



RICE UNIVERSITY  
**Shell Center for  
Sustainability**



**SUSTAINABLE DEVELOPMENT OF  
HOUSTON DISTRICTS:**

**ENVIRONMENTAL  
DEVELOPMENT**

The Health of the City

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**RICE**







# Sustainable Development of Houston Districts:

## The Health of the City

by

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## Theme - Atmosphere

### Sub Theme - Air Quality

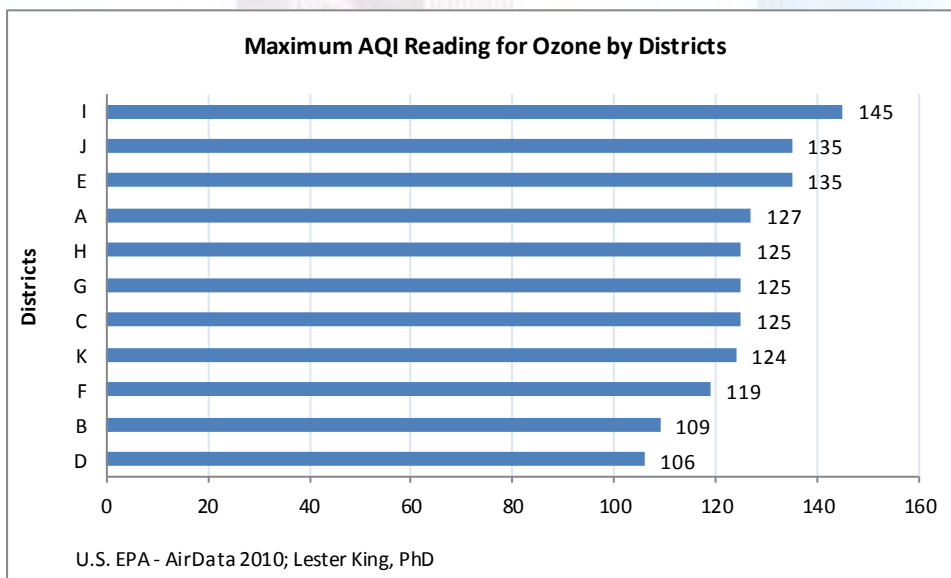
#### Indicator - Ambient concentrations of air pollutants

Ground-level ozone is formed when volatile organic compounds (VOCs) and nitrogen oxides (NOx) react in sunlight. The Houston area has high ambient concentrations of ozone and has traditionally been in violation of one-hour and eight-hour ozone standards (King, 2012).

**Sustainability Benefit:** The Houston Region is in attainment for some of the regulated National Ambient Air Quality Standards (NAAQS).

**Sustainability Issue:** Houston is situated next to petrochemical plants, refineries and one of the largest industrial ports in the country. Additionally, Houstonians drive long distances because the City of Houston is large and homes are separated from jobs, services, and daily needs.

The metric, Maximum Ozone Index Concentration is used to measure the indicator *Ambient Concentration of Air Pollutants*:



**Figure 42: Maximum Ozone Index Concentration**

- The average district in the city of Houston had a maximum air quality index (AQI) value of 125 in 2010.
- AQI values of 101 – 150 are 'Unhealthy for Sensitive Groups'. People with lung disease, older adults and children are at greater risk from exposure to ozone. Persons with heart disease are added to the previously mentioned group as also being at greater risk from the presence of particles in the air. All districts in Houston recorded monitors with AQI values in this range.

- AQI values of 151 – 200 are ‘unhealthy’. At this level everyone may experience adverse health effects and persons of sensitive groups may experience serious effects. Monitors outside of Houston but within Harris County recorded AQI values in this range.





**Theme - Freshwater**

**Sub Theme - Water Demand**

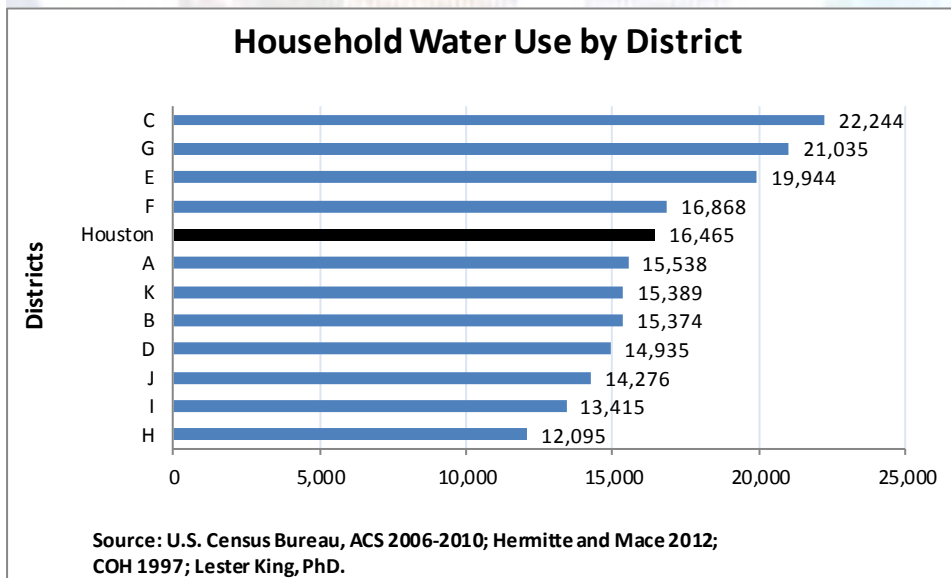
**Indicator - Water Use**

In 2006 the City of Houston Municipal water use was 346,393 acre-feet per year. Harris County excluding Houston used approximately 250,000 acre-feet that year for municipal purposes (Region H Water Planning Group, 2010). The City of Houston is the largest water supplier in the region and is responsible for supplying customers in Harris County and portions of the surrounding 7 counties. This complicates issues for drought response management since Houston water needs do not establish hierarchical preference between needs of customers within the city limits versus those outside of the city limits. As a result most reports and policies projecting Houston water needs are regionally focused without ability to identify the specific needs of users within the city limits.

**Sustainability Benefit:** Water use per capita has decreased over time.

**Sustainability Issue:** Large quantities of water, treated to drinking standards, is used for lawn irrigation in Houston. Lawn irrigation strains the capacity and infrastructure of the water distribution service and can account for as much as 60% - 70% of a typical residential customer’s water usage in the summer months (Texas Agricultural Experiment Station, 2002).

The metric Household Water Use by District was chosen to measure the indicator *Water Use*:



**Figure 43: Household Water Use by District**

- The analysis of household water use in Houston shows that the average households in the average district in Houston uses 16, 465 acre feet per year of water. This is the

equivalent of 5,365,143,826 gallons of water a year. Households in this analysis represent a total of 52% of the total amount of water consumed in Houston.

- Districts C, G, E and F use above the average in the city as a result of having more households, with district C using the most water among households in the city.
- District A, K, B, D, J, I and H use below the average amount of water among households totaled by district in the city.



## Theme - Land

### Sub Theme - Flooding

#### Indicator – Flood Plain Expansion

Flooding in Houston is a critical issue regarding resilience of the city to natural hazards. Resiliency efforts focus on either mitigation efforts or adaptation efforts, which together articulate strategies for hazard reduction or impact response respectively. Mitigation strategies are cited as those proactive solutions to reduce the impacts of natural hazards before they occur and hence are promoted as the best course of action for sustainability (Schwab & Topping, 2008). Mitigation actions for urban areas to reduce flooding focus mainly on increasing development regulations in the floodplains and abandonment of developments in the floodplain (White, 2008). Floodplain mapping helps in the effort to find solutions for flooding mitigation, however according to the Harris County Flood Control District (HCFCD), 65% of the area in Harris County that flooded during Tropical Storm Allison was outside of the mapped regulatory floodplain (Harris County Flood Control District, 2004).

**Sustainability Benefit:** The delineation of the 100-year floodplain is the first step in targeting areas for flood mitigation strategies

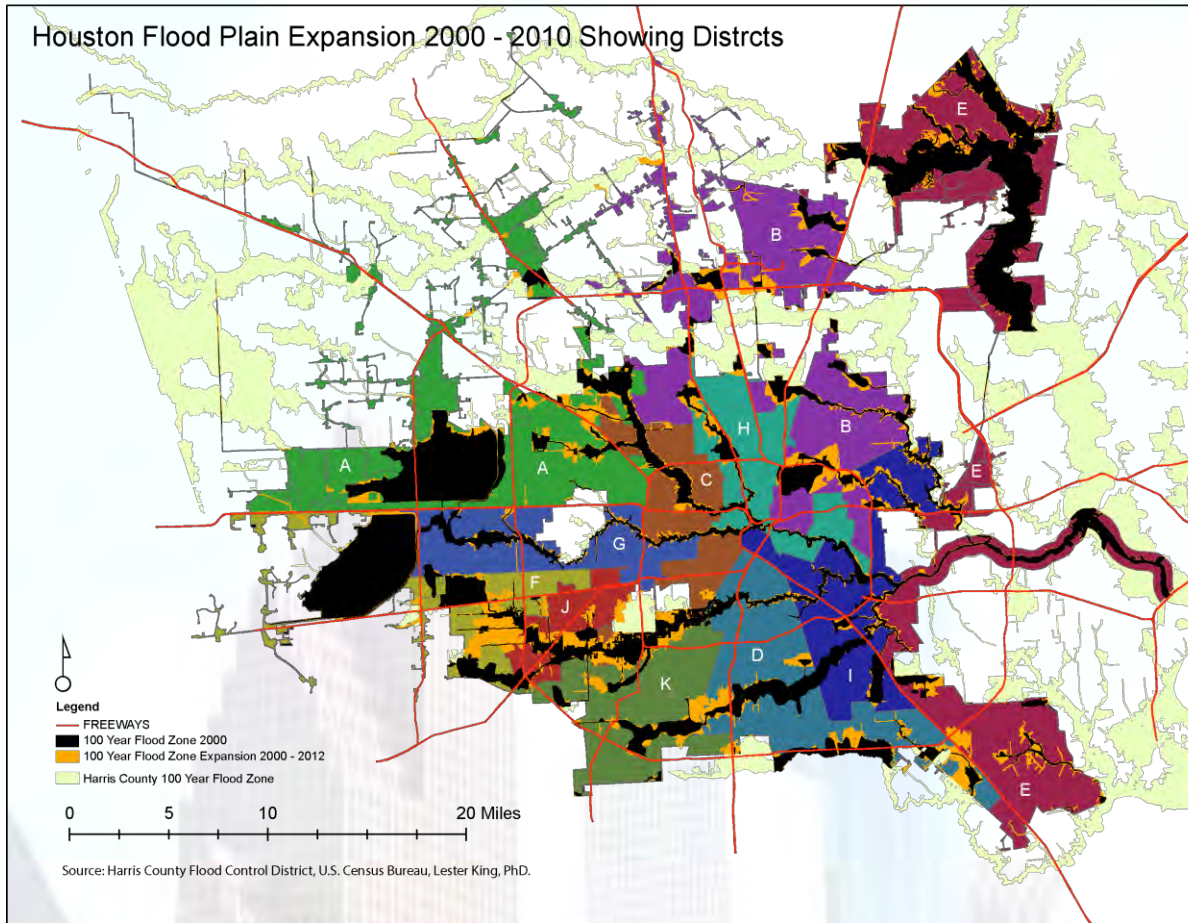
**Sustainability Issue:** Stormwater detention and retention and efficient conveyance into the bayous; in addition to development restrictions in the floodplain must be increased to significantly combat flooding in Houston.

The following metrics are used to measure the indicator *Flood Plain Expansion*:

Figure 44: Houston floodplain expansion 2000 - 2012

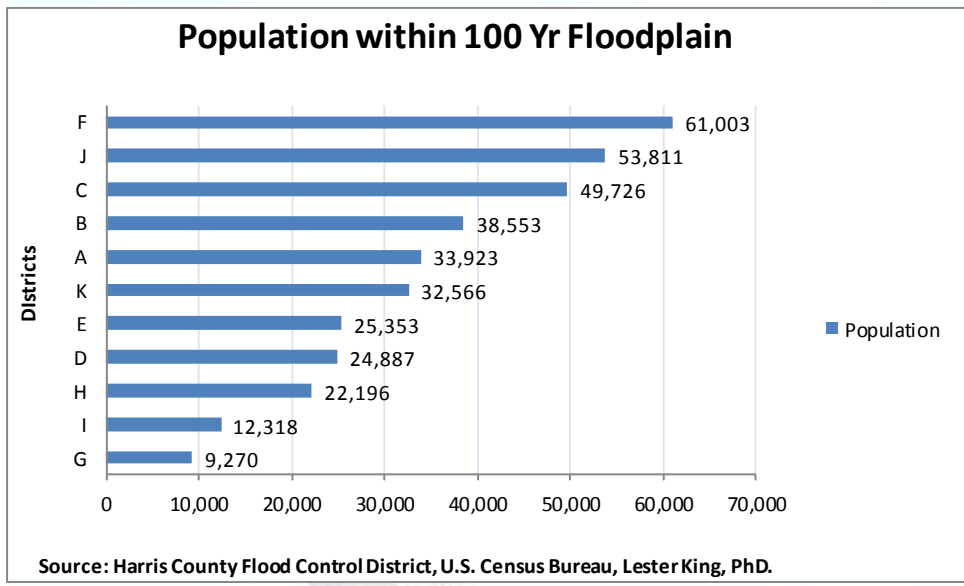
Figure 45: Population within 100 Yr Floodplain





**Figure 44: Houston floodplain expansion 2000 - 2012**

- The 100 year floodplain expanded by 11,375 acres to cover 26% of the City of Houston, between 2000 and 2012.
- An estimated 17% of Houstonians and approximately 149, 000 housing units are in the 100 year floodplain (King, 2012).



**Figure 45: Population within 100 Yr Floodplain**

- The above figure shows the tremendous variance of persons vulnerable to flooding disasters in Houston.
- Populations in districts vulnerable to flooding range from 61,003 persons in District F to 9,270 persons in District G.
- The above figure and previous map shows that flooding is a hazard that impacts persons from every district across the city.



## Theme - Land

### Sub Theme - Land Cover

#### Indicator - Land Cover Change

During the period 2000 to 2025, if development practices remain the same, the United States is expected to lose 7 million acres of farmland and 7 million acres of ecologically fragile lands to real estate development (Burchell, Downs, McCann, & Mukherji, 2005). Houston is considered a real estate developer friendly city with few development regulations. It is also considered one of the more sprawling cities in the country. This sprawl can be defined by low density, low accessibility, poor continuity, low centrality, low concentration, and absence of mixed land uses (Cutsinger & Galster, 2006). Since development is not focused in targeted areas, most lands in the city are technically available for real estate development, the resulting land coverage is primarily low density development. As a result of this type of development practice, a significant amount of natural land and habitat has been converted to development. Analysis shows there has been a loss of 25% of Big Thicket, 14% of Coastal Marshes, 21% of Columbia Bottomlands, 31% of Piney Woods, 16% of Post Oak Savannah, 40% of Coastal Prairie, and 11% of Trinity Bottomlands ecosystems in the wider Houston region (Blackburn, 2011).

**Sustainability Benefit:** Houston is a large city capable of absorbing a lot of growth and development.

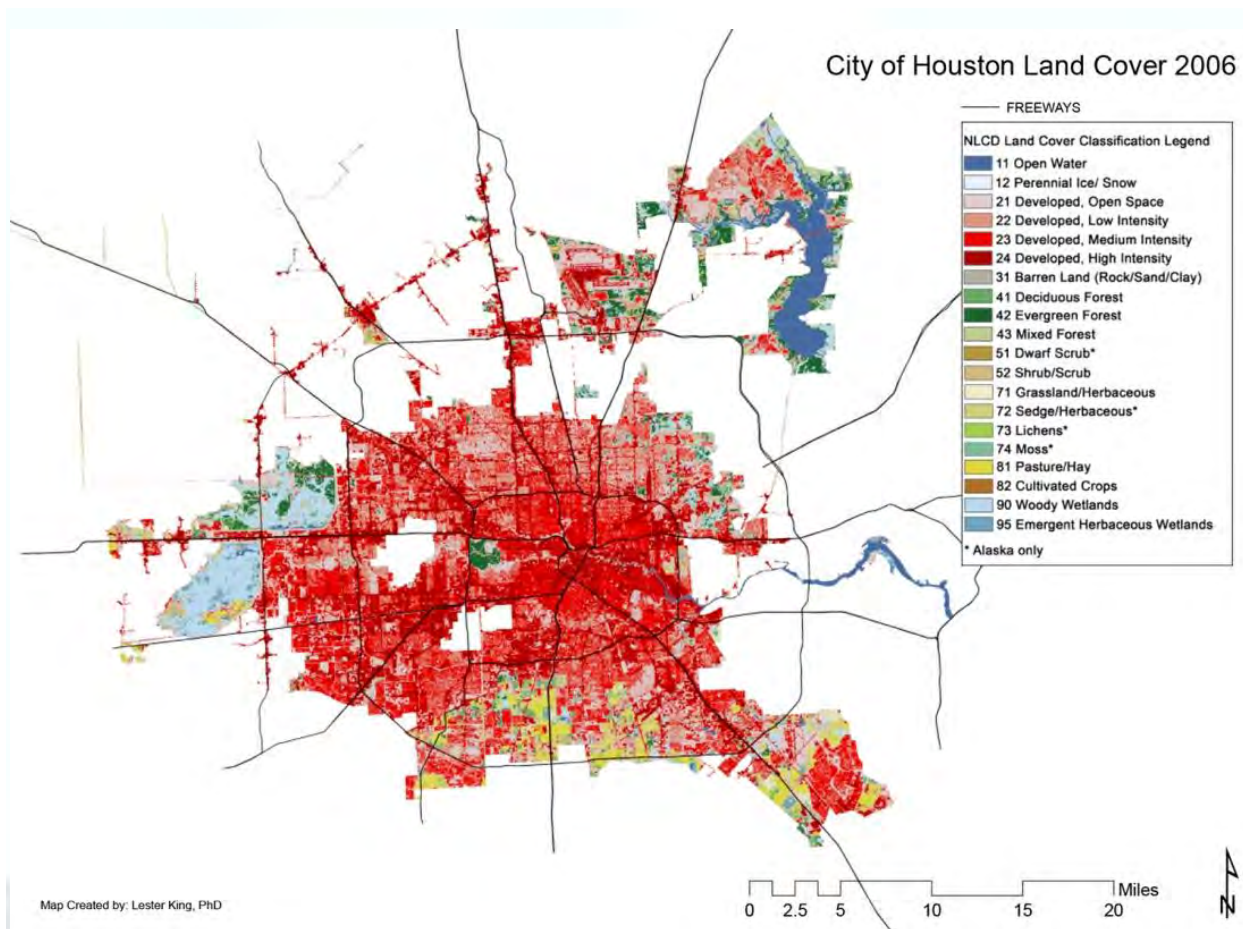
**Sustainability Issue:** Growth and development in Houston does not maximize land utility since most development in the city is comprised of single story buildings. As a result more open space and natural areas are developed, commuting distances increased and the city's overall carbon footprint is increased.

The following metrics were used to measure Land Cover Change:

Figure 46: City of Houston Land Cover 2006

Figure 47: Land cover by district



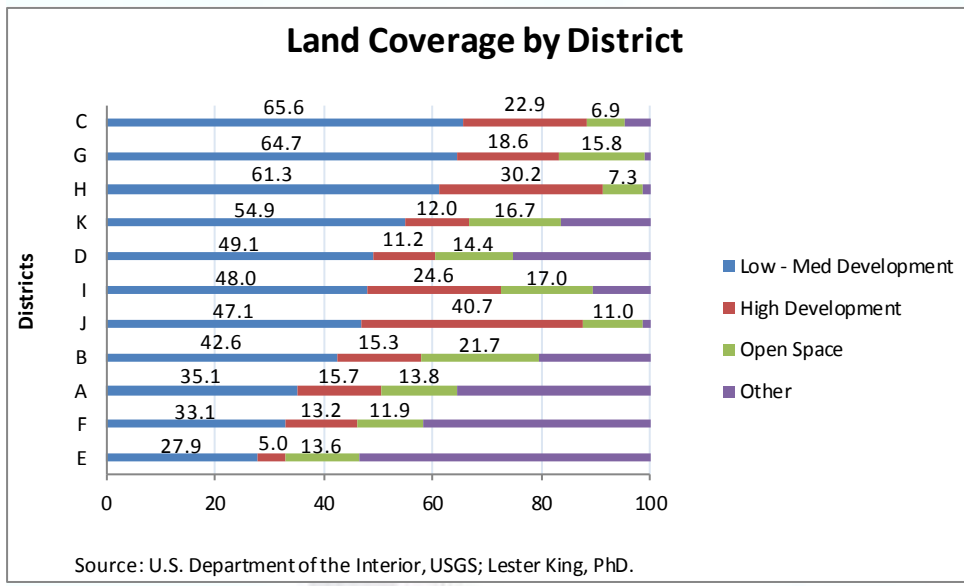


Source: US Department of the Interior – USGS

**Figure 46: City of Houston Land Cover 2006**

- The 2006 land cover map shows the newly annexed areas to the north-west and west of the city as being areas of predominately high to medium intensity development.
- The city is primarily covered by low – medium development.





**Figure 47: Land cover by district**

- Low – Medium intensity development is the prevailing land cover except in Districts A, F and E.
- Low – Medium intensity development is defined as areas with a mixture of constructed materials and vegetation. These areas have impervious surfaces covering 20% - 79% of the total cover and most commonly include single-family housing units.
- Districts J, H, and I have the highest percentages of high intensity development with 40.7%, 30.2%, and 24.6% respectively.
- Open space ranges from 6.9% to 21.7%. This type of land cover includes areas with lawn cover such as parks and golf courses.



**Theme - Land**

**Sub Theme - Land Use**

**Indicator - Land Use Mix**

Land Use Mix is an important indicator for sustainable development since it addresses the availability of services and activity destinations in proximity to living spaces. The pattern of growth can be considered as more important than the amount of growth, since the pattern determines such things as resource efficiency and traffic management (Roseland, 1998). The major contemporary ideas in planning include increasing land use mix as an objective or goal (U.S. Green Building Council, 2009).

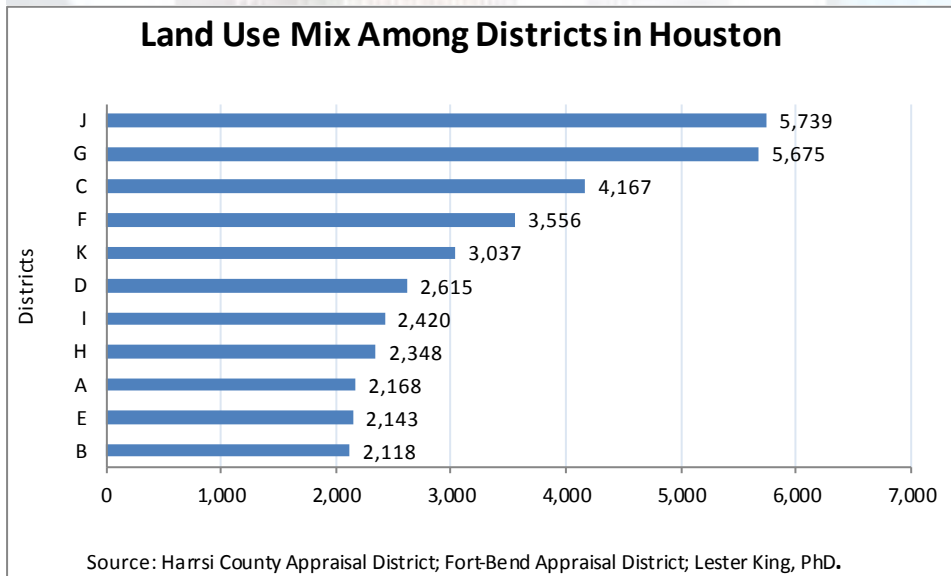
**Sustainability Benefit:** Since Houston does not have the statutory zoning authority, the process of achieving more mixed-use developments would be easier to accomplish. Most contemporary planners do not advocate for Euclidean zoning since it leads to separation of land uses (Schindler, 2012).

**Sustainability Issue:** Socio-cultural historical norms in Houston have established a precedent for separation of single family housing from other land use types, especially multifamily housing. This practice is very similar to what occurred in the state of Ohio in the 1920s and gave impetus to the development of the practice of land use zoning as a means of preventing mixing of land uses (Power, 1989). In Houston this practice of separation of single family from multifamily developments is even without regard for the market segment the multifamily development will target (Sarnoff, 2013).

**The following metrics were used to measure Land Use Mix:**

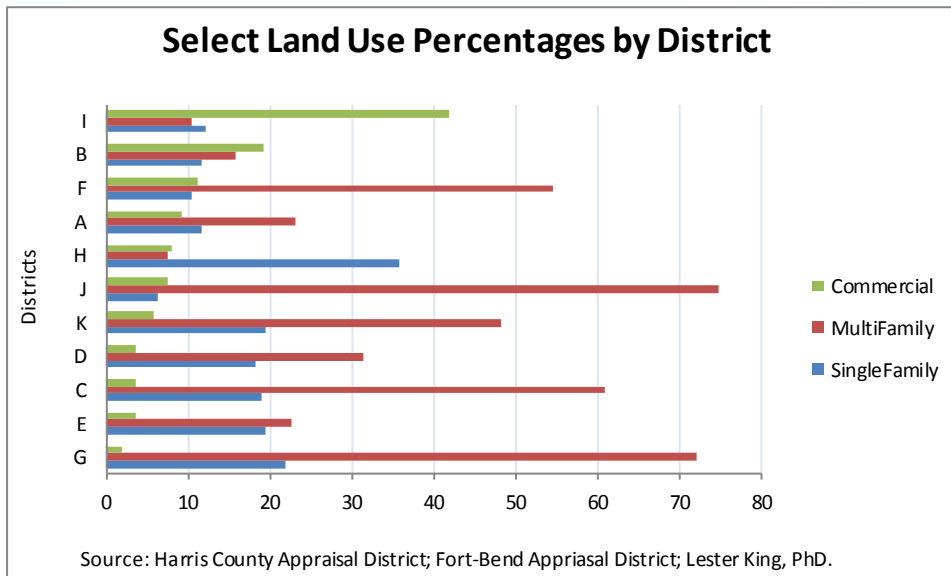
Figure 48: Land Use Mix in Houston

Figure 49: Select Land Use Percentages by District



**Figure 48: Land Use Mix in Houston**

- The above figure shows the degree of land use mix in Houston using the Herfindahl-Hirschman Index (HHI). The index ranges from 0 to 10,000 with zero signifying a high degree of land use mixing and 10,000 signifying no land use mixing.
- District B has the highest degree of land use mixing with an index value of 2,118, while District J has the lowest level of land use mixing with an index value of 5,739.



**Figure 49: Select Land Use Percentages by District**

- The above figure compares percentages of single family, multifamily and commercial land use in Houston.
- The figure shows that districts with higher percentages of commercial land have lower percentages of multi-family and single family property. Further research needs to be conducted to determine the degree to which this is true.
- Four districts, J, G, C and F have more than 50% of the land area devoted to multifamily land use.
- Multifamily, single family, and commercial land use constitute approximately 41%, 16% and 10% of total land uses respectively.

# Environmental Development Policy Recommendations

## THEME – Atmosphere

### Sub Theme – Air Quality: Indicator – Ambient Pollutants



- Expand the air quality monitoring network.
- A Gulf Coast Mobility Plan is needed for coastal cities since the efficient delivery of logistics reduces air pollution generated from this sector.
  - Citizens can help with the following:
    - Organize citizen monitoring projects.
    - Report incidents and odors.
    - More citizen representation on regional planning for air pollution.
  - Local government can contribute the following:
    - Improve toxics monitoring.
    - Determine seamless coverage for monitoring network.
    - Improve regional governance for air quality.
  - Non-profit groups can contribute the following:
    - Organize public meetings for educational and involvement purposes.
    - Organize citizen monitoring efforts.

## THEME – Fresh Water

### Sub Theme – Water Demand: Indicator – Water Use



- A strong Drought Contingency Plan is needed and public education campaign.
- Need better assessment of end user water demand such as landscape irrigation.
- Need to establish a city Water Vulnerability Tax.
  - Local governments can contribute the following:
    - Improve education of users on water reduction strategies.
    - Improve regulation of irrigation systems.
  - Businesses can contribute the following:
    - Market opportunity for alternative water conservation and delivery system

## THEME – Land

### Sub Theme – Flooding: Indicator – Floodplain Expansion



- Need to accelerate conversion of property in floodplains to open space.
- Eliminate development in the floodplain.
  - Local government can contribute the following:

- Establish a Transfer of Development rights fund to reduce development in the floodplain.
- Non-profit groups can contribute the following:
  - Advocacy for elimination of floodplain development.

#### **Sub Theme – Land Cover: Indicator – Land Cover Change**



- Stronger policies for green space acquisition are needed.
  - Local government can contribute the following:
    - Develop a green space acquisition plan.
    - Convert properties in the Land Assemblage program to greenspace.
    - Collaborate with school for shared use of playgrounds.
  - Non-profit groups can contribute the following:
    - Studies on the benefits of greenspace expansion to business and the community.

#### **Sub Theme – Land Classification: Indicator – Jobs/Housing Balance**



- Development codes are not robust enough to increase livability in the city.
- The development codes should include elimination of minimum lot sizes or setbacks; complete streets; encouraging housing closer to job centers etc.
  - Local government can contribute the following:
    - Improve infrastructure efficiencies
    - Implement fee for service based on proximity to job centers.
  - Non-profit groups can contribute the following:
    - Study on local versus suburban costs.





**Sustainable Development  
of Houston Districts:**

**A Sustainability  
Indicators Study**

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