighted sites)</th>
<th>Hazardous Waste Facilities/Generators (weighted sites)</th>
<th>Impaired Water Bodies (number of pollutants)</th>
<th>Solid Waste Sites/Facilities (weighted sites and facilities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Value</td>
<td>21.3</td>
<td>5.75</td>
<td>0.73</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Percentile</td>
<td>84.44</td>
<td>24.74</td>
<td>82.19</td>
<td>15.12</td>
<td>0</td>
</tr>
</tbody>
</table>

### Sensitive Population Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Children (&lt;10) and Elderly (&gt;65) (percent)</th>
<th>Asthma (rate per 10,000)</th>
<th>Low Birth Weight (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Value</td>
<td>25.9</td>
<td>104.45</td>
<td>0.05</td>
</tr>
<tr>
<td>Percentile</td>
<td>62.88</td>
<td>97.13</td>
<td>36.24</td>
</tr>
</tbody>
</table>

### Socioeconomic Factor Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Educational Attainment (percent)</th>
<th>Linguistic Isolation (percent)</th>
<th>Poverty (percent)</th>
<th>Unemployment (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Value</td>
<td>54</td>
<td>26.1</td>
<td>70.5</td>
<td>19.84</td>
</tr>
<tr>
<td>Percentile</td>
<td>95.05</td>
<td>89.35</td>
<td>94.39</td>
<td>92.90</td>
</tr>
</tbody>
</table>

Source: California EPA and Office of Environmental Health Hazard Assessment, Oct. 2014, p. 15
# Calculation of CalEnviroScreen Score for Tract 6071004900

<table>
<thead>
<tr>
<th>Indicator Percentiles</th>
<th>Pollution Burden</th>
<th>Population Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposures (7 indicators)</td>
<td>Environmental Effects (5 indicators)</td>
<td>Sensitive Populations (3 indicators)</td>
</tr>
<tr>
<td>98.47</td>
<td>+ (0.5 × 84.44)</td>
<td>62.88</td>
</tr>
<tr>
<td>+ 74.24</td>
<td>+ (0.5 × 24.74)</td>
<td>+ 97.13</td>
</tr>
<tr>
<td>+ 71.47</td>
<td>+ (0.5 × 82.19)</td>
<td>+ 36.24</td>
</tr>
<tr>
<td>+ 0.0</td>
<td>+ (0.5 × 15.12)</td>
<td></td>
</tr>
<tr>
<td>+ 63.31</td>
<td>+ (0.5 × 0.0)</td>
<td></td>
</tr>
<tr>
<td>+ 73.41</td>
<td></td>
<td></td>
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<tr>
<td>+ 83.86</td>
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</tr>
</tbody>
</table>

Average Percentile

\[
\frac{568 \div (7 + (0.5 \times 5))}{59.79} = 567.94 \div 7 = 81.13
\]

Scaled Component Scores (Range 0 – 10)

\[(59.79 \div 82.49) \times 10 = 7.25 \quad (81.13 \div 96.22) \times 10 = 8.43\]

CalEnviroScreen Score

\[7.25 \times 8.43 = 61.12\]

(61.12 is in the top 5% of CalEnviroScreen census tracts statewide)

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* Indicators from the Environmental Effects component were given half the weight of the indicators from the Exposures component.

* The tract with the highest average percentile for Pollution Burden in the state had a value of 82.49.

* The tract with the highest average percentile for Population Characteristics in the state had a value of 96.22.

Source: California EPA and Office of Environmental Health Hazard Assessment, Oct. 2014, p. 16
Spatial Scale/Social Impact

Issues

• Efforts to reduce GHG emissions and air pollution by reducing vehicle travel and emissions are closely aligned in urban areas
  – Acting on one, affects the other
  – Actions today not just altruistic focusing on the far future
  – Can improve regional current conditions and our near future
  – In addition to the co-benefits of more vibrant urban places

• Sustainable communities strategies rare case of triple win strategies

• Cap and trade programs, on the other hand, because the scale of pollution impacts may differ, may not be closely aligned
  – Acting on the global scale may not bring regional airshed improvements or neighborhood scale improvements in pollution
  – Could result in win-lose strategies, if issues not addressed
<table>
<thead>
<tr>
<th>Planning Process Stages</th>
<th>Research Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning Analysis</td>
<td>Downscaling global and large-scale modeling to the regional/local scale to establish likely impacts at urban scale</td>
</tr>
<tr>
<td></td>
<td>New modes of conducting vulnerability assessments under conditions of uncertainty when traditional risk analysis not appropriate</td>
</tr>
<tr>
<td>Generating Alternative Options</td>
<td>See above</td>
</tr>
<tr>
<td>Assessment /Appraisal of Alternative Strategies</td>
<td>Appropriate appraisal methods for adaptation strategies under conditions of uncertainty, intergenerational costs and benefits, and intangibles, that take into account distributional impacts of strategies</td>
</tr>
<tr>
<td>Adoption of Plans</td>
<td>Techniques for public education and engagement, and political leadership on issues to ensure public support and decision making</td>
</tr>
<tr>
<td>Implementation</td>
<td>On institutional, legal and financial barriers</td>
</tr>
<tr>
<td>Evaluation of plans/Monitoring</td>
<td>Identifying and evaluating indicators. How costly are they to track and what institutional changes are needed for ongoing monitoring?</td>
</tr>
</tbody>
</table>
Research Needs on Implementation Issues

Institutional Issues

Property rights and public powers—
Property rights regimes are likely to influence the ability of governments to act on adaptation plans

Market conditions and how they interact with UP—
weak property markets, slow UP-initiated changes, less public leverage on private development

Spatial/political mismatch—
fragmentation within metropolitan areas makes some of these policies difficult to implement

Fragmentation within local governments, between urban planning and multiple urban management agencies,
makes for uncoordinated and at times conflicting purposes

Degree of coordination and support among national, provincial and local governments—
extent will influence the effectiveness of some policies

Temporal aspects of UP
UP aimed at future development, and full consequences of policy change may take two or more decades
Research Needs on Financing Climate Change Adaptation

• In the US, the financing options for adaptation to climate change are not sufficient and many barriers to develop the infrastructure and technology needed to ensure:
  – e.g., adequate water resources for California in the face of decreasing supplies
• If it’s problematic for California and the U.S., even if COP 21 generates commitments from most countries for global climate funds, it will be more problematic for lower income countries to finance needed changes.

• Are there innovative ways of financing infrastructures and changes needed for climate change adaptation?
Conclusion

• Urban areas key emitters of GHGs and will bear major burden of climate change impacts
• Little focus on urban areas in climate change research community until recently
• UP is a vital instrumentality for achieving GHG reductions in most sectors, and for adapting to climate change impacts
• In adaptation discussions, much focus on strategies, but little understood institutional issues are major barriers to fully utilize UP to both mitigate and adapt to climate change