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MEASURING URBAN RESILIENCE FOR TRANSITION TOWARD POST-CARBON SCENARIOS

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INTRODUCTION

The present research is the result of three years of investigation in the field of Urban Resilience and Post-Carbon Transition, developed during the doctoral program "Urban Regeneration and Economic Development" (XXXIII cycle) at the Università Mediterranea di Reggio Calabria, PAU department. During these years I had the opportunity to take part on three exchange programs (the International Module in Spatial Panning Development at KU university of Leuven-IMPSD 2018, a research/work experience at the Resilience Department of Milan municipality-2019, and the research activities conducted at the Northeastern University) that allowed me to explore the topics under different approaches (academic or professional oriented) and reach a broad understanding of the theoretical assumptions and their application in the field of urban management and policy design. In particular, in the last year I had the opportunity to take part to the TREnD project[1] (*Transition with Resilience for Evolutionary Development*), to which my thesis refers, providing some insights on the theoretical framework and laying the groundwork for a further development of the case study of the City of Boston.

Started on June 2019, TREnD is a Horizon2020-MSCA-RISE2018 project led by the CLUDs Lab (PAU Department) finalized at strengthening the regional capabilities in triggering, implementing and managing Transition Management (TM) strategies towards driving "resilience-building" processes. The project aims to combine 'transition' with 'resilience-building' processes in framing novel strategies based on the Evolutionary Economy's assumption. "The goal is to stimulate regional diversification as a co-creation of solutions for development problems, implementing transitional tailored placed-based innovation policies"[2]. The project is articulated in four Work Packages and involves the investigation of different territorial contexts in EU and US, with the aim to identify potential drivers of Transition Management and Resilience strategies.

WP1: Transition Management and Resilience in the Evolutionary Economy Perspective

WP2: Transition Management and Spatial Planning: towards a new territorial dimension of the Cohesion Policy

WP3: Responses to external shocks: case study analysis through a resilience perspective

WP4: Open access Toolkit: a new gateway for regional transition policies

As part of the WP1, the first objective of my thesis is to provide a frame of references for linking together Resilience and Post Carbon Transition in the Evolutionary framework. and to search a set of indicators for measuring of urban resilience and low-carbon transition trends.

Both the topics were already mainstreamed in academic and political debates –and particularly in regard to climate change concerns, but their relevance increased even further with the emerging of the Covid-19 crisis, as it at once tested the resilience of urban systems and pushed post-carbon transition into the center of economic recovery proposals. Even before the Coronavirus, the increasing awareness on the problems of climate change and fossil-fuels greenhouses gas emissions pushed politics and academics to draw transition strategies toward Post-Carbon scenarios (e.g EU Just Transition Mechanism). The concept of Post Carbon embodies a deep rupture in the traditional carbon-dependency pathways: it is not just a shift from one set of fuels to another, but involves a much deeper transformation at physical, social, economic, institutional and political levels, even including change in individual lifestyle. For how urgent is the necessity to break the current path-dependency on fossil fuels, the problem is so radicated in the global socio-economic system that the hypothesis of radical changes sound quite unattainable. Intended as “a form of intelligent long-term planning through small steps based on lerning and experimenting” (Rotmans and Loorbach, 2010), through the Transition Management it is possible to design priorities and incremental actions to guide the process of carbon dependency phase out.

In a context of disruptive shocks –as current pandemic and climate change emergencies are- the thematic of resilience provides several insights to understand factors that can foster or undermine urban systems’ response. As originally defined as ‘the ability of a system to return to an equilibrium or steady-state after a disturbance ” (Holling 1973,1986), the concept of resilience has been broadly discussed on literature, with a proliferation of definitions and interpretations that have also partially modified its meaning, shifting from “equilibrium-based” to change-based “evolutionary” perspective (“a permanent process of adjustment and change, and the positive contribution of change to structural improvement” (Wink, 2014)). Embracing the Evolutionary approach means to understand that complex systems are continuously changing across different phases of in-stability (the adaptive cycle - Holling, 1986), and that crises can be interpreted as events of ‘creative destruction’ (Schumpeter, 1942) during which the collapse of existing orders paves the way for new ‘waves of innovation’. These assumptions allow us to think at the current crisis as a transition accelerator, as it emerges from a world that was already changing and releases the potential for reshaping the future in new directions. Applying the Evolutionary paradigm to the concept of resilience means shifting the idea of the shock-recovery from the ‘bouncing back’ objective of restoring the precedent equilibrium, to the ‘bouncing forward’ vision of ‘building it back better’. Under this logic, Resilience-building processes and Transition Management objectives converge, as both oriented to address structural changes toward a more resilient, equitable and sustainable socio-economic system, based on the ‘zero carbon-zero poverty’ double vision. Combining together Resilience and Transition Management, it is possible to obtain a new operational framework that allows planners and decision makers to transform the risks and stresses affecting a city in opportunities of urban regeneration oriented to Post-Carbon objectives. Stemming from risks and vulnerability assessment, it is possible to identify priority actions and design solutions to address at once resilience and sustainable transition objectives. The second objective of my thesis is to search a set of urban indicators to measure resilience and Post-Carbon transition trends.

The research design is structured on two main blocks: the first is based on a deep literature review process, focusing particularly on the topics of global changes, climate emergency, resilience strategies, post-carbon scenarios, transition management and evolutionary development (Ch II-III); the second is based on the case study of the city of Boston, being one of the main areas of investigation selected within the TREnD project, as it provides interesting insights into resilience building process and post carbon transition policy implementation (IV). The case study consists in two different phases: the first involves the analysis of the Boston Resilience Strategy (visions, goals, initiatives and actions) with the aim to identify the existing synergies with other current plans at local, metropolitan and state level, and understand how they are mutually contributing to strengthen city preparedness to shocks and achieve the goal of decarbonization; the second phase involves a spatialization of municipal selected actions, with the aim to visualize how resilience building process and transition initiatives take place in the urban context taking into account social vulnerability and climate-related territorial risks. Stemming from the outcomes of the MAPS-LED project (*Multidisciplinary Approach to Plan Smart Specialization Strategies for Local Economic Development*-H2020-MSCA-RISE2014[3]), the case study involves the analysis of the 4 target areas precedently identified by the precedent MAPS-LED project. as clusters of innovation within the city of Boston's boundaries.

	Block 1	Block 2
Aim	Literature Review	Case Study
Objectives	Global Trends	Strategy Analysis
	Conceptual Framework	Strategy Spatialization
	Indicators	Target Area Trends
Sources	Research, Gate, …	Census Track, …
Tools	Literature Review form, Voyant text analysis	Python, ArcGIS, Survey form

CHAPTER I
Understanding Crisis to manage Transition

"When written in Chinese, the word *crisis* is composed of two characters: one represents *danger* and the other represents *opportunity*." (John F. Kennedy, 1959)

A World in Crisis

After the presidential campaign speeches of John F. Kennedy, these words entered in American popular culture as an inspiring slogan to reverse the collective imaginary during crisis events, but they actually contain an etymologic mistake: the second character does not exactly mean "opportunity", but something more like "change point". History shows that the most relevant shifts in the world occurred in the wake of major crises, when the destruction of existing orders led new waves of creative innovation favoring evolution and progress.

The 2020 will go down in history as the year in which the COVID-19 pandemic paralyzed the world, paving the way for a deeper global crisis whose evolution has only just begun. Since the corona virus first appeared in the Chinese town of Wuhan in late 2019, it has rapidly spread around the world, shocking at once not only health care system, but also global economy, energy sector, labor market, civil society, national institutions and even geopolitics. At the time of writing, while we witness the race between vaccines and new virus variants, many cities around the world are still experiencing lock-down and restrictive measures with destructive impacts on local economies, employment and income security. While people are waiting for going back to normality, the idea that "nothing will ever return to the prior sense of normalcy" is beginning to be wide spread (Schwab and Malleret, 2020). The Coronavirus narrative is increasingly taking shape as a turning point toward a global 'new normal'[4].

Although the collective attention is fully focused on the Coronavirus narrative, unfortunately it is not the only emergency taking place in the world at the present time. As reported by United Nations Office for Disaster Risk Reduction, if compared with the previous two decades (2000-2019) the 2020 was a record-breaking year in term of climate-related extreme events and economic losses (UNDRR 2021). Warmer temperatures and increased drought triggered an unprecedented wildfire season, destroying millions of land hectares worldwide, particularly in the Arctic, Australia, California and the western U.S., and Brazil[5]. The Atlantic hurricane season more than doubled the average seasonal activity, counting the highest number of named storms and major hurricanes on record, with damage costs that exceeded $37 billion in U.S. [6]. Floods have been observed as the most common disaster worldwide, accounting more than 200 events that caused a significant number of deaths, especially in East Africa, South Asia and China[7]. Extreme temperature and heat waves were the deadliest types of disaster in Europe accounting for 42% of total deaths (6340 deaths recorded). As declared by the Alliance of World Scientists at the down of 2020, "The climate crisis has arrived and is accelerating faster than most scientists expected" (*World Scientists' Warning of a Climate Emergency*, Ripple et al. 2019).

Despite the striking difference of their nature, climate change and pandemic emergency appears like the two faces of the same coin, both emerging from the globalized world of the new *Anthropocene* era (Asayama et al. 2020, O'Callaghan-Gordo & Antò 2020) and reflecting the uncertainties of the modern 'world risk society' (Beck, 1986/1992/1996/2006), both exacerbating vulnerabilities driven by social inequalities and triggering deep transformative changes on global, local and individual scale (Zinn 2020). They also share another common feature: despite scientists have long been sounding the alarm about possible calamities caused by human actions, the governments paid insufficient attention to science's warnings and their actions to prevent catastrophic impacts of global disasters have been quite inadequate (Asayama et al. 2021). As stated in Giddens' Climate Change paradox, "since the dangers posed by global warming aren't tangible, immediate or visible in the course of day to day life, however awesome they appear, many will sit on their hands and do nothing of a concrete nature about them" (Giddens, 2009).

The Covid-19 pandemic raised awareness about the global catastrophic risks of the 21st century, highlighting the complex interconnectedness of their cascade effects and testing our *un-preparedness* in front of such multi-scale events. It emerges the importance of strengthening international cooperation and efficient governance to facilitate fast decision processes and limit damages during emergencies (GCF, 2020; WEF, 2021). Resilience building approaches play a central role in the framework of disaster risk reduction, aiming to enhance preparedness for effective response and enable a fast recovery from shocks (UNISDR Sendai framework, 2015).

On the other hand, the Covid-19 crisis pushes us to think about new future scenarios, bringing to the forefront technologic innovation, social equity and green economy as key levers for a "building back better" recovery. As the double threat of peak-oil and climate change is more and more looming, the paradigm of a Post-Carbon transition has becomes a mainstream issue in Post-Covid19 recovery discourses. Many world leaders, especially in Europe and U.S., seem to welcome the possibility to incorporate Green New Deal and Just Transition objectives in their recovery funds, fostering more sustainable economic models through investment in green industry (Lidskog 2020, OECD 2020). In this sense, if we think about how *stay-at-home* measures facilitated digital innovation and how recovery fund could incentivize green industry and low carbon economy, the crisis could be interpreted as a transition accelerator. It remains to be seen, however, how much the perceived imperative of economic recovery, as combined with the current acceleration of digital transition, will ensure the realization of the "zero poverty/zero carbon" vision or will continue to exacerbate the existing pattern of social inequality.

During the last year, a wide increasing literature has been produced to investigate the connections between Covid-19 pandemic and Climate Change. Beyond the controversial hypothesis of a cause-effect link, the evolution of Covid-19 crisis provides several lessons to be learned to face global future challenges, especially referring to the wicked threat of Climate Change. This chapter provides a comparison between Covid19 and Climatic emergencies, trying to understand how the current crisis is intersecting (fostering or contrasting) ongoing sustainable transition pathways and what kind of innovation is emerging from the current 'gale of creative destruction' (Schumpeter 1942).

"Human activities are significantly influencing Earth's environment in many ways in addition to greenhouse gas emissions and climate change. Anthropogenic changes to Earth's land surface, oceans, coast and atmosphere and to biological diversity, the water cycle and biogeochemical cycles are clearly identifiable beyond natural variability. They are equal to some of the great forces of nature in their extent and impact. Many are accelerating. Global change is real and is happening *now*." (*Amsterdam Declaration on Global Change*, 2001)

Since the late nineteenth century, scientists have become increasingly aware of the extent of human influence on planet Earth and its atmosphere. With his "Man and Nature" -first published in 1864 and then reprinted in 1874 as "The Earth as Modified by Human Action"- George Perkins Marsh was a pioneer in environmental discourses, challenging the myth of the inexhaustibility of the Earth's resources and denouncing the dramatic environmental changes caused by human societies. Some years later, building on the prior works of Joseph Fourier, John Tyndall and Claude Pouillet, the Nobel Prize for Chemistry Svante Arrhenius demonstrated the correlation between the greenhouses gases (GHGs) trapped in the atmosphere and major changes in Earth's surface temperature, stating that emissions of carbon dioxide from the burning of fossil fuels and other combustion processes were large enough to cause global warming (1896). In 1926, another notable contribution came from the Russian geologist V.I. Vernadsky, who recognized the increasing power of mankind as a part of the *biosphere*, coining with his collegues P. Theilard de Chardin and E. Le Roy the term "*Noösphere*" (the sphere of thoughts) to emphasize the growing role of human brainpower and its potential for developing technological innovations, in shaping future existence and environmental patterns. Influenced by Vernadsky's "Biosphere" (1926), the chemist J. Lovelock formulated the *Gaia Theory* (1972), describing the Earth as a unique complex system, where the *biosphere*, the *atmosphere*, the *hydrosphere* and the *pedosphere* self-regulate themselves through mutual dynamics of homeostatic balance –also defined "negative feedback"- able to stabilize the temperature of the Earth's atmosphere within certain limits. Despite the critics generated by this theory on scientific debate, Lovelock's *Gaia* led to a new understanding of the Earth system as a whole, driving the beginning of Earth System Science in the 1980s and inspiring several international research programs on *global change*. In 1986 a NASA-led research produced the first system-dynamics representation of the Earth System -known as the NASA Bretherton Committee diagram- coupling the physical climate system and the biogeochemical cycles, and treating human activities as significant driving forces for change in the system (Fig1).

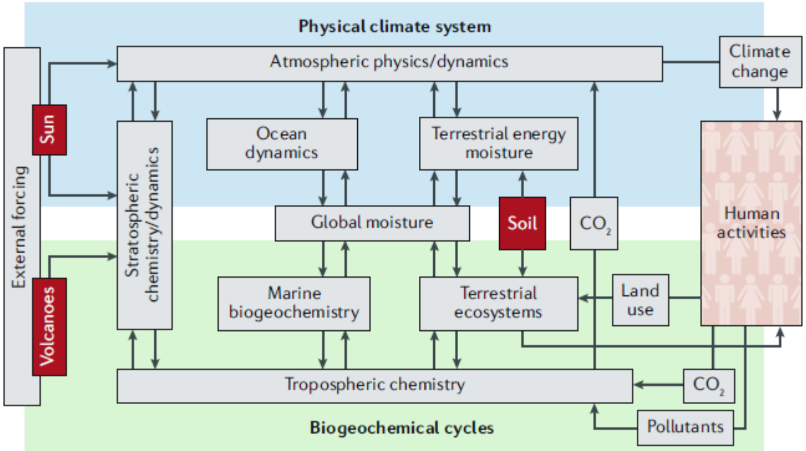


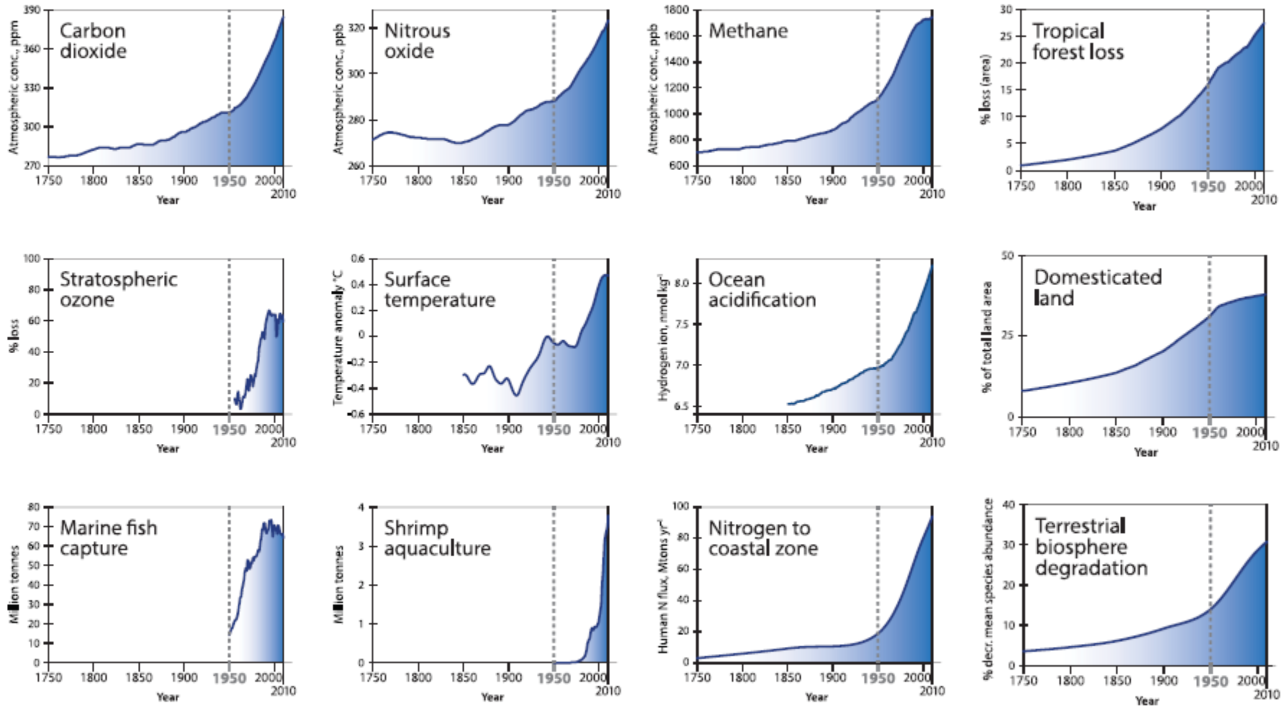
fig. 1. The NASA Bretheron diagram of Earth System, reproduced from the NASA Earth System Science Overview (1986) Source: Steffen et al. 2020

Several terms have been coined over the last two centuries to emphasize the mankind's role in major global changes (*Anthropozoic era* by Stoppani, 1873; *Psychozoic era* by LeConte, 1877;; *Technocene* by Ter Stepanian, 1988; *Anthrocene* by Revkin, 1992; *Homogenocene* by Samways 1999; Capitalocene by Moore, 2014; *Chthulucene* by Haraway, 2014; *Urbicene* by Swyngedouw, 2017; *Urbanocene* by Wes, 2017; etc..), but, among all, the word *Anthopocene* gained the greatest success both inside and outside the academy, up to become a mainstream paradigm for the "human age". Originally coined in the 1980s by the ecologist Eugene Stoermer, the term was formally introduced in the scientific literature thanks to the Nobel Prize Paul Crutzen (Crutzen & Stoermer, 2000), who used it to define a *new geologic epoch* in which humans activities are compared to the 'great forces of nature', having a 'dominant influence on climate and the environment' (Oxford English Dictionary, 2014) and driving major changes at global scale.

Inspired by Crutzen's vision, the professor Will Steffen led a research project for the International Geosphere-Biosphere Programme (IGBP), with the aim of determining human-driven changes to Earth system through a comparison of socio-economic and environmental trends from 1750 up to 2000. The primary evidence of the research was a parallel dramatic growth on the human enterprise and Earth system's parameters starting after the Second World War. Echoing the Polanyi's *Great Transformation* (1944), this phenomenon was named *The Great Acceleration* and early became an iconic symbol of the *Anthropocene*, highlighting 'the most rapid transformation of the human relation with the natural world in the history of humankind" (Steffen et al. 2004). Although the authors themselves acknowledge that "correlation in time does not prove cause-effect", its graphs (Fig2) became very relevant on scientific literature because they well captured "the holistic, comprehensive and interlinked nature of the post-1950 changes simultaneously sweeping across the socio-economic and biophysical spheres of the Earth System" (Steffen et al. 2015).

The Great Acceleration

Earth system trends



Socio-Economic trends

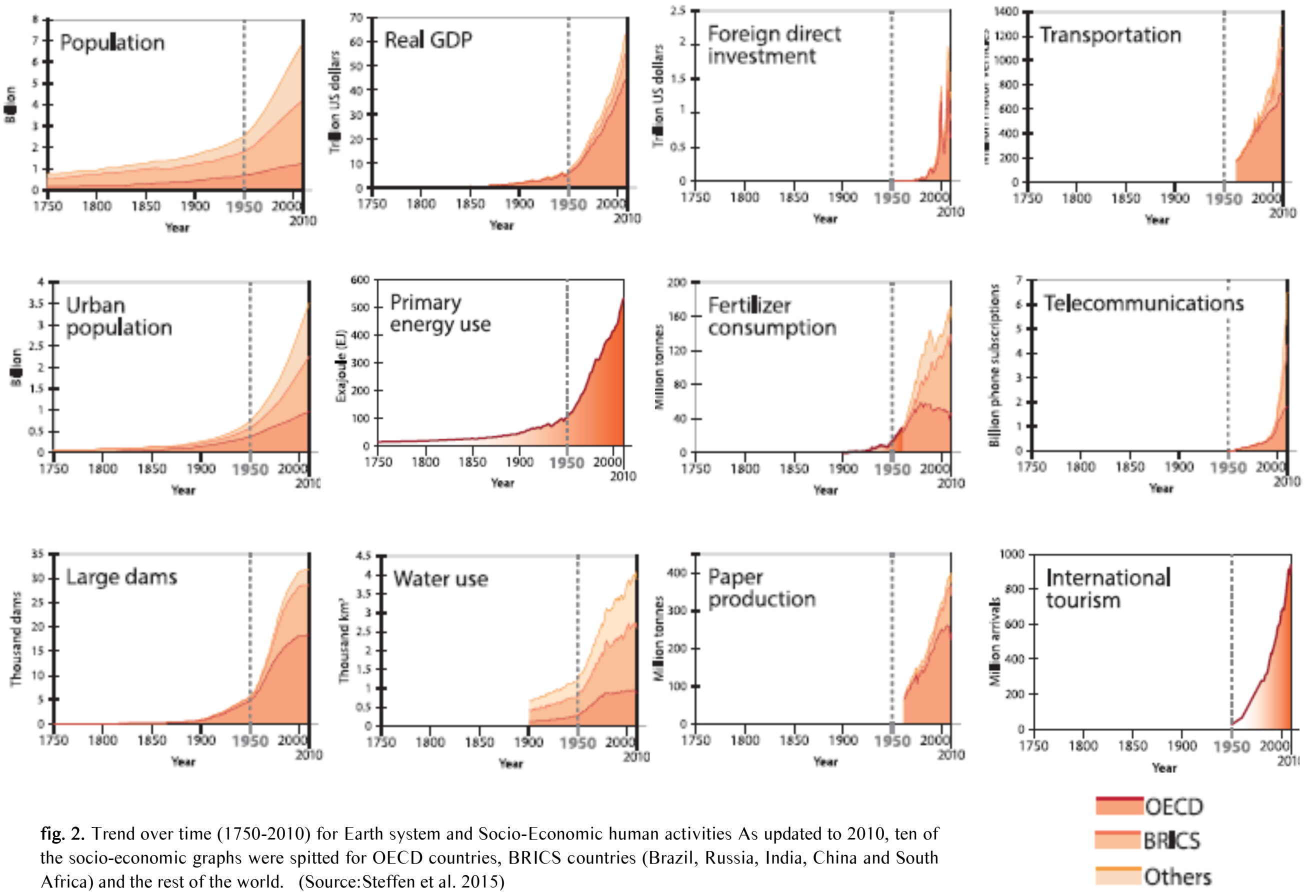


fig. 2. Trend over time (1750-2010) for Earth system and Socio-Economic human activities As updated to 2010, ten of the socio-economic graphs were spitted for OECD countries, BRICS countries (Brazil, Russia, India, China and South Africa) and the rest of the world. (Source:Steffen et al. 2015)

Aimed to catch the major trajectories of *global change*, *The Great Acceleration* graphs were based on a set of 12 socio-economic indicators (including population, economic growth, resource use, urbanization, globalization, transport and communication) and 12 Earth System indicators (atmospheric composition, stratospheric ozone, climate system, water and nitrogen cycles, marine ecosystem, land systems, tropical forest and terrestrial biosphere degradation), both showing an overall "no-analogue state" in human history (Steffen et al. 2004). Despite the cyclical occurrence of *hiatus* periods and great oscillations in historical climate trends, the global mean surface air temperature (GMST-measured over both land and oceans) recorded an extra-ordinary rise since 1970s (fig 3), with the 2006-2015 decade reaching around 0.87°C more than preindustrial level (IPCC 2013). Observed mean land surface air temperature has risen even twice, increasing by around 1.53°C since pre-industrial times, driving drought phenomena and affecting food production. The atmospheric concentration of carbon dioxide, nitrous oxide and methane exceeded preindustrial levels by about 40% (CO_2), 150% (CH_4) and 20% (N_2O), and are continuously increasing due to anthropogenic fossil fuel emissions and net land use change emissions, influencing climate system and ocean acidification, with related consequences in terrestrial and marine ecosystem and biodiversity (IPCC 2013).

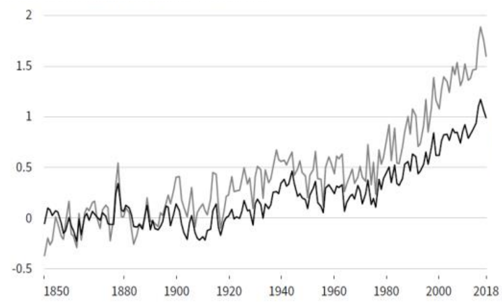
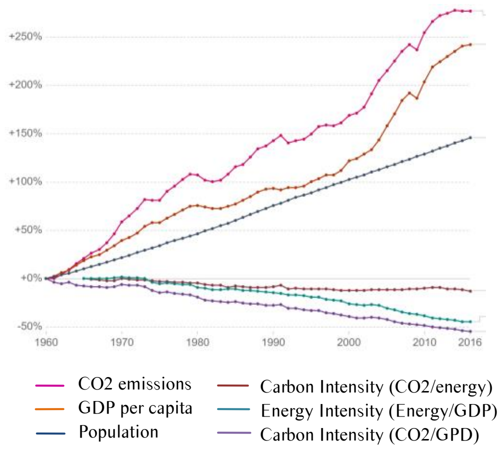


fig.3. Change in Temperature from 1850 to 2018:
Global Mean Surface Temperature (black)
Land Mean Surface Temperature (grey)
(Source: : IPCC SRCCL-2018)

The rise in GHGs emissions parallels closely the trends of world's population, economic growth and primary energy use. The socio-economic *Great Acceleration* graphs clearly show a phenomenal growth of the human enterprise after the Second World War, both in economic activity, and hence in resource consumption and demand for goods and services. Between 1970 and 1997, the global consumption of energy increased by 84%, and consumption of materials also increased dramatically to supply resources for agriculture, food production, forestry, industrial development, transport, international commerce, etc. (Steffen et al. 2004). These percentages, however, are not equally distributed around the world, but strongly linked to the prosperity level of every country. As updated to 2010, the socio-economic trends have been differentiated for 'wealthy countries' (OECD), 'emerging economies' (Brazil, Russia, India, China and South Africa) and 'the rest of the world'(fig 2b), with the objective to 'explore equity issues in terms of the differential pressure that various groups of countries apply to the Earth System' (Steffen et al. 2015). Splitting some of these graphs, the authors noticed that most of the population growth since 1950 has been in the non-OECD countries, while the global economy (GDP), and hence consumption, is still strongly dominated by OECD world. As population, income and energy consumption are identified as the major drivers of CO_2 emissions (fig 4), these trends also reflect a different distribution of

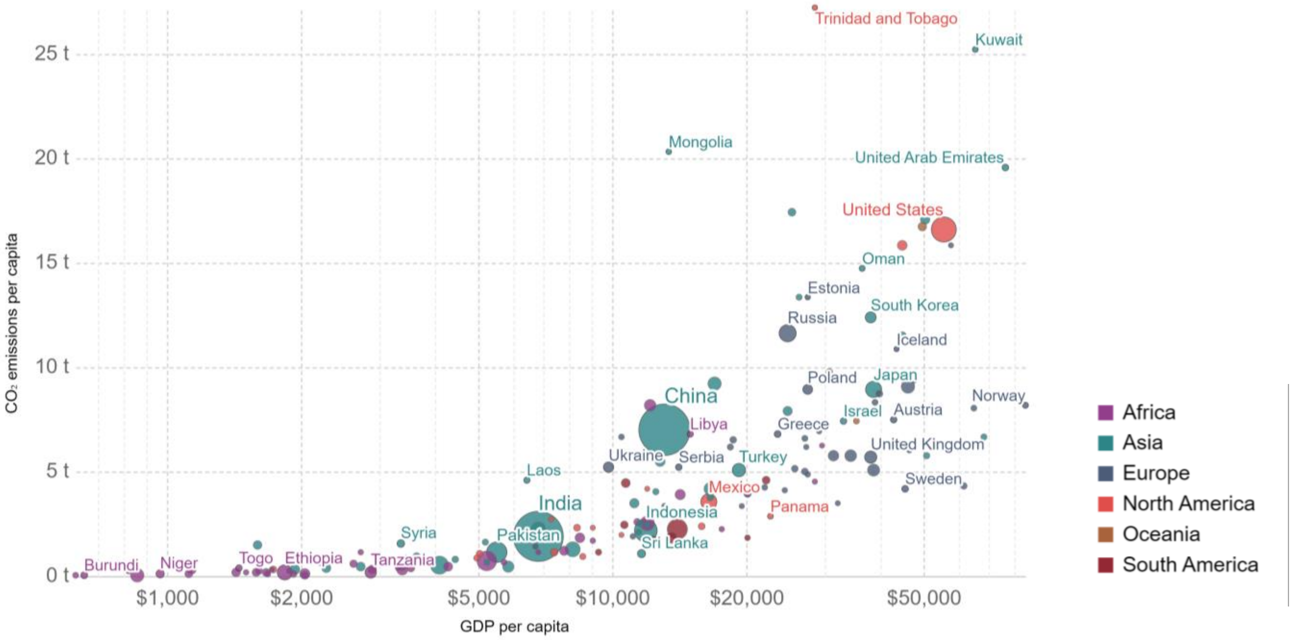


Emissions *= Pop. x GDP x Energy/GDP x CO2/Energy*

fig.4. Percentage change in the four drivers of global CO_2 emissions (Source: *Our World in Data* based on Global Carbon Project UN, 2021. *https://ourworldindata.org/emissions-drivers*)

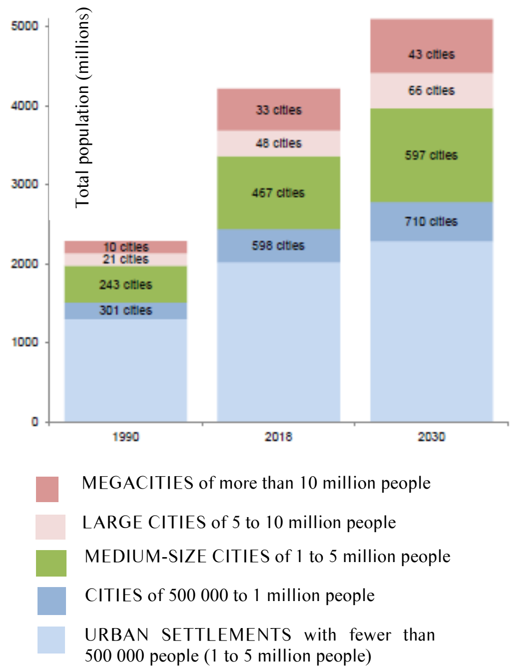
GHGs emission across countries (fig.5). Current data from *ClimateWatch* show that 64% of GHG emissions come from just 10 countries, while the 100 least-emitting contributed less than 3%[8].

fig.5. CO2 emissions per capita vs GDP per capita, 2018. (Source: *Our World in Data* based on Global Carbon Project UN, 2021



One of the most significant trends triggering the *Great Acceleration* of GHGs emissions is the rapid rate of urbanization, strongly related to the exponential growth of the demographic index[9], as well as to the rise of economic activities. In 1800 only 3 percent of the world's population lived in cities, but the metric increased to 47 percent by the end of the twentieth century, with a drastic rise since 1950s (UN-DESA 2019). At that time, there were 83 cities with more than 1 million people, but this number increased to more than 540 by 2018, accounting more than 30 megacities (fig 6). As today, almost 56 percent of Earth's population is concentrated in urban areas[10] and this percentage is expected to increase to nearly 70 percent by 2050 (UN-Habitat 2020, UN-DESA 2019) with other 10 cities forecasted to exceed the number of 10 million inhabitants (fig 6). Underlying these population statistics and forecasts are large and complex economic, social, political, and demographic changes, including the multiplication in the size of the world's economy. As most of the global GDP is generated in urban centers and most of the new investments have concentrated there, the process of urbanization is strongly related to economic development: all wealthy nations are predominantly urbanized (fig.7) and rapid urbanization in low income nations is usually associated with a rapid economic growth (World Bank 2019). Most of the world's largest cities are in the most

fig.6. Population and number of cities of the world, by size class of urban settlement, 1990, 2018 and 2030. Source : UN-DESA 2019.



prosperous nations; moreover it is interesting to observe how cities which economies increase as a result of globalization are growing both in size and importance, often becoming centers of more extended metropolitan regions (Sassen, 2012).

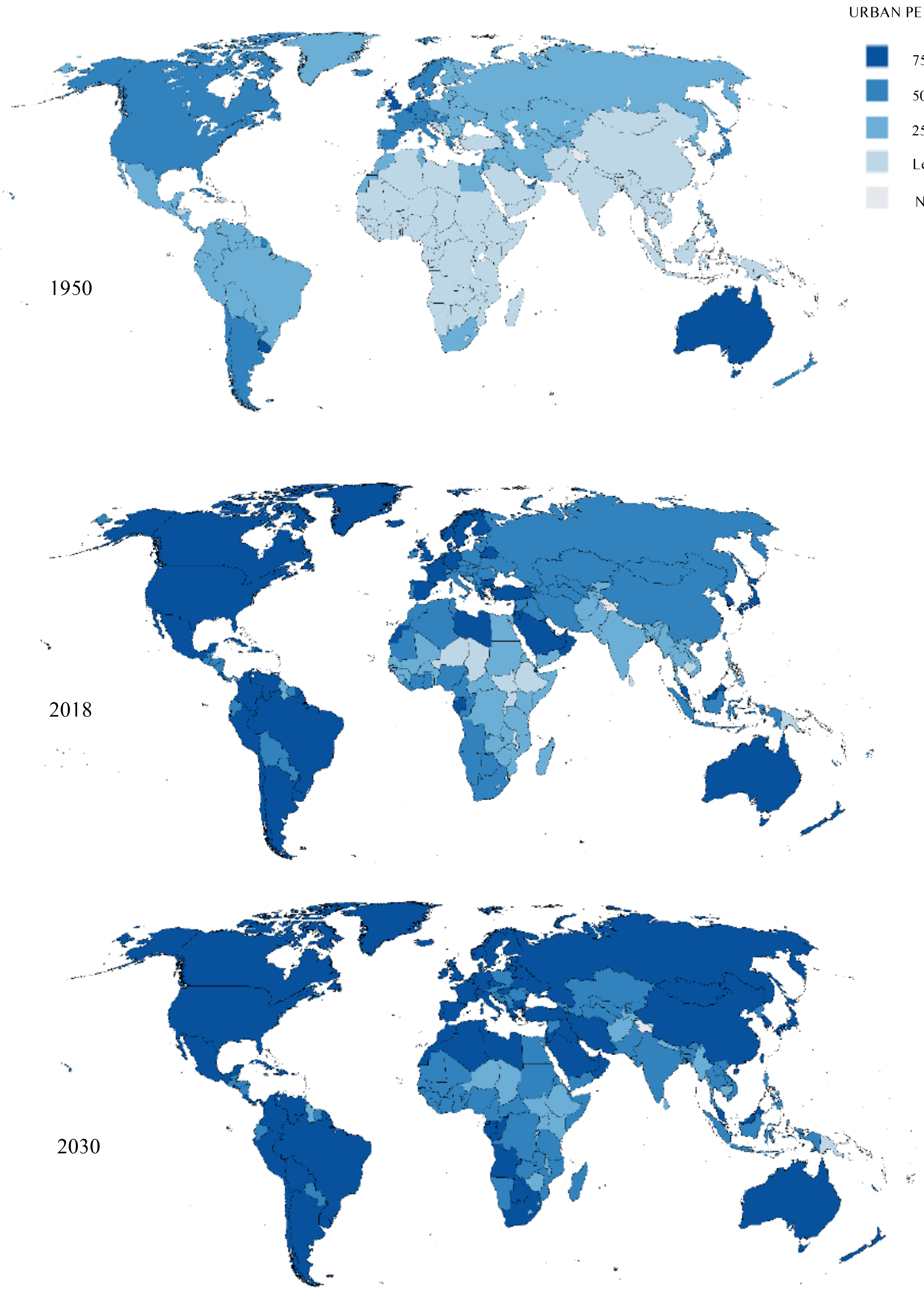


fig.7 Percentage of population in urban areas, 1950, 2018 and 2030. Source : UN-DESA 2019.

Urbanization is arguably the most significant form of land-use and land-cover change, having considerable effects on the pattern, dynamics and functionality of ecosystems (Elmqvist et al. 2013). This can be clearly observed along the rural-urban gradient and the increasing amount of land consumption, which lead a decline in the share of wild and semi-natural areas, with a high level of fragmentation and loss of biodiversity. Particularly in the developed world and especially in U.S., post-World War II motorization led to the phenomenon of *urban sprawl*, the low-density expansion of large urban areas into the surrounding rural landscape, broadly defined as "excessive spatial growth of cities" (Brueckner 2000; Kasanko et al.2006; Bengston et al. 2005). Angel et al. (2011a, 2011b) forecasted that global urban land cover would be nearly 1.3 million km^2 by 2030 and 1.9 million km^2 by 2050- respectively increasing of 110 percent and more than 210 percent since 2000- triggering an increasing loss of canopy cover and biodiversity degradation and threating the green infrastructures that helps cities to mitigate and adapt to climate change impacts.

If in terms of size, cities occupy only 2 percent of the world landmass, in terms of climate impact they have an enormous footprint, consuming over two-thirds of the world's energy and producing more than 70 percent of anthropogenic global CO2 emissions (UN-Habitat 2011). The impacts of urban agglomerations have been subject to numerous modeling studies and observation campaigns, focusing on both global and local climate alterations deriving by different spatial patterns. Urban density and building material properties influence local weather, altering surface air temperature and ventilation and creating localized warming phenomena within the city, such as 'urban heat islands' (UHI) or extreme heat waves. Spatial organization and transport system heavily influence GHGs emissions, and urban car-dependent life-styles exacerbate air pollution, also affecting citizens' health and wellbeing. Particularly significant is the contribution of large cities, whose extent of build environment, high population density and large number of business have a pronounced impact on the local and regional energy balance, as well on environmental issues such as surface temperature, waste products and air quality (Folbert et al. 2015). It is estimated that the 50 largest cities together emit an amount of greenhouse gases equivalent to 2600 megatons of carbon dioxide per year, more than the annual total amount of some countries (World Bank 2009). Moreover, megacity-coastal interactions may also impact the hydrological cycle and pollutant removal process through the development of fog, clouds and precipitation in cities and adjoining coastal areas (Shepherd et al. 2002).

Despite these considerations, the relationship between urban density, energy consumption and –by extension- GHG emissions is not easily generalizable, as strongly influenced by context-specific variables where social, economic, urban structure, transport and environmental factors all play an important role. The paper of Dodman (2009) demonstrated this providing an analytical review of the implications of different urban densities for GHG emissions and climate change mitigation and adaptation. He argued that density is only one of several factors that affect energy use of town and cities, and that a broader analysis concerning urban form and structure as well as urban processes and economic status is important to understand this relationship. Indeed in same cases denser cities have a positive impact on energy use and associated emissions, as the proximity of homes and business can encourage walking, cycling and mass transport, leading a decline on gasoline use per capita: “Dense urban settlements can therefore be seen to enable lifestyles that reduce per capita greenhouse gas emissions through the concentration of services that reduces the need to travel large distances, the (generally) better provision of public transportation networks, and the constraints on the size of residential dwellings imposed by the scarcity and high cost of land” (Dodman 2009). A further observation emerges by Dodman’s analysis in regard of the economic status of the countries where the examined cities are located: “in low income countries, residents of denser settlements are likely to have higher per capita emissions as a function of their greater wealth than residents of surrounding areas; in high-income countries, residents of denser settlements are likely to have lower per capita emissions than residents of surrounding areas as a result of smaller housing units and greater use of public transportation systems” (Dodman 2009). Thus the influence of urban density on GHG emissions can have opposite results when analyzed in a context-specific lens. .

Another relevant trend characterizing the Great Acceleration of global changes –and perhaps the most relevant on current times- is the increasing level of globalization. The combination of foreign direct investment, international tourism and telecommunication gives some sense of the rapidly increasing degree of globalization and connectivity (Steffen et al. 2015). Global cities emerge as central nodes of a more and more connected global network of cities, where the flow of goods, services, people, labor and ideas is enormously expanded through digitalization, and “place-based” limits are overcome. While, as claimed by neoclassical economic theory, this increase in flows and the liberalization of international trade “increase the pie” by giving consumers a greater opportunity to choose, at the same time trade globalization alters production and consumption dynamics, often leading to unsustainable spatial implications: “The spatial distancing leads to transport and the associated energy consumption and greenhouse gas emission. The informational distancing, in turn, affects the ability of the consumer to make environmentally and socially informed consumption decision." (Fuchs & Lorek, 2001). As Walker and King (2008:2000) argued describing the problem, "Next time you buy something with 'Made in China' stamped on it, ask yourself who was responsible for the emissions that created it." On the other side, as globalization leads to the diffusion of information and technological innovation, global cities emerge as hubs of innovation, and could play a key role in the diffusion of new technologies for C.C. mitigation and adaptation solutions.

The Climate Emergency

"We declare clearly and unequivocally that planet Earth is facing a climate emergency. To secure a sustainable future, we must change how we live. [This] entails major transformations in the ways our global society functions and interacts with natural ecosystems."

(Ripple *et al.* 2019)

In 1992 more than 1500 scientists from all around the world signed the first *World Scientists' Warning to Humanity*[11], expressing their concerns about the future of the whole living world and calling government leaders to undertake immediate actions toward "a great change in the stewardship of the Earth and life" (Kendal et al. 1992). In their manifesto, they explicitly declared that human activities were on a 'collision course' with Earth's environment, leading irreversible damages that could have disastrous consequences on global scale, even threatening the future existence of the human species. "A new ethic is required - a new attitude toward discharging our responsibility for caring for ourselves and for the Earth." (Kendal et al. 1992)

Twenty-five years later, a second notice was launched by the Alliance of World Scientists, counting more than 15000 signatories from 184 countries[12]. Despite 40 years of global climate negotiations since the First World Climate Conference (Geneva 1979), few progresses have been made and still far from being sufficient to avoid the collapse (Ripple et al. 2017). The time-series data reported by the authors in the second document (fig.8) clearly show that the alarming trends denounced in the 1992 scientists' warning were getting even worse.

Especially worrisome were the trajectories of 'potentially catastrophic climate change', as connected to rising GHGs emissions from fossil fuels (Hansen et al. 2013), deforestation (Keenan et al. 2015) and massive agricultural production (Ripple et al. 2014).

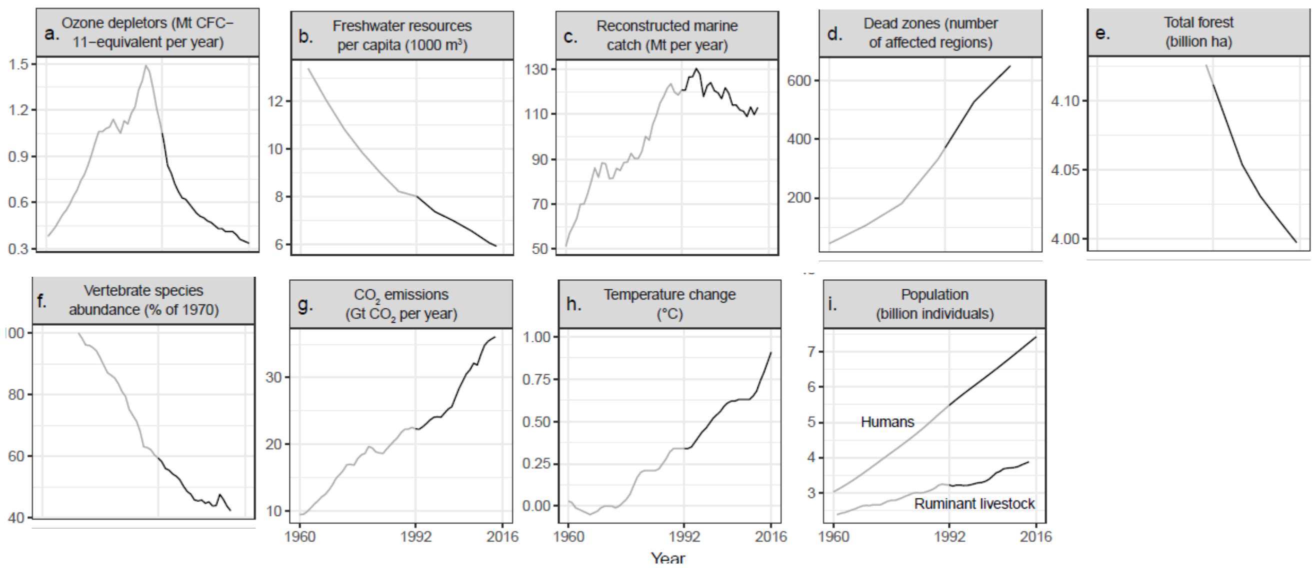
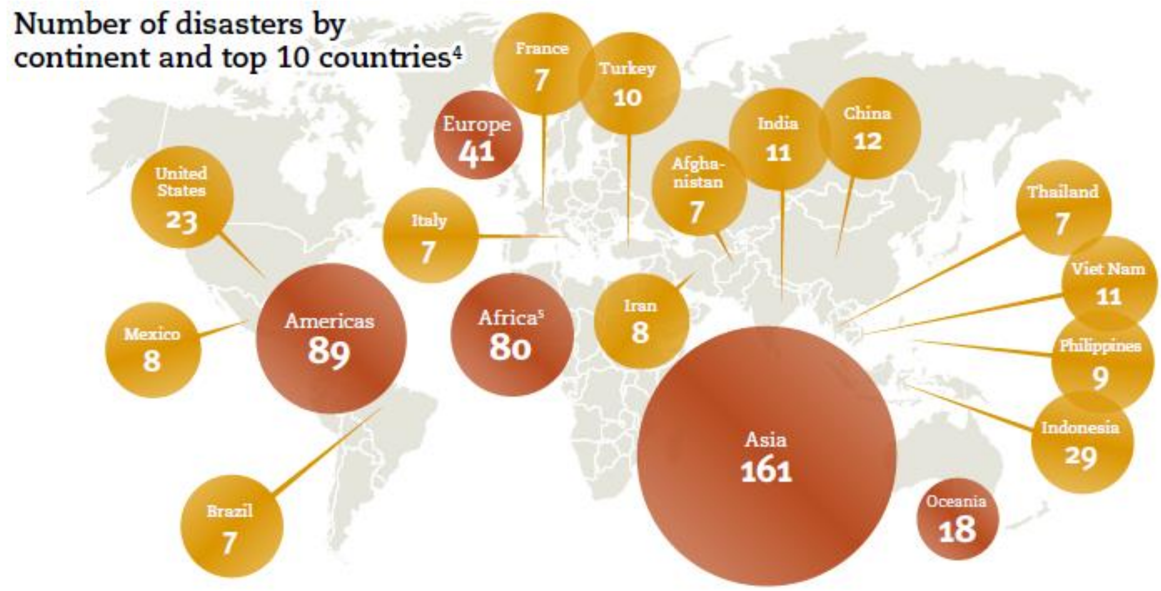


fig. 8. Trend over time (1960-2016) for environmental issues identified in the 1992 scientists' warning to humanity. The years before and after the 1992 scientists' warning are shown as gray and black line, respectively.
(Source: *World Scientists' Warning to Humanity: A second notice*, Ripple et al., 2017)

At the beginning of 2020, just three years after the second notice of concerned scientists, the Alliance of World Scientists renewed the alarm with a 'clear and unequivocal' declaration of Climate Emergency, undersigned by over 11000 scientists from over 150 countries (*World Scientists' Warning of a Climate Emergency*, Ripple et al 2019). "The climate crisis has arrived and is accelerating faster than most scientists expected" (Ripple et al. 2019)

Looking at the extreme natural events occurred just in the last year (fig. 9), it is clear that the Climate Change is increasingly affecting Earth life, bringing death and destruction almost in a daily basis. As stated in the 2020 disasters report of UNDRR, "in comparison to the previous two decades, 2020 was higher than the annual average in terms of number of recorded events and the annual average of economic losses" (CRED & UNDRR. 2020).

fig. 9. Number of disasters by continent and top 10 countries; Tab 1. Top mortality 2020; Tab 2..Top economic losses 2020
(Source CRED & UNDRR. 2020)



The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. In 2014 the IPCC produced their fifth assessment report (AR5)[13], which included a summary of global climate change observations seen thus far, as well as projections for what we should anticipate in the future. The primary difference between the AR5 and all past IPCC reports is that the AR5 assesses a substantially larger knowledge base of relevant scientific, technical, and socioeconomic literature, facilitating a more comprehensive assessment across a broader set of topics and sectors. The AR5 also included expanded coverage of human systems, adaptation, and the ocean. One of the most important items of note in the AR5 is that "climate-change impacts are strongest and most comprehensive for natural systems."[14] This makes an even stronger case for natural resource protection and restoration, as they are also the primary sources of "defense" from impacts to development. In summary, global mean surface temperatures have increased by 0.85° C (1.53°F) since the late 1800s with most of this warming having occurred in the last 50 years. Further, the AR5 reported environmental trends including sea level rise, increases in greenhouse gas emissions, surface ozone variations, ocean acidification and low-oxygen, increases in precipitation levels more intense precipitation patterns, decreases in sea ice cover, and increases in the flow off of the Greenland and West Antarctic ice sheets. Further observations include increased precipitation levels, simultaneously more intense precipitation patterns that result in more droughts, damaging rainfall and more variable climate patterns. These observations capture a global shift in weather patterns that are anticipated to continue further in the future, though the magnitude of these changes remains uncertain and is largely dependent on global emission rates. Under current policies, global temperature are expected to exceed 1.5° C around 2035, 2°C around 2053 and 3.2° C by 2100.

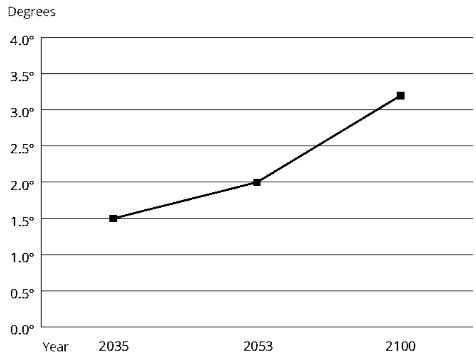
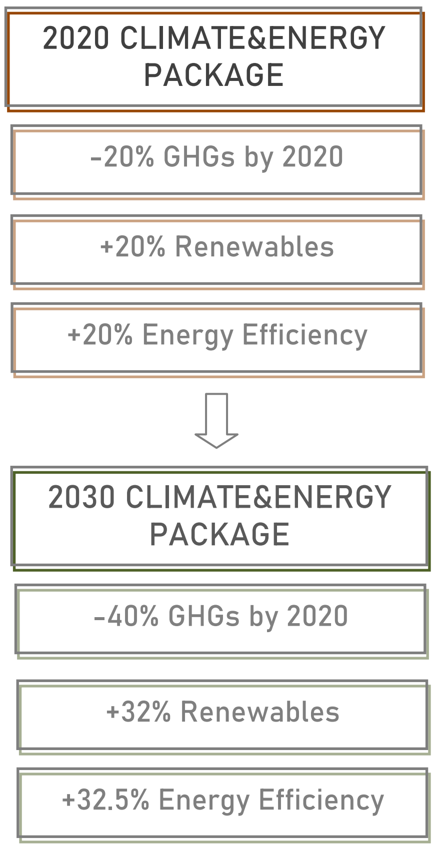


fig. 10. Global temperature prediction by 2100 (Source: Global Catastrophic Risks 2020, Global Challenges Foundation)

In 2015, during the 21st Conference of Parties, the United Nations Framework Convention on Climate Change (UNFCCC) launched the Paris Agreement, setting goals and objectives for climate change mitigation and adaptation, and in particular: "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5° above pre-industrial levels" (United Nation, 2015). The countries that joined the agreement have thus committed to achieve the following objective by 2020: reducing carbon emission by 20%; increasing energy efficiency by20%; increasing the use of renewable energy by20%.



The 2020 has just gone, new future targets have already been set, but – how repeatedly stated on the warnings of the Alliance of World Scientists- the route to achieve carbon-neutrality is still long away.

Learning from current crisis

"Originally, *krisis* meant decision (fr. Greek *krino*): in the evolution of an uncertain process, it was a decisive moment which allowed a diagnosis. Today crisis means lack of decision. It is the moment out of which springs uncertainties as well disruption." (Morin, 1993)

The current crisis provides important lessons to be learned to better manage global risks and avoid catastrophic impacts of future shocks, especially thinking at the ongoing climate change emergency. First we should look at the early stage of the emergency, when a sudden external shock required immediate action to stem the damage. Secondly, we should look deeper at the consequent crisis, as it reveals the internal disruptions that were already ongoing in the socio-economic system before the pandemic. Third we could look at the consequences of such a crisis on existing trajectories of global change to understand what are the possible future scenarios for a post-Covid19 "new normality".

The first lesson that emerges from the analysis of the initial response to the shock is the importance of a fast decision process based on scientific evidences to contain the emergency. Institutional deficits, including a lack of preparedness and hesitant decision-making, can lead catastrophic delays in social reaction, compromising the time available to limit the damages. The corona crisis showed how denial of the evidence and late response by governments can lead to profound and far-reaching consequences, including the loss of human lives (e.g. Trump administration in the USA or Bolsonaro in Brazil). "There are critical points after which a certain level of damage cannot be forestalled anymore" (Vinke et al. 2020). In the framework of risk management, the magnitude of the emergency is identified as the product of *risk* and *urgency* (fig 11). In the diagnosis and prognosis of threats, risks are described by the intensity of the damage (D) and the probability for the damage to be incurred (p). Both are interested by a grade of uncertainty that scientific models can partially cover. On the other side, the level of urgency takes into account temporal variables, such as the intervention time (T: the time-span from the point that a risk is identified to the point of impact) and the reaction time (τ: the time needed to minimize or avoid the damage), and can be considered a multiplier of risks. The sense of urgency strongly depends also to the public perception, which can determine a faster or slower reaction. Scientific predictions could expand the timespan for intervention, but to change risk perception it is crucial a credible and effective communication of scientific information.

$$E = R \times U = p \times D \times \tau / T$$

Emergency = **R**isk x **U**rgency
Risk= **p**robability x **D**amage
Urgency= reaction **t**ime / Intervention **T**ime

Fig11. Risk and Urgency as the main variables to identify in the Emergency framework. Source: adapted from Vinke et al. 2020

The coronavirus crisis was a shock, but should not have been a surprise. Epidemiologists and other scientific experts have been warning for years about the high possibility of future viral pandemics.

As population increases and presses into natural areas, the chances of new viruses affecting world population grow even greater. Moreover the ease and extent of travel in our globalized era make the spread of diseases around the world happen more rapidly, with global cities emerging as major nodes of diffusion. Since 2006, pandemics appeared at the top list of global risks international reports. In the last 20 years, SARS, H1N1, Ebola, and MERS showed the risks of such viruses racing across borders, and highlighted the urgent need of preparing for effective national and global responses. Despite that, in front of the emerging of Covid19 pandemic, governments and major international institutions appeared quite unprepared to stem the cascading effects that followed the collapse of health care system. The New York Time opinion columnist Thomas Friedman described the Covid-19 pandemic as a *black elephant*, "a cross between a *black swan* –an unlikely, unexpected event with enormous ramifications- and the *elephant in the room* –a looming disaster that is visible to everyone, but no one wants to address"[15]. In the eyes of scientists the actual outbreak was a predictable event, just like the threat of an abrupt climate change is. Both are *black elephants*, "wicked" dilemmas no one would like to care. Both are a manifestation of the *Anthropocene*, the result of increasing human pressure on the planet, at once threatening and arising from our hyper-globalized society, where risks –as well as ideas and opportunities- have no spatial boundaries.

Despite these similarities, the most striking difference between the two crises is the urgency to withstand the rapid spread of the pandemic as compared to the slow and weak action to mitigate longstanding, scientifically well-documented, and accelerating climate change (Lidskog 2020). Temporal and epistemic analysis show inverse dynamics in the evolution of the two emergencies. The urgency of action on climate change has been heavily stressed for years by the scientific community (e.g. IPCC reports or the 3 warnings to humanity signed by thousands of scientist in almost 30 years) and became quite mainstreamed in international political debates, with different groups arguing either for the necessity of a radical change or a more gradual incremental transition. Despite that, as actually the impacts of global warming are experienced as spatially localized events and not universally perceived as immediate threats for the whole humanity, there is still a huge gap between what has been done and what needs to be done to achieve the objectives of the Paris Agreement and avoid the irreversible consequences of an abrupt climate change. "Paradoxically the temporal regime developed for climate change makes it possible to hesitate and even postpone necessary action" (Lidskog 2020)

On the opposite, the temporal perception of Covid-19 is based on an extreme time compression that not leaves space for well documented scientific knowledge: in the initial modeling of the virus outbreak, there was no peer review due to the necessity of rapid information made available for government (Gallaghan 2020). The pandemic shows tangible and immediate consequences everywhere at the same time, if not directly experienced by population, enormously echoed by global media; thus such extreme sense of urgency did not leave time to postpone action for further investigation on the origin and the nature of the virus or either for analyzing the socio-economic impacts of containment measures. Contrary to the attitude that politicians showed towards climate or environmental scientists –whose voice has gone unheard for years- the valorization of medical knowledge had an important role in directing the policy orientation, with negative effects of lockdowns considered secondary to the primary aim of 'flatting the curve' and preserving health system. Decision-makers were quick to implement measures to contain the pandemic because they could be personally held accountable for rising death numbers. On the other hand, citizens largely obeyed the newly imposed constraints, because the threats of the corona pandemic are perceived as imminent and personal, and also because such stringent measures were expected to be limited into a temporary range of a few months.

Despite the differences between the two emergencies, a common issue occurs in their management mechanism, that is the growing role of models, data and forecasting in legitimizing interventions. Although the criteria for collecting and comparing data are notably different, data visualization emerges as an important tool to inform civil society on the direction, speed and severity of the evolving trends, as well on probable future development. The Covid-19 emergency also highlighted the central role of mass-media in the dissemination of data and in communicating urgent measures, showing their ever-increasing power in influencing the risks perception of population. On the other side of the coin, despite their controversial influence on human behavior, in time of social distancing social media became also the major route for networking and community support, contributing in a certain sense to strengthen social resilience (Mano 2020).

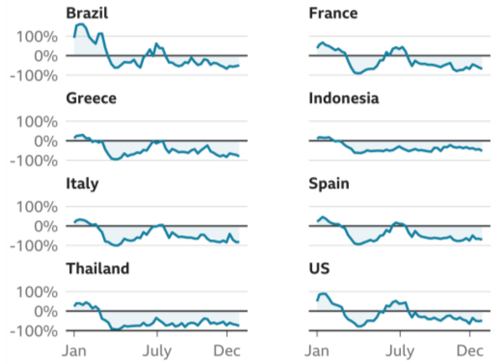
The crisis is a "mirror into which we can look and see exposed both our individual selves and our collective societies" (Hulme 2009). As much it advances, it reveals the weaknesses of existing arrangements and institutions worldwide, as well the unpreparedness in front of global threats of high level complexity and interconnectedness. Moreover it brings to the light what was hidden within the 'normality', the internal disruptions that were already ongoing before the pandemic, and the incapacity of international, national and local governments to respond to the evolving needs of the society in a world that is rapidly changing. Thus, the first image this crisis reflects is the underlying chronic social illness of the world, which is the pervasive socio-economic inequality leading vulnerabilities (Zinn 2020). Indeed the crisis exploded in an already hyper-turbolent environment: *Black Lives Matter* protests over racial injustice in June 2020, as well as the *Strikes for Future* young movement for climate justice in late 2019, both reflect a collective desire to bring real change into the society.

In the narrative of global changes, the 2020 Covid19 emergency intersected the trajectories of the *Great Acceleration*, temporary slowing down the growth of some trends (such as GHGs emissions, private transportation, international tourism and GDP) and giving a further acceleration to other phenomena, such as digitalization and renewables expansion in the market. Stringent government measures- such as the ban of mass gatherings, the closure of schools, the reduction of economic activities, travel restrictions and draconian home confinement- drastically altered the patterns of energy demand around the world, causing the largest decline since World War II. Mobility restriction strongly affected the transport sector (from 40 to 80% transport decrease across the world), leading a historic crash in crude oil demand, with prices dropping down to negative in April 2020 (fig 12). Lockdown measures restricted commercial and industrial activities, causing a fall on electricity demand by around 20-30% in the first half of the year. Global CO2 emission declined by 5.8% -around 2GT Co2- the largest ever decline and almost five times greater than the 2009 drop that followed the global financial crisis (IEA 2021). Travel industry and global tourism fell down drastically and are still long away from recovery (fig 13). Cultural and creative sectors (such as museum, performing arts, live music, festivals, cinema, etc.) have been among the most affected by social distancing measures, with an abrupt drop in revenues that still have hard repercussions for the value chain of their suppliers (OECD 2020). Massive digitalization coupled with emerging technologies, such as virtual and augmented realities, created new form of cultural experience and new business model with market potential.

Impacts of Pandemic on global changes trends

fig. 12. Historic Crash of Crude Oil price as April 2020 Source: Bloomberg 2020
https://www.bloombergquint.com/business/oil-worth-less-than-nothing-points-to-a-deepening-global-crisis

fig. 13. Global tourism industry 2019-2020
Source: International Monetary Fund, (IMF 2020)
https://www.bbc.com/news/business-51706225



Some cultural and creative sectors, such as online content platform, have profited from the increased demand for cultural content streaming during lockdown, but the benefits from this extra demand have largely accrued to the largest firm in the industry. Moreover, although the emerging of new stream platforms allowed business and education sectors to survive, the *great acceleration* of digitalization exacerbated social inequalities –in same cases low income people cannot afford the cost of new technologies- and multiplied the risks of cybernetic attacks (IMF 2021, OECD 2020). Global economy shrunk by 4.4% -the worst decline since Great Depression of 1930s (IMF 2020)- dragging most of the world's countries into recession (fig 14) and causing a rising rate of unemployment all over the world (fig 15).
However, since "a crisis is not permanent", but "manifests itself between temporal boundaries" (Morin, 1993), these effects are only temporary and recovery stimulus packages open the way to new future forecast. IEA's projections indicate that, as Covid19 restrictions are lifted, global economic output is set to rebound by 6% in 2021, pushing the global GDP more than 2% higher than 2019 levels. Electricity demand is forecasted to grow by 4.5% and emerging markets are expected to drive an increase in global energy by 4.6%, pushing global energy use 0.5% above pre-Covid19 levels.

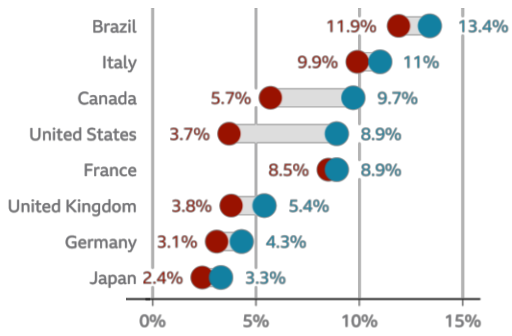


fig.15. Yearly unemployment rate change, between 2019 (blue) and 2020 (red)
Sourcs: International Monetary Fund, IMF 2020

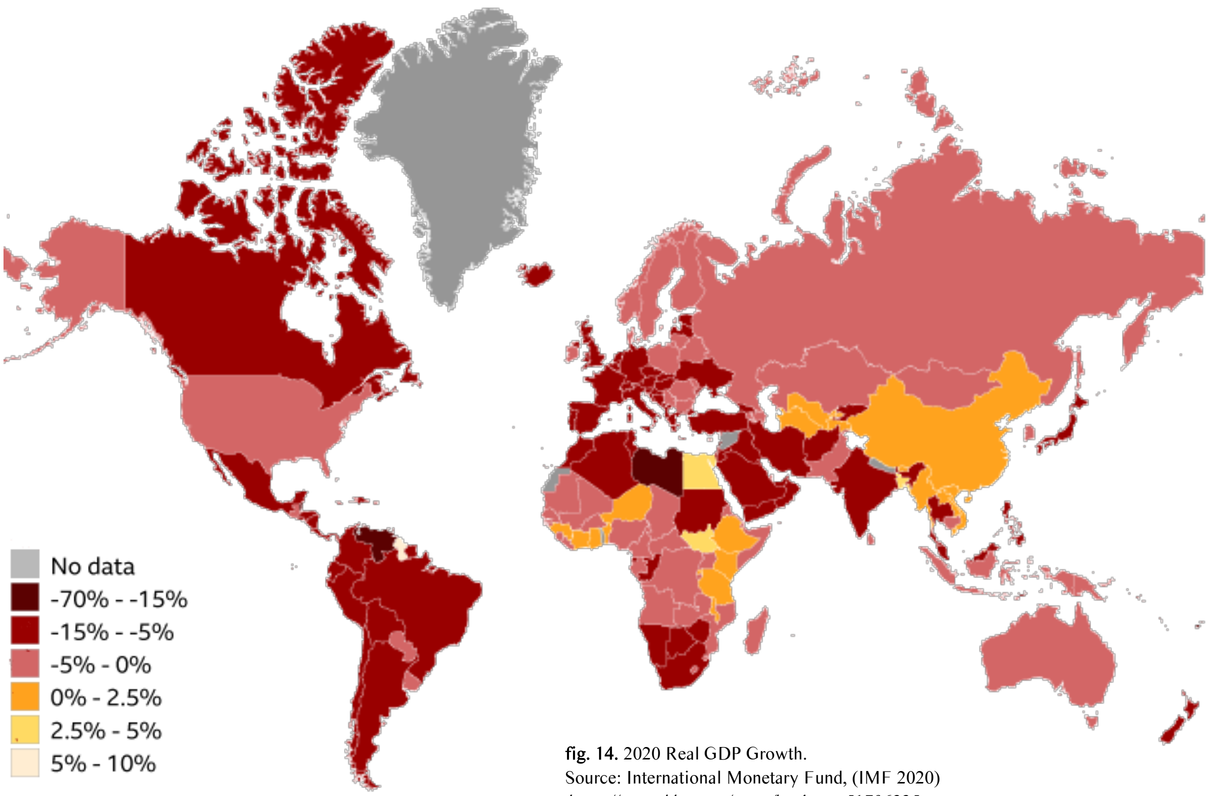


fig. 14. 2020 Real GDP Growth.
Source: International Monetary Fund, (IMF 2020)
https://www.bbc.com/news/business-51706225

As demand for coal, oil and gas rebound with economies recover, global energy-related CO2 emissions are projected to grow by nearly 5% with an increase of over 1500 Mt CO2, just 1.2% below the 2019 peak (fig 16; IEA, 2021). On the other hand, renewable technologies gained a positive momentum, emerging as “the success story of the Covid-19 era” (IEA, 2021). Despite lower electricity demand and construction delays due to the pandemic emergency, long-term contracts and continuous installation of new plants underpinned renewable growth into the market: in 2020 the demand for renewables grew by 3% and in 2021 it is expected to increase across all key sectors –power, heating, industry and transport. Renewable electricity generation is projected to expand by more than 8%, with Solar PV and wind forecasted as the most promising technologies, contributing for two-thirds of sectorial growth.

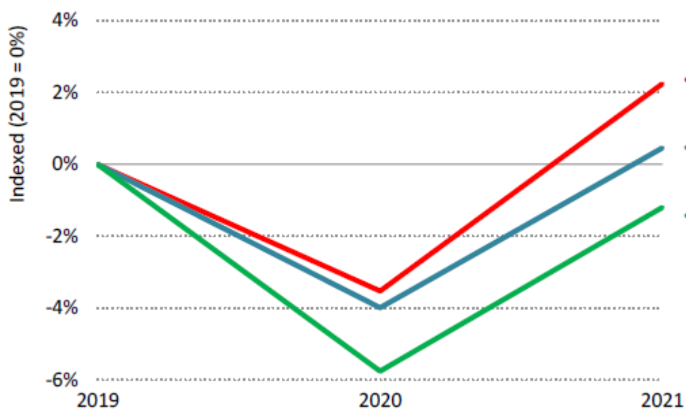


fig. 16. Evolution of global GDP, total primary energy demand, and energy-related CO2 emissions, relative to 2019. Source: IEA, 2021.

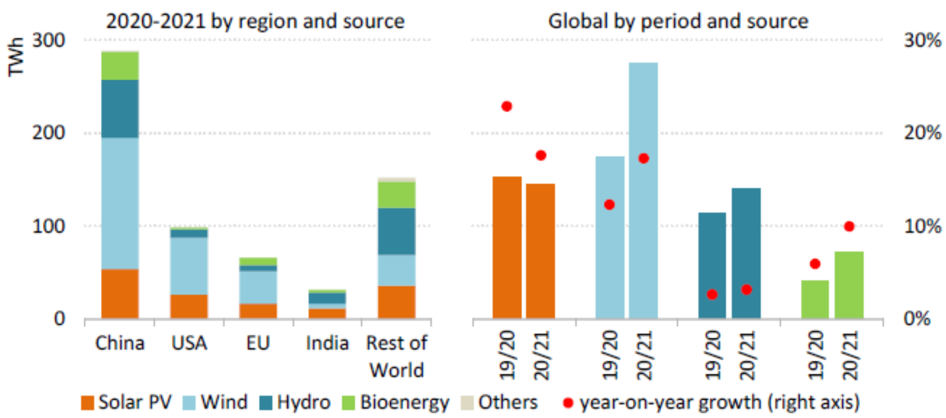


fig. 17. Renewable energy generation increase by technology, country and region. Source: IEA, 2021.

The emerging COVID19 crisis and the necessity to define a new recovery plan bring the proposal of a Green New Deal to the fore in both EU and US contexts, embracing the objectives of the Just Transition program to link together crisis response, climate emergency and social justice issues for a more equitable, resilient and sustainable future development. In this panorama, the thematic of Post-Carbon Transition becomes a central issue for GND proposals, bringing multi-layered solutions to address both the challenges of climate change and the socio-economic problems underlying the current pandemic crisis: “to achieve net-zero greenhouse gas emissions through a fair and just transition for all communities and workers” and “to create millions of good, high-wage jobs and ensure prosperity for all people” (Galvin and Healy 2020).

CHAPTER II
Transition with Resilience. An Evolutionary Framework

Building the conceptual Framework

The concept of Post Carbon embodies a deep rupture in the traditional carbon-dependency pathways: it is not just a shift from one set of fuels to another, but involves a much deeper transformation at physical, social, economic, institutional and political levels, even including change in individual lifestyle.

The field of Transition Management focuses on the trajectory of change, and therefore, seeks to uncover the origins, patterns, and mechanisms that drive these transitions. In this multi-layer perspective, Urban Transition is defined as a 'co-evolving process which lead the community of an urban system to progressively transforming and re-organizing theselves in a way that meets long-term sustainable development goals' (Johannessen and Wamsler, 2017).

On the other side, in the past decade the concept of Urban Resilience has been enormously mainstreamed both in academic debate and political propaganda. At urban level, resilience strategies have been emerging as useful tools to manage shocks and stresses affecting cities, embracing the evolutionary concept of 'adaptive change' and shifting the paradigm of resilience from the 'bounce back' to the 'bounce forward' approach. This change of perspective, together with a multi-dimensional approach, bring resilience-building processes closer to the Sustainable Transition objectives, addressing shocks, stresses and vulnerabilities as opportunities to design better future scenarios.

As part of the Work Package 1 of TreNd project, the first objective of this thesis is to develop a new conceptual framework embracing both Transition Management strategies and Resilience-building policies under the lens of Evolutionary theories. This chapter provides a literature review about the main theoretical concepts used to build the new framework.

Transition Management toward Post Carbon Scenarios

The topic of Post-Carbon Transition has been gradually been gathering steam in political and academic debate: the existing literature provides a variety of other terms converging on the objective os sustainable transition (low-carbon -Peters et al., 2010; Bulkeley et al. 2011; Gossop,2011;), zero-carbon (Dunster et al, 2008), carbon-neutrality, climate-neutrality, etc) "but post carbon cities is not only a new concept beyond "low carbon", it implies a paradigm shift about relationships between energy and city" (Vidalenc 2013). Post carbon cities is proposed as a concept allowing to put in a nutshell energy and climate issues Energy and climate would become an essential issues, at the same time as long term target (reduction of GHG) and as short term requirements (resilience with regards to oil price rising and supply disruption)

As fossil fuel currently dominates the global energy system, the ideal of a Post Carbon City is quite difficult to shift into reality: it builds upon issues beyond greenhouse gas (GHG) emissions, energy conservation and climate change and adds "a broader set of concerns including economic justice, behaviour change, wellbeing, mutualism, land ownership, the role of capital and the state, and selfmanagement" (Breil 2015). It embodies a drastic rupture in the trajectories of urban carbon-dependency, a radical revolution that affects not only the physical dimension of the city (the build infrastructures and technological system), but also its intangible system (socio-economic layer or immaterial infrastucture- Loorbach, 2010), undermining the basic mechanism of competitive economies (production/consuption), other than people lifestyles and habits. Using again the words of Schumpeter, Post-Carbon Transition needs all the "Creative Destruction" power of Innovation, as also all the collaborative environment that a knowledge-based innovation ecosystems can offer to urban reality: *"knowledge-based [urban] development [is] the transformation of knowledge resources into local development [which] could provide a basis for sustainable development" (*Knight, 1995, pp.225-226*)."*

Transition Management has been defined as "*a form of intelligent long-term planning through small steps based on learning and experimenting*" (Rotmans & Loorbach, 2010) and involves multiple domains, scales and levels. To design the transition process at urban level, it is necessary to have a good understanding of initial conditions (context analysis) and a clear vision of the objectives to achieve (goals) in a determined period of time (long-run). Despite that, TM processes do not explicit "*clear-cut objectives or normatively defined principles to steer the process of transition dynamics towards a more sustainable world*" (Rauschmayer, Bauler, & Schäpke; 2015). Shortcomings of the model concern also the metrics regarding both the impacts and the indicators for measure the ongoing process (Rotmans & Loorbach, 2010).

In this panorama, the Wuppertal Institute (*leading international think tank for sustainability research*) introduced the Transformative Science as a new research concept "*that is not limited to observing and describing processes of transformation, but rather becomes an agent in these processes, simultaneously learning about and proactively catalysing transformations to sustainability"*. It proposes a transdisciplinary research programme system knowledge oriented, that is structured in 4 topic divisions (Future Energy and Industry Sistems, Energy, Transport and Climate Policy, Sustainable Production and Consumption, Circular Economy) and 13 research units strictly interrelated. Among them emerges the Urban Transition sector that pursues the vision of a "*low-emission, resilient, climate-sensitive and socially active and innovative city"* and extends the research fields to three policy areas (*Climate protection/energy, climate change adaptation and sustainability*), pointing out 4 key topics of urban sustainability: Transition of governance, Transition of city economics and energy economy, Transition of construction and living in buildings and urban districts, Transition of land use and residential development.

Urban Resilience and Resilience Strategies

Over the past decade, resilience-building approaches have grabbed an increasing attention in climate adaptation policies, environmental management, regional economic development and strategic planning. Originally referring to the mechanical property of materials of springing back to the precedent state of equilibrium after a temporary disturbance (fr. Latin *resil-ire* : 'to bounce back'), the term entered in the field of ecology in the early 1960s with multiple meanings emerging from different scientific traditions (Holling 1961, Morris 1963, Lewontin 1969). The most cited author to explain the origin of the modern resilience theory is the ecologist C.S. Holling, who first proposed a distinction between the engineering equilibrium-based definition of resilience and the significance it assumes for dynamic and complex ecosystems: "It is useful to distinguish two kinds of behavior. One can be termed *stability* which represents the ability of a system to return to an equilibrium state after a temporary disturbance; the more rapidly it returns and the less it fluctuates, the more stable it would be. But there is another property, termed *resilience*, that is a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationship between state variables" (Holling 1973). Since then the Holling's non-equilibrium paradigm of resilience has been largely adopted in ecologic discourses, especially referring to the socio-ecological system (SES) framework, where resilience is defined as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks" (Valker, Holling, Carpenter & Kinzig 2004).
In the last years, the term became very popular also across other disciplines (e.g. psychology, sociology, geography, urban planning,

etc.), with a proliferation of meanings and definitions that led scholars affirm that “resilience is in danger of becoming a vacuous buzzword from overuse and ambiguity” (Rose 2007).

Among all the interpretations emerges the metaphor of Evolutionary Resilience (Davoudi 2012a) whose framework is based on the idea of “continuing and progressive change” of complex systems (Krugman, 1996) and it is connected with the adaptive cycles of panarchic theory (growth, conservation, creative destruction and reorganization - Holling and Gunderson 2002). In the Evolutionary perspective, resilience is interpreted as “the ability of complex social-ecological systems to change, adapt or transform in response to stress and strain” (Carpenter et al., 2005) or “the ability of a region or urban system to change its structure and function rapidly and successfully in response to a shock” (Simmie and Martin, 2010) or also as “a permanent process of adjustment and change” (Wink, 2014). Change is key factor and the reactive perception of resilience that characterizes “emergency planning” and “shock therapy” is rejected in favour of a new proactive view in which communities play a vital role cultivating preparedness through learning capacity and seeking potential transformative opportunities through adaptation and innovation (Mehmood 2016).

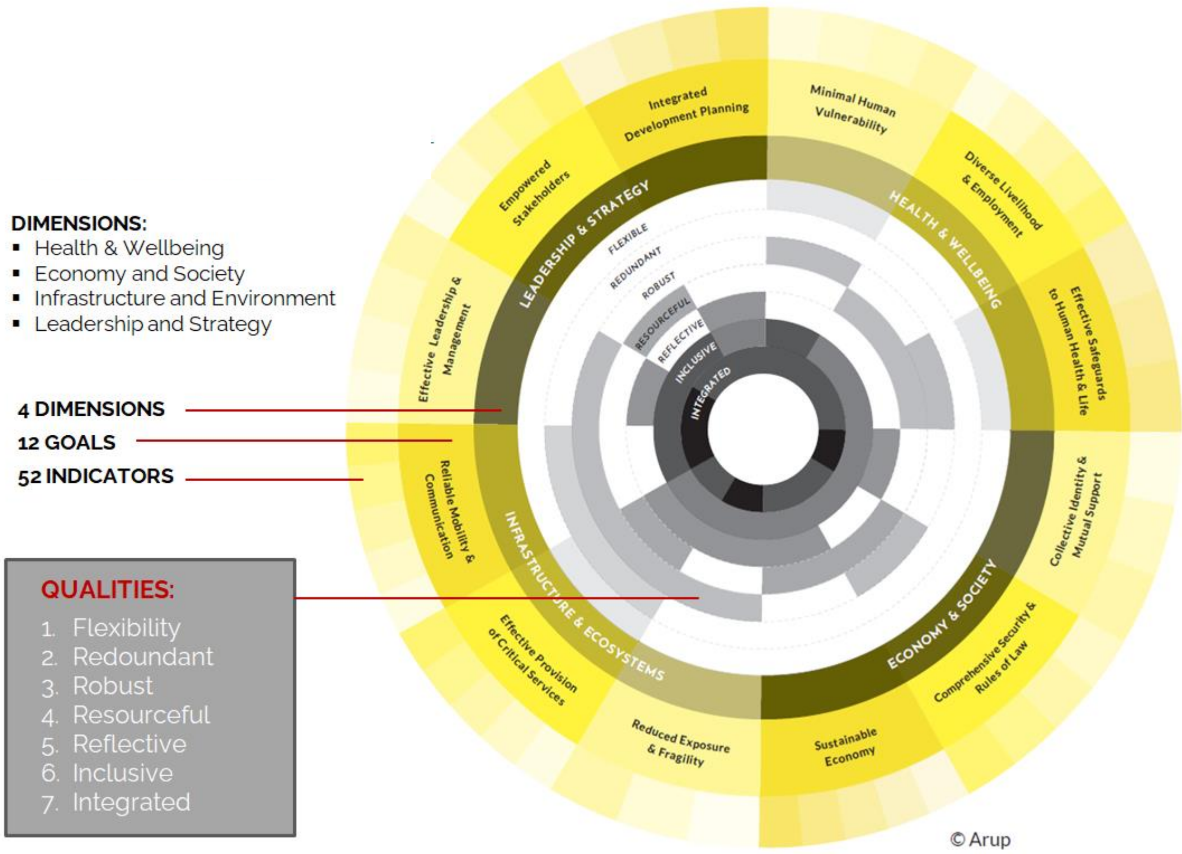
In the Adaptive Cycle of Evolutionary theory, crisis is interpreted as a phases of Creative Destruction, characterized by a period of chaotic collapse and uncertainty and followed by a phase of reorganization (“time of innovation, restructuring and greatest uncertainty but with high resilience” -Pendall et al., 2010, p. 76). This concept originates from Schumpeter’s “gale of Creative Destruction”, a methaphor used to describe the role of innovation in the evolutionary mechanism of Capitalistic system: “a process of mutation, that incessantly revolutionalizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one”(Schumpeter, 1942).

Another interesting perspective that blends resilience with sustainable transition is addressed by Peter Newman who defines urban resilience as “the capability to anticipate, plan for, and mitigate the risks, and seize the opportunities, associated with economic, environmental, and social change” (Newman et al., 2017). His framework turns around the transition from an ‘exploitive city’ -in which wealth is associated with ever increasing ecological footprint- to a ‘resilient city’ (‘sustainable’ + ‘regenerative’) – in which wealth is associated with fossil fuel reduction. His vision of urban resilience is based on a transition-oriented development, “as a response to the global climate change associated with fossil fuel dependency and subsequent greenhouse gas emissions” (Newman et al., 2009).

Since the 1990s, global financial institutions such as the International Monetary Fund (IMF 2005), the World Bank (2006) and the Bank for

International Settlements (2002, 2008) have increasingly incorporated strategies of 'resilience' into their logistics of crisis management, financial regulation and development economics. After the disaster of 9/11, resilience has become a byword among agencies charged with coordinating security responses to climate change, critical infrastructure protection, natural disasters, pandemics and terrorism (Cabinet Office, 2007; World Bank, 2008; World Economic Forum, 2008), reorienting policies toward a horizon of critical future events that we cannot predict or prevent, but merely adapt to by 'building resilience'. The concept of resilience has now become 'a pervasive idiom of global governance'(Walker 2011)

In 2013 the Rockefeller Foundation launched the '100 Resilient Cities' program, with the aim of developing an international network to help cities to build their urban resilience strategies. Grounding on the Resilience Framework provided by City Resilient Index (Arup 2015), Resilience Strategies interest 4 aspects of urban dimension, such as Heath and Wellbeing, Economy and Society, Infrastructure and Environment, Leaders and Strategy.



CHAPTER III
Measuring TreNds

A problem of metric

In field of urban management, indicators are recognized as useful tools for policymakers, offering an overall snapshot of the city that highlights relevant issues to be prioritized in policies design and implementation (UN-Habitat 2013). Well-designed indicators measure trends over time, playing a central role in the monitoring and evaluation process of current policies and allowing decision makers to make adjustments where required (OECD 2018). As the concept of sustainable development became a mainstream issue in the international debate, conventional indicators based on classical model of economic growth appeared insufficient and quite inadequate to catch the holistic framework proposed by the Urban SDG 11 (Gómez-Álvarez et al. 2018). During the 2016 World Economic Forum in Davos, the leaders of international organizations argued that the Gross Domestic Product (GDP) –introduced by Simon Kuznets in the 1930s and still the major indicator of economic prosperity - is not the best way to assess the complex dynamics resulting from urbanization processes (Thomson 2016). New metrics were required to measure urban progress within the three pillars of Sustainable Development. The evolution of urban metrics runs in conjunction with the conceptualization of development, well-being and prosperity, up to incorporate the new mainstream paradigms of sustainability, resilience and low-carbon transition.

This chapter investigates the problem of metrics, identifying the main scientific contributions to asset methods to measure transition. In the same chapter, it is presented a new set of indicator based on the proposed framework.

The evolution of Urban Indicators

Three main generations of indicators have been identified in the evolution of urban metrics (Gómez-Álvarez et al. 2018). The first emerged in 1960s, when the World Bank launched the first World Development Indicators Series (Wong 2006, 2014). It focused on classical economic variables to measure urban progress and development through three main dimensions: the economic dimension, through GDP; the demographic dimension, through population count; and the size dimension, through city sprawl. This way to measure cities through isolated indicators catches only a small piece of city puzzle, but is not capable to reflect the complexity of urban systems, neither adequate to grab issues such as well-being in terms of quality of life.

The second originated with the Agenda 21 (UNCED - United Nations Conference on Environment and Development, 1992), but it was implemented with the introduction of Millennium Development Goals (MDGs), a suite of eight goals -measurable and universally agreed- focused on a broader understanding of development, which paid greater attention to human and ecological well-being and encompasses the aim of fostering progress in 'developing countries' (UNDP – United Nation Development Program, 2016). As a result of target specific policy questions, new sets of indicators were developed shifting from the conventional macroeconomic perspective to a broader approach that included new dimensions, themes and methods for a deeper analysis of local context. As example of this generation of indicators, there are: *The Global City Indicators Program* [16](GCIP), developed by the World Bank in 2008 with a strong focus on the performance of cities' public services; the *Cities Data Book*[17] (CDB), formulated by the Asian Development Bank in 2001, whose broad environment-related categories (water, wastewater, solid, waste, noise and so forth) go into great detail on specific concerns of each sector; the *Global Urban Indicator*[18], created by UN-Habitat in 1996 and focused on the concerns of cities in developing countries (OECD 2012).

The third generation of urban indicators corresponds to a more holistic conceptualization of city prosperity, promoted with the establishment of the 17 Sustainable Development Goals (SDGs) and the 2030 Development Agenda (2015), and materialized in the *City Prosperity Index* (CPI). The publication of the *State of the World's Cities 2012/2013: Prosperity of Cities* (UN-Habitat 2013) introduced a new multidimensional paradigm of sustainable development, in which collective well-being and public goods take a central position. For example, since 2013 some countries around the world adopted the *Social Progress Index*[19] , a *Beyond GDP* framework designed to monitor and enhance progress in societal development.

With the third generation of indicators, it emerges also the necessity to address an international standardization of urban metrics. With this intent, the *World Council on City Data* (WCCD)[20] was founded in Canada in 2014, expanding as a global network of cities that embrace ISO standardized data to address urban management, planning and investment process as well as results and progress monitoring. Under the supervision of WCCD, in 2018 three international standards have been published by the International Organization for Standardization (ISO) in Geneva and globally recognized as the WCCD ISO 37120 Series on City Data. The Council's City Data Platform now includes over 276 key performance indicators (KPIs), divided in three indicator sets and 19 themes (Tab 1):

- ISO 37120- Indicators for Sustainable Cities;
- ISO 37122- Indicators for Smart Cities
- ISO 37123- Indicators for Resilient Cities

WCCD has also developed an audit protocol for cities of any size and geographical location to report data accordingly with these three international standards. Actually 100 cities of 35 countries joined the network.

With SDG11, urban dynamics assume the potential to lead transformative changes that, if effectively steered, could help to overcome major global challenges. "This new approach does not only respond to the crises by providing safeguards against new risks, but it also helps cities to steer the world towards economically, socially, politically and environmentally prosperous urban futures." (Clos, quoted in UN-Habitat 2013)

Many attribute of urban center can be measured and compared: populations vary from a few hundred to more than 20 million, areas vary from less than one to thousands of square kilometers, average life expectancy at birth varies from more than 80 years to less than 40 years, GHG emissions per person (intonnes of carbon dioxide equivalent) vary by more than 100 (Dodman, 2009; Hoornweg et al., 2011), and average per capita incomes vary by a factor of at least 300. So too does the funding available to local governments per person (UCLG, 2010).

ISO 37120 Indicators for Sustainable Cities	ISO 37122 Indicators for Smart Cities	ISO 37123 Indicators for Resilient Cities
ECONOMY ▪ City's unemployment rate (C) ▪ Assessed value of commercial and industrial properties as a % of total assessed value of all properties (S) ▪ % persons in full-time employment (S) ▪ Youth unemployment rate (S) ▪ Number of businesses * (S) ▪ Number of new patents * per year(S) ▪ Annual number of visitor stays (overnight) * (S) ▪ Commercial air connectivity (S) ▪ Economy profile indicators (P) - Average household income - Annual inflation rate based on the average of the past five years - City product per capita **EDUCATION** ▪ % of female school-aged population enrolled in schools ▪ % of students completing primary education: survival rate ▪ % of students completing secondary education: survival rate ▪ Primary education student–teacher ratio ▪ % of school-aged population enrolled in schools ▪ Number of higher education degrees * **ENERGY** ▪ Total end-use energy consumption per capita (GJ/year) ▪ % of total end-use energy derived from renewable sources ▪ % of city population with authorized electrical service ▪ Number of gas distribution service connections * ▪ Final energy consumption of public buildings per year (GJ/m2) ▪ Electricity consumption of public street lighting per km of lighted street (kWh/year) ▪ Average annual hours of electrical service interruptions per household ▪ Energy profile indicators ▪ Heating degree days ▪ Cooling degree days **ENVIRONMENT AND CLIMATE CHANGE** ▪ Fine particulate matter (PM2.5) concentration ▪ Particulate matter (PM10) concentration ▪ GHG emissions (tonnes per capita) ▪ % of areas for natural protection ▪ NO2 (nitrogen dioxide) concentration ▪ SO2 (sulfur dioxide) concentration	**ECONOMY** ▪ % of service contracts providing city services which contain an open data policy ▪ Survival rate of new businesses * ▪ % of the labor force employed in occupations in the information and communications technology (ICT) sector ▪ % of the labor force employed in occupations in the education and research and development sectors **EDUCATION** ▪ % of city population with professional proficiency in more than one language ▪ Number of computers, laptops, tablets or other digital learning devices available per 1 000 students ▪ Number of science, technology, engineering and mathematics (STEM) higher education degrees * **ENERGY** ▪ % of electrical and thermal energy produced from wastewater treatment, solid waste and other liquid waste treatment and other waste heat resources, as a share of the city's total energy mix for a given year ▪ Electrical and thermal energy (GJ) produced from wastewater treatment per capita per year ▪ Electrical and thermal energy (GJ) produced from solid waste or other liquid waste treatment per capita per year ▪ % of the city's electricity that is produced using decentralised electricity production systems ▪ Storage capacity of the city's energy grid per total city energy consumption ▪ % of street lighting managed by a light performance management system ▪ % of street lighting that has been refurbished and newly installed ▪ % of public buildings requiring renovation/refurbishment ▪ % of buildings in the city with smart energy meters ▪ Number of electric vehicle charging stations per registered electric vehicle **ENVIRONMENT AND CLIMATE CHANGE** ▪ Percentage of buildings built or refurbished within the last 5 years in conformity with green building principles ▪ Number of real-time remote air quality	**ECONOMY** ▪ Historical disaster losses as a percentage of city product (C) ▪ Average annual disaster loss as a percentage of city product (S) ▪ Percentage of properties with insurance coverage for high-risk hazards (S) ▪ Percentage of total insured value to total value at risk within the city ▪ Employment concentration ▪ Percentage of the workforce in informal employment ▪ Average household disposable income **EDUCATION** ▪ Percentage of schools that teach emergency preparedness and disaster risk reduction ▪ Percentage of population trained in emergency preparedness and disaster risk reduction ▪ Percentage of emergency preparedness publications provided in alternative languages ▪ Educational disruption **ENERGY** ▪ Number of different electricity sources providing at least 5% of total energy supply capacity ▪ Electricity supply capacity as a percentage of peak electricity demand ▪ Percentage of critical facilities served by off-grid energy services **ENVIRONMENT AND CLIMATE CHANGE** ▪ Magnitude of urban heat island effect ▪ Percentage of natural areas within the city that have undergone ecological evaluation for their protective services ▪ Territory undergoing ecosystem restoration as a percentage of total city area ▪ Annual frequency of extreme rainfall events ▪ Annual frequency of extreme heat events ▪ Annual frequency of extreme cold events ▪ Annual frequency of flood events ▪ Percentage of city land area covered by tree canopy ▪ Percentage of city surface area covered with high-albedo materials contributing to the mitigation od urban heat islands

▪ O3 (ozone) concentration ▪ Noise pollution ▪ % change in number of native species **FINANCE** ▪ Debt service ratio (debt service expenditure as a percentage of a city's own-source revenue) ▪ Capital spending as a % of total expenditures ▪ Own-source revenue as a % of total revenues ▪ Tax collected as a % of tax billed ▪ Finance profile indicators - Gross operating budget per capita - Gross capital budget per capita **GOVERNANCE** ▪ Women as a % of total elected to city-level office ▪ Number of convictions for corruption and/or bribery by city officials * ▪ Number of registered voters as a % of the voting age population ▪ Voter participation in last municipal election (% of registered voters) **HEALTH** ▪ Average life expectancy ▪ Number of in-patient hospital beds * ▪ Number of physicians * ▪ Under age five mortality per 1000 live births ▪ Number of nursing and midwifery personnel * ▪ Suicide rate * **HOUSING** ▪ % of city population living in inadequate housing ▪ % of population living in affordable housing ▪ Number of homeless * ▪ % of households that exist without registered legal titles ▪ Housing profile indicators: - Total number of households - Person per unit - Vacancy rate (residential) - Living space (m^2) per meters - Secondary residence rate - Residential rental dwelling units as a % of total dwelling units **POPULATION & SOCIAL CONDITION** ▪ % of city population living below the international poverty line ▪ % of city population living below the national poverty line ▪ Gini coefficient of inequality ▪ Population and social conditions profile indicators - Annual population change	monitoring stations per km^2 ▪ % of public buildings equipped for monitoring indoor air quality **FINANCE** ▪ Annual amount of revenues collected from the sharing economy as a percentage of own-source revenue ▪ % of payments to the city that are paid electronically based on electronic invoices **GOVERNANCE** ▪ Annual number of online visits to the municipal open data portal * ▪ % of city services accessible and that can be requested online ▪ Average response time to inquiries made through the city's non-emergency inquiry system (days) ▪ Average downtime of the city's IT infrastructure **HEALTH** ▪ % of the city's population with an online unified health file accessible to health care providers ▪ Annual number of medical appointments conducted remotely* ▪ % of the city population with access to real-time public alert systems for air and water quality advisories **HOUSING** ▪ % of households with smart energy meters ▪ % of households with smart water meters **POPULATION & SOCIAL CONDITION** ▪ % of public buildings that are accessible by persons with special needs ▪ % of municipal budget allocated for the provision of mobility aids, devices and assistive technologies to citizens with special needs ▪ % of marked pedestrian crossings equipped with accessible pedestrian signals ▪ % of municipal budget allocated for provision of programmes designated for bridging the digital divide **RECREATION** ▪ % of public recreation services that can be booked online **SAFETY** ▪ % of the city area covered by digital surveillance cameras **SOLID WASTE** ▪ % of waste drop-off centres (containers)	**FINANCE** ▪ Annual expenditure on upgrades and maintenance of city service assets as a % of total city budget ▪ Annual expenditure on upgrades and maintenance of storm water infrastructure as a % of total city budget ▪ Annual expenditure allocated to ecosystem restoration in the city's territory as a % of total city budget ▪ Annual expenditure on green and blue infrastructure as a % of total city budget ▪ Annual expenditure on emergency management planning as a % of total city budget ▪ Annual expenditure on social and community services as a percentage of total city budget ▪ Total allocation of disaster reserve funds as a percentage of total city budget **GOVERNANCE** ▪ Frequency with which disaster-management plans are updated ▪ % of essential city services covered by a documented continuity plan ▪ % of city electronic data with secure and remote back-up storage ▪ % of public meetings dedicated to resilience in the city ▪ Number of intergovernmental agreement dedicated to planning for shocks as percentage of total intergovernmental agreements ▪ % of essential services providers that have documented business continuity plan **HEALTH** ▪ % of hospital equipped with back-up electricity supply ▪ % of population with basic health insurance ▪ % of population that is fully immunized ▪ Number of infectious disease outbreaks per year **HOUSING** ▪ Capacity of designated emergency shelters per 100000 population ▪ % of buildings structurally vulnerable to high-risk hazards ▪ % of residential buildings not in conformity with building codes and standards ▪ % of damaged infrastructure that was "built back better" after a disaster ▪ Annual number of residential properties flooded as a % of total residential properties in the city

- % of foreign born population - Population demographics - % of new immigrants population - % of non-citizen city population - Number of university students * **RECREATION** ▪ m^2 of public indoor recreation space per capita ▪ m^2 of public outdoor recreation space per capita **SAFETY** ▪ Number of firefighters * ▪ Number of fire-related deaths * ▪ Number of natural-hazard-related deaths * ▪ Number of police officers * ▪ Number of homicides * ▪ Number of volunteer and part-time firefighters * ▪ Response time for emergency response services from initial call ▪ Crimes against property * ▪ Number of deaths caused by industrial accidents * ▪ Number of violent crimes against women * **SOLID WASTE** ▪ % of city population with regular solid waste collection ▪ Total collected municipal solid waste per capita ▪ % of the city's solid waste that is recycled ▪ % of the city's solid waste that is disposed of in a sanitary landfill ▪ % of the city's solid waste that is treated in energy-from-waste plants ▪ % of the city's solid waste that is biologically treated and used as compost or biogas ▪ % of the city's solid waste that is disposed of in an open dump ▪ % of the city's solid waste that is disposed of by other means ▪ Hazardous waste generation per capita (tonnes) ▪ % of the city's hazardous waste that is recycled **SPORT & CULTURE** ▪ Number of cultural institutions and sporting facilities * ▪ % of municipal budget allocated to cultural and sporting facilities ▪ Annual number of cultural events * **TELECOMMUNICATION** ▪ Number of internet connections * ▪ Number of mobile phone connection * **TRASPORTATION** ▪ Km of public transport system* ▪ Annual number of public transport trips per capita	equipped with telemetering ▪ % of the city population that has a door-to-door garbage collection with an individual monitoring of household waste quantities ▪ % of total amount of waste in the city that is used to generate energy ▪ % of total amount of plastic waste recycled in the city ▪ % of public garbage bins that are sensor-enabled public garbage bins ▪ % of the city's electrical and electronic waste that is recycled **SPORT & CULTURE** ▪ Number of online bookings for cultural facilities * ▪ % of the city's cultural records that have been digitized ▪ Number of public library book and e-book titles * ▪ % of city population that are active public library users **TELECOMMUNICATION** ▪ % of the city population with access to sufficiently fast broadband ▪ % of city area under a white zone/dead spot/not covered by telecommunication connectivity ▪ % of the city area covered by municipally provided Internet connectivity **TRANSPORTATION** ▪ % of city streets and thoroughfares covered by real-time online traffic alerts and information ▪ Number of users of sharing economy transportation * ▪ % of vehicles registered in the city that are low-emission vehicles ▪ Number of bicycles available through municipally provided bicycle-sharing services * ▪ % of public transport lines equipped with a publicly accessible real-time system ▪ % of the city's public transport services covered by a unified payment system ▪ % of public parking spaces equipped with e-payment systems ▪ % of public parking spaces equipped with real-time availability systems ▪ % of traffic lights that are intelligent/smart ▪ City area mapped by real-time interactive street maps as a percentage of the city's total land area ▪ % of vehicles registered in the city that are autonomous vehicles ▪ % of public transport routes with municipally provided and/or managed Internet connectivity for commuters ▪ % of roads conforming with autonomous	▪ % of residential properties located in high- risk zones **POPULATION AND SOCIAL CONDITIONS** ▪ Vulnerable population as a percentage of city population ▪ % of population enrolled in social assistance programs ▪ % of population at high risk from natural hazards ▪ Percentage of neighborhoods with regular and open neighborhood association meetings ▪ Annual percentage of the city population directly affected by natural hazards **RECREATION** **SAFETY** ▪ % of city population covered by multi-hazard early warning system ▪ % of emergency responders who have received disaster response training ▪ % of local hazard warnings issued by national agencies annually that are received in a timely fashion by the city ▪ Number of hospital beds in the city destroyed or damaged by natural hazards * **SOLID WASTE** ▪ Number of active and temporary waste management sites available for debris and rubble per km^2 **SPORT & CULTURE** **TELECOMMUNICATION** ▪ % of emergency responders in the city equipped with specialized communication technologies able to operate reliably during a disaster event **TRANSPORTATION** ▪ Number of evacuation routes available per 100000 population **URBAN/LOCAL AGRICULTURE & FOOD SECURITY** ▪ % of city population that can be served by city food reserves for 72 hours in an emergency ▪ % of city's population living within one kilometer of a grocery store **URBAN PLANNING** ▪ % of city area covered by publicity available hazard maps ▪ Pervious land areas and public space and pavement built with porous, draining materials as a percentage of city land area

- % of commuters using a travel mode to work other than a personal
- km of bicycle paths and lanes
- Transportation deaths *
- %of population living within 0,5 km of public transit running at least every 20 min during peak periods
- Average commute time
- Trasportation profile indicators:
  - Number of personal automobiles per capita
  - Number of two-wheeled motorized vehicles per capita

URBAN/LOCAL AGRICULTURE & FOOD SECURITY

- Total urban agricultural area*
- Amount of food produced locally as a % of total food supplied to the city
- % of city population undernourished
- % of city population that is overweight or obese — Body Mass Index

URBAN PLANNING

- Green area (hectares) *
- Areal size of informal settlements as a % of city area
- Jobs–housing ratio
- Basic service proximity
- Urban planning profile indicators:
  - Population density (per km^2)
  - Number of trees *
  - Built-up density

WASTEWATER

- Percentage of city population served by wastewater collection
- % of city's wastewater receiving centralized treatment
- % of population with access to improved sanitation
- Compliance rate of wastewater treatment

WATER

- % of city population with potable water supply service
- % of city population with sustainable access to an improved water source
- Total domestic water consumption per capita (litres/day)
- Compliance rate of drinking water quality
- Total water consumption per capita (litres/day)
- Average annual hours of water service interruptions per household
- % of water loss (unaccounted for water)

driving systems

- Percentage of the city's bus fleet that is motor-driven

URBAN/LOCAL AGRICULTURE & FOOD SECURITY

- Annual percentage of municipal budget spent on urban agriculture initiatives
- Annual total collected municipal food waste sent to a processing facility for composting per capita (in tonnes)
- % of the city's land area covered by an online food-supplier mapping system

URBAN PLANNING

- Annual number of citizens engaged in the planning process *
- % of building permits submitted through an electronic submission system
- Average time for building permit approval (days)
- % of the city population living in medium-to-high population densities

WASTEWATER

- % of treated wastewater being reused
- % of biosolids that are reused (dry matter mass)
- Energy derived from wastewater as a percentage of total energy consumption of the city
- % of total amount of wastewater in the city that is used to generate energy
- % of the wastewater pipeline network monitored by a real-time datatracking sensor system

WATER

- % of drinking water tracked by real-time, water quality monitoring station
- Number of real-time environmental water quality monitoring stations*
- % of buildings in the city with smart water meters

- % of city land area in high-risk zones where risk-reduction measures have been implemented
- % of city department and utility services that conduct risk assessment in their planning and investment
- Annual number of critical infrastructures flooded as a percentage of critical infrastructure in the city
- Annual expenditure on water retention measures as a percentage of city prevention budget

WASTEWATER

WATER

- Number of different sources providing at least 5% of total water supply capacity
- % of city population that can be supplied with drinking water by alternative methods for 72 hours

***** number per 100000 population
ISO 37120: file:///C:/Users/miria/Downloads/UNI1606400_EEN.pdf
ISO 37123: https://www.iso.org/obp/ui/#iso:std:iso:37123:ed-1:v1:en

CHAPTER IV
Boston Case Study

This chapter is dedicated to the description of the case study of the city of Boston, as it is a paradigmatic case of successful policy integration of resilience-building initiatives and post-carbon transition goals. Many cities in New England have been affected by shocks formulating new development trajectories and generating structural changes in their economic systems. These cities responded to the shocks with different strategies with a common element: context policies. Policies focused on the empowerment of context conditions rather than to reach a generic policy objective. The city of Boston is a paradigmatic example. It is a city that has changed its development trajectories over time becoming in the last three decades a global leading actor in the knowledge and innovation field.

Stemming from a multi-scale perspective, from the state level, to the metropolitan region up to the city of Boston, strategic initiatives oriented toward climate resilience and Post-carbon transition have been investigated. In particular the analysis has been related to the six target area previously identified as areas of influence of innovation ecosystems in the precedent MAPS LED project.

Historical Background and Territorial Dimension

The story of Boston is a story of land transformation. Founded on 1630s on the Shawmut Peninsula in the north east coast of the Atlantic Ocean (Massachusetts Bay), the city of Boston is known to be one of the oldest municipalities in the United States. At the time of its foundation, much of the land underlying the actual urban configuration did not even exist, but was submerged by water: the small peninsula where the first settlement of English puritans had place, covered less than 800 acres and was connected to the mainland only by a narrow neck along the line of present-day Washington Street (fig 19). Between 1630 and 1890s the city almost tripled its area, with operations of hills flatting and landfill that drastically changed its geomorphology, transforming the original colonial town in a larger urban reality (fig.20). After the American Revolution, Boston became one of the world's wealthiest international trading ports, with a consequent increasing in land reclamation and municipal annexation. Since the early nineteenth century, the city experienced a significant growth and expansion due to a massive amount of European immigrants, reaching the peak of more than 800,000 residents in 1950s. Soon after, between 1950 and 1980, the city experienced a dramatic drop in population (fig 18), due to several factors, such as its rigid weather that made the city unpleasant to live, the rising of private transportation that required larger roads and broader space for parking lots –incompatibly with high density cities, the decline of manufacturing due to delocalization of industries in the suburbs whit cheapest labor and transport costs, and government

fig. 18 Change of Boston population (1800-2020). Source: World Population Review 2021 *https://worldpopulationreview.com/us-cities/boston-ma-population*

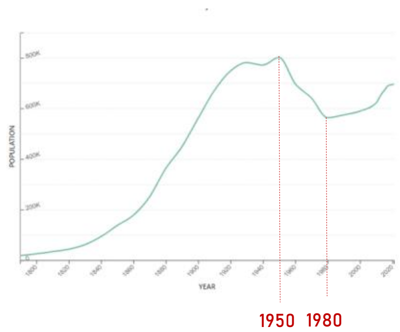


fig. 19 A plan of the town of Boston in 1775 created by Sir Thomas Hyde. Source: Norman B. Leventhal Map Center Collection (https://collections.leventhalmap.org/search/commonwealth:3f462w86j#image)

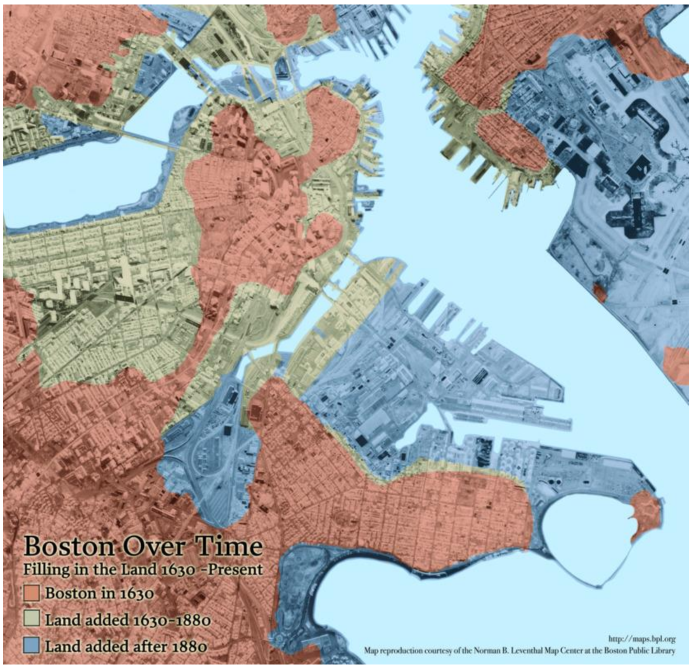


fig. 20 Boston city land transformation since 1630.
Source: Digital Commonwhealth, Massachusetts Collection on line
https://www.digitalcommonwealth.org/search/commonwealth:q524n559t

policies that trying to manage income disparities pushed the rich out of the city (Glaeser 2004). Despite that, the city had the capacity to reinvent itself and twenty years later it reborn as one of the richest cities in the country. With more than 35 institutes of high education, Boston is actually one of the most important centers of scientific research, innovation and technological development, attracting not only tourists but also professionals and students visitors from all around the world.

As today, the city proper covers 48.28 square miles (just 0.6% of the 7,800 square miles of Massachusetts commonwealth), with an estimated population of 694,600 in 2019[21] –the highest in New England- and a population density of 14,414 people per square mile of land. Future projections estimate an increase in population of around 15-17% by 2030, with an expected number of residents ranging from 710 000 to 724 000[22]. Seat of the Suffolk County[23] (fig. 21) and state capital of the commonwealth of Massachusetts, Boston is also the economic and cultural anchor of a larger metropolitan area known as Greater Boston[24], officially described by Census statistics as Metropolitan Statistical Area –MSA- or the broader Combined Statistical Area –CSA- (fig1). With approximately 4.8 million people estimated within the MSA and 8.1 million people within the CSA, the Greater Boston is one of the largest and most densely populated metro areas in the U.S.[25].

Boston, MA

Country:	United States
Region:	New England
State:	Massachusetts
County:	Suffolk
Total Urban Area:	89.62 sq mi
Land Area:	48.28 sq mi
Water:	41.28 sq mi
Population (2019):	694 600
Density:	14 414 p/sq mi
MSA Area:	3,486.2 sq mi
MSA Population:	4,873,019
MSA Density	1,397.8 p/sq mi
CSA Area:	10 600 sq mi
CSA Population:	8 041 313

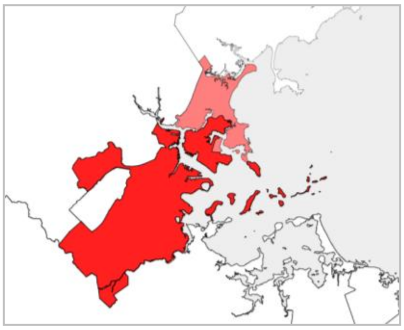


fig. 21 Localization of the city of Boston (red) in Suffolk County

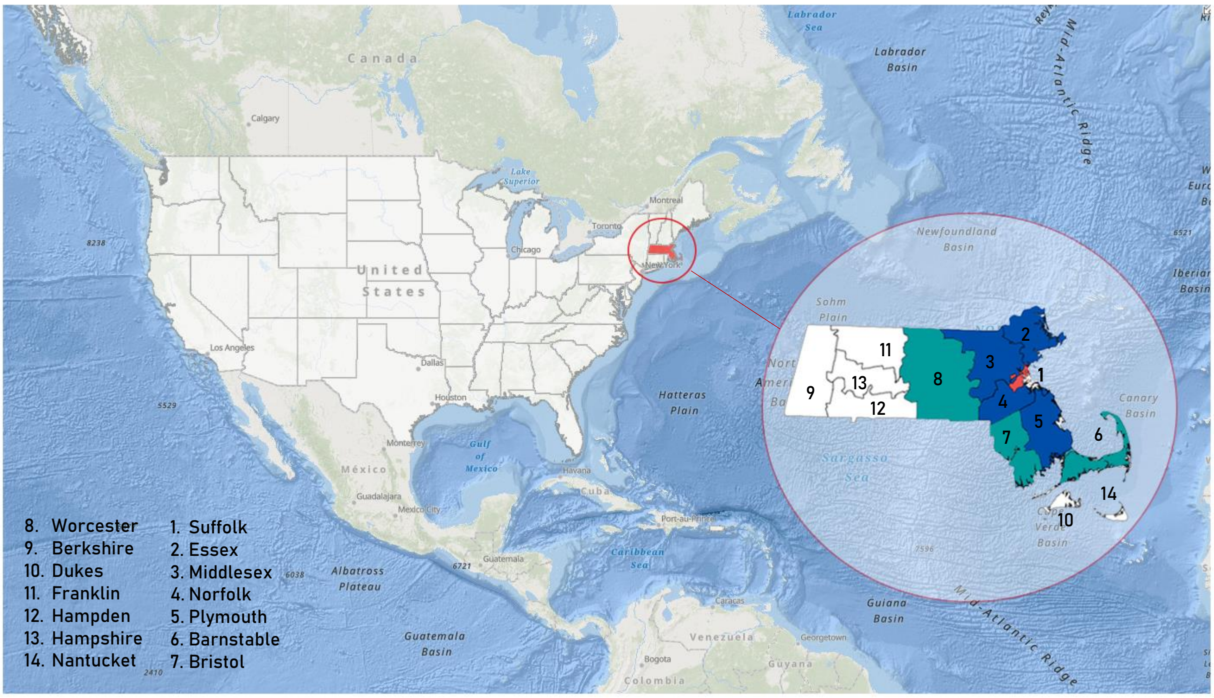


fig. 22 Geographical location of the Massachusetts commonwealth and its counties (a): in red, the city of Boston within the Suffolk county and the Greater Boston Metropolitan Region, identified as metropolitan statistical area -Boston-Cambridge-Newton MSA (blue) or as the broader combined statistical area -Boston-Worcester-Providence CSA (in green the CSA counties of Massachusetts)
Source: personal elaboration

At metropolitan level, the major issues concerning the Greater Boston, -such as housing and displacement, economic development, public health, climate and clean energy, and transport planning- are administrated by the Metropolitan Area Planning Council (MAPC), a regional planning agency created in 1963 under the Massachusetts General Law (Chapter 40B Section 24)[26]. Representating 101 cities and towns, the MAPC district covers a total land area of 1,422 square miles, divided in eight subregional organizations: South Shore Coalition (SSC), Three Rivers Interlocal Council (TRIC), South West Advisory Planning Committee (SWAP), Metro West Regional Collaborative (Metro West or MWRC), Minuteman Advisory Group on Interlocal Coordination (MAGIC), North Suburban Planning Council (NSPC), North Shore Task Force (NSTF), and the Inner Core Committee (ICC).

Among all, the ICC is the largest subregion, representing about 51 percent of the MAPC population –over 1.6 million residents- and including the largest number of communities: Arlington, Belmont, Boston, Brookline, Cambridge, Chelsea, Everett, Lynn, Malden, Medford, Melrose, Milton,* Needham*, Newton, Quincy, Revere, Saugus, Somerville, Waltham, Watertown, and Winthrop.

INNER CORE COMMITTEE (MAPC)

1.Arlington
2.Belmont
3.Boston
4.Brookline
5.Cambridge
6.Chelsea
7.Everett
8..Lynn
9.Malden
10.Medford
11.Melrose
12.Milton*
13.Needham*
14.Newton
15.Quincy
16.Revere
17.Saugus
18.Somerville
19.Waltham
20.Watertown
21.Winthrop

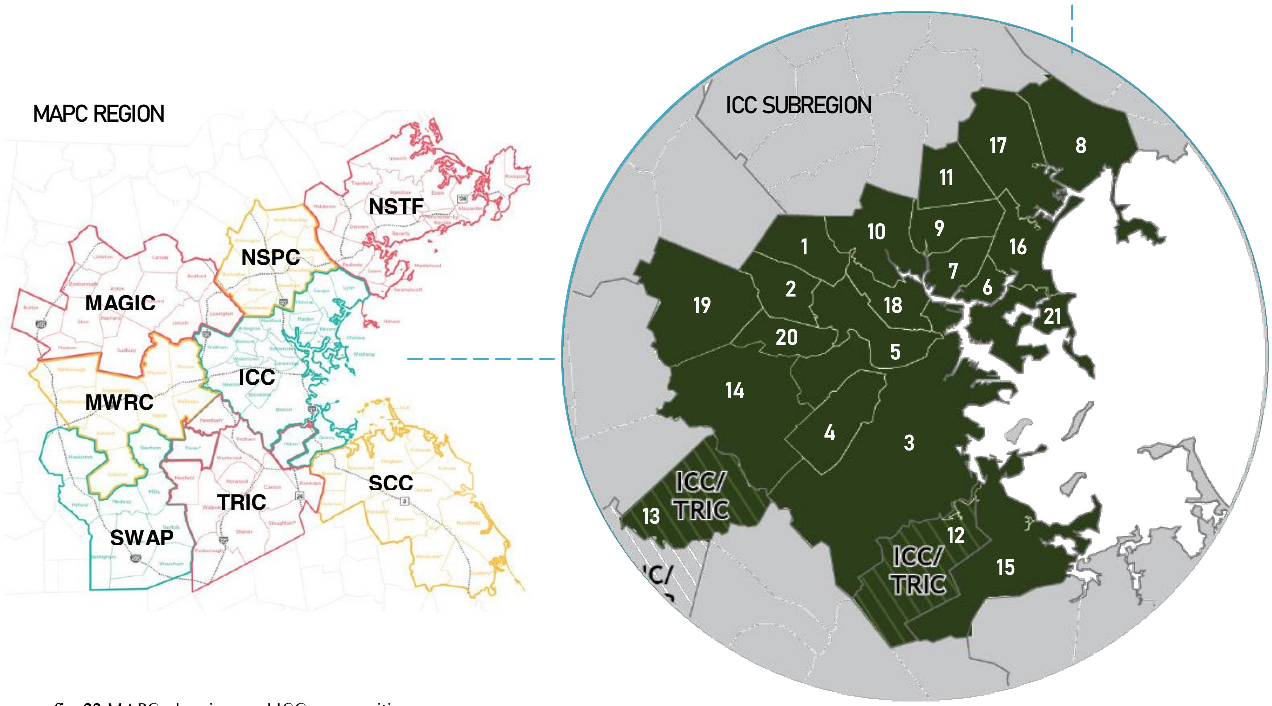
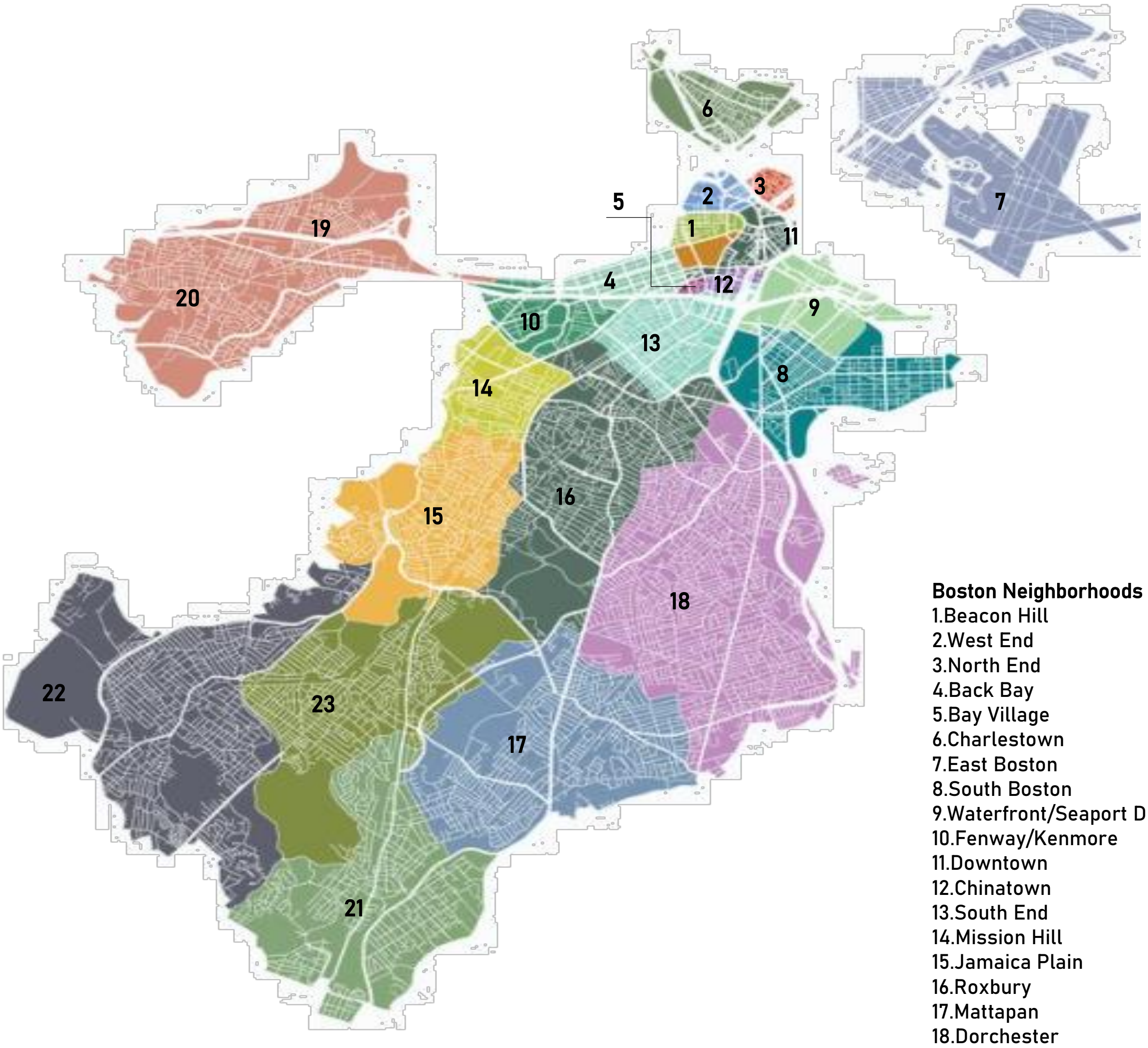


fig. 23 MAPCsubregions and ICC communities
Source:*https://www.mapc.org/aboutus/#:~:text=Established%20in%201963%2C%20MAPC%20is,Law%20Chapter%2040B%20Section%2024.*

At city level, 23 neighborhoods are officially recognized within the urban area by the City of Boston's Office of Neighborhood Services (fig.24), but as the city grew and evolved across time their definition has been subject to several changes. Moreover they have different configurations overlapping, unofficially designated by other local authorities (e.g. Boston Planning & Development Agency, City Parking Clerk, City's Department of Neighborhood Development). While much of the city has prospered, certain neighborhoods, especially minority communities, have been left behind: lack of affordable housing, fewer educational opportunities and less preparation for good jobs threaten to divide the city further along racial and economic lines.



Boston Neighborhoods
1.Beacon Hill
2.West End
3.North End
4.Back Bay
5.Bay Village
6.Charlestown
7.East Boston
8.South Boston
9.Waterfront/Seaport District
10.Fenway/Kenmore
11.Downtown
12.Chinatown
13.South End
14.Mission Hill
15.Jamaica Plain
16.Roxbury
17.Mattapan
18.Dorchester
19.Allston
20.Brighton
21.Hyde Park
22.West Roxbury
23.Rosindale

fig. 24 City of Boston Neighborhoods.

According with the *Climate Change Adaptation Report* (2011), during the last two decades the state of Massachusetts experienced 'higher impacts than global averages for several climate change indicators'(MA EOEEA 2011)[27]: the temperature change has been more severe than global average, reaching about 1°C (1.8°F) warming since 1970, with winter temperature increasing by 0.72°C (1.3°F) per decade and an average of 12 days per summer season above 32°C (90°F). Sea level has increased of a 2.6mm (.1 inches) per year since 1921, compared to the global average of 1.7mm (.07 inches) per year. Seasonal lake ice thawing has occurred earlier in the spring, anticipating the 'ice-out' phase by about 9-16 days. Regional precipitation has increased by about 10% over the last 50 years, with a rising frequency of severe storms and hurricanes (e.g. Irene 2011, Sandy 2012) and higher risks of flash flooding damages affecting both coastlines and inlands (MA EOEEA 2011). Heavy snowfall events have been experienced in much of the northern U.S. as consequence of large fluctuations in the North Polar Vortex. Climate change projections are expected even to exacerbate natural hazards, increasing their severity, duration or frequency (fig25), and affecting residents, governments, local communities, infrastructures, natural resources and the private sectors with different degree of exposure and consequences across the Commonwealth (fig26).

FLOOD-RELATED DISASTERS

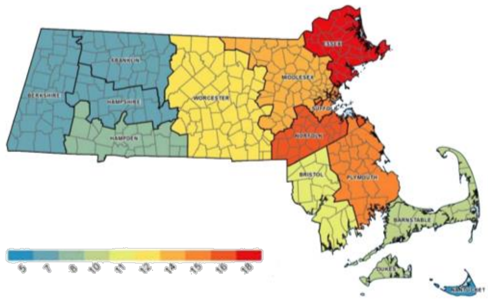


fig. 26 Number of FEMA flood-related declared disasters by county (1954-2017)
Source: *Massachusetts Hazard Mitigation and Adaptation Plan 2018*

MASSACHUSETTS CLIMATE CHANGE
PROJECTIONSAND RELATED NATURAL HAZARDS

CLIMATE CHANGES	RELATED NATURAL HAZARDS	PROJECTIONS BY THE END OF THIS CENTURY
Changes in precipitation	– Inland flooding – Drought – Landslide	– Annual precipitation: Increase up to 16% (+7.3 inches) – Days with rainfall accumulation 1+ inch: Increase up to 57% (+4 days) – Consecutive dry days: Increase 18% (+3 days) – Summer precipitation: Decrease
Sea level rise	– Coastal flooding – Coastal erosion – Tsunami	– Sea level: Increase 4.0 to 10.5 feet along the Massachusetts coast
Rising temperatures	– Average/extreme temperatures – Wildfires – Invasive species	– Average annual temperature: Increase up to 23% (+10.8 degrees Fahrenheit) – Days/year with daily minimum temperatures below freezing: Decrease up to 42% (-62 days) – Winter temperatures: Increase at a greater rate than spring, summer, or fall – Long-term average minimum winter temperature: Increase up to 66% (+11.4 degrees Fahrenheit) – Days/year with daily maximum temperatures over 90 degrees Fahrenheit: Increase by up to 1,280% (+64 days) – Growing degree days: Increase by 23% to 52%
Extreme weather	– Hurricanes/tropical storms – Severe winter storms/nor'easters – Tornadoes – Other severe weather	– Frequency and magnitude: Increase

fig. 25 Climate Change Projections for Massachusetts.
Source: SHMCAP 2018 (https://www.mass.gov/files/documents/2018/09/18/SHMCAP-September2018-Executive-Summary.pdf)

As the major part of the state population is located in Greater Boston area and projections show an expected increase of 22.5% by 2035 (fig 26), this region may result the most vulnerable due to the high number of people and infrastructure exposed to hazards or climate change impacts. Increases in development may also exacerbate the impacts of hazards -such as flooding and extreme heat- due to excessive land consumption and density of build environment. The map of vulnerabilities provided by the Metro Boston Climate Adaptation Strategy 2011 shows a concentration of vulnerable population in the Inner Core Subregion, and in particular in coastal areas and within the Boston city boundaries (fig27-28).

VULNERABILITY LEGEND

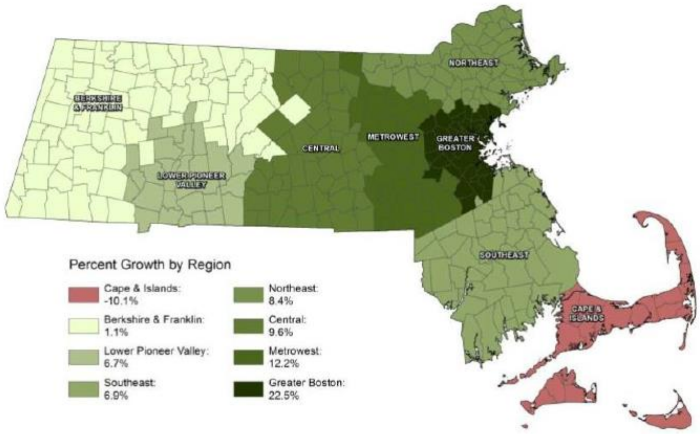


fig. 26 Projecter Percent Growth by Region 2010-2035 Source: SHMCAP 2018

MAPC- VULNERABLE POPULATION
Low income and Linguistic Isolation

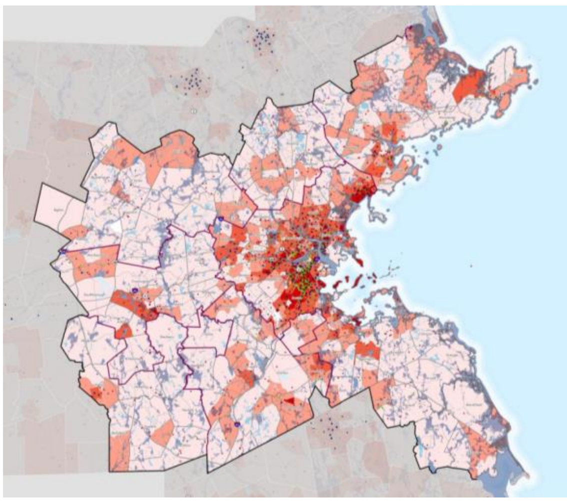


fig. 27 MAPC- Vulnerability Distribution MAPC
Source: https://www.mapc.org/wp-content/uploads/2019/03/RCCAS_full_report_rev_8-28-14.pdf

ICC- VULNERABLE POPULATION
Low income and Linguistic Isolation

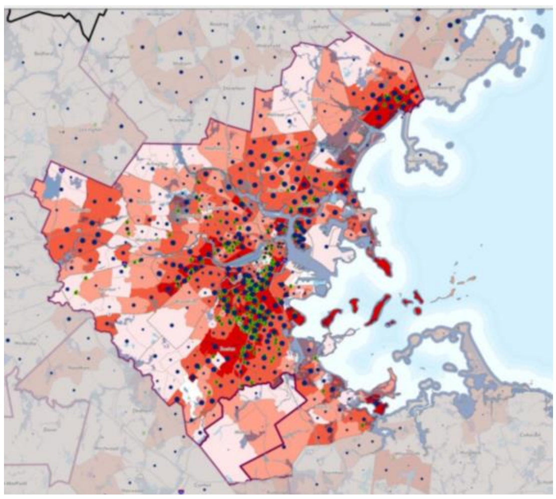


fig. 28 ICC - Vulnerability Distribution MAPC

In planning for climate adaptation or mitigation, understanding social vulnerabilities and their spatial distribution is an essential step, because it helps to define priorities for public initiatives. All the main plans or strategies focused on resilience or post-carbon transition in Boston have a section dedicated to social vulnerability (e.g. Resilient Boston 2017, Boston Carbon Free 2019, and Climate Adaptation Plan 2019 update), and addressing social inequality is now as a fundamental point for public policies. In the Carbon Free Boston Social Equity Report (2019) "social vulnerability" is defined as "the lack of capacity to withstand hard times- that is to prepare for, respond to, and recover from emergency", and vulnerable population is "more likely to suffer disproportionately because of their existing social circumstances, such as those associated with age, gender, race, medical illness, disability, literacy, and English proficiency" (Carbon Free Boston Social Equity Report 2019). If the importance of the concept could sound implicit for the resilience framework, understanding social vulnerabilities is equally important in defining actions to address energy transition and climate mitigation: "the observed sensitivity of those population to changes in the cost of energy, access to and uptake of energy efficiency and renewable energy incentives, and their access and use of transportation services that may be affected by action taken to reduce GHG emission" (Boston Carbon Free 2019). As assessed in Climate Ready Boston and Resilient Boston, these communities are also the most affected by climate change impacts –such as increased flooding and extreme temperature- because they have few instruments to react to adverse events (fig 30).

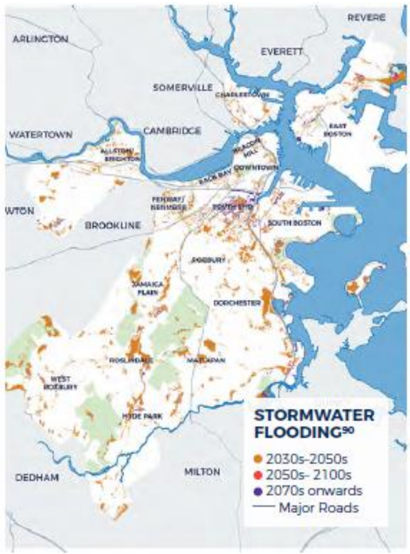
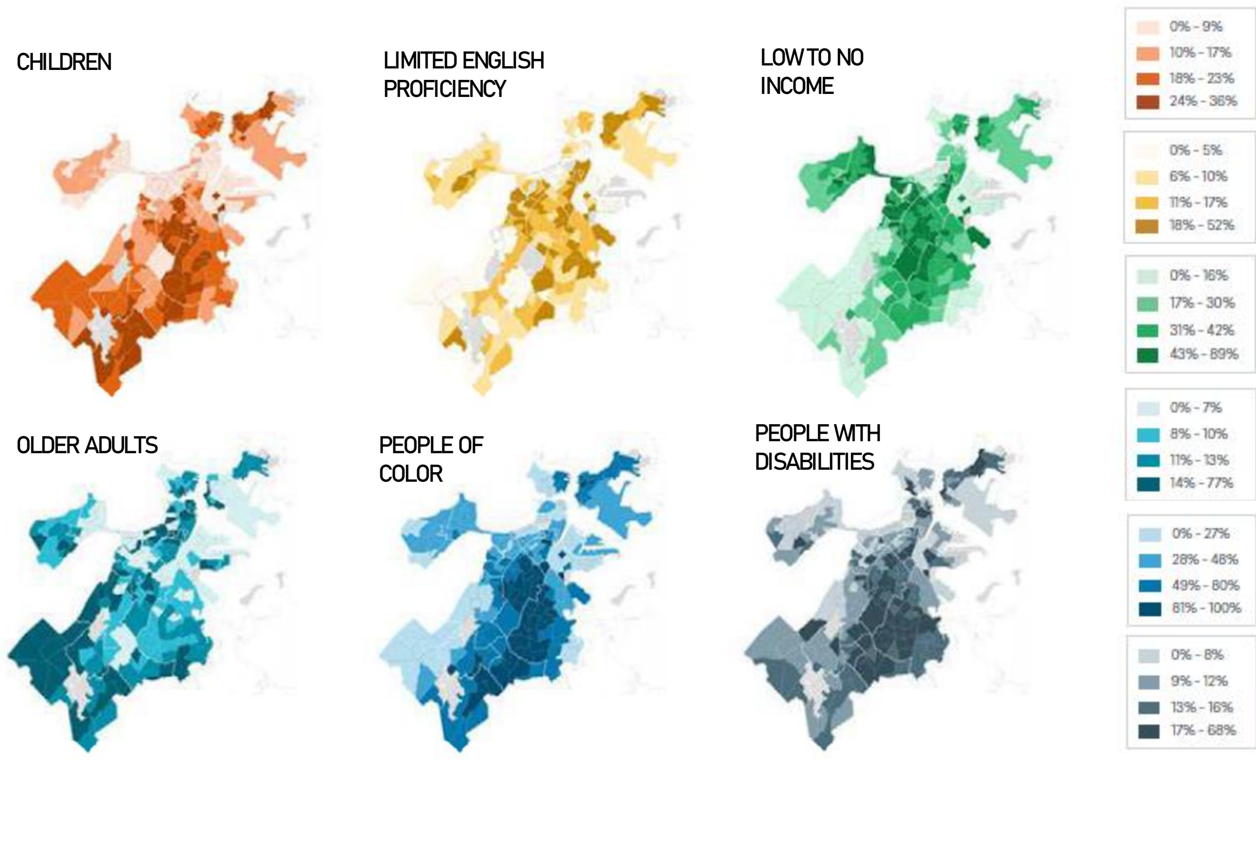


fig. 29 Stormwater flooding from 10-year. 24-hours storm with varying climate condition.
Source Climate Ready Boston 2019

fig. 30 Maps of Social Vulnerabilities
Source: Carbon Free Boston



As previous mentioned, the urban development of the city of Boston had been unequally distributed across the city neighborhoods, triggering high disparities also between close areas As we can see from the map of the Social Vulnerability Index (fig 33), a large part of vulnerable population is concentrated in the neighborhoods of Roxbury, Dorchester and Mattapan, while the neighborhoods close to the center, to the seaport and to the main universities show a lower index (fig 33). This concentration of vulnerabilities almost reflects income distribution: a story map from Esri geographic information systems provider highlights "Wealth Divides" for five cities with severe inequality, including the city of Boston[28] (fig 32). It shows how the median household income changes enormously between the core city and the most external neighborhood, taking the example of Jamaica Plain and Forest Hills: just crossing the Arnold Arboretum it change from $162,291 to $34,366.

On the other hand, looking at the physical connotation of climate urban vulnerability, the major risks are highly concentrated in the waterfront areas, where although the social vulnerability is low, the exposure to the effects of the expected sea level rise is very high. Climate Ready Boston shows three sea level rise scenarios for near term (2030-2050), midterm (250-2100) and long term (2070s onward), expecting an increase of respectively 9 inch, 21 inch, and 36 inch (fig.31). Storm surge and high tides could increase the sea level during severe storm events in particular seasons and stormwater and wastewater outflow could also be impacted by increased sea level rise.

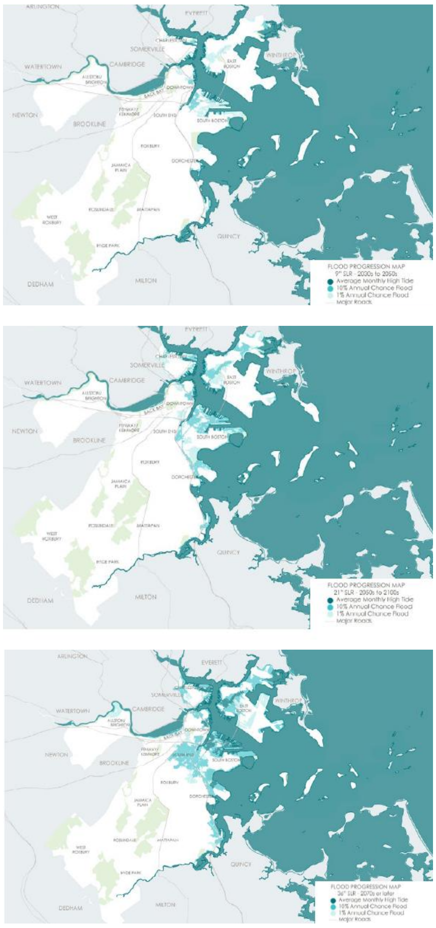


fig. 31 Sea Level rise scenarios for near term (2030s-2050s), Mid Term (250s-2100s) and Later term (2070s onwards)
Source: Climate Ready Boston 2019

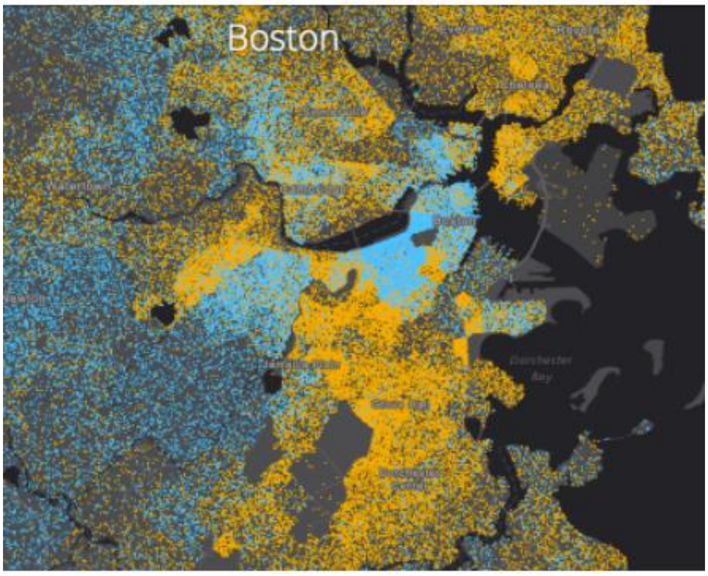


fig. 32 Wealth disparities. Screenshot from ESRI storymap
https://storymaps.esri.com/stories/2016/wealth-divides/index.html

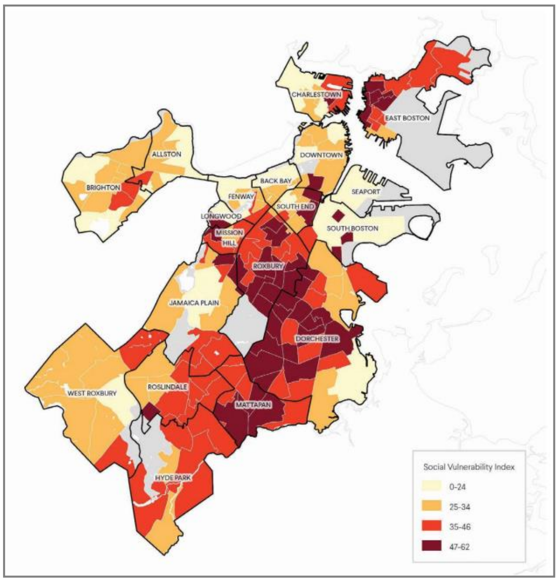


fig. 33 Maps of Social Vulnerability Index
Source: Carbon Free Boston Social Equity Report 2019

At the end of the century, between 10 and 20 percent of Charlestown, East Boston, Downtown, and South Boston will face flooding at high tide, even when there is no storm. In the latter part of the century (2070 or later), the buildings most exposed to coastal and river flooding will be predominantly residential and mixed-use and almost 88,000 people (nearly 15 percent of Boston population) will be highly affected by these events.

But sea level rise is not the only problem the city has to face in relation to climate change: on 22 April 2019, Boston experienced 2.3 inches of rain, breaking an 82-year old record. On January 2018, the city was shocked by a “bomb cyclone” that caused tidal surge and ice flooding. In the winter of 2015, Boston broke its all-time seasonal snow record since 1872. While annual snowfall is expected to decrease, the B.R.A.G. report states a future increase of the frequency of extreme rainfall, with an amount of precipitation in extreme events increasing by as much as 20 %. Both inland and coastal communities are already experiencing increased flooding due to higher rivers and groundwater levels. Aging stormwater infrastructure increases these risks, especially for vulnerable communities. Flooding roadways, homes and mass transit routes could lead to high impact on citizens' daily lives and business operations.

Increase in extreme temperature is also expected: the Fourth National Climate Assessment by the U.S. Global Change Research Program reports that by mid-century, there will be 20 to 30 more days per years with a maximum temperature of more than 90°F (32°C). Increase in extreme highs and extreme lows will place stress on residents and infrastructure, and heat island effect would be exacerbated. Projection of more and longer heatwaves, and the associated heat-related mortality is a related concern, especially for vulnerable communities. Heat-releted mortality was measured as 2.9 per 100,000 people per year from 1985 to 2016. By 2080s, this rate may more than triple to 10.5 per 100,000 under a moderate emission scenario and could reach 19.3 per 100,000 in a “ business as-usual” emission scenario.

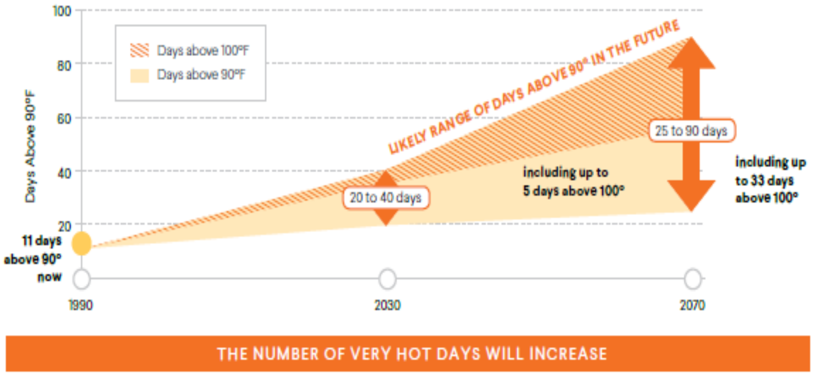


fig. 34 Projections of Climate Change in Boston.
Source: Climate Ready Boston 2019

Evacuation costs alone in the Northeast region resulting from sea level rise and storms during a single event could range between $2 billion and $6.5 billion (Ruth et al., 2007). A sea level rise of 0.65 meters (26 inches) in Boston by 2050 could damage assets worth an estimated $463 billion (Lenton et al., 2009). “While the costs of making changes and actively managing the built and natural environments to buffer the impacts of climate change may be substantial, the cost of inaction may be far higher.” (Climate Change Adaptation Report 2011).

The State of Massachusetts started to take proactive actions to face climate change threats since early 2000s, releasing its first *Climate Protection Plan* in 2004[29]. In 2008 Governor Deval Patrick signed the *Global Warming Solution Act*, setting the ambitious goal of 25% GHG emissions reduction below the 1990 baseline level by 2020, and extending the target to 80% by 2050. Drafted by the Executive Office of Energy and Environmental Affairs (EEA) in 2010 - then updated in 2015, the *Clean Energy and Climate Plan* (CECP) outlined the pathway for reaching the GWSA’s emission limit, by featuring a broad set of policies investing in 3 main objectives: energy efficiency, building and vehicles electrification and the replacement of fossil fuels with renewable energy sources. Since then, the Commonwealth of Massachusetts has made great strides in implementing feasible and cost-effective measures for GHG emission reduction, promoting financial programs, coordinating state agencies, engaging stakeholders, providing technical assistance for municipal climate vulnerability preparedness plans (MVP program 2017), and evaluating progresses. Moreover in 2018, following the Governor Baker’s Executive Order 569, mitigation goals have been integrated with climate adaptation objectives through the adoption of the *State Hazard Mitigation and Climate Adaptation Plan* (SHMCAP), “the first of its kind to comprehensively integrate climate change impacts and adaptation strategies with hazard mitigation planning” (SHMCAP 2018).

Examples of successful state initiatives aimed to advance the reduction of emissions and accelerate the transition to renewable energy are: Mass Solar Loan, Smart Incentives, Net Metering, Mass Save: No Cost Home Energy Assessment, Empower Massachusetts, and Solarize Mass CEC. In particular during the course of *Climate Resilience and Energy Democracy* at the Northeastern University of Boston (2020) I had the occasion to investigate the *Solarize Mass Program* (Solarize Mass CEC), through the development of the case study of the city of Salem conducted with several interviews with the main actors of the project. Launched by Massachusetts Clean Energy Center (MassCEC) in partnership with the Green Communities division of Massachusetts Department of Energy Resources (DOER)

Climate Resilience and Energy Transition Plans: from state to urban level

Climate Action Timeline
State level

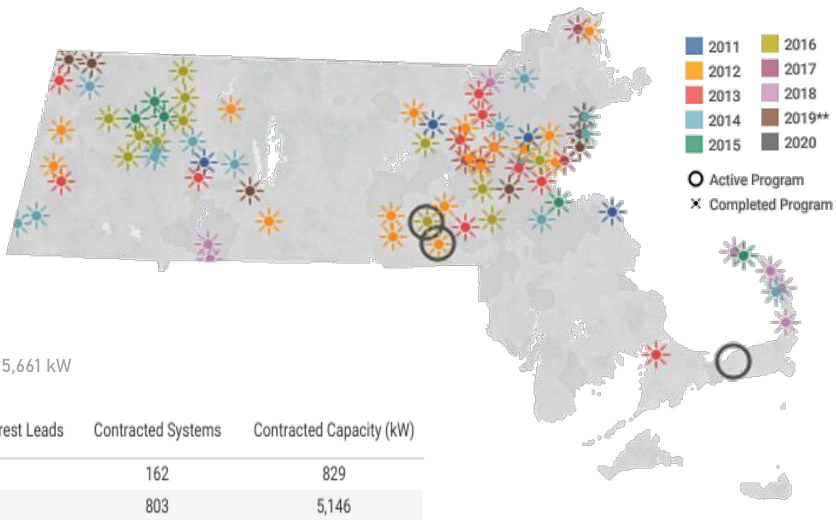
- Ongoing-Statewide Resilience Master Plan (SRMP)
- 2020-MassDOT Statewide Climate Change Adaptation Plan
- 2019-2050 Roadmap
- 2018-MA State Hazard Mitigation and Climate Adaptation Plan (SHMCAP)
- 2018-Massachusetts H 4835
- 2017-Municipal Vulnerability Preparedness Program (MVP)
- 2016-Executive Order 569
- 2015-2020 Clean Energy and Climate Plan (CECP)-Update
- 2014-MA Coastal Resilience Grant
- 2013-MA Environmental Policy Act Regulations (MEPA)
- 2010- 2020 Clean Energy and Climate Plan (CECP)
- 2008-MA Global Warming Solutions Act
- 2008-MA StormSmart Coast Program
- 2007-Regional Greenhouse Gas Initiative (RGGI)
- 2004-Massport Resiliency Program
- 2004-MA Climate Protection Plan

GWSA pathways
⇩
-25% GHGs by 2020
⇩
-80% GHGs by 2050

the initiative was aimed to increase the adoption of small-scale solar electricity systems. The project started in 2011 as part of Governor Deval Patrick’s initiative to install 250 megawatts (MW) of solar power in Massachusetts by 2017, and was implemented in 2017 with Solar Mass Plus program, promoting additional technologies such as air source heat pumps, battery storage, electric vehicles, ground source heat pumps, and solar hot water. It has been repeatedly demonstrated that top-down approaches, such as public policies and alternative financing mechanisms, play a key role in breaking down the initial barriers related to the introduction of innovative technologies in the energy system (Sunter, Castellanos, & Kammen, 2019; Cranmer & Baker, 2019). Pivot projects act like ‘seeds’ for the social diffusion of low-carbon solutions and the case of the rapid growth of Solar PV market in US -and in particular in Massachusetts with Solarize Mass model- is a clear example of the importance of incentive policies in promoting clean-energy resources (Stokes & Breetz, 2018). The Solarize Mass pilot projects had such great success that the initiative rapidly became adopted by communities throughout the Commonwealth (Solarize Mass Pilot Overview 2012). Since its launch, 75 cities and towns have participated in Solarize Mass and Solarize Mass Plus programs, almost 20,000 individuals expressed their interest, and over 3,700 residents and business owners signed contracts resulting in over 25.66 megawatts of contracted capacity (Solarize Mass Program Result 2019).

SOLARIZE MASS

fig. 35 The Solarize Mass Program contracts in map
Source: https://www.masscec.com/solarize-mass-program-results



SOLARIZE MASS PROGRAM RESULTS
85 Communities, 3,759 System Contracted, 25,661 kW

Year	Number of Communities*	Community Interest Leads	Contracted Systems	Contracted Capacity (kW)
2011	4	1,363	162	829
2012	17	5,405	803	5,146
2013	10	3,122	551	3,838
2014	15	4,067	932	6,141
2015	5	1,621	254	1,749
2016	12	2,054	549	3,987
2017	5	518	90	629
2018	7	862	161	1,235
2019**	7	869	257	2,108
2020	3			
Grand Total	85	19,881	3,759	25,661

fig. 36 The Solarize Mass Program Results
Source: https://www.masscec.com/solarize-mass-program-results

Through this kind of financial initiatives and a multilevel policy approach (from state to metropolitan to urban initiatives), the last year the Commonwealth of Massachusetts achieved the GWAS' 2020 goal of 25% GHG emissions. The most recent GHG Inventory[30] shows that in 2017 the GWSA's goal was almost met, with a reduction of GHG emissions of 22.4% (fig 1/2).

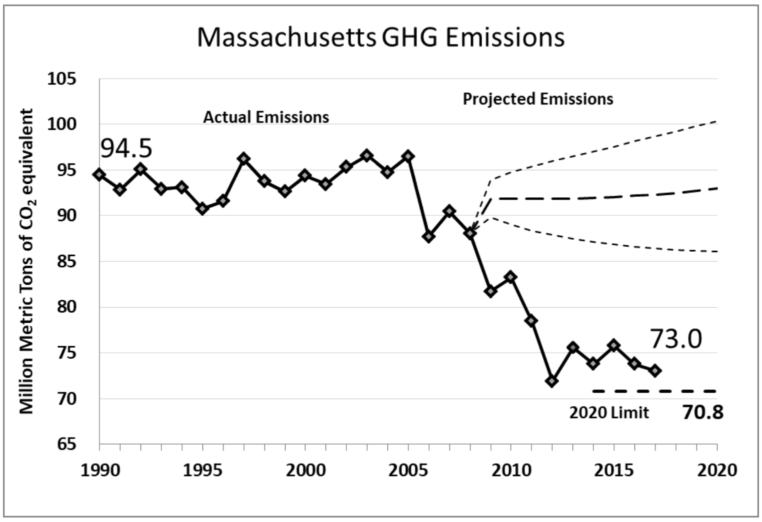


fig. 37 Massachussetts GHG emission trend
Source: https://www.mass.gov/lists/massdep-emissions-inventories#greenhouse-gas-baseline,-inventory-&-projection-

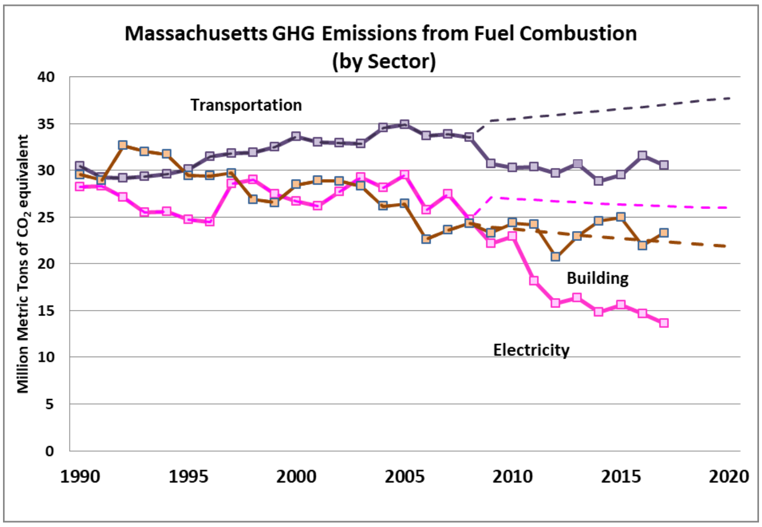


fig. 38 Massachussetts GHG emission trend by sector
Source: https://www.mass.gov/lists/massdep-emissions-inventories#greenhouse-gas-baseline,-inventory-&-projection-

As just stated, the result obtained from the Massachusetts Commonwealth in term of GHG emissions derive from an intregrated work of policy implementation across different territorial dimensions, by scaling down policies and actions from state to metropolitan to city level (table2).

In 2008 the Boston Metropolitan Area draft out its first regional plan (*Metro Future* 2008) defining 65 specific goals for the year 2030, organized in 6 topic areas such as: sustainable growth, housing, health communities, regional prosperity, transportation and healt environment. In particular among the goals setted for the topics of sustainable growth and health environment , we can find specific issues related to climate resilience and energy transition (goals 10, 56, 57 and 59) with defined objectives to reach through related strategies (tabl.1).

Climate Action Timeline Metropolitan Level

Ongoing-Metro Common 2050
2020-Pathways to Climate Resilience
2016-Metro Boston Climate Mitigation Commitment
2014-Metro Boston Regional C.C. Adaptation Strategy
2008-Metro Future

TOPIC 1: SUSTAINABLE GROWTH

GOAL10: "The region to be prepared for and resilient to natural disaster and climate change"

OBJECTIVES:

- Updated and implemented PreDisaster Mitigation plans for all municipalities
- Zero structural defiicient dams for the region
- Limited new growth in flood zones

TOPIC 6: HEALTH ENVIRONMENT

GOAL57: "The region will use progressively less energy for electricity, heating, cooling, and transportation."

OBJECTIVES:

- Limit regionwide average annual energy demand for heating, cooling, lighting, and appliances in new housing units to 75 million btus per unit
- Reduce total energy demand for passenger transportation by 38%.
- Reduce per-capita energy demand in the residential sector by 38% from 2000 – 2030
- 100% alternative fuel vehicles for non-emergency municipal and state vehicles by 2030

TOPIC 6: HEALTH ENVIRONMENT

GOAL56: "The region will be a national leader in reducing greenhouse gas emissions"

OBJECTIVES:

- Reduce regional CO2 emissions related to electrical generation and commercial, industrial, residential, and trasportation uses of 33% respect 2000 level
- Reduced regional transportation-related emissions of 40% respect 2000 level
- 100% of municipalities participating in the Climate Protection Campaign

TOPIC 6: HEALTH ENVIRONMENT

GOAL59: "The region will produce more renewable energy and will obtain more of its energy from renewable sources."

OBJECTIVES:

- Purchase from renewable sources electricity equivalent to 25% of year 2000 electricity demand by 2030
- Build at least 400 MW of clean energy capacity in the MAPC region.

Stemming from the Metro Future goals and building upon findings of the Massachusetts Climate Change Adaptation Report (2011), in 2014 theMAPC launched the first Metropolitan Climate Change Adaptation Strategyassessing regional vulnerabilities and definig more specific climate change goals and objectives. The main principle orienting the Strategy draft was to build "a holistic, multi-hazard approach that integrates climate change risks and focuses on prevention, preparedness, response and recovery, with an emphasis on prevention and preparedness measures". Due to the complexities of adaptation, measures and objectives have been defined for 3 different time horizons, prioritizing actions for Near-Term (2014-2020), Mid-Term (2020-2035) and Long-Term (2035-2050). The classification of fields of intervents has been structured on six main topics, regarding:

1. Mitigation and Adaptation
2. Natural Resources Protection and Preservation
3. Coastal Zone Protection
4. Built Environment and Infrastructure
5. Health and Human Resources
6. Local Economy and Government

On 2015, during the first Metro Boston Climate Preparedness Summit, the Metro Mayors Coalition lauched a taskforce to address the vulnerabilities of the region's interconnected infrastructure systems with the aim "to work together to reduce the region's greenhouse gas emission and prepare their communities for climate change". In 2016 the Taskforce expanded its target, pointing to become a Net Zero Region by 2050. Actually a new regional plan -Metro Common 2050- is still in definition, building new 'shared vision' through a participatory process of citizens' engagement[31].

LAW/PLAN/ STRATEGY	YEAR	RESEARCH FOCUS	LINK
STATE LEVEL – MASSACHUSETTS			
Statewide Resilience Master Plan (SRMP)	Not published	RESILIENCE	https://www.mass.gov/service-details/statewide-resilience-master-plan-srmp
MassDOT Statewide Climate Change Adaptation Plan	2020	RESILIENCE	https://www.mass.gov/massdot-statewide-climate-change-adaptation-plan
2050 Roadmap	2019	TRANSITION	https://www.mass.gov/info-details/ma-decarbonization-roadmap
Massachusetts State Hazard Mitigation and Climate Adaptation Plan (SHMCAP)	2018	RESILIENCE TRANSITION	https://www.mass.gov/service-details/massachusetts-integrated-state-hazard-mitigation-and-climate-adaptation-plan
Massachusetts H 4835	2018	RESILIENCE	https://www.adaptationclearinghouse.org/resources/massachusetts-h-4835-an-act-promoting-climate-change-adaptation-environmental-and-natural-resource-protection-and-investment-in-recreational-assets-and-opportunity.html
Municipal Vulnerability Preparedness Program (MVP)	2017	RESILIENCE	https://resilientma.org/mvp/
Executive Order 569	2016	RESILIENCE TRANSITION	https://www.mass.gov/executive-orders/no-569-establishing-an-integrated-climate-change-strategy-for-the-commonwealth
Massachusetts Coastal Resilience Grant	2014	RESILIENCE	https://www.adaptationclearinghouse.org/resources/massachusetts-coastal-resilience-grant-program.html
Massachusetts Environmental Policy Act (MEPA) Regulations	2013	RESILIENCE TRANSITION	https://www.adaptationclearinghouse.org/resources/massachusetts-environmental-policy-act-mepa-regulations.html
Clean Energy and Climate Plan for 2020 (CECP)	2010 (2015 update)	RESILIENCE TRANSITION	https://www.resilientma.org/resources/resource::2014
MA Global Warming Solutions Act	2008	TRANSITION	https://www.mass.gov/service-details/global-warming-solutions-act-background
MA StormSmart Coast Program	2008	RESILIENCE	https://www.adaptationclearinghouse.org/resources/massachusetts-stormsmart-coasts-program.html
Regional Greenhouse Gas Initiative (RGGI)	2007	TRANSITION	https://www.mass.gov/regional-greenhouse-gas-initiative-rggi
Massport Resiliency Program	2004	RESILIENCE	http://www.massport.com/massport/business/capital-improvements/sustainability/climate-change-adaptation-and-resiliency/
Massachusetts Climate Protection Plan	2004	RESILIENCE TRANSITION	https://www.washingtonpost.com/wp-srv/health/documents/mass-climate-plan.pdf
METROPOLITAN LEVEL-MAPC			
Metro Common 2050	On Development	RESILIENCE TRANSITION	https://metrocommon.mapc.org/
Pathways to Climate Resilience	2018	RESILIENCE	https://barrfdn.issuelab.org/resources/35487/35487.pdf
Metro Boston Regional Climate Change Adaptation Strategy	2014	RESILIENCE	https://www.mapc.org/wp-content/uploads/2019/03/RCCAS_full_report_rev_8-28-14.pdf
Metro Future	2008	RESILIENCE TRANSITION	https://www.mapc.org/get-involved/metrofuture-our-regional-plan/

CITY LEVEL – BOSTON MUNICIPALITY			
Climate Action Report	2020	RESILIENCE TRANSITION	https://www.boston.gov/news/city-boston-releases-2020-climate-action-progress-report
Boston Carbon Free	2019	TRANSITION	http://sites.bu.edu/cfb/
Climate Action Plan update	2019	RESILIENCE TRANSITION	https://www.boston.gov/departments/environment/boston-climate-action
Zero Waste Boston	2019	TRANSITION	https://www.boston.gov/environment-and-energy/zero-waste-boston
Resilient Boston Harbor	2019	RESILIENCE	https://www.boston.gov/environment-and-energy/resilient-boston-harbor
Resilient Boston	2017	RESILIENCE	https://www.boston.gov/departments/resilience-and-racial-equity
Imagine Boston 2030	2017	RESILIENCE TRANSITION	https://www.boston.gov/civic-engagement/imagine-boston-2030
Go Boston 2030	2017	RESILIENCE	https://www.boston.gov/departments/transportation/go-boston-2030
Greenovate Boston 2030	2017	RESILIENCE TRANSITION	https://www.greenovateboston.org/
Climate Ready Boston Plan	2016	RESILIENCE	https://www.adaptationclearinghouse.org/resources/climate-ready-boston-climate-change-sea-level-rise-projections-for-boston.html
Open Space & Recreational Plan 2015-2030	2015	RESILIENCE	https://www.mass.gov/service-details/open-space-and-recreationplans#:~:text=Open%20Space%20and%20Recreation%20Plans%20are%20a%20tool%20through%20which,needs%20of%20its%20community%20members.
BuildBPS	2015	RESILIENCE	https://www.bostonpublicschools.org/buildbps
Greenovate Boston 2014 Climate Action Plan – update	2014	RESILIENCE TRANSITION	https://www.cityofboston.gov/images_documents/Greenovate%20Boston%202014%20CAP%20Update_Summary_tcm3-49733.pdf
Boston Housing 2030	2013	RESILIENCE	https://www.boston.gov/finance/housing-changing-city-boston-2030#:~:text=Walsh%20released%20Housing%20a%20Changing,live %20in%20Boston%20in%202030.
Building Energy Reporting & Ordinance (BERDO)	2013	TRANSITION	https://www.boston.gov/departments/environment/building-energy-reporting-and-disclosure-ordinance
First Climate Action Plan	2007	RESILIENCE TRANSITION	https://www.cityofboston.gov/climate/pdfs/capjan08.pdf

Tab1. Overview of the main strategies oriented to resilience and post carbon transition, from state to metropolitan to city level.

"Boston is tacking a combined approach to address climate change that encompasses both reducing emission and adapting to climate-related hazards. (…) Investment in climate readiness will support new and improved open space snd continued greenhouse-gas reduction will aid a growing economy of green-energy jobs at all skill levels. By acting now, Boston can strengthen its role as a bold leader in emission reductions and climate adaptation." (Imagine Boston 2030)

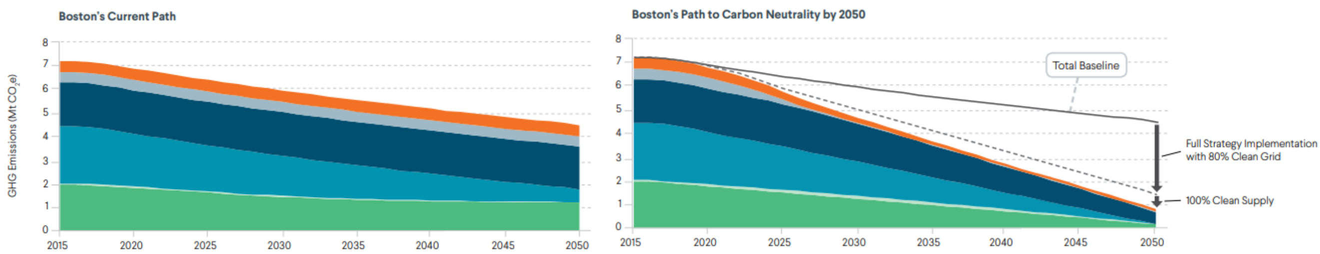
The City of Boston has a long history of climate action, often anticipating even federal and metropolitan initiatives. In 2000, Boston joined the Cities for Climate Protection Campaign –an international municipal governance organization led by the U.N. Environment Programme and the International Council for Local Environment Initiatives (ICLEI). The first *Climate Action Plan* was released in 2007. Since then, the City has adopted ambitious long-term strategies, including for mitigation, adaptation, waste reduction, mobility, and community connectedness.

In 2011, the city of Boston set carbon reduction goals of 25% by 2020 and 80% by 2050 below 2005 levels. Some years later, through the *Global Covenant of Mayors* (GCoM), Boston was committed to follow the Global Protocol for Community-scale GHG Emission Inventories (GPC). Signing the *Metro Boston Climate Commitment* in 2016, the Mayor even strengthened municipal emission reduction goals, pledging to make Boston carbon neutral by 2050[32]. In *Imagine Boston 2030*, the city's long term strategic plan adopted in 2017, an interim carbon reduction goal of 50% by 2030 was also set.

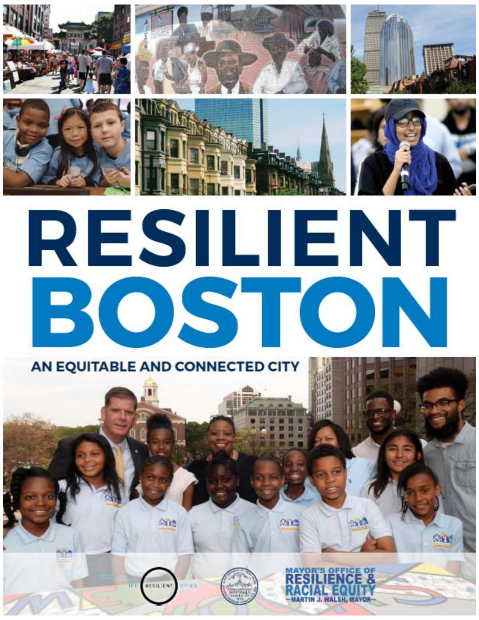
In 2019 the Boston municipality adopted the *Carbon Free Boston*, a long term framework of strategies for achieving the ambitious goal of carbon neutrality by 2050, developed by the Green Ribbon Commission in collaboration with the department of Earth Environment and the Institute for Sustainable Energy (Boston University). This strategic document was drafted building upon a comprehensive analysis of key driver of emissions, alternative technologies and policy choices, and focused particularly on energy demand for building, transport, waste and energy sectors.

Climate Action Timeline
City Level

2020- Climate Action Report
2019 – Boston Carbon Free
2019 – Climate Action Plan update
2019 – Zero Waste Boston
2017 -Mayor Walsh strengthened emission reduction goal for carbon neutrality
2017 – Resilient Boston
2017 – Image Boston 2030
2017 – Go Boston 2030
2017 – Greenovate Boston 2030
2016 Mayor Walsh elected to the C40 Committee
2016 – Climate Ready Boston Plan
2015- Boston joins the Carbon Neutral Cities Alliance
2015 –Open Space & Recreational Plan 2015-2030
2015- BuildBPS
2014 - Boston joins C40
2014–Greenovate Boston 2014 Climate Action Plan – update
2014-Boston Housing 2030
2014-Boston joins 100 Resilient City Network
2013- Building Energy Reporting & Ordinance (BERDO)
2013- Green Ribbon Commission
2010- Sparking Boston's Climate Revolution
2007 Exectutive order by Mayor Menino commits Boston to 80x50 reduction in GHGs
2007 – First Climate Action Plan
2005- Boston adopts the U.S. Mayor Climate Protection Agreement
2000- Boston joins the Cities for Climate Protection Campaign of ICLEI- Local Government for Sustainability



In the same year of the Boston Carbon Free release, it was also updated the Climate Action plan, bringing together climate adaptation and mitigation initiatives, with the aim to reach zero carbon transition while fostering climate resilience. By 2017, Boston reduced emissions from municipal building by more than 40 percent below 2005 levels, thanks to both effective municipal regulation and the declining costs of renewables technology.



Prior to 2012, the primary focus was on climate mitigation and sustainability and the Office of Environmental and Energy Services was the leading administrative unit for designing and managing related interventions. After the Hurricane Sandy in 2012, the city diversified its programs, including resilience of the built environment to natural hazard. Additionally the Maraton bombing of 2013 increased the interest of public administration to resilient building approaches, as related with emergency and risks management.

In late 2014, Boston joined the 100 Resilient Cities network, an initiative sponsored by the Rockefeller Foundation "to help cities around the world to become more resilient to the physical, social, and economic challenge of the 21st century" (Boston Resilient Strategy, 2018). Within this initiative, the Foundation provided municipalities with the financial support for sustaining the costs of drafting the Resilience Strategy, but also the technical support of a network of expertise (e.g. ARUP, Veolia, etc). In September 2015 Dr. Atyia Martin was named Boston Chief Resilience Officer, and under her supervision and a large work of stakeholder engagement the Boston Resilience Strategy has been launched in 2017.

"A major goal of Resilient Boston is to bring together other major Boston planning efforts into one coordinated strategy to leverage investment, maximize benefits, streamline efficiencies across implementation agencies, and embed racial equity and social justice." (Resilient Boston 2017).

The Strategy builds upon the finding of a preliminary assessment the main stress and shock affecting the city, identified as: economic inequality; climate change and environmental stress; terrorism and community trauma; health inequities; educational opportunity gaps; aging and inequitable transportation infrastructure; systemic racism.

RESILIENCE CHALLENGES

- ECONOMIC INEQUALITY
- CLIMATE CHANGE & ENVIRONMENTAL STRESSES
- TERRORISM
- COMMUNITY TRAUMA
- HEALTH INEQUITIES
- EDUCATIONAL OPPORTUNITY AND ACHIEVEMENT GAPS
- AGING INEQUITABLE TRANSPORTATION INFRASTRUCTURE
- SYSTEMIC RACISM

Following the City Resilience Framework, the Strategy is articulated in 4 different visions, respectively focusing on society, governance, economy, and infrastructures:

VISION 1: REFLECTIVE CITY, STRONGER PEOPLE
VISION 2: COLLABORATIVE, PROACTIVE GOVERNANCE
VISION 3: EQUITABLE ECONOMIC OPPORTUNITY
VISION 4: CONNECTED, ADAPTIVE CITY

Building over the City Resilience framework (Arup), each vision has been defined with a series of goals (13), target (47) and actions (71) to apply a heterogenic multidimensional strategy at every layer of city.

BOSTON RESILIENCE STRATEGY:
How is it structured?

Visions: Aspirational views of the future that we believe will lead to an equitable and *Resilient* Boston.

Goals: Proposed ways of achieving the Visions based on the highest-priority needs identified in the community engagement process.

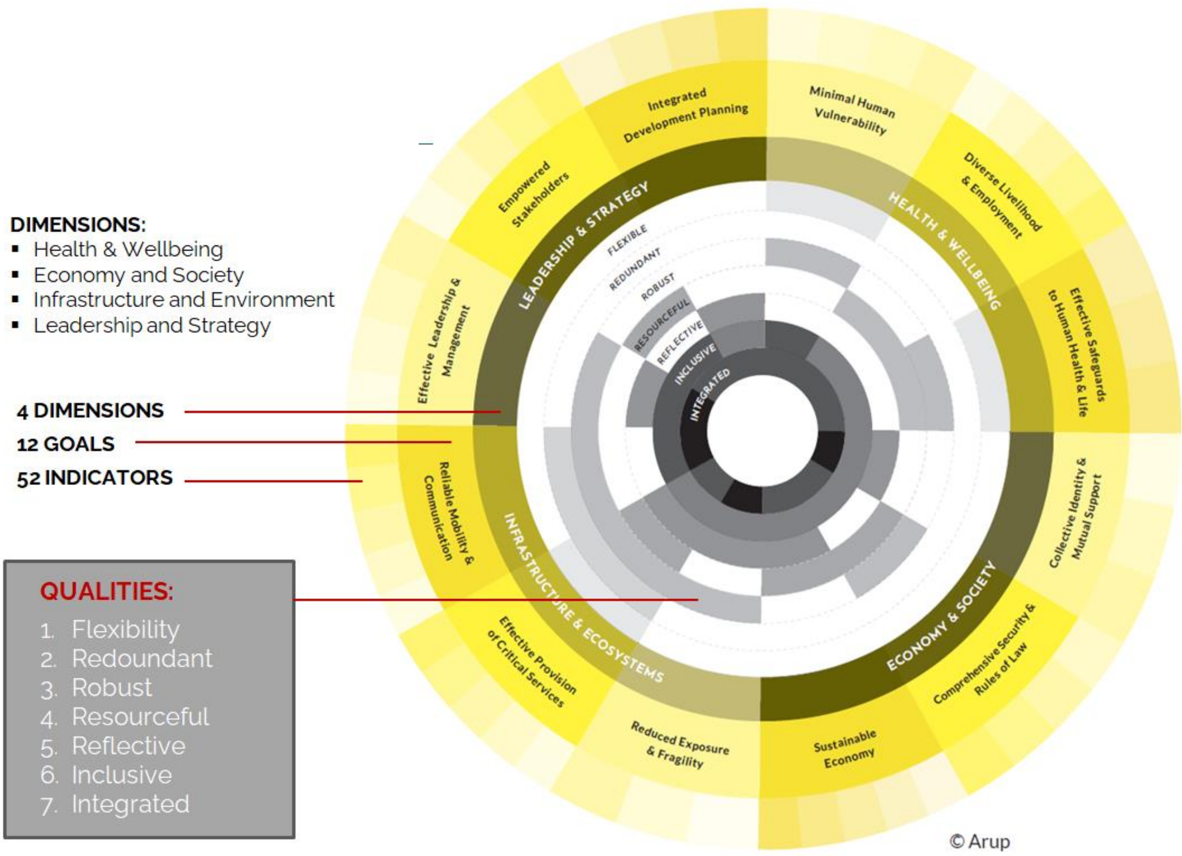
Initiatives: Policies, programs, or practices that the City and partners will implement to help reach the Goals.

Actions: Concrete steps that illustrate how we plan to advance each initiative.

Targets: Measures for tracking progress toward achieving the Visions, Goals, and Initiatives within the Resilience Strategy. These targets are meant to be starting points to help us establish pathways for measuring the achievements of our Goals moving forward.

Timeframe: The general amount of time required to implement an action. These timeframes include:

- **Short term:** Within one year
- **Midterm:** Within two to three years
- **Long term:** Within four to five years



VISION 1: REFLECTIVE CITY, STRONGER PEOPLE

INITIATIVE	TIME FRAME	IMPLEMENTATION PARTNERS	ACTION
1: Launch Racism, Equity, and Leadership (REAL) Resilience Program	Short Term	**City:** Human Resources, Office of Diversity, Boston Public Health Commission, Fair Housing and Equity, Mayor's Office for Immigrant Advancement, Commission for Persons with Disabilities, Office of Women's Advancement, Elderly Commission	**1-1: Develop Resilience and Racial Equity Toolkit** **1-2: Resilience and Racial Equity Progress** **1-3: Sharing Best Practices for Advancing Racial Equity** **1-4: City Employee Survey**
2: Partner with Boston Organizations to Advance Racial Equity	Short Term	**City:** Mayor's Office of New Urban Mechanics, Mayor's Office of Economic Development, Boston Public Health Commission **Community/Private Sector:** Greater Boston Chamber of Commerce, Boston Society of Architects, Enterprise Community Partners, Design for Equity, Massachusetts League of Community Health Centers	**2-1: Advance Racial Equity in the Private Sector** **2-2: Inclusive Growth and Equitable Development** **2-3: Community Equity Catalysts**
3: Connect Bostonians to Reflect and Confront Racial Inequity	Short Term	**City:** Mayor's Office of New Urban Mechanics **Community/Private Sector:** Northeastern University, Everyday Boston, Outside the Box Agency, Boston Justice History Group, Teen Empowerment, Research and Evaluation Collaborative, Strategic Decisions LLC, Boston University	**3-1: Dialogue for Reflections and Solutions** **3-2: Citywide Storytelling** **3-3: History for Today** **3-4: Citywide Community Survey**
4: Increase Access to Mental Health and Trauma Resources	Short Term	**City:** Boston Public Health Commission **Community/Private Sector:** Vital Healing Project, The Guild	**4-1: Neighborhood Trauma Teams** **4-2: Community Access to Mental Health and Wellness** **4-3: Disaster Behavioral Health Network**

VISION 2: COLLABORATIVE, PROACTIVE GOVERNANCE

INITIATIVE	TIME FRAME	IMPLEMENTATIONPARTNERS	ACTION
5: Improve City Employment Equity	Short to Midterm	**City:** Office of Diversity, Human Resources, Human Services Cabinet	**5-1: Targeted Outreach** **5-2: Mayor's Diversity Task Force** **5-3: Hiring Toolkit and Employee Support**
6: Drive Innovation in Community Engagement	Short to Midterm	**City:** Mayor's Office of New Urban Mechanics, Civic Engagement Cabinet, City of Boston Data Analytics Team, Department of Innovation and Technology **Community/Private Sector:** NeighborWorks America, Impact Hub	**6-1: Design Labs** **6-2: Community Engagement 2.0** **6-3: Youth Civic Engagement and Neighborhood Exploration Pilot** **6-4: Community Resilience Fellowship Program**
7: Pioneer Interactive Resilience Platform	Short to Midterm	**City:** Department of Innovation and Technology	**7-1: Interactive Resilience Strategy** **7-2: Relevant Resources and Tools**
8: Create a Funding Pipeline for Community-Led Resilience Initiatives	Short Term	**City:** Mayor's Office of New Urban Mechanics, Civic Engagement Cabinet **Community/Private Sector:** ioby, City Life/Vida Urbana, The Guild, Ujima Project, New England Grassroots Fund, The Boston Foundation	**8-1: Crowdsource Funding Platform** **8-2: Funding for Community Spaces** **8-3: Grassroots Funding**
9: Leverage City Data to Advance Equity	Midterm	**City:** Mayor's Office of New Urban Mechanics, Department of Innovation and Technology, Boston 311	**9-1: Boston 311 Enhancement** **9-2: Research and Evaluation Collaborative (REC)**

VISION 3: EQUITABLE ECONOMIC OPPORTUNITY

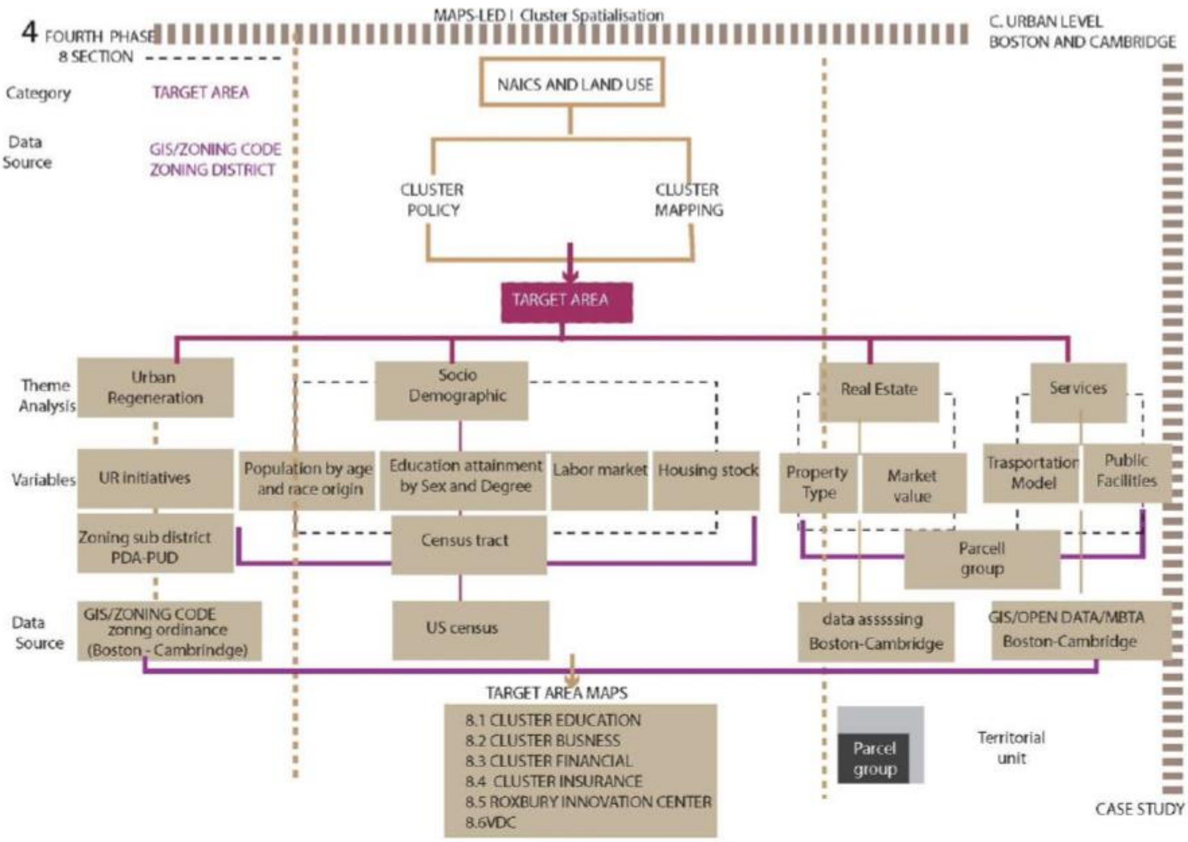
INITIATIVE	TIMEFRAME	IMPLEMENTATION PARTNERS	ACTION	STATUS
10: Link Bostonians to Jobs, Entrepreneurship, and Financial Empowerment Tools	Long Term	**City:** Office of Workforce Development, Office of Financial Empowerment, Boston Planning & Development Agency: Research & Evaluation Division **Community/Private Sector:** NatureWORKS	**10-1: Targeted Economic Forecast**	In Planning
			10-2: Workforce Development for a Changing Economy	In Planning
			10-3: Financial Resilience	In Progress
11: Remove Barriers Facing Small Businesses and Entrepreneurs	Short Term	**City:** Office of Policy and Planning, Boston Planning & Development Agency, Mayor's Office for Immigrant Advancement **Community/Private Sector:** Initiative for a Competitive Inner City, Impact Hub	**11-1: Small Business Resources**	In Planning
			11-2: Business Zoning and Design Changes	In Planning
			11-3: Small Business Lending in Historically Underserved Neighborhoods	In Progress
			11-4: Leverage Anchor Institutions to Support Small Businesses	In Planning
12: Keep Bostonians in Boston: Addressing Housing Challenges	Short Term	**City:** Office of Housing Stability, Boston Home Center **Community/Private Sector:** Rebuilding Boston Together	**12-1: Home Ownership and Maintenance**	In Progress
			12-2: Affordable Housing Production	In Progress
			12-3: Anti-Displacement Legislative Package	In Progress
13: Create an Economic Mobility Lab	Midterm	**City:** Mayor's Office of New Urban Mechanics, Mayor's Office of Policy, Mayor's Office of Economic Development, Boston Planning & Development Agency, Office of Workforce Development, Office of Financial Empowerment, Boston Public Schools, Boston Public Health **Community/Private Sector:** UMass Boston, The Rockefeller Foundation, 100RC	**13-1: Research and Analysis**	In Planning
			13-2: Scaling Success	In Planning
			13-3: Service Coordination	In Planning
14: Increase Access to Broadband and Wifi	Midterm	**City:** Department of Information Technology/Office of Digital Equity, Boston Public Schools, Boston Housing Authority	**14-1: Internet Access in Schools**	In Development
			14-2: Internet Access in Housing Developments	In Development
			14-3: 21st Century Access Fund	In Progress
15: Prepare All Students for Equitable Postsecondary Education and Career Opportunities	Midterm	**City:** Boston Public Schools, Office of Workforce Development **Community/Private Sector:** Roxbury Community College, Bunker Hill Community College, Massachusetts Bay Community College, Commonwealth of Massachusetts	**15-1: Restorative Education**	In Development
			15-2: Tuition-Free Higher Education	In Progress
			15-3: Dual Enrollment	In Progress
			15-4: Connect Education to Employment	In Planning
16. Improve Early Childhood Education Outcomes	Short Term	**City:** Boston Public Schools, Office of Workforce Development **Community/Private Sector:** Boston Basics, Bunker Hill Community College, Full Frame Initiative, Eos Foundation, Metro Credit Union	**16-1: Resilience-Building Approach for Children and Youth**	In Planning
			16-2: Universal Pre-K	In Progress
			16-3: Boston Basics	In Progress
			16-4: Children's Savings Accounts	In Progress

VISION 4: CONNECTED, ADAPTIVE CITY

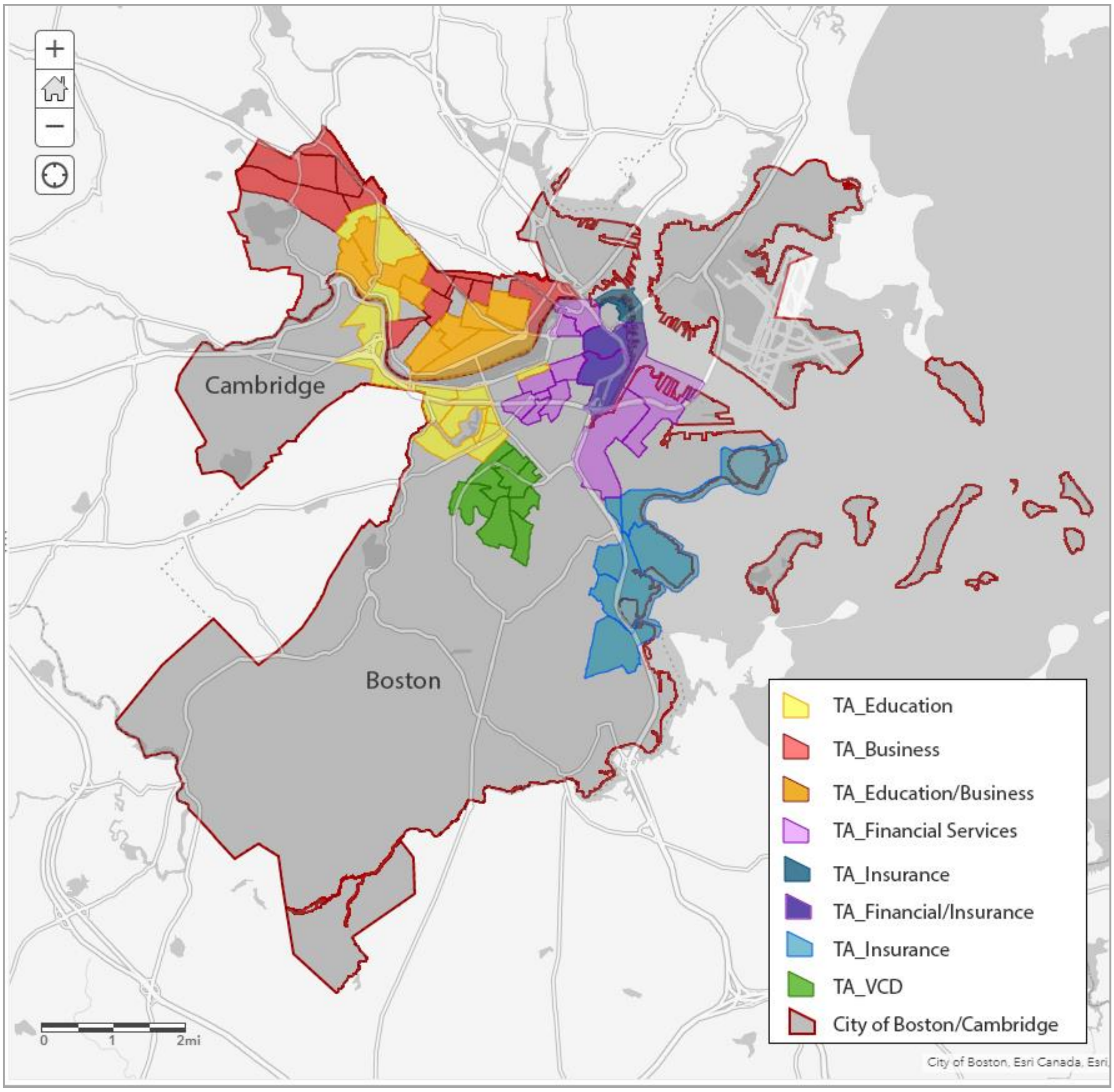
INITIATIVE	TIMEFRAME	IMPLEMENTATION PARTNERS	ACTION	STATUS
17: Advance Resilient Transportation Systems	Midterm	**City:** Public Works, Transportation Department **Community/Private Sector:** Massachusetts Bay Transportation Department, Transportation for All	**17-1: Fairmount Indigo Line Service Improvements to Promote Equity**	In Development
			17-2: Climate-Resilient Transportation Infrastructure	In Planning
			17-3: Sidewalk Maintenance Policy	In Planning
18: Develop Place-Based Mitigation and Adaptation Strategies	Short Term	**City:** Environment, Energy, and Open Space Cabinet, Boston Planning & Development Agency **Community/Private Sector:** Neighborhood of Affordable Housing, Harvard Graduate School of Design, New Jersey Institute of Technology Technical Assistance to Brownfields Program	**18-1: Engagement and Research**	In Progress
			18-2: Evaluation and Replication	In Progress
			18-3: Remediation and Reactivation of Brownfields	In Planning
19: Expand Distributed Energy to Vulnerable Communities	Long Term	**City:** Boston Planning & Development Agency, Environment, Energy, and Open Space Cabinet	**19-1: Lower Roxbury Microgrid Pilot**	In Development
			19-2: Expand Microgrids	In Progress
20: Adapt for Extreme Heat	Long Term	**City:** Environment, Energy, and Open Space Cabinet, Elderly Commission, Boston Public Health Commission, Human Services Cabinet **Community/Private Sector:** Trust for Public Land	**20-1: Heat and Vulnerability Analysis**	In Planning
			20-2: Heat Adaptation Projects	In Planning
			20-3: Update Boston's Heat Emergency Action Plan	In Planning
21: Protect Vulnerable Communities from Impact of Flooding	Short Term	**City:** Environment, Energy, and Open Space Cabinet, Boston Planning & Development Agency **Community/Private Sector:** 100RC	**21-1: Neighborhood Water Management**	In Planning
			21-2: Resilient Fairmount Corridor	In Planning
22: Empower Collaborative, Resilient Response to Disruptions	Short Term	**City:** Environment, Energy, and Open Space Cabinet, Boston Public Health Commission, Mayor's Office of Emergency Management	**22-1: Climate Risk Engagement Campaign**	In Development
			22-2: Neighborhood Response Plans	In Progress
23: Invest in Adaptation Projects	Long Term	**City:** Environment, Energy, and Open Space Cabinet, Boston Planning & Development Agency **Community/Private Sector:** 100RC	**23-1: Cost of Inaction Analysis**	In Planning
			23-2: Zoning and Designing for Resilience	In Development
			23-3: Financing Resilient Infrastructure	In Planning

From TreNd to MAPS LED

The last part of my research project focuses on the analysis of the 6 target areas precedently identified by the MAPS LED project as areas of influence of the emerging innovation ecosystems. After a larger cluster analysis extended at the whole MSA the target areas have been selected within the two municipalities of Boston and Cambridge and, as we can see in the map, they consist in: Educational, Ventur Development Center (VDC), Financial Services, Roxbury,-Insurance, Business Services. For each area I updated the socio-economy data gathered from the Census Track, and in particular from the ACS surveys. Additionally I also applied the maps of climatic risks (and in particular sea level rise, heat island maps) and spatialized some of the initiatives recently developed or just planned.

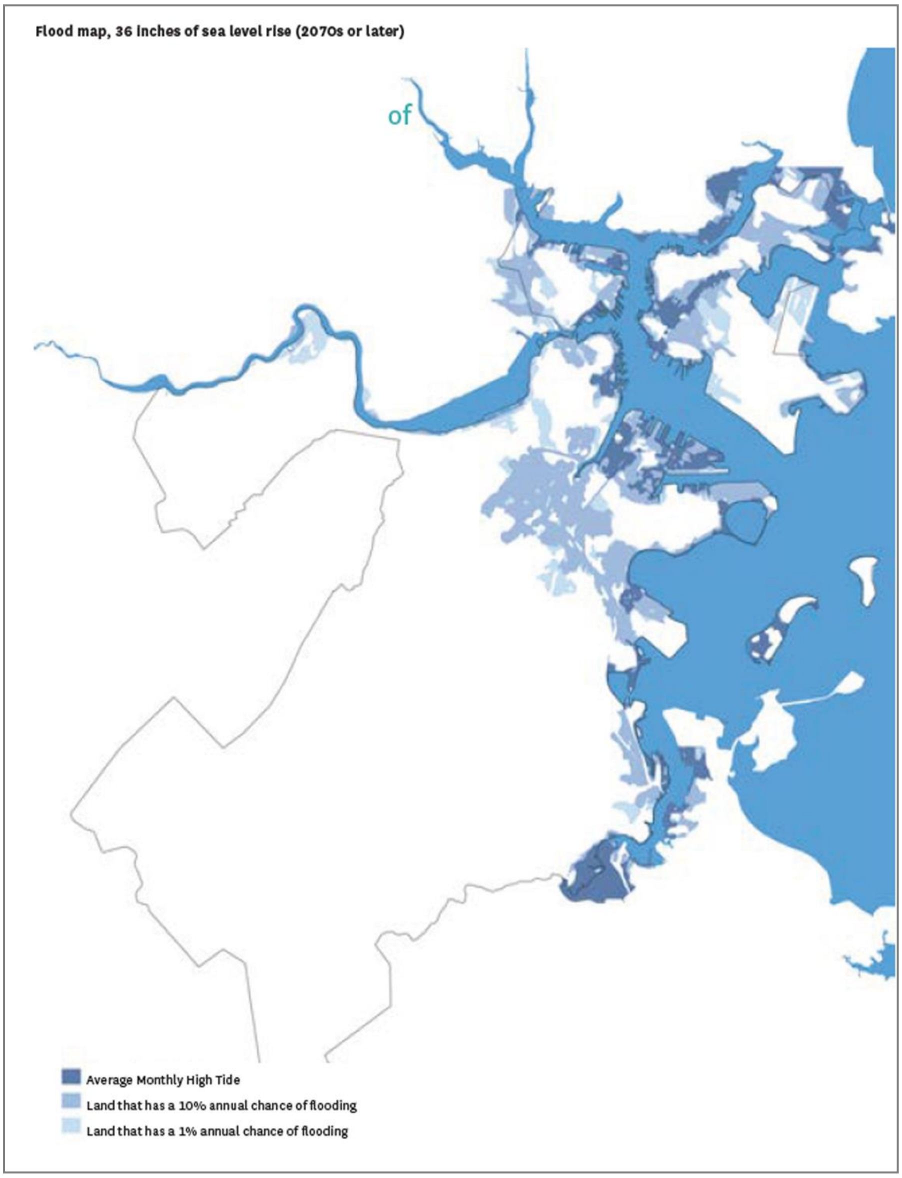


TARGET AREAS' LOCATION



TARGET AREA	LOCATION	LAND AREA (square miles)	POPULATION (*ACS 2018)	DENSITY (people per sqmi)
TA1_Education	City of Boston City of Cambridge	3,786	89496*	26803*
TA2_Business	City of Cambridge	4,229	78098	18467
TA3_Financial	City of Boston	2,692	38685	14370
TA4_Insurance	City of Boston	0,734	14650	19957
TA5_Roxbury	City of Boston	1,214	23227	19140
TA6_VDC	City of Boston	1,941	21347*	10997*

SEA LEVEL RISE



Definitions:

9-inch Sea Level Rise: By the end of the 2050s, 9 inches of sea level rise is expected consistently across emissions scenarios and is likely to occur as early as the 2030s. 9" Climate scenario and coastal/riverine hazard flooding data are the MassDOT-FHWA high sea level rise scenario for 2030. Actual sea level rise value is 0.62 feet above 2013 tide levels, with an additional 0.74 inches to account for subsidence.

21-inch Sea Level Rise: In the second half of the century, 21 inches is expected across all emissions scenarios. 21" Data were interpolated from the MassDOT-FHWA 2030 and 2070/2100 data.

36-inch Sea Level Rise: The highest sea level rise considered, 36 inches, is highly probable toward the end of the century. This scenario has a greater than 50 percent chance of occurring within this time period for the moderate emissions reduction and business-as-usual scenarios and a nearly 50 percent chance for the major emissions reduction scenario. 36" Climate scenario and coastal/riverine hazard fooding data are the MassDOT-FHWA high sea level rise scenario for 2070/intermediate sea level rise scenario for 2100. Actual sea level rise value is 3.2 feet above 2013 tide levels, with an additional 2.5 inches to account for subsidence.

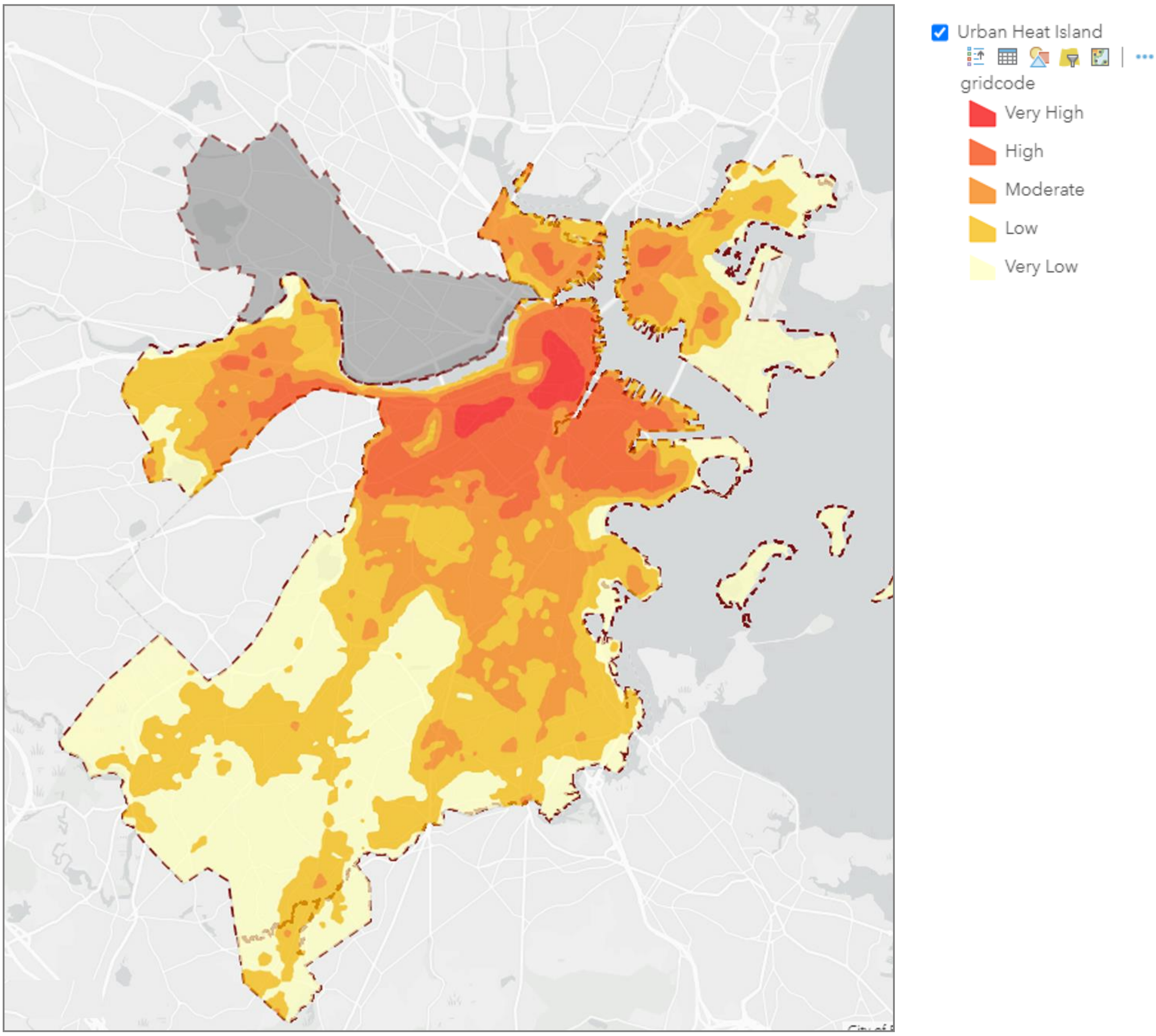
High Tide: Average monthly high tide is approximately two feet higher than the commonly used mean higher high water (MHHW, the average of the higher high water levels of each tidal day), and lower than king tides (the twice-a year high tides that occur when the gravitational pulls of the sun and the moon are aligned).

10% Annual Flood: A "10 percent annual chance flood" is a flood event that has a 1 in 10 chance of occurring in any given year. Another name for this flood, which is the primary coastal flood hazard delineated in FEMA FIRMs, is the "10-year flood."

Fig 39. Area of potential coastal and riverine flooding in Boston under various sea level rise scenarios (9-inch in 2030s, 21-inch in 2050s, and 36-inch in 2070s) at high tide and in the event of storms with an annual exceedance probability (AEP) of 10 and 1 percent. (Source: *Imagine Boston 2030*)

Each target areas have been confronted with the maps of risks provided by Climate Ready Boston's Vulnerability Assessment, with the aim to identify the areas most affected by climatic stressors (sea level rise flooding, stormwater flooding, heat surface temperatures). (https://www.boston.gov/sites/default/files/imce-uploads/2017-01/crb_-_focus_area_va.pdf)

URBAN HEAT ISLANDS



TREE CANOPY COVER

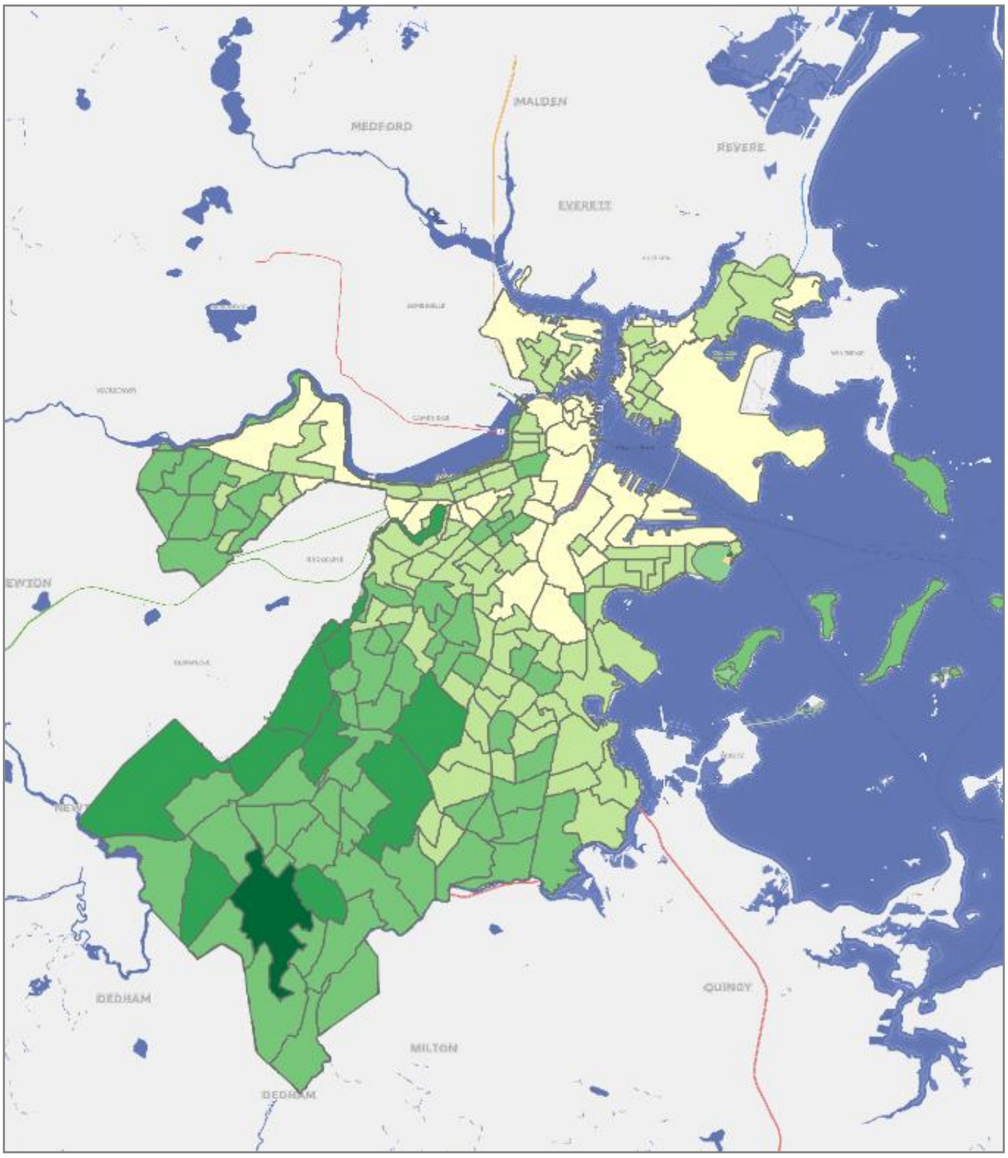


Fig. 40 Tree Canopy Cover % . Source: https://experience.arcgis.com/experience/3ec8e8ba79b547a5a0108c63112599bd

Tree canopy can help mitigate the heat island effect, particularly in densely urbanized and industrialized areas. In Boston, there is a statistically signicant negative relationship between tree canopy, "Greenness," and air temperature, indicating that areas with higher tree canopy and "Greenness" help reduce the urban heat island effect. Confronting Heat Island map and Tree Canopy Cover layer, it is possible to observe that the greatest urban heat island effect is concentrated in the urban core and north-eastern parts of Boston, where there is low tree canopy.

IMAGINE BOSTON 2030

CHALLENGEs:

- Productive Economy
- Growing Population
- Affordability
- Inequality
- Changing Climate
- Transformative Technology

GOALs:

- Encourage affordability, reduce displacement, improve quality of life
- Increase access to opportunity
- Drive inclusive economic growth
- Promote a healthy environment and prepare for climate change
- Invest in open space, arts & culture, transportation, and infrastructure

INITIATIVEs' CATEGORIEs:

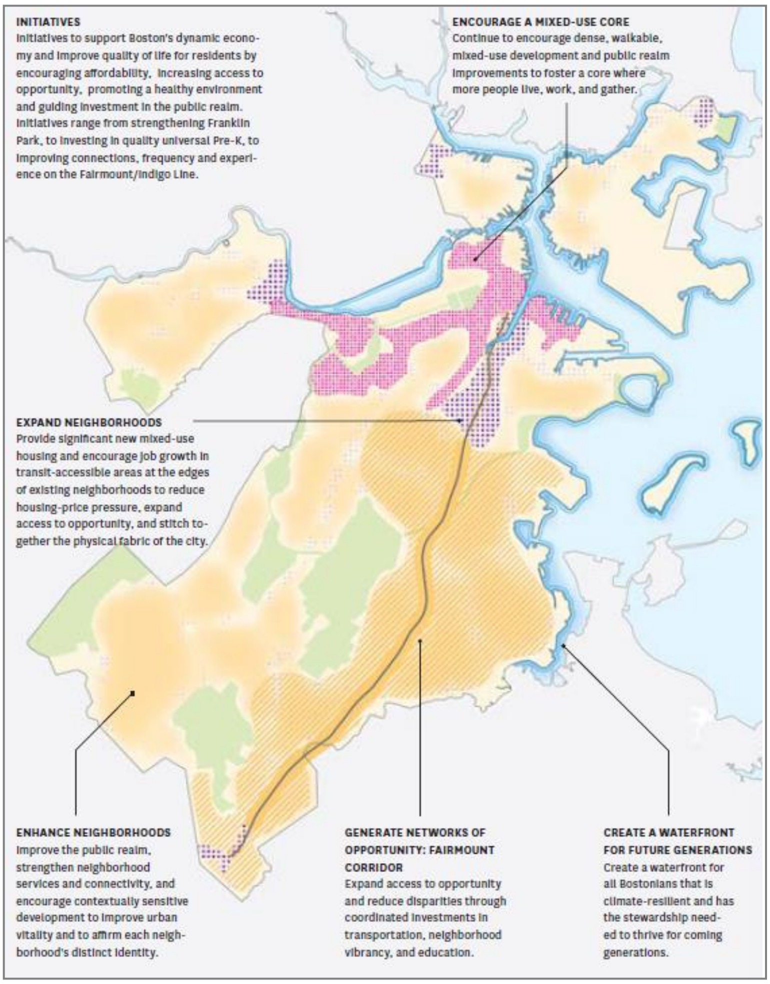
- Housing
- Health and Safety
- Education
- Economy
- Energy and Environment
- Open Space
- Transportation
- Techonology
- Arts and Culture
- Land Use Planning

ACTIONs:

"Action areas are physical locations where initiatives come together to respond to key opportunities and challenges" (Image Boston 2030)

The plan is oriented to take action to:

- Enhance Neighborhoods
- Encourage Mixed-use Core
- Expand Neighborhoods
- Create a Waterfront for Future Generations (climate-resilient)
- Generate a Network of opportunity Fairmount Corridor

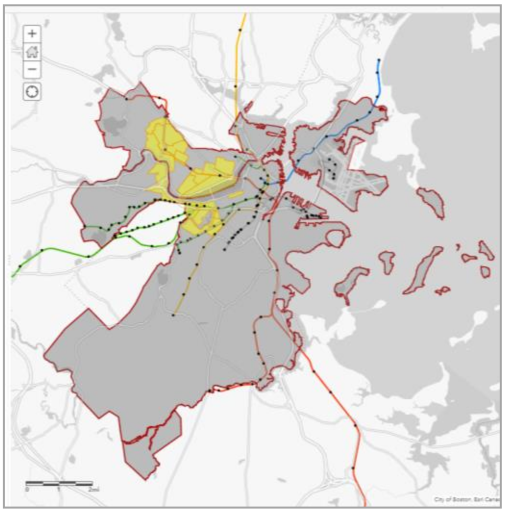


TARGET AREA	IMAGE BOSTON 2030 INITIATIVE & ACTIONS
TA1_Education	> WATERFRONT p. 246
TA2_Business	> WATERFRONT p. 246
TA3_Financial	> Encourage a Mixed-Use Core p. 180- 184 > Expand Neighborhoods p.193: – Newmarket and Widett Circle p.213-216 –Fort Point Channel p.219-223 > WATERFRONT p. 246
TA4_Insurance	> WATERFRONT p. 246
TA5_Roxbury	> Generate a Network of Opportunity- Fairmount Corridor
TA6_VDC	> Upham's Corner (Enhanced Neighborhood Pilot p. 161) > WATERFRONT p. 246

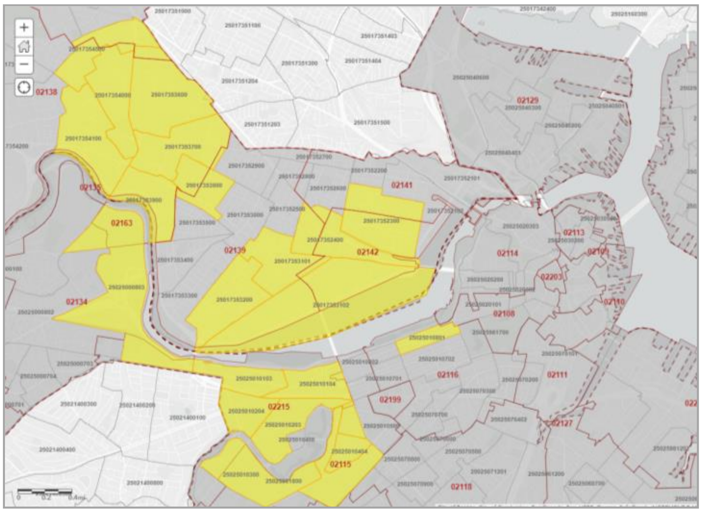
Target Areas' Analysis

Target Area 1_ **Education**

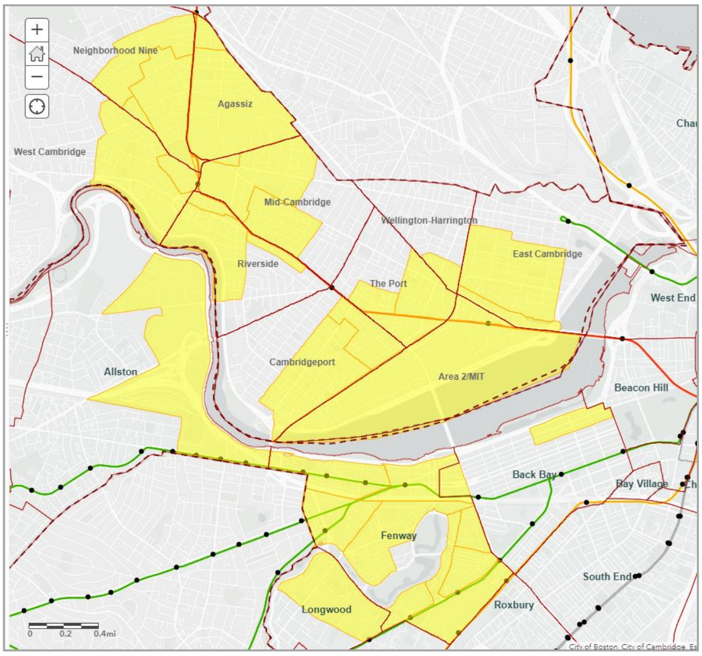
TARGET AREA LOCALIZATION



CENSUS TRACK ID & ZIP CODE



NEIGHBORHOODs



City of Cambridge (Census Tract)	City of Boston (Census Tract)
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25017353600	25025010403
25017353700	25025010404
25017353800	25025010405
25017353900	25025010801
25017354000	25025000803*
25017354100	
25017354500	

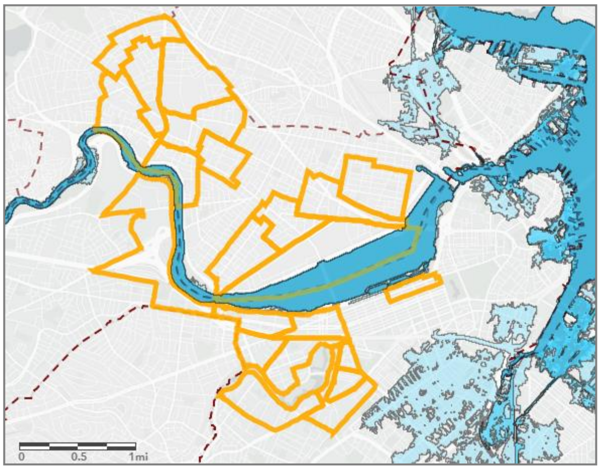
CITY: Boston/Cambridge
CLUSTER: Education
LAND AREA: 3,786 sqmi
POPULATION: 38683
POP DENSITY: 89496 people/sqmi*

ZIP CODEs:
> <u>CAMBRIDGE</u>: 02140, 12138, 02139, 02141, 02142 > <u>BOSTON</u>: 02163, 02134, 02215, 02115, 02116

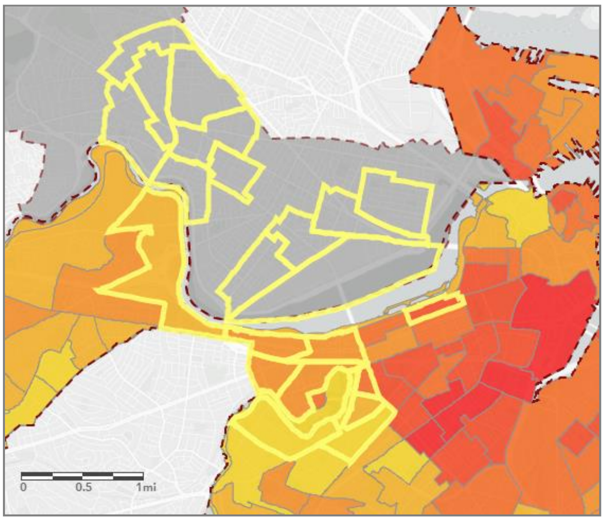
NEIGHBORHOODs:
> <u>CAMBRIDGE</u>: Agassiz, Neighborhood Nine,Mid Cambridge, Riverside, Cambridge Port, The Port, East Cambridge, Area 2/MIT > <u>BOSTON</u>: Allstone, Fenway, Longwood, Back Bay

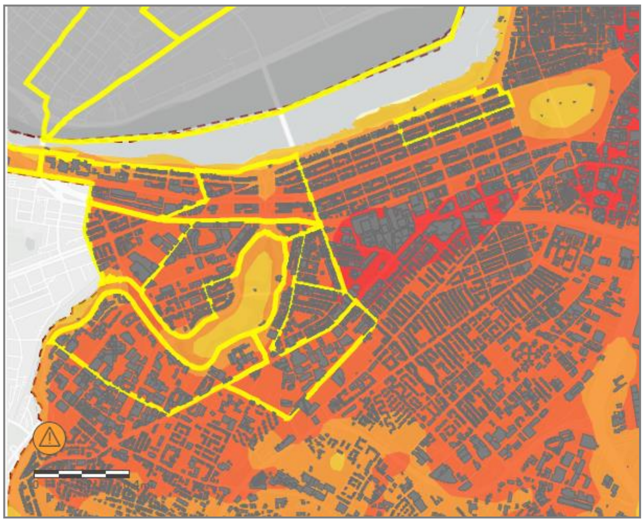
* No data are available for the Census Track 25025000803, thus the Population Density has been calculated with the exclusion of the respective land area

SEA LEVEL RISE



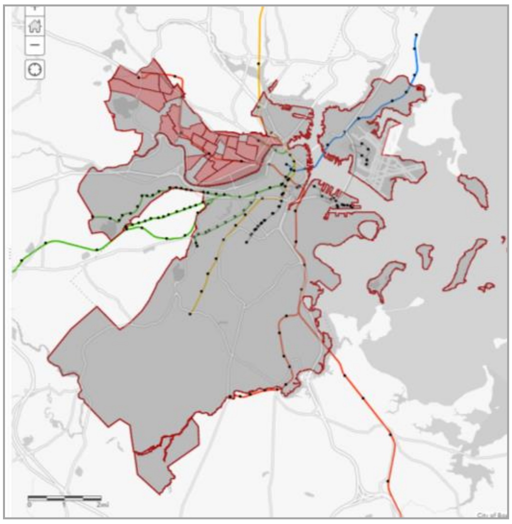
URBAN HEAT ISLAND



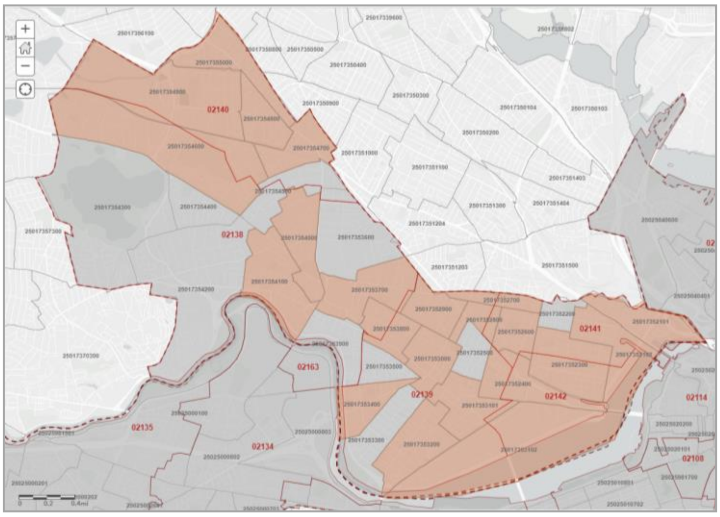


Target Area 2_ **Business**

TARGET AREA LOCALIZATION



CENSUS TRACK ID & ZIP CODE



City of Cambridge (Census Tract)	
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25017352300	25017353700
25017352400	25017353800
25017352600	25017354000
25017352700	25017354100
25017352800	25017354600
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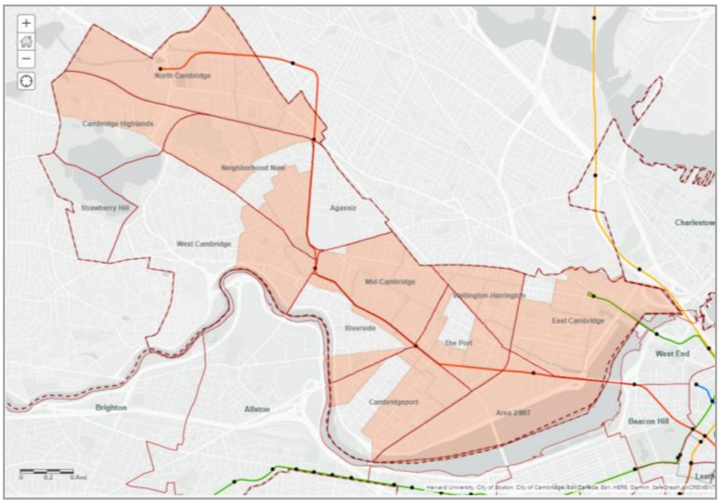
NEIGHBORHOODs



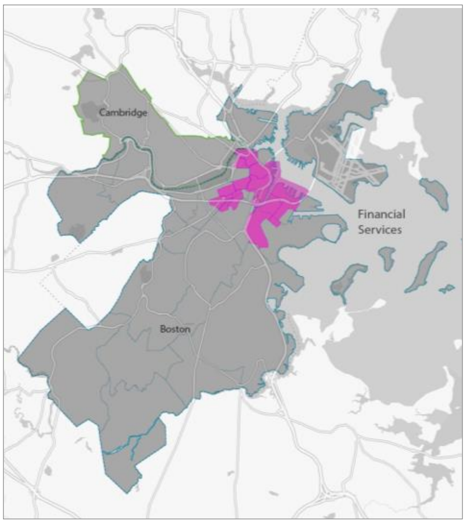
CITY: Cambridge
CLUSTER: Business
LAND AREA: 4,229 sqmi
POPULATION: 78098
POP DENSITY: 18467 people/sqmi

ZIP CODEs: 02140, 02138, 02139, 02141, 02142

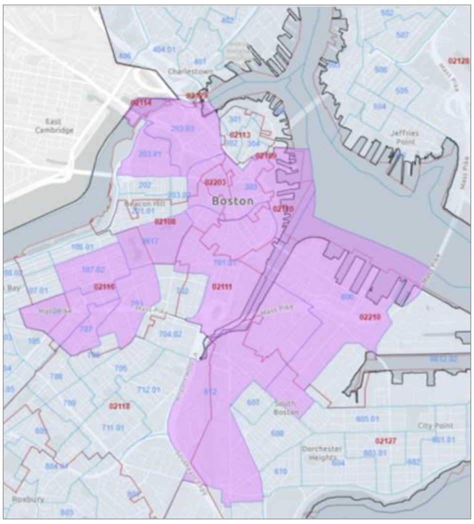
NEIGHBORHOODs: North Cambridge, Cambridge Highlands, Neighborhood Nine, West Cambridge, Mid-Cambridge, Riverside, Cambridgeport, The port, Wellington-Harrington, East Cambridge, Area2 /MIT

The Business target area is entirely located in the City of Cambridge. Through ACS Census Tract data, it was possible to identify the Socio-Demographic trends over the last 10 years (2009-2019), but the target area has been excluded from the analysis of climate vulnerabilities and planning initiatives because it is not included in Boston city boundaries.

TARGET AREA LOCALIZATION



CENSUS TRACK ID & ZIP CODE



City of Boston CT_ID
25025010600
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25025020301
25025020303
25025030300
25025060600
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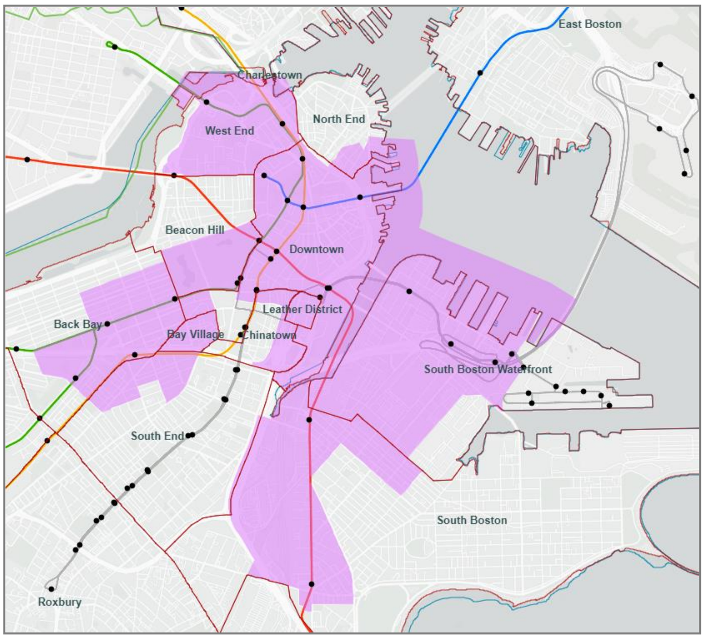
25025070101
25025070300
25025070700
25025981700

NEIGHBORHOODs



CITY: Boston
CLUSTER: Financial Services
LAND AREA: 2,692 sqmi
POPULATION: 38683 *
POP DENSITY: 14370 people/sqmi *

ZIP CODEs: 02108, 02109, 02110, 02111, 02114, 02116, 02127, 02199, 02203, 02210

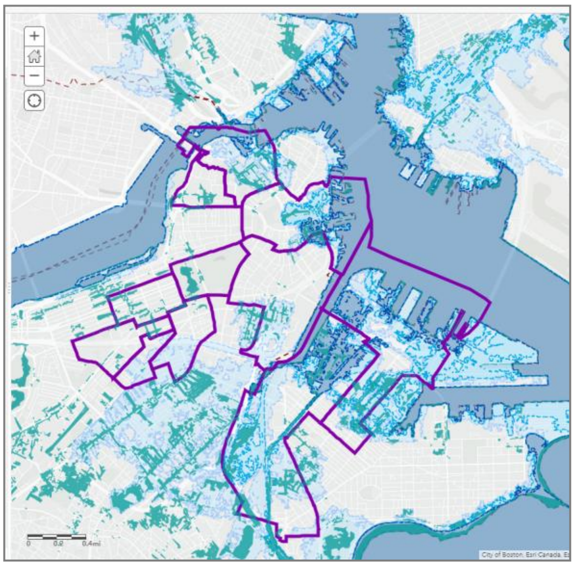
NEIGHBORHOODs: Downtown, Beacon Hill, Back Bay, Bay Village, Chinatown, Leather District, North End, South Boston Waterfront, South Boston, West End.

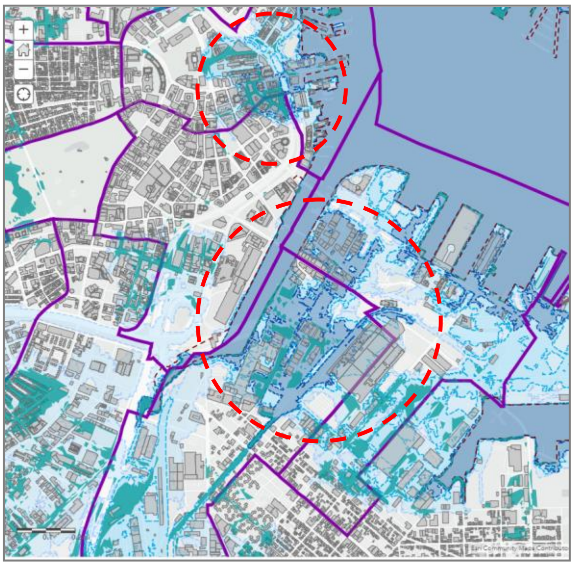
The Target Area Financial Services is located in the north-east neighborhoods of Downtown, Beacon Hill, Back Bay, Bay Village, Chinatown, Leather District, North End, South Boston Waterfront, South Boston, West End. It intersects two of the main clusters identified by the MAPS-LED project at urban level: the Cluster of Financial Services –mostly concentrated in Downtown- and Performing Arts – with a particular agglomeration of establishments in the Back Bay Area.

The target area was traditionally an Irish working-class neighborhood. From the socio-demographic analysis it emerges a relevant percentage of white people (around 70%) with respect to other races (see Appendix TA3).

* No data are available for the Census Track 25025981700: Population and Population Density values have been calculated with the exclusion of this area.

SEA LEVEL RISE

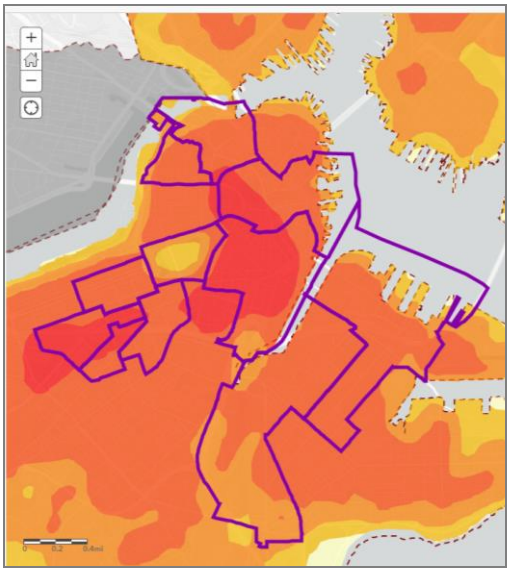




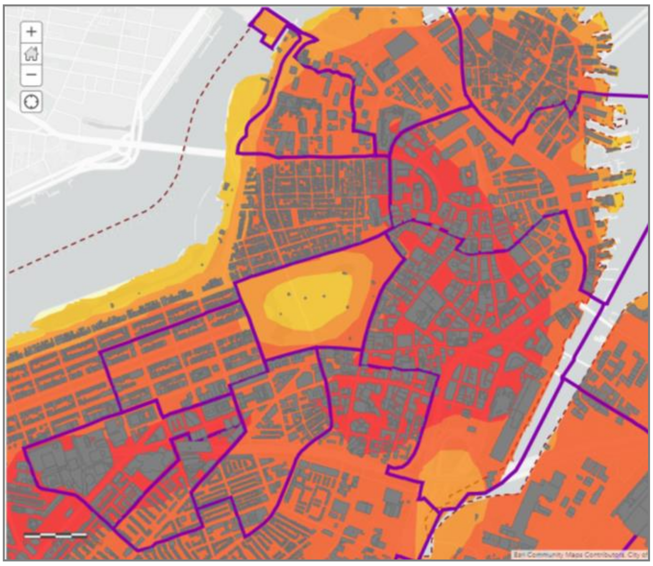
The area shows a high vulnerability in regard to the risk of flooding, particularly interesting the Census Tract 25025060600 and 25025061200, where the sea level rise affects a cospicuous number of buildings, and the 25025030300, where the risk of stormwater flooding involve a large area. Despite that, thanks to the recent development initiatives and to the proximity with the city core, the target area is an actractive zone for families and young professionals, as demonstrated by the average value of the Med Gross Rent, that is the highest among the 6 target areas (see APPENDIX section).

As we can observe from the heat island maps, all the census tracts of the target area are affected by high surface temperatures, and in particular the ones located in the Downtown neighborhood. This corresponds to the high density of buildings (see the detail map of Heat Islands), as well to the low percentage of Tree Canopy Cover. However the map of Tree Canopy Cover Change shows that a growing percentage of tree cover occurring in the last years

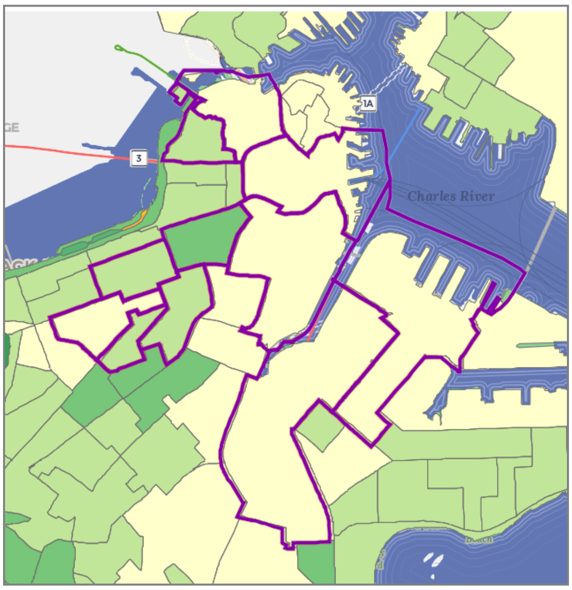
HEAT ISLANDs MAP



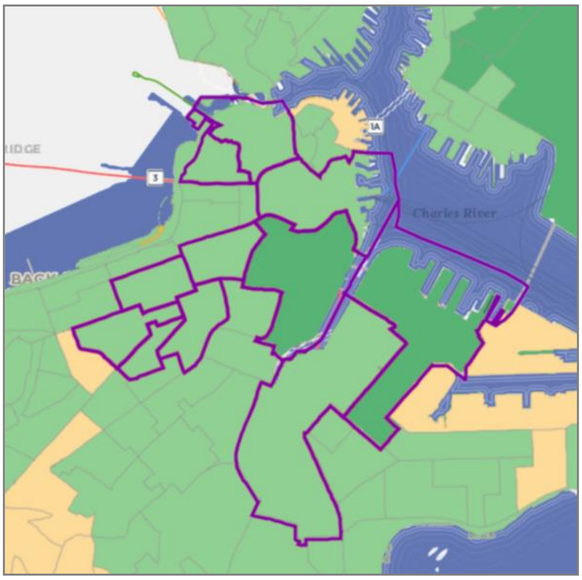
HEAT ISLANDs MAP_detail



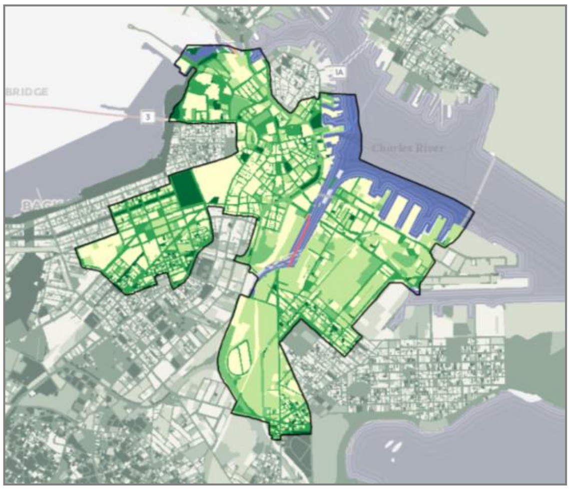
% CANOPY COVER_Census Tract



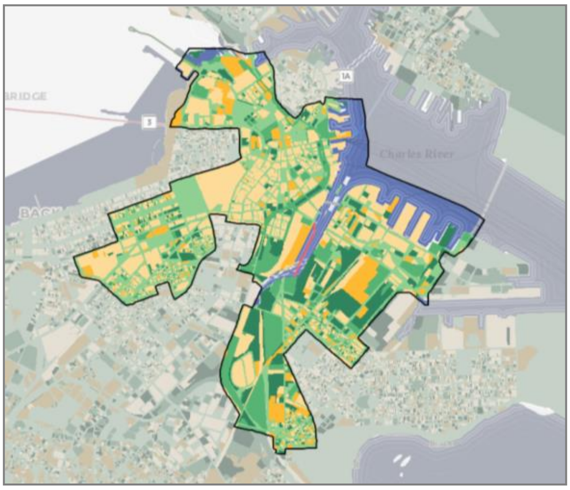
% CANOPY COVER CHANGE_Census Tract



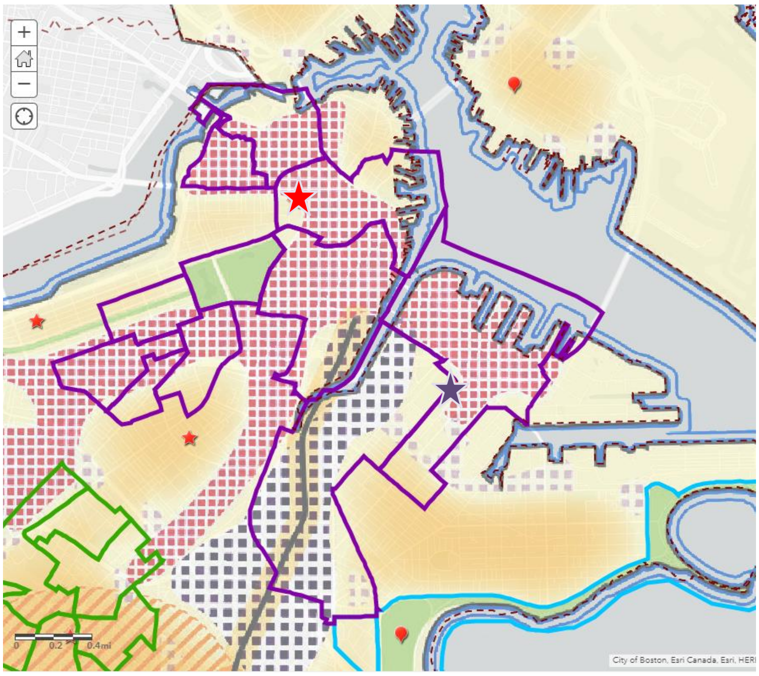
% CANOPY COVER_parcel



% CANOPY COVER CHANGE_parcel



IMAGINE BOSTON 2030



★ IN PROGRESS

Climate Ready South Boston

Neighborhood Focus Area

South Boston has experienced rapid transformation as the result of a development boom and significant investment. The neighborhood is also identified in the *Climate Ready Boston* report as the most exposed to future sea level rise and as a key flood entryway. This project will identify short- and long-term solutions that protect South Boston and the rest of the City.

The project kicked off in Fall 2017 and will run through Summer 2018.

★ UPCOMING

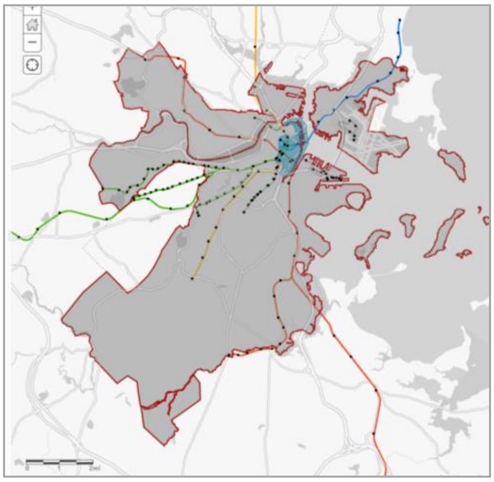
Climate Ready Downtown Boston

Neighborhood Focus Area

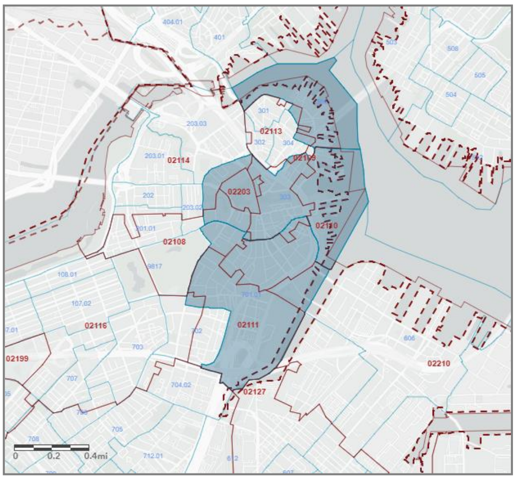
The Downtown focus area comprises several neighborhoods that lie in the northern part of Boston, including the West End, the North End, the Financial District, Chinatown, and the Leather District. Much of the Downtown waterfront will be exposed to coastal flooding by the end of the century.

Target Area 4_ **Insurance**

TARGET AREA LOCALIZATION



CENSUS TRACK ID and ZIP CODE



City of Boston CT_ID
25025030300
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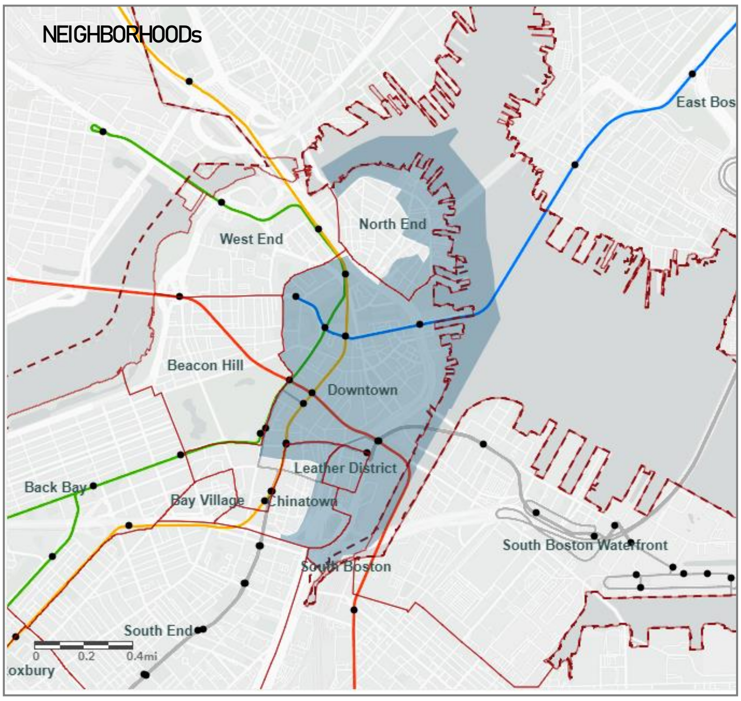
25025070101



CITY: Boston

CLUSTER: Insurance

LAND AREA: 0,734 sqmi

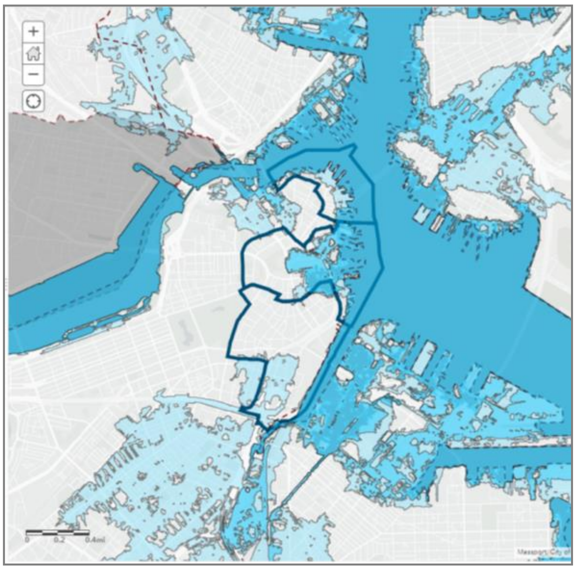
POPULATION: 14650

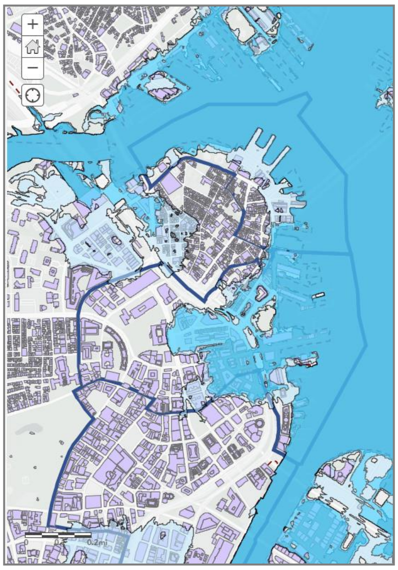
POP DENSITY: 19957 people/sqmi

ZIP CODEs: 02109, 02110, 02111, 02203

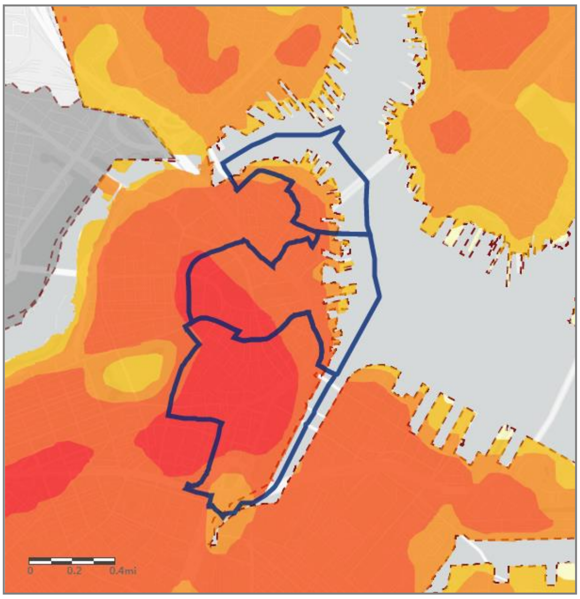
NEIGHBORHOODs: Downtown, Chinatown, Leather District, North End

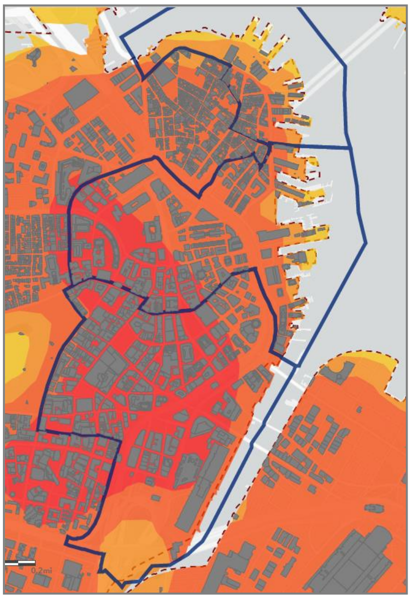
SEA LEVEL RISE



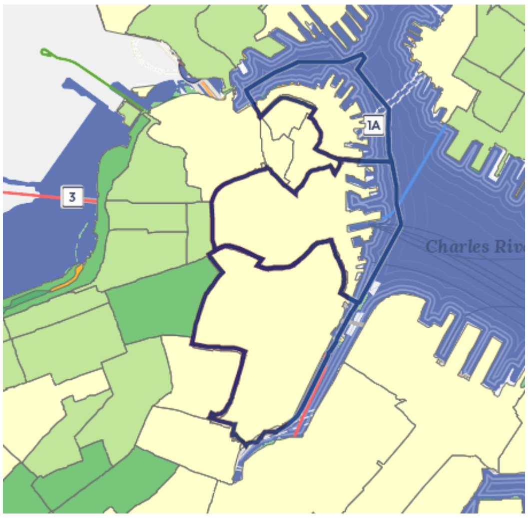


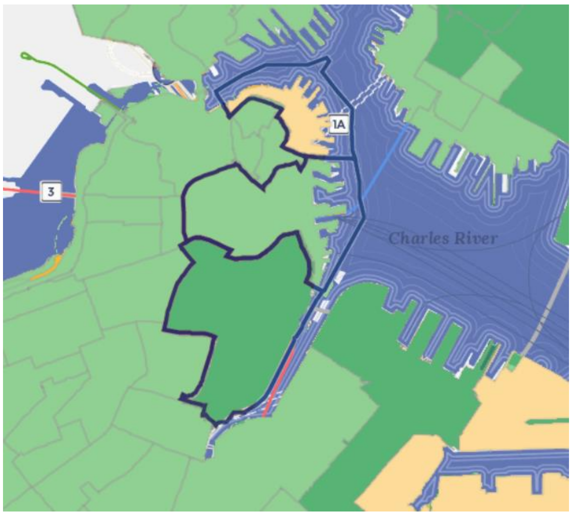
HEAT ISLAND MAPs



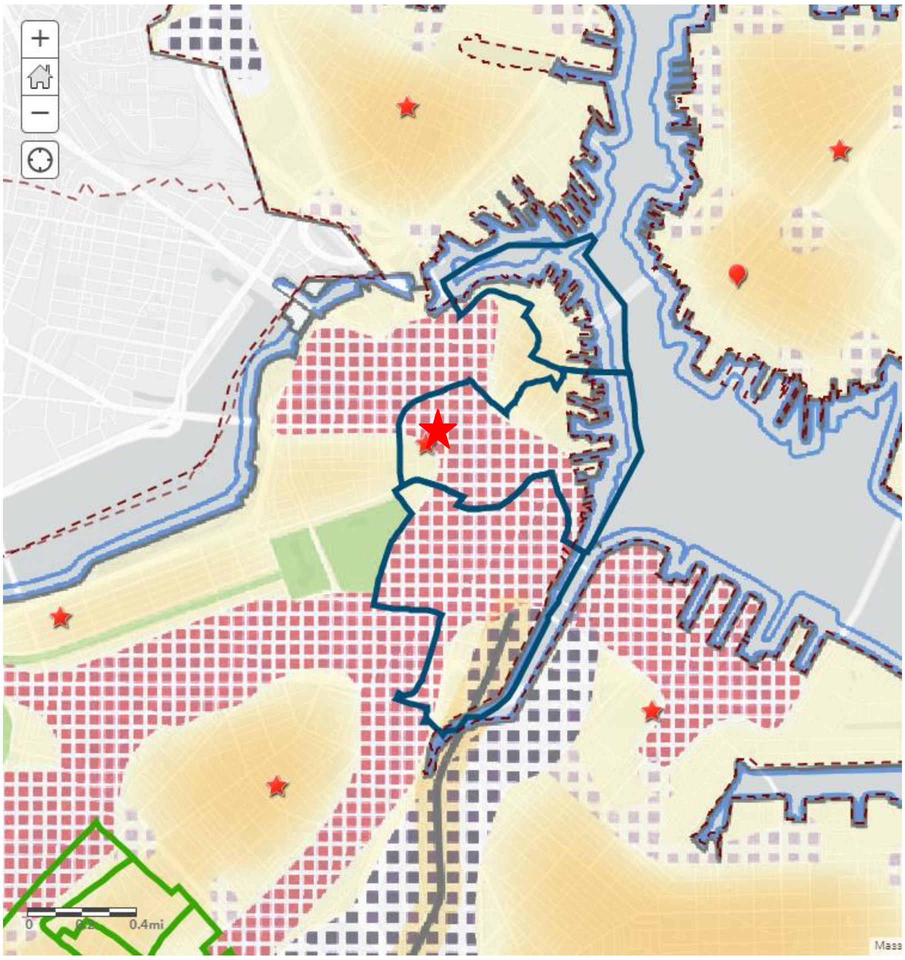


% CANOPY COVER





IMAGINE BOSTON 2030 & CLIMATE READY BOSTON

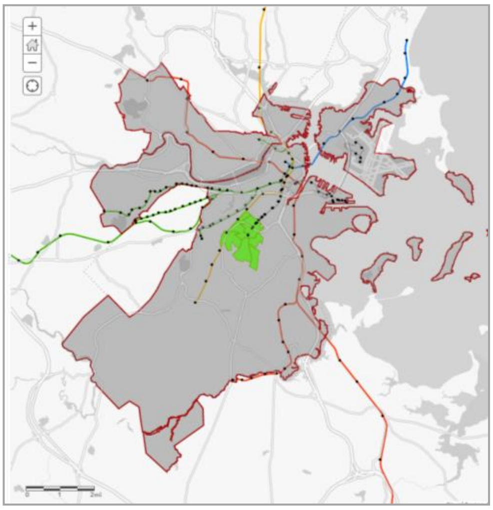


★ UPCOMING
Climate Ready Downtown Boston
Neighborhood Focus Area

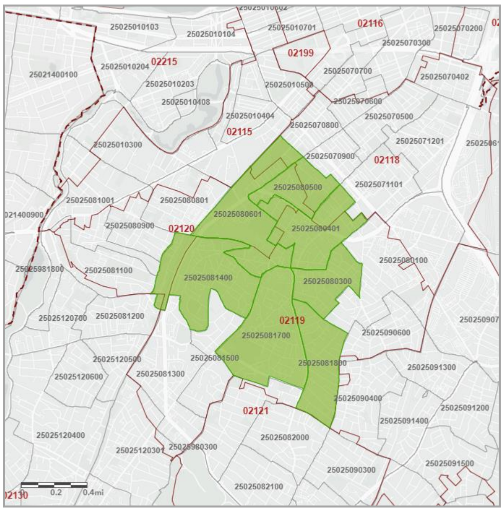
The Downtown focus area comprises several neighborhoods that lie in the northern part of Boston, including the West End, the North End, the Financial District, Chinatown, and the Leather District. Much of the Downtown waterfront will be exposed to coastal flooding by the end of the century.

Target Area 5_ **Roxbury**

TARGET AREA LOCALIZATION



CENSUS TRACK ID and ZIP CODE

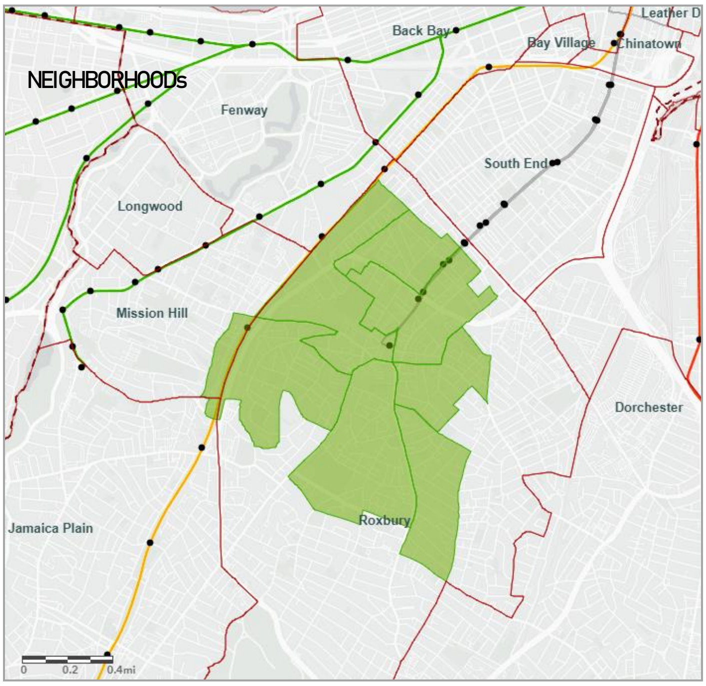


City of Boston CT_ID
25025080300
25025080401
25025080500
25025080601
25025081400
25025081700
25025081800

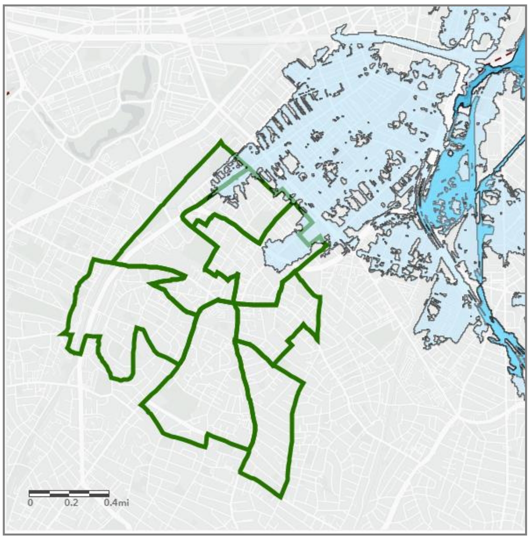
CITY: Boston
CLUSTER: Roxbury
LAND AREA: 1,214 sqmi
POPULATION: 23227
POP DENSITY: 19140 people/sqmi

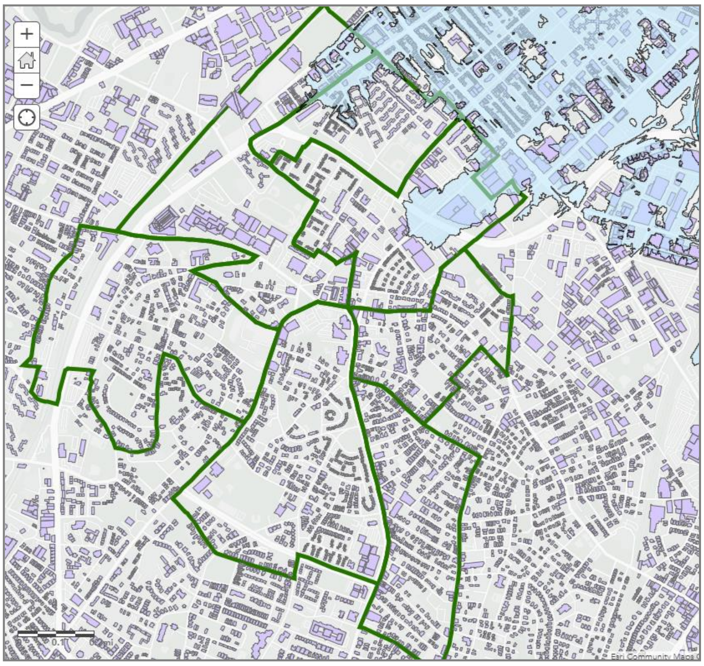
ZIP CODEs: 02119, 02120, 02118

NEIGHBORHOODs: Roxbury, Mission Hill

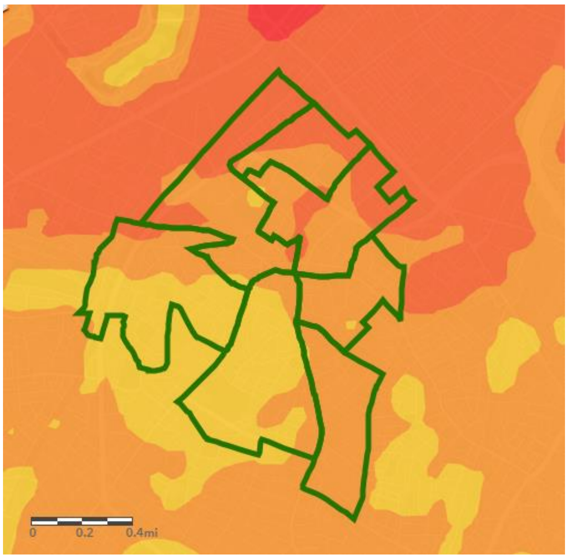


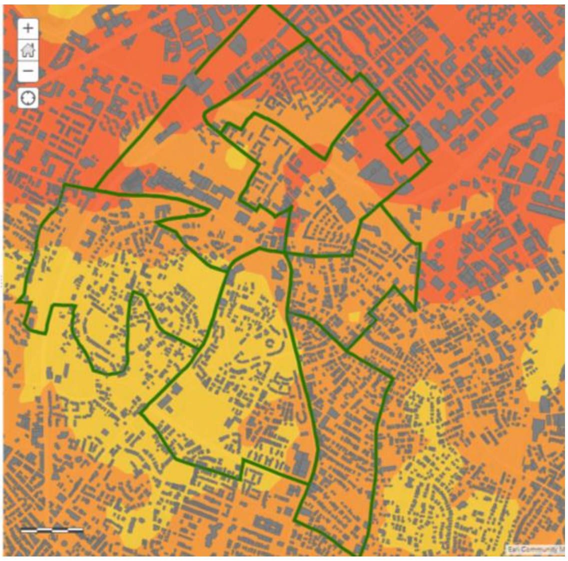
SEA LEVEL RISE



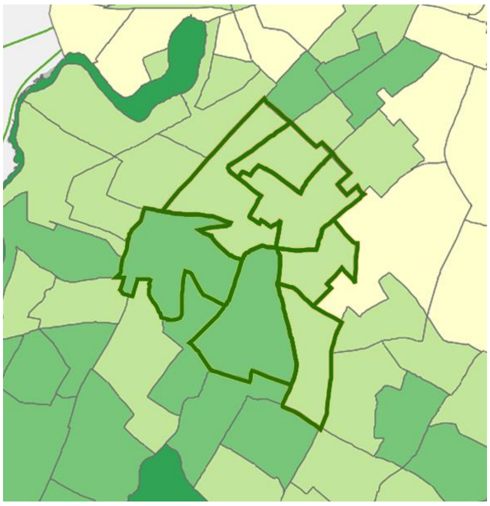


HEAT ISLAND MAPs

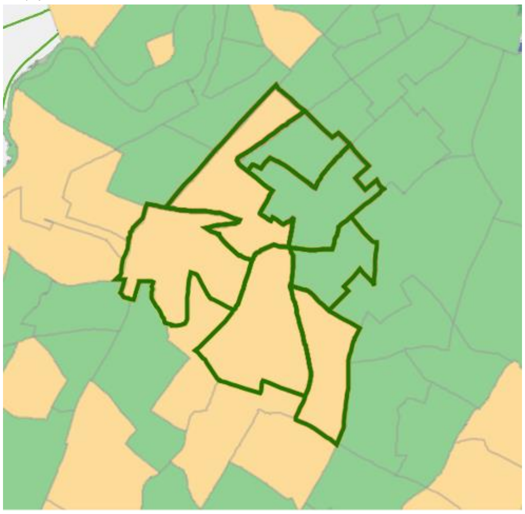


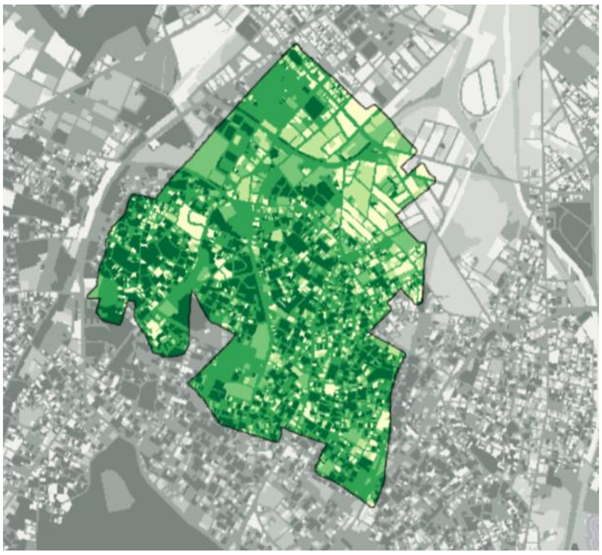


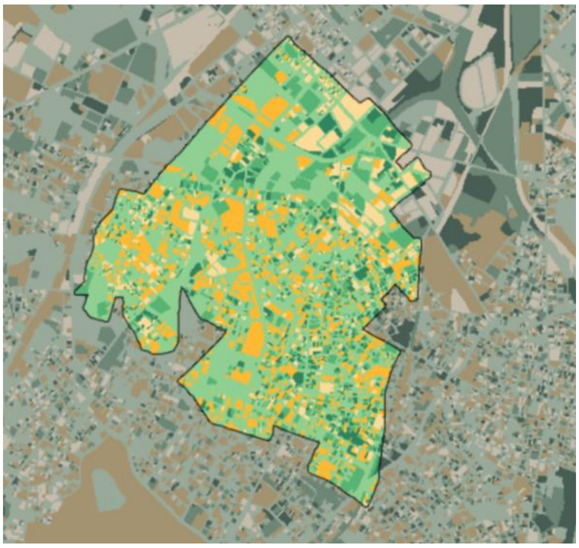
% CANOPY COVER



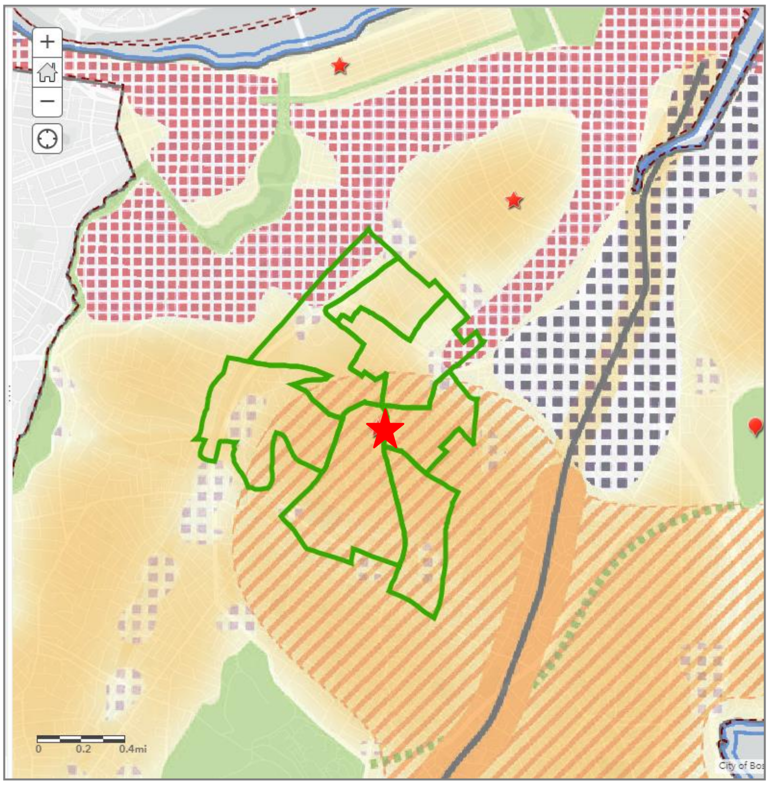
% CANOPY COVER CHANGE







IMAGINE BOSTON 2030



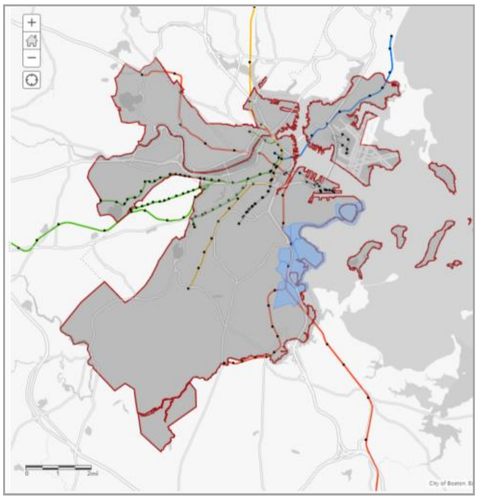
★ UPCOMING

Climate Ready Roxbury
Neighborhood Focus Area

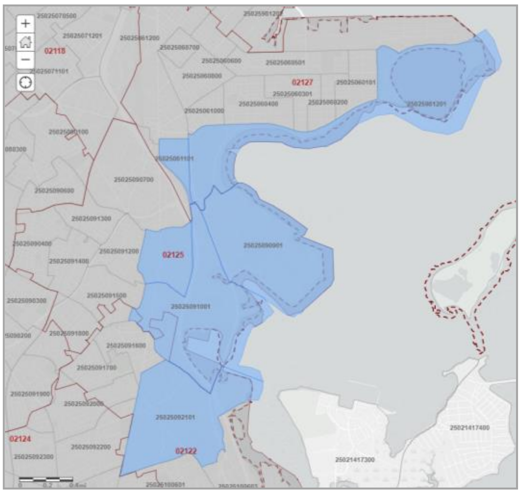
Roxbury, like many neighborhoods in Boston, is at the convergence of several future climate hazards and vulnerabilities including coastal and stormwater flooding, extreme heat, and socially vulnerable populations.

Target Area 6_ **Venture Development Center(VDC)**

TARGET AREA LOCALIZATION

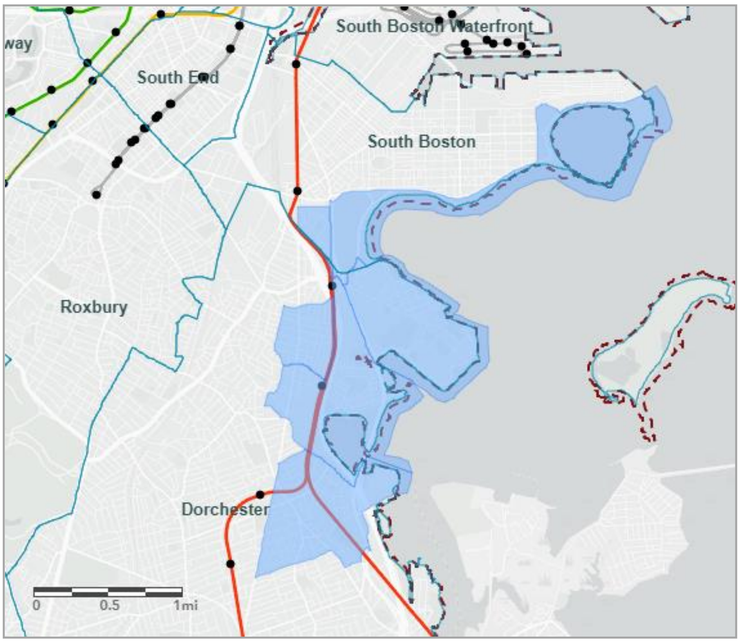


CENSUS TRACK ID & ZIP CODE



City of Boston CT_ID
25025981201
25025090901
25025091001
25025092101
25025061101
25025091100

NEIGHBORHOODs



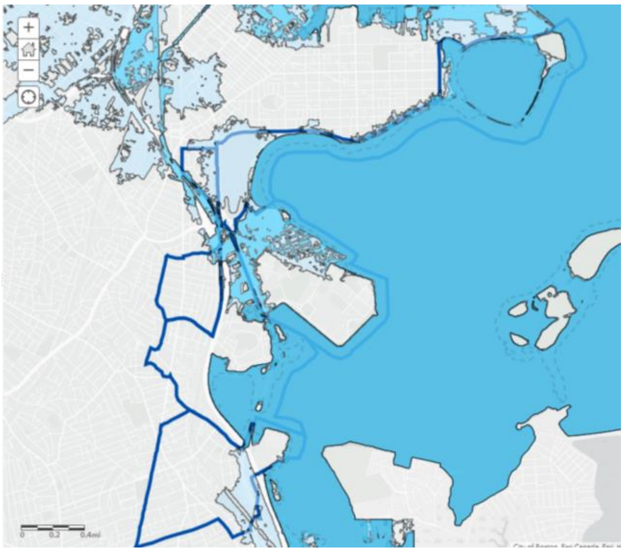
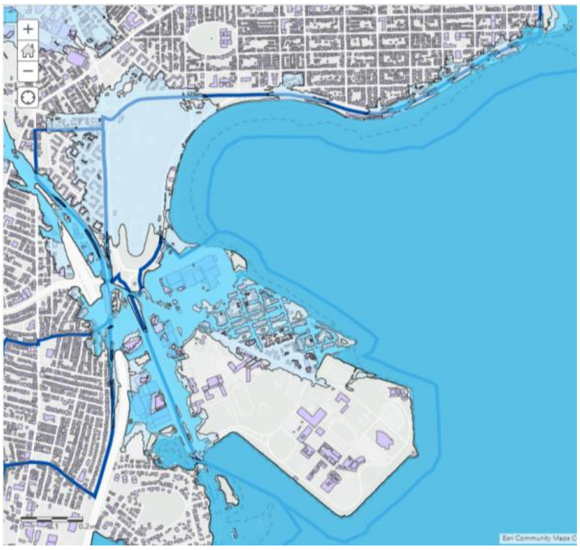
CITY: Boston
CLUSTER: VDC
LAND AREA: 1,637 sqmi
POPULATION: 21347*
POP DENSITY: 13037 people/sqmi [2]

ZIP CODEs: 02122, 02125, 02127

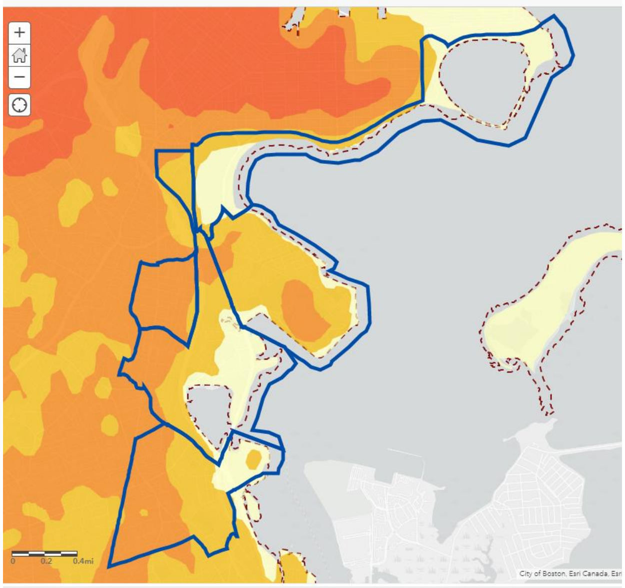
NEIGHBORHOODs: Dorchester, South Boston

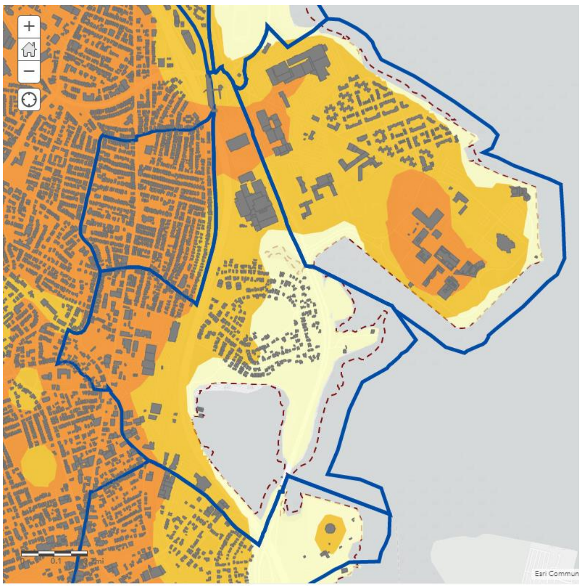
[2] No data are available for the Census Track 25025981201: the Population Density has been calculated with the exclusion of the respective land area

SEA LEVEL RISE

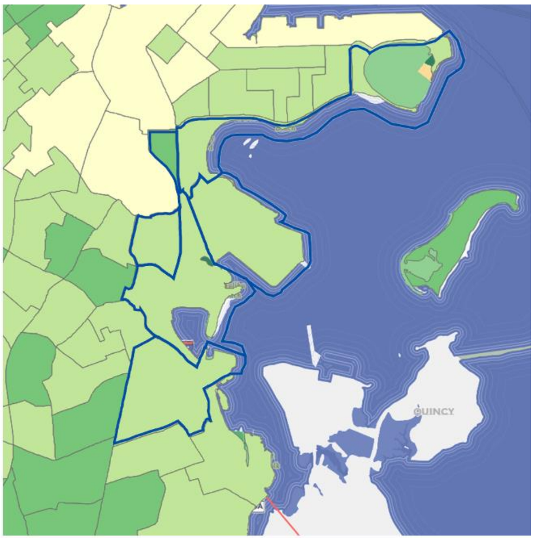



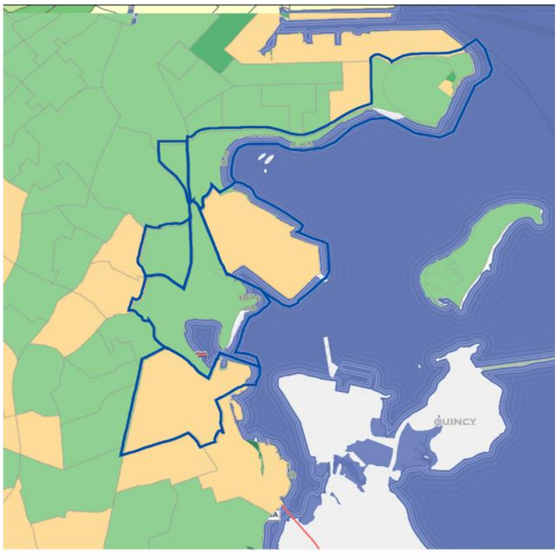
HEAT MAP

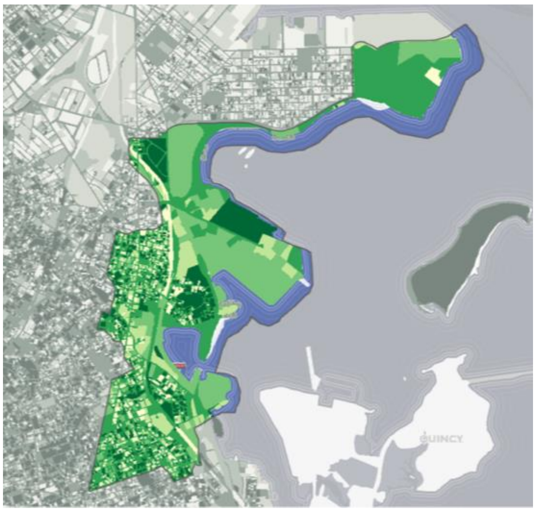


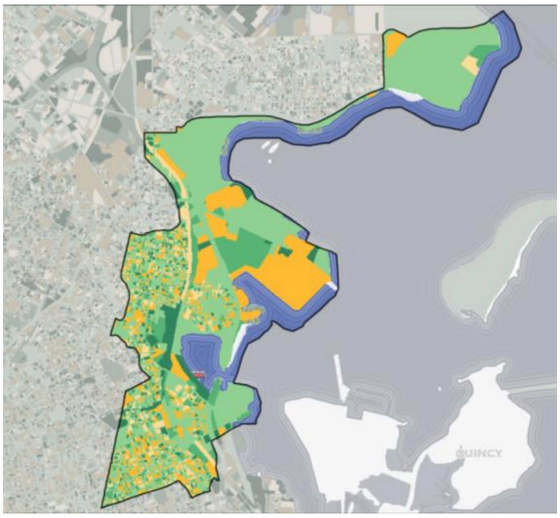


TREE CANOPY COVER

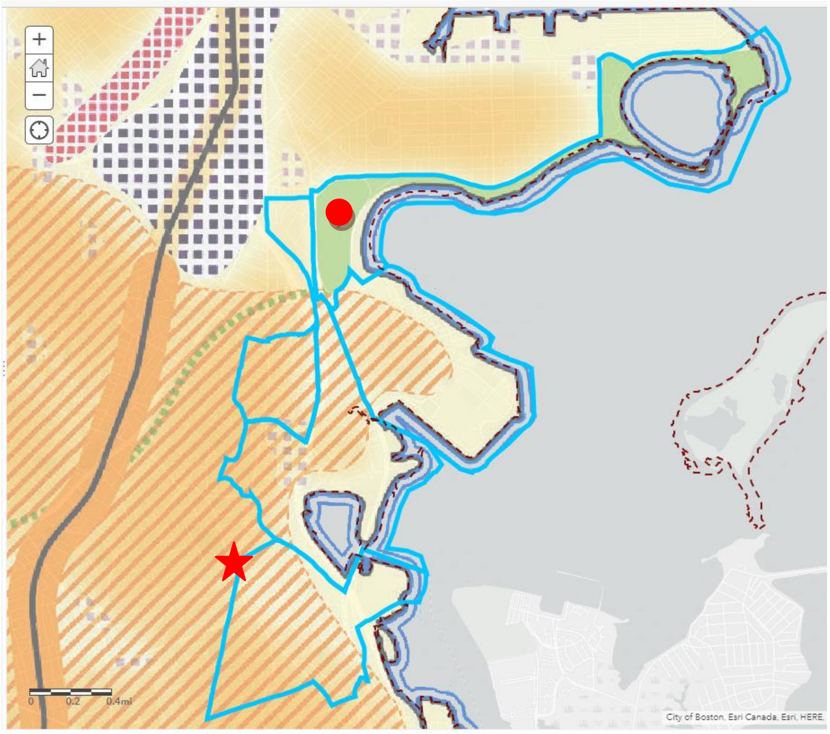








IMAGINE BOSTON 2030



IN PROGRESS

Moakley Park

The City is developing a comprehensive Vision Plan addressing recreational needs, park opportunities, and coastal and storm water flooding concerns.

The Vision Plan for Moakley Park will begin in 2017. This study will evaluate the entire park, all structures (including buildings), and infrastructure to assess future park renovations and climate resiliency potential.

UPCOMING

Climate Ready Dorchester

Neighborhood Focus Area

Dorchester is the largest neighborhood in Boston in terms of both population and geographic area. It is bounded by South Boston to the north, Dorchester Bay to the east, the Neponset River to the south, and Mattapan and Roxbury to the west. In the second half of the century, large areas of Dorchester will be exposed to high-probability flooding.

Conclusions

Climate change and Covid-19 pandemic emerge as the twin threats of our time, both manifesting the consequences of the 'Great Acceleration' of global changes in the Anthropocene, the epoch in which human activities lead so important alterations on Earth systems to menace its equilibrium, as well as humankind future. As most of the world population lives in urban areas and most of socio-economic activities are concentrated there, cities appear as the main responsible for unsustainable trends regarding the increasing level of greenhouse gas emissions, environmental degradation, and energy and material resource depletion. Cities can be therefore considered drivers of climate change. At the same time and for the same reason, hosting a large amount of people, cities are also the most affected by climate-related extreme events and other external shocks. As demonstrated by current pandemic, high density cities become particularly vulnerable to any sort of stresses and shocks, being such complex systems so interconnected in a globalized society to multiply people exposure to risks. On the other hand, if well planned and managed, cities could have a positive role in the global challenges of climate change and sustainability, offering a promising intervention level for decisive local actions, especially in terms of public policy and smart transformations of built environment.

The emerging COVID19 crisis and the necessity to define a new recovery plan, bring the proposal of a Green New Deal to the fore in both EU and US contexts, embracing the objectives of the Just Transition program to link together crisis response, climate emergency and social justice issues for a more equitable, resilient and sustainable future development. In this panorama, the thematic of Post-Carbon Transition becomes a central issue for GND strategies, bringing multi-layered solutions to address both the challenges of climate change and the socio-economic problems underlying the current pandemic crisis ("to achieve net-zero greenhouse gas emissions through a fair and just transition for all communities and workers" and "to create millions of good, high-wage jobs and ensure prosperity for all people" (GND 2018, Galvin and Healy 2020)). On the other side, in front of such a shock as the Coronavirus pandemic, the topic of resilience offers usefull insights to understand the factors that can influence the response of urban systems to disruptive events. Shifting the concept of resilience from ‘equilibrium-based’ assumptions to the evolutionary approaches, it is possible to combine the resilience framework with transition management principles and objectives, and thus obtain a new operational framework for planners and decision makers, helping them in transforming climate-related risks in new opportunities for post-carbon oriented urban regeneration initiatives. Thanks to the 100 Resilience Cities network, Resilience strategies are now emerging in many cities of the world, working in synergy with other urban/regional/national plans to

In the process of policy implementation, the phases of monitoring and evaluation are extremely important as they provide insights on results and outcomes of undertaken actions. They imply the identification of appropriate indicators (quantitative and/or qualitative), that need to be SMART (Doran 1981): Specific (Specific- target a clear and well-defined attribute); Measurable (quantify or qualitatively describe the attribute);Assignable (specify who will do it); Realistic (state what can be achieved given available resources). In the third chapter I described the evolution of three main generations of urban indicators, finding in the WCCD ISO 37120 series on City Data the most complete set of indicators for measuring urban transition trends toward sustainability (ISO37120), Resilience (37123), and Smart Cities (37122). The original idea was to use this set of indicators for elaborating the transition trends on the development of the case study of the city of Boston, but –despite a large availability of data- they were not sufficient to cover all the analysis of the target areas.

The case study has been thus conducted on two main steps: the first was focused on a multiscalar analysis of existing plans and strategies oriented to post-carbon transition and climate resilience and currently ongoing at national, metropolital and municipal level. In 2020 the Commonwealth of Massachusetts achieved the GWAS’s goal of 25% reduction of GHG emission. It demonstrates how it is possible to achieve carbon neutrality objectives through integrated policies scaled down at different territorial dimensions. At the same time, the Boston Resilience Strategy works in synergy with other urban plans to define operative actions within the 4 visions proposed.

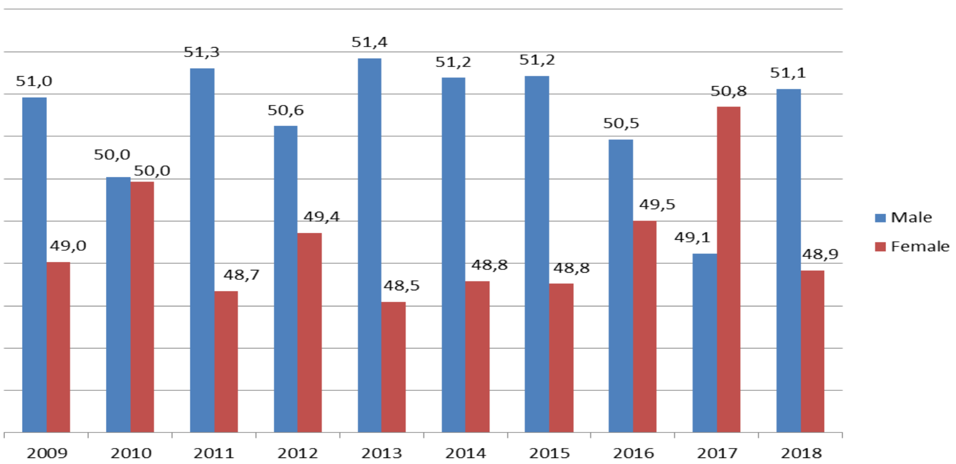
As a further level of analysis, I studied the six target areas identified by the preceding MAPS-LED project as the influence areas of innovation clusters. Each target area, has been analysed through the socio-demographic profile, providing some relevant trends over 2009-2018 timeframe. The target areas have been also studied in relation to climate related risks maps (sea level rise flooding, stormwater flooding, urban heat island) , with the aim to understand how current and planned initiatives intend to address climated vulnerabilities.

APPENDIX

Target Areas’ Socio-Demographic Analysis

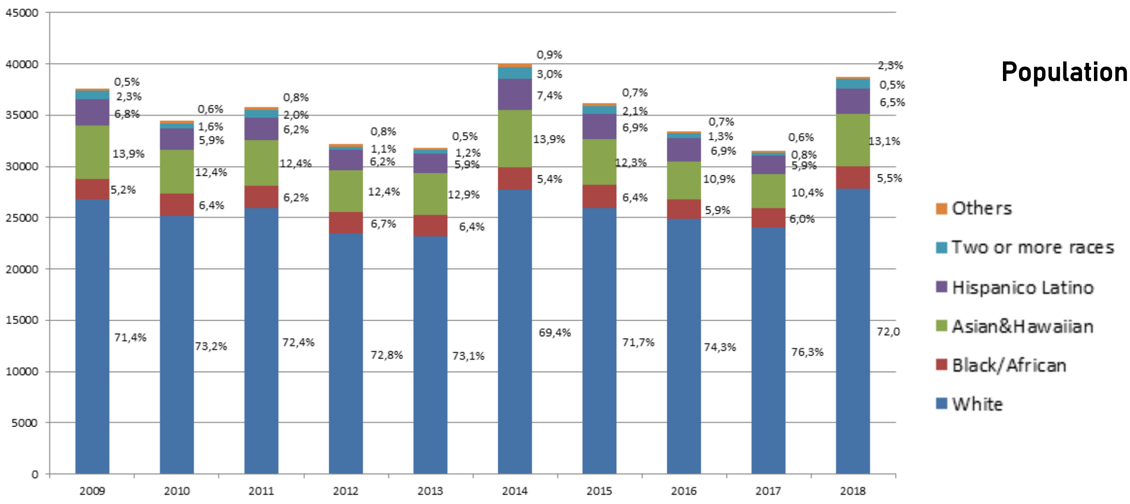
TA3_ Financial Services
Socio-Demographic Analysis

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
POPULATION BY SEX										
TOT	37544	34417	35788	32218	31770	40032	36149	33458	31508,5	38685
Male	19133	17214	18360	16309	16337	20493	18514	16885	15476	19753
Female	18403	17195	17418	15903	15424	19531	17626	16564	16021	18924
	%									
Male	51,0	50,0	51,3	50,6	51,4	51,2	51,2	50,5	49,1	51,1
Female	49,0	50,0	48,7	49,4	48,5	48,8	48,8	49,5	50,8	48,9
POPULATION BY RACE										
White	26811	25197	25915	23456	23223	27774	25904	24845	24041	27867
Black/African	1937	2187	2228	2143	2025	2180	2296	1964	1893	2145
Asian&Hawaiian	5217	4267	4423	3998	4107	5582	4448	3652	3289	5070
Hispanico Latino	2537	2019	2222	2004	1862	2958	2493	2325	1861	2514
Two or more races	865	540	729	347	385	1197	761	442	247	894
Others	177	207	271	270	168	341	247	230	177,5009	195
	%									
White	71,4	73,2	72,4	72,8	73,1	69,4	71,7	74,3	76,3	72,0
Black/African	5,2	6,4	6,2	6,7	6,4	5,4	6,4	5,9	6,0	5,5
Asian&Hawaiian	13,9	12,4	12,4	12,4	12,9	13,9	12,3	10,9	10,4	13,1
Hispanico Latino	6,8	5,9	6,2	6,2	5,9	7,4	6,9	6,9	5,9	6,5
Two or more races	2,3	1,6	2,0	1,1	1,2	3,0	2,1	1,3	0,8	2,3
Others	0,5	0,6	0,8	0,8	0,5	0,9	0,7	0,7	0,6	0,5



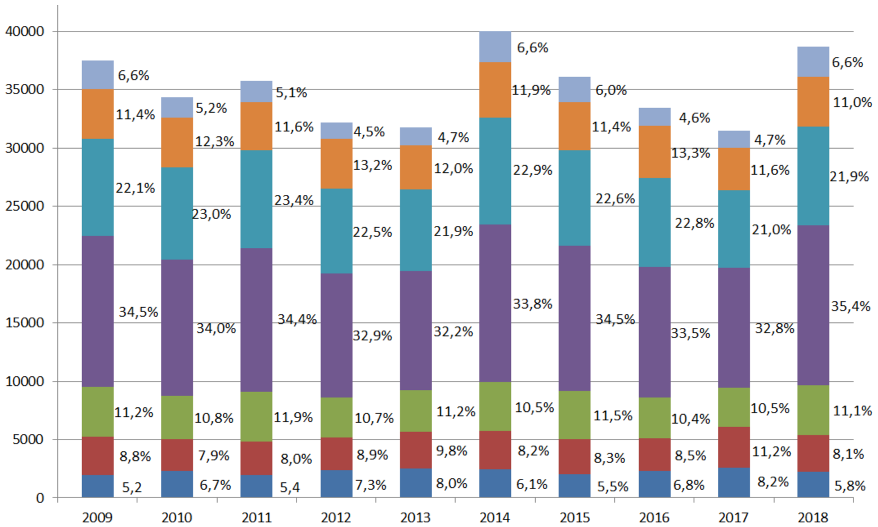
Population by Sex

Population by Race



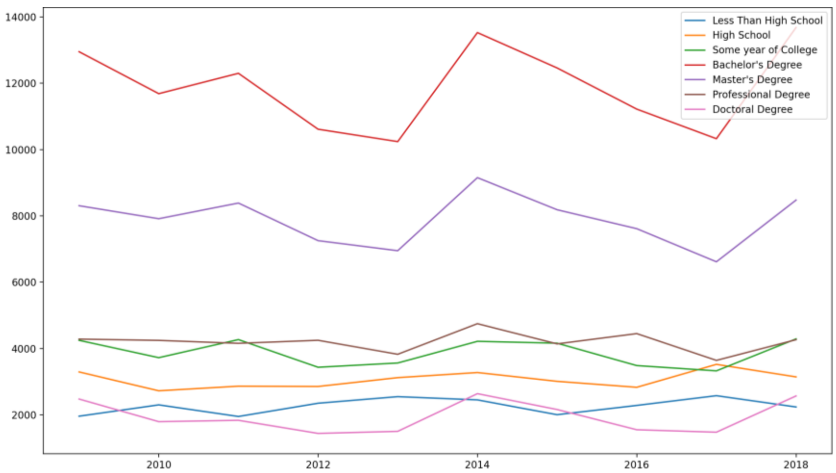
TA3_ Educational Attainment Analysis

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TOT POPULATION	37544	34417	35788	32218	31770	40032	36149	33458	31508,5	38685
EDUCATION										
Less than High School	1956	2298	1947	2347	2546	2448	2001	2281	2575	2234
High School	3291	2722	2862	2853	3119	3273	3008	2828	3520	3141
Some Year of College	4245	3722	4267	3432	3561	4215	4159	3483	3324	4288
Bachelor's Degree	12952	11687	12301	10614	10240	13529	12463	11221	10328	13683
Master's Degree	8306	7914	8387	7252	6949	9153	8185	7614	6614	8476
Professional Degree	4282	4243	4155	4246	3824	4747	4138	4448	3640	4264
Doctoral Degree	2473	1791	1832	1437	1499	2636	2158	1547	1473	2567
%										
Less than High School	5,2	6,7	5,4	7,3	8,0	6,1	5,5	6,8	8,2	5,8
High School	8,8	7,9	8,0	8,9	9,8	8,2	8,3	8,5	11,2	8,1
Some Year of College	11,3	10,8	11,9	10,7	11,2	10,5	11,5	10,4	10,5	11,1
Bachelor's Degree	34,5	34,0	34,4	32,9	32,2	33,8	34,5	33,5	32,8	35,4
Master's Degree	22,1	23,0	23,4	22,5	21,9	22,9	22,6	22,8	21,0	21,9
Professional Degree	11,4	12,3	11,6	13,2	12,0	11,9	11,4	13,3	11,6	11,0
Doctoral Degree	6,6	5,2	5,1	4,5	4,7	6,6	6,0	4,6	4,7	6,6



Educational Attainment

- Doctoral Degree
- Professional Degree
- Master's Degree
- Bachelor's Degree
- Some Year of College
- High School
- Less than High School

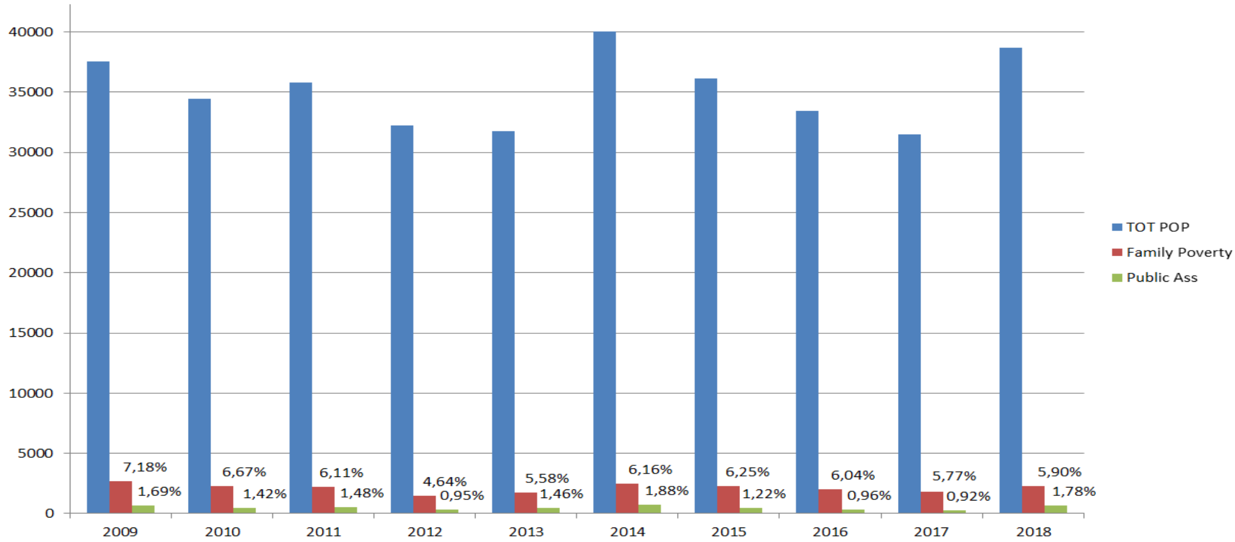


Educational Attainment TreNd (2009-2018)

TA3_ Economic Analysis

ECONOMY											
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	CHANGE 2009-2018
TOT POP	37544	34417	35788	32218	31770	40032	36149	33458	31508,501	38685	
Median Household Income ($)	105466	88382	97160	82874	76544	114299	101582	87952	81761	110933	+5,18%
Public Ass	636	490	531	306	464	753	441	322	289	687	+ 8,02 %
Public Ass %	1,69	1,42	1,48	0,95	1,46	1,88	1,22	0,96	0,92	1,78	
Family Poverty	2694	2294	2186	1494	1773	2464	2260	2019	1819	2282	-15,28%
Family Poverty %	7,18	6,67	6,11	4,64	5,58	6,16	6,25	6,04	5,77	5,90	

Family Poverty and Public Assistance



GINI INDEX (Income Inequality)											
CT_ID	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	CHANGE 2009/2018
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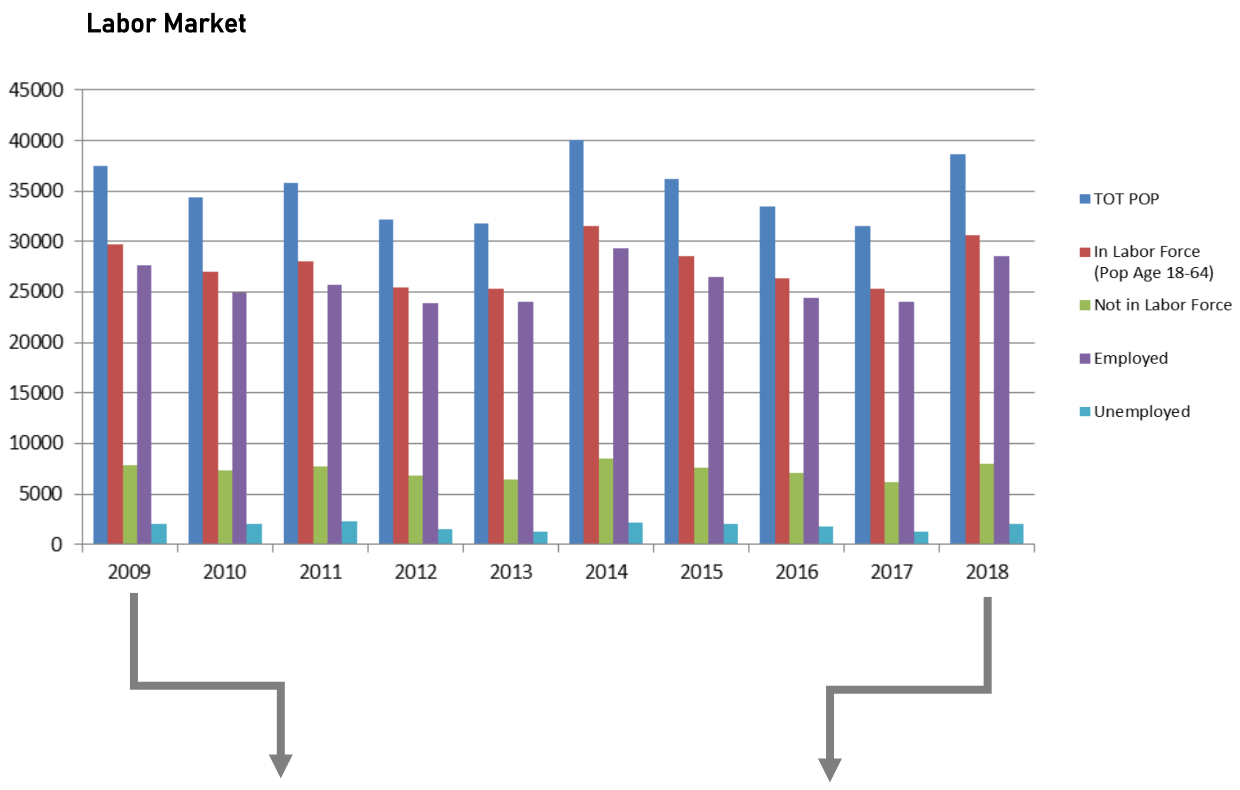
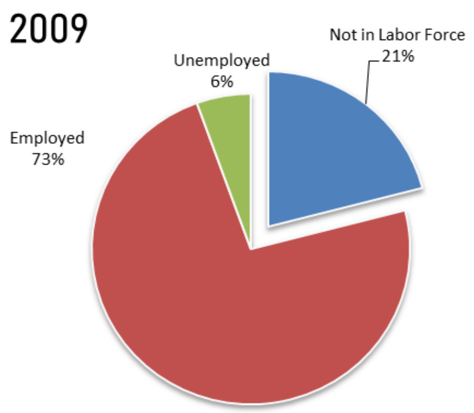
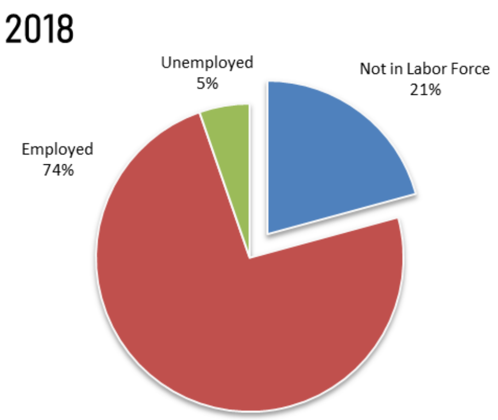
25025010702	0,5645	0,5291	0,5459	0,575	0,57	0,5745	0,5482	0,557	0,544	0,5658	0,001
25025020301	0,5272	0,4838	0,5018	0,4329	0,486	0,5506	0,511	0,4439	0,51	0,5431	0,016
25025020303	0,535	0,5486	0,5452	0,5502	0,557	0,5203	0,5203	0,5544	0,51	0,5278	-0,007
25025030300	0,5786	0,5206	0,534	0,508	0,486	0,561	0,5683	0,4901	0,485	0,5836	0,005
25025060600	0,3665	0,4004	0,4016	0,4423	0,456	0,4625	0,4048	0,4015	0,442	0,4316	0,065
25025061200	0,4502	0,5047	0,4557	0,5057	0,5	0,4485	0,4495	0,4791	0,435	0,4562	0,006
25025070101	0,661	0,6727	0,6524	0,6785	0,694	0,6351	0,6514	0,66	0,702	0,6367	-0,024
25025070300	0,5088	0,5519	0,5087	0,5427	0,574	0,5248	0,511	0,5661	0,574	0,5108	0,002
25025070700	0,5551	0,5724	0,5808	0,5794	0,618	0,5924	0,5489	0,5958	0,586	0,5736	0,019
25025981700	NA	NA	NA	NA	NA	NA	NA	NA	0,702	NA	NA
VAL MEDIO	0,53094	0,53936	0,53415	0,54458	0,5552	0,54849	0,53153	0,5359	0,5374	0,54422	**+0,013**

LABOR MARKET										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TOT POP	37544	34417	35788	32218	31770	40032	36149	33458	31508	38685
In Labor Force (Pop Age 18-64)	29666	27013	28039	25439	25284	31544	28521	26323	25314	30653
In Labor Force %	79	78	78	79	80	79	79	79	80	79
Employed	27596	24978	25762	23928	24037	29369	26524	24477	24098	28607
Employed %	93	92	92	94	95	93	93	93	95	93
Unemployed	2070	2035	2277	1511	1247	2175	1997	1846	1216	2046
Unemployed %	7	8	8	6	5	7	7	7	5	7



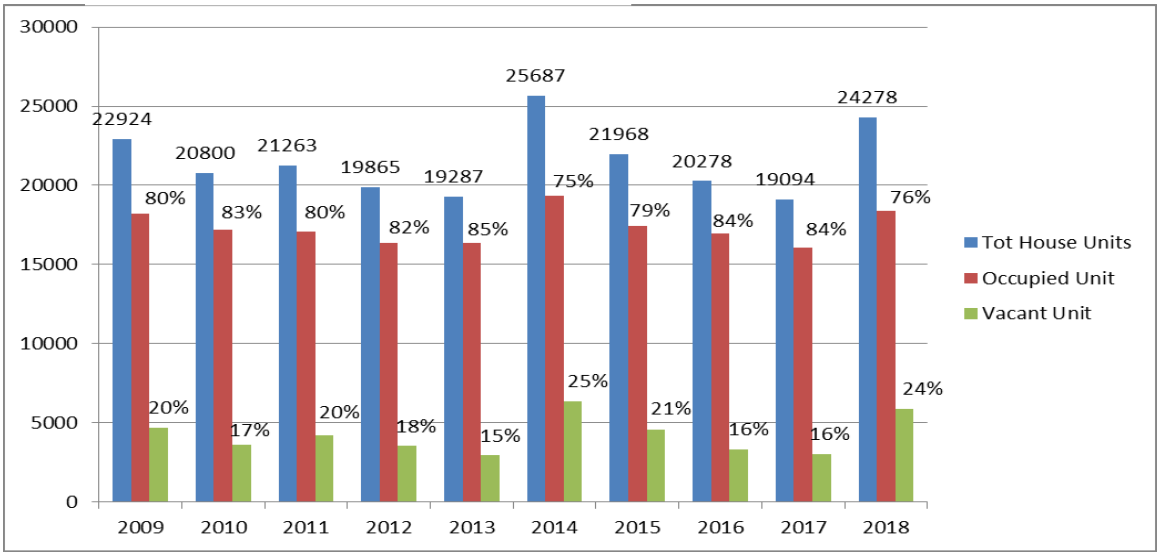




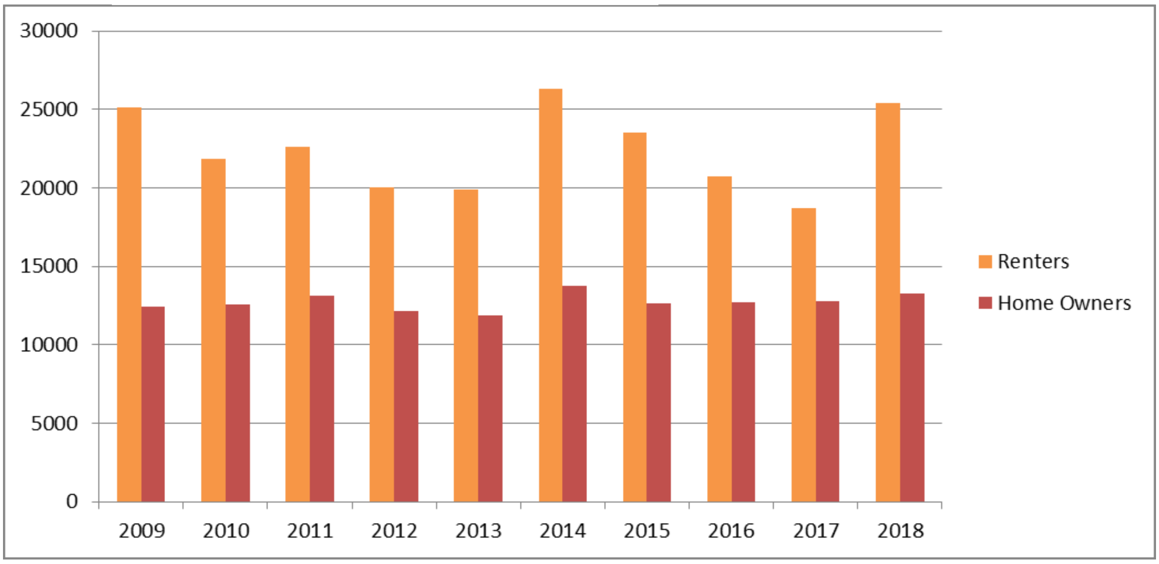
TA3_ Housing Stock

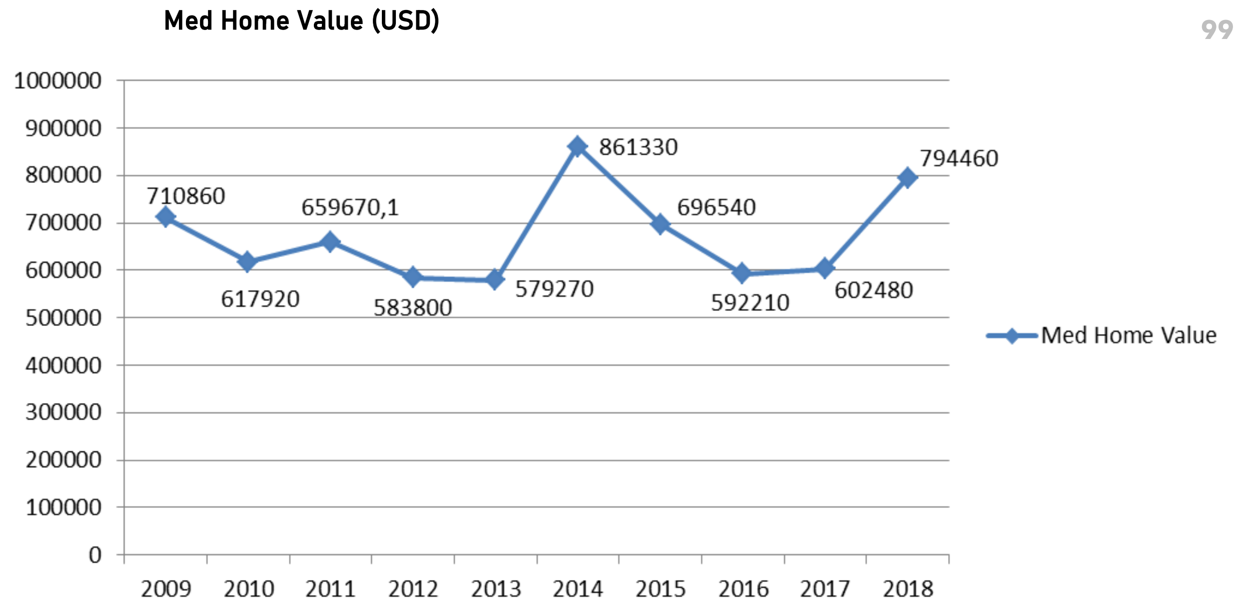
HOUSING STOCK										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Tot House Units	22924	20800	21263	19865	19287	25687	21968	20278	19094	24278
Vacant Unit	4685	3631	4192	3528	2937	6340	4552	3345	3005	5907
TOT POP	37544	34417	35788	32218	31770	40032	36149	33458	31508,5	38685
Renters	25112	21830	22620	20038	19906	26284	23490	20730	18702	25386
Renters %	66,89	63,43	63,21	62,20	62,66	65,66	64,98	61,96	59,36	65,62
Home Owners	56218	50690	51805	48429	47072	62860	53649	49508	46281	59601
Home Owners%	33,09	36,54	36,77	37,77	37,31	34,32	34,99	38,01	40,61	34,35
US $										
Med Gross Rent	2153	1828	1856	1777	1661	2346	2114	1803	1627	2284
Med Home Value	710860	617920	659670,1	583800	579270	861330	696540	592210	602480	794460

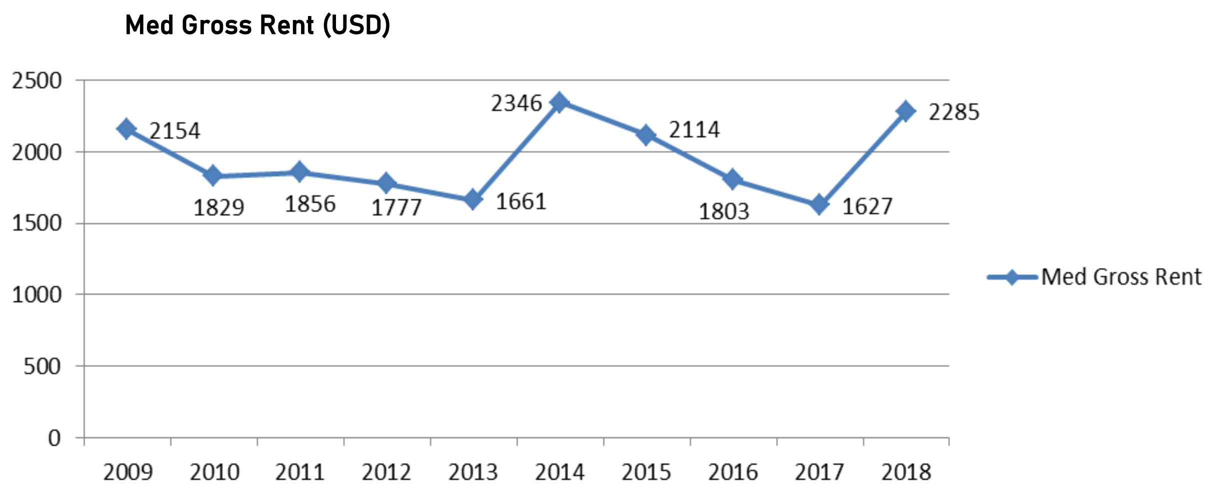
House Units



Renters & Home Owner



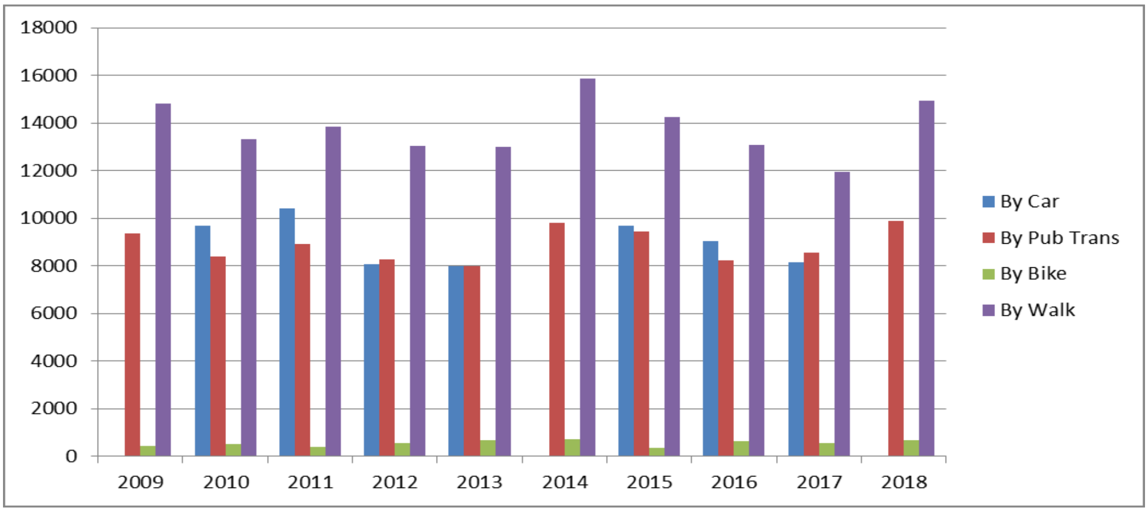

Med Home Value (USD)
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
710860
617920
659670,1
583800
579270
861330
696540
592210
602480
794460
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Med Home Value


Med Gross Rent (USD)
2500
2000
1500
1000
500
0
2154
1829
1856
1777
1661
2346
2114
1803
1627
2285
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Med Gross Rent

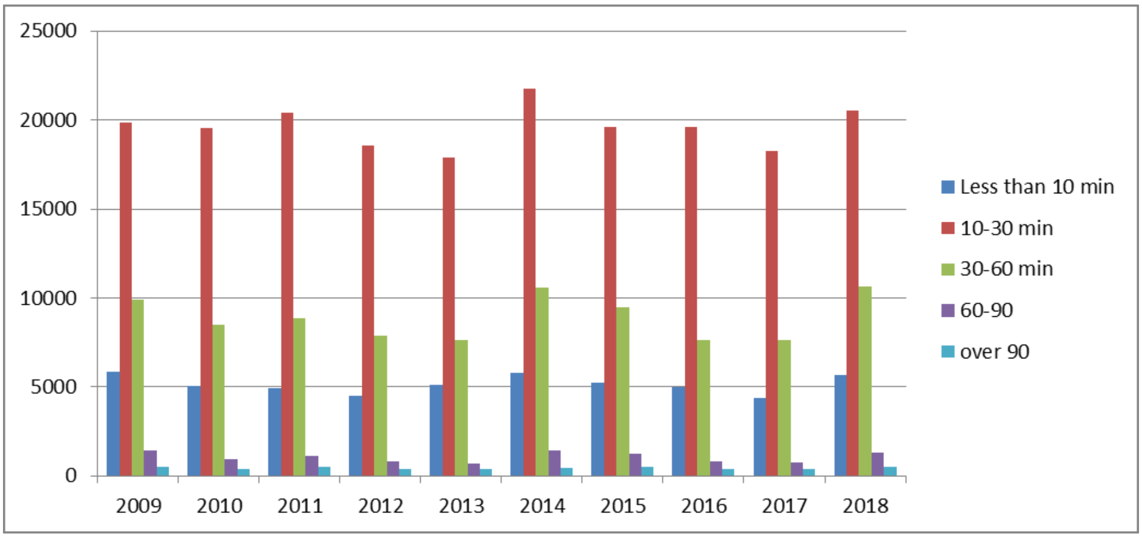
TA3_ Transport

TRANSPORT										
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
By Car	NA	9670	10431	8061	8006	NA	9702	9048	8133	NA
By Pub Trans	9367	8379	8922	8270	7990	9821	9446	8238	8564	9888
By Bike	416	535	383	570	669	734	344	652	552	682
By Walk	14806	13320	13829	13024	12977	15860	14238	13071	11962	14947
COMMUTING TIME										
Less than 10 min	5822	5040	4947	4531	5139	5809	5262	5022	4402	5684
10-30 min	19841	19527	20398	18562	17915	21772	19618	19582	18282	20528
30-60 min	9932	8515	8831	7904	7609	10595	9482	7625	7645	10625
60-90	1415	927	1104	795	685	1403	1258	798	779	1302
over 90	512	381	486	401	400	433	504	410	374	523

Commuting by

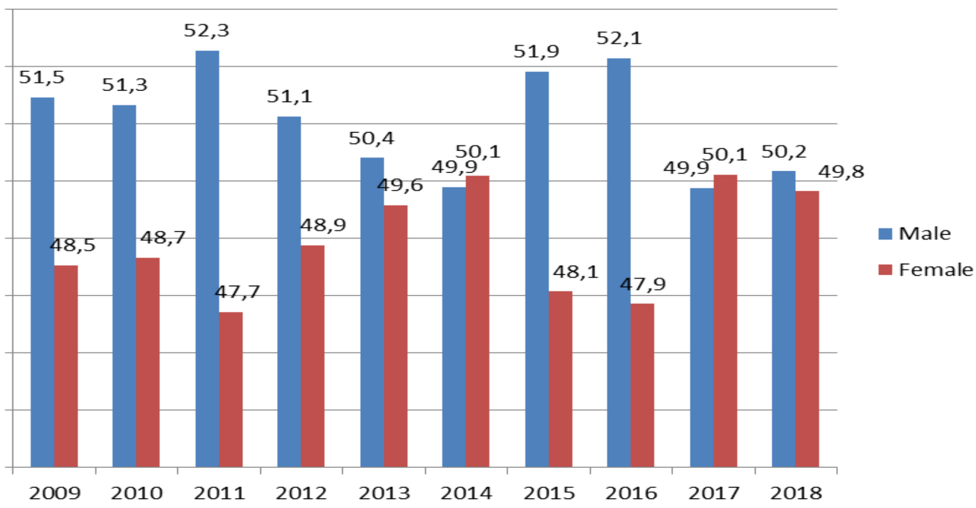


Commuting time

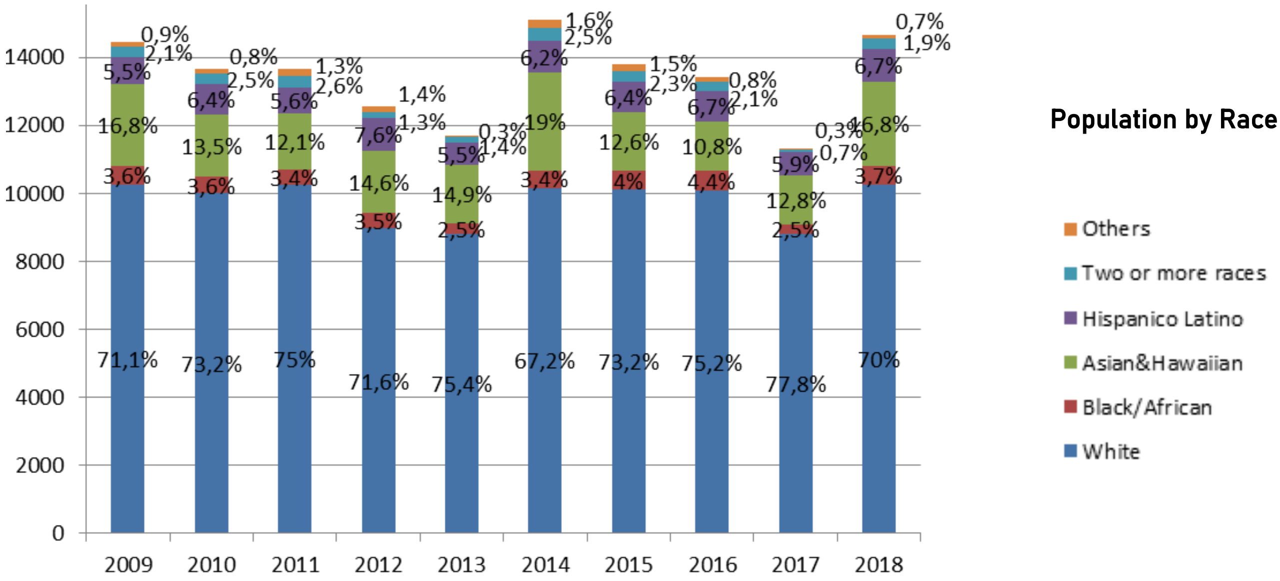


TA4_ Insurance
Socio-Demographic Analysis

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
POPULATION BY SEX										
TOT	14439	13653	13651	12549	11687	15118	13789	13406	11326	14650
Male	7430	7007	7136	6415	5890	7543	7158	6989	5648	7349
Female	7006	6643	6512	6133	5794	7572	6628	6415	5675	7298
	%									
Male	51,5	51,3	52,3	51,1	50,4	49,9	51,9	52,1	49,9	50,2
Female	48,5	48,7	47,7	48,9	49,6	50,1	48,1	47,9	50,1	49,8
POPULATION BY RACE										
White	10268	9998	10240	8980	8807	10162	10100	10075	8807	10261
Black/African	524	489	464	443	296	518	556	592	284	549
Asian&Hawaiian	2426	1837	1650	1830	1740	2873	1733	1448	1448	2462
Hispanico Latino	799	875	760	957	647	939	883	896	669	988
Two or more races	299	338	355	167	159	381	312	285	81	281
Others	123	116	182	172	38	245	205	110	36,69	109
	%									
White	71,1	73,2	75,0	71,6	75,4	67,2	73,2	75,2	77,8	70,0
Black/African	3,6	3,6	3,4	3,5	2,5	3,4	4,0	4,4	2,5	3,7
Asian&Hawaiian	16,8	13,5	12,1	14,6	14,9	19,0	12,6	10,8	12,8	16,8
Hispanico Latino	5,5	6,4	5,6	7,6	5,5	6,2	6,4	6,7	5,9	6,7
Two or more races	2,1	2,5	2,6	1,3	1,4	2,5	2,3	2,1	0,7	1,9
Others	0,9	0,8	1,3	1,4	0,3	1,6	1,5	0,8	0,3	0,7



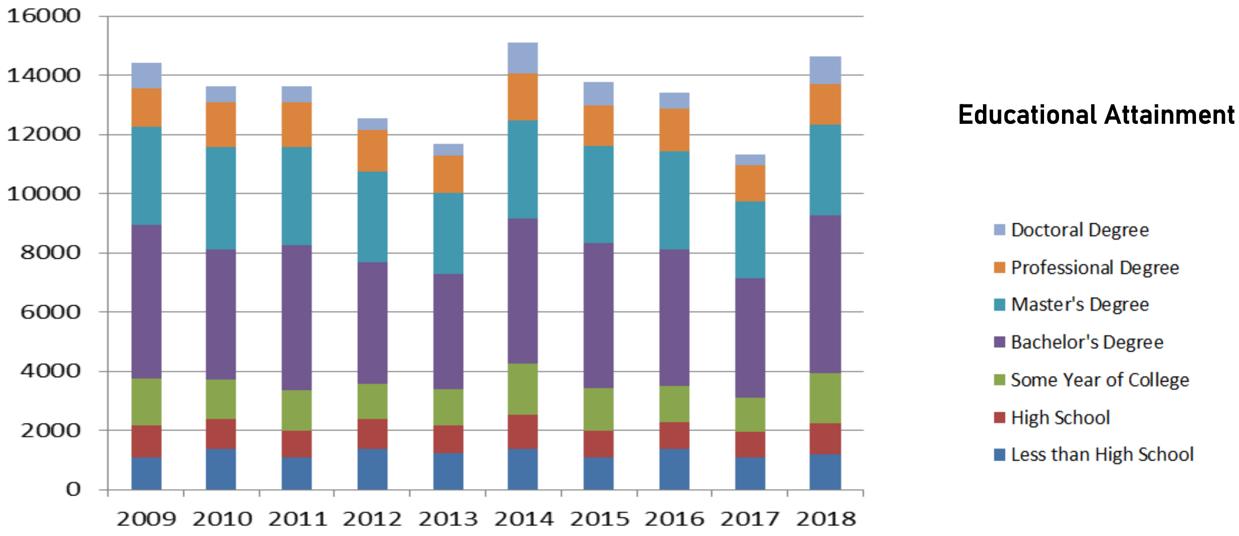
Population by Sex

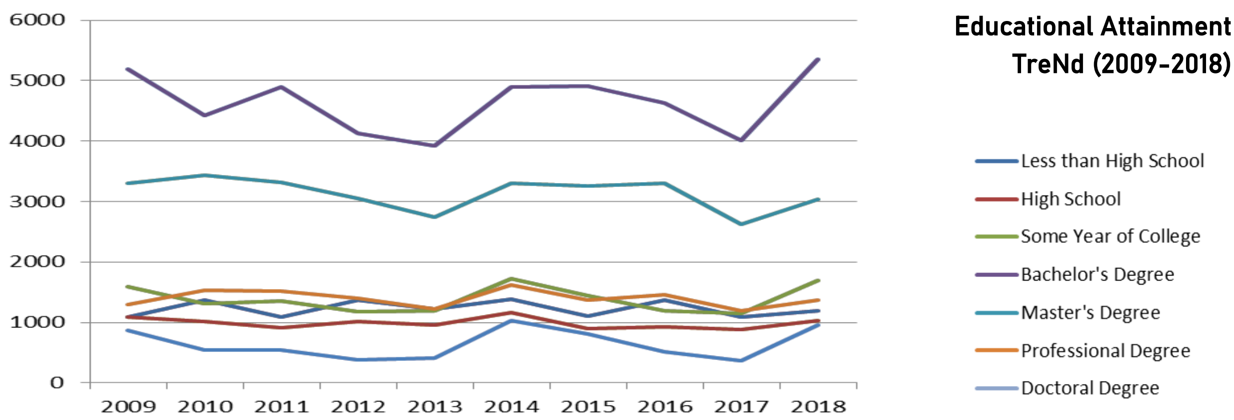


Population by Race

TA4_Educational Attainment Analysis

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TOT POPULATION	37544	34417	35788	32218	31770	40032	36149	33458	31508,5	38685
EDUCATION										
Less than High School	1082	1372	1095	1366	1224	1378	1103	1372	1088	1198
High School	1092	1020	910	1015	963	1161	897	925	885	1034
Some Year of College	1596	1316	1353	1182	1196	1725	1439	1197	1145	1696
Bachelor's Degree	5186	4418	4897	4133	3921	4897	4910	4627	4008	5351
Master's Degree	3303	3436	3322	3058	2738	3298	3261	3299	2628	3036
Professional Degree	1296	1534	1523	1405	1226	1618	1363	1464	1199	1376
Doctoral Degree	872	546	539	378	407	1031	805	512	362	951
%										
Less than High School	7,5	10,0	8,0	10,9	10,5	9,1	8,0	10,2	9,6	8,2
High School	7,6	7,5	6,7	8,1	8,2	7,7	6,5	6,9	7,8	7,1
Some Year of College	11,1	9,6	9,9	9,4	10,2	11,4	10,4	8,9	10,1	11,6
Bachelor's Degree	35,9	32,4	35,9	32,9	33,6	32,4	35,6	34,5	35,4	36,5
Master's Degree	22,9	25,2	24,3	24,4	23,4	21,8	23,6	24,6	23,2	20,7
Professional Degree	9,0	11,2	11,2	11,2	10,5	10,7	9,9	10,9	10,6	9,4
Doctoral Degree	6,0	4,0	3,9	3,0	3,5	6,8	5,8	3,8	3,2	6,5

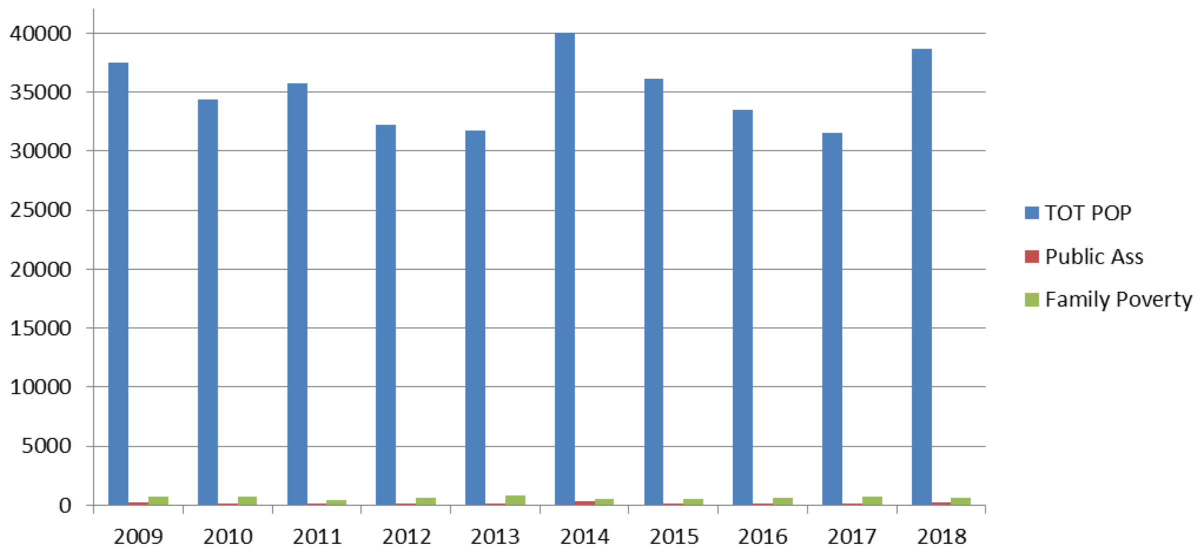




TA4_ Economic Analysis

ECONOMY										
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**CHANGE 2009-2018**
TOT POP	37544	34417	35788	32218	31770	40032	36149	33458	31509	38685	
Median Household Income ($)	99433	92368	97932	89608	76899	104866	98305	99225	82975	104462	5,06
Public Ass	242	161	123	118	120	322	84	133	87	269	11,16
Public Ass %	0,64	0,47	0,34	0,37	0,38	0,80	0,23	0,40	0,28	0,70	
Family Poverty	705	725	471	607	862	582	494	624	713	600	-14,82

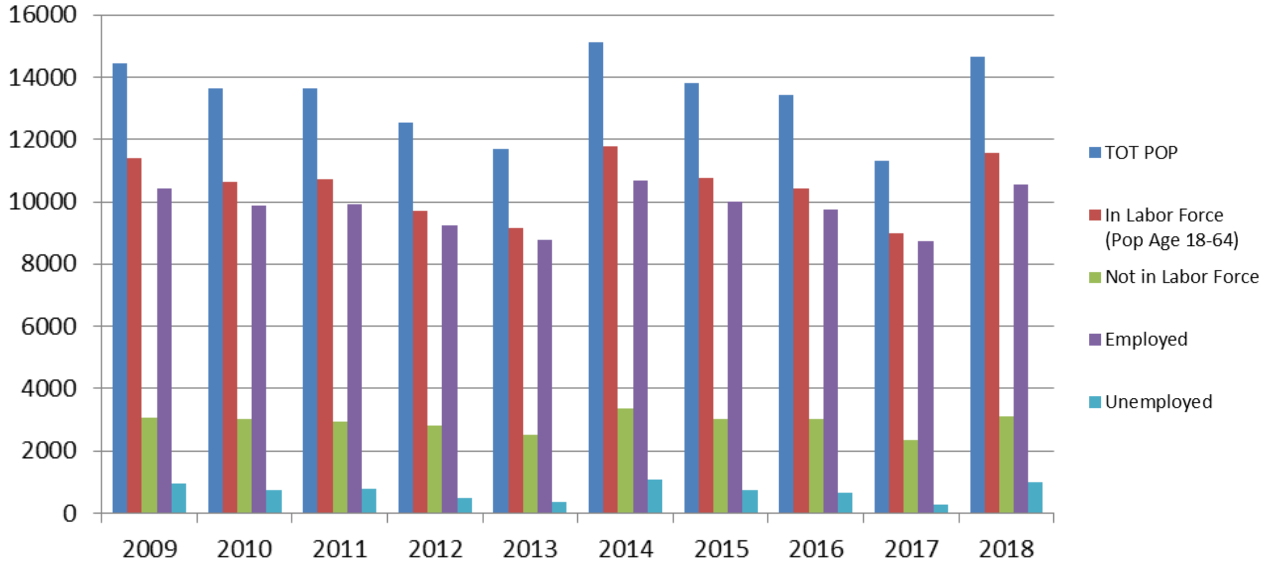
Family Poverty and Public Assistance

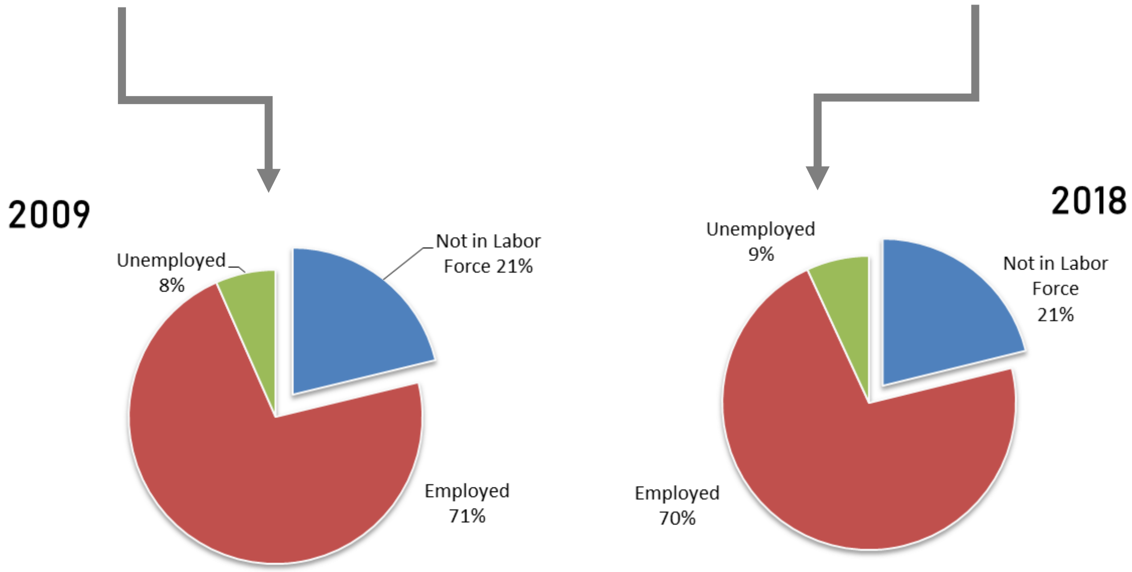


CT_ID	GINI										CHANGE 2009/2018
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
25025030300	0,5786	0,5206	0,534	0,508	0,486	0,561	0,5683	0,4901	0,485	0,5836	0,005
25025030500	0,5109	0,5645	0,5545	0,5566	0,491	0,5391	0,5438	0,5289	0,523	0,5403	0,005
25025070101	0,661	0,6727	0,6524	0,6785	0,694	0,6351	0,6514	0,66	0,702	0,6367	0,029
VAL MEDIO	0,5835	0,5859	0,5803	0,581	0,557	0,5784	0,5878	0,5597	0,57	0,5869	0,003

LABOR MARKET										
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
TOT POP	14439	13653	13651	12549	11687	15118	13789	13406	11326	14650
In Labor Force (Pop Age 18-64)	11375	10625	10700	9720	9153	11770	10763	10403	9001	11548
In Labor Force %	79	78	78	77	78	78	78	78	79	79
Employed	10420	9881	9921	9237	8780	10673	10006	9745	8711	10536
Employed %	92	93	93	95	96	91	93	94	97	91
Unemployed	955	744	779	483	373	1097	757	658	290	1012
Unemployed %	8	7	7	5	4	9	7	6	3	9

Labor Market

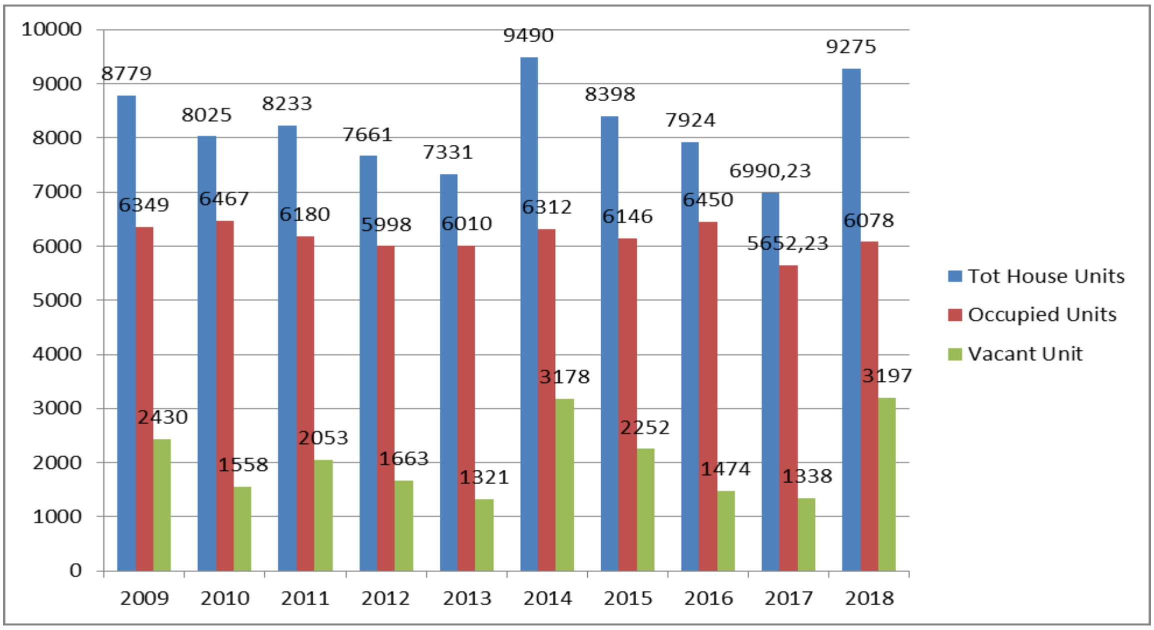




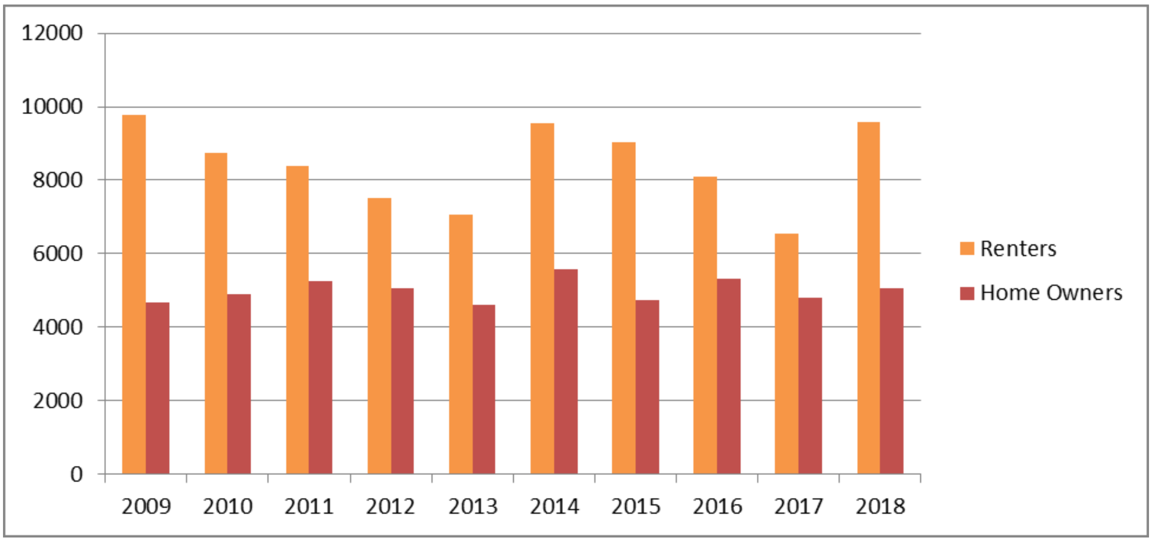
TA4_ Housing Stock

HOUSING STOCK										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Tot House Units	8779	8025	8233	7661	7331	9490	8398	7924	6990,2	9275
Vacant Unit	2430	1558	2053	1663	1321	3178	2252	1474	1338	3197
TOT POP	14439	13653	13651	12549	11687	15118	13789	13406	11326	14650
Renters	9775	8756	8379	7499	7064	9535	9049	8086	6534	9587
Renters %	67,70	64,13	61,38	59,76	60,44	63,07	65,62	60,32	57,69	65,44
Home Owners	4661	4894	5269	5047	4620	5580	4737	5317	4789	5060
Home Owners%	32,28	35,85	38,60	40,22	39,53	36,91	34,35	39,66	42,28	34,54
US $										
Med Gross Rent	2095	1892,7	1957,7	1794,3	1619	2307,3	2082	1923,7	1539,3	2205
Med Home Value	738800	704367	694767	657633	666133	916733	713667	707000	673900	796800

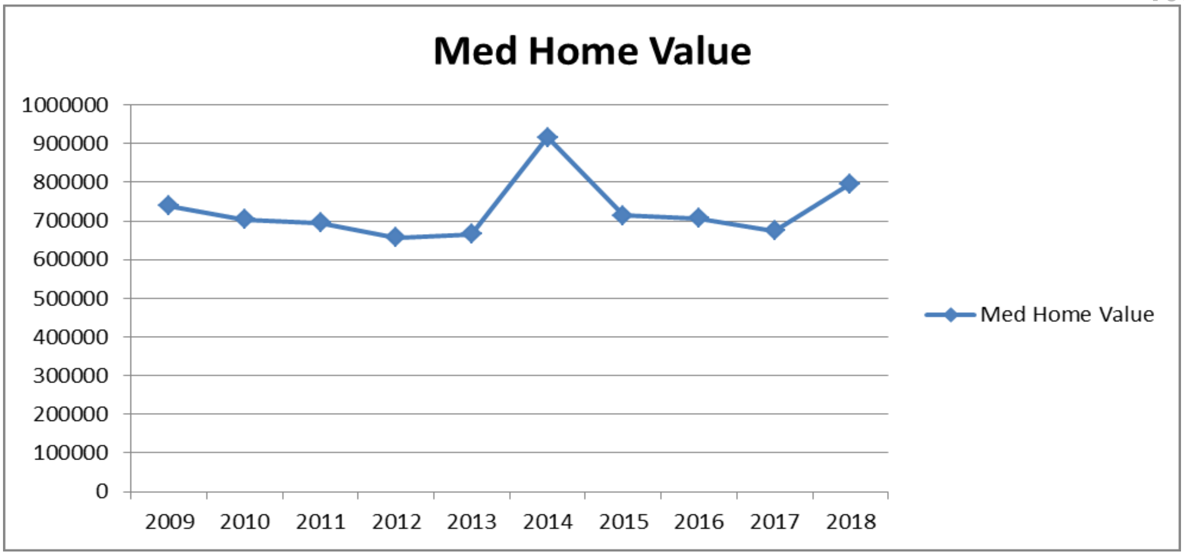
House Units



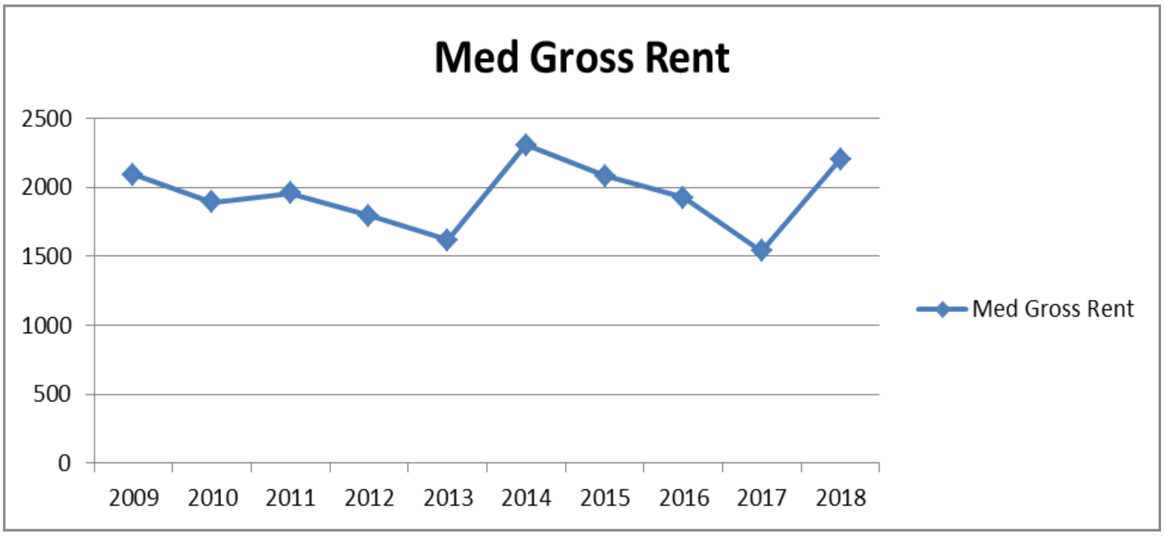
Renters & Home Owner



Med Home Value (USD)

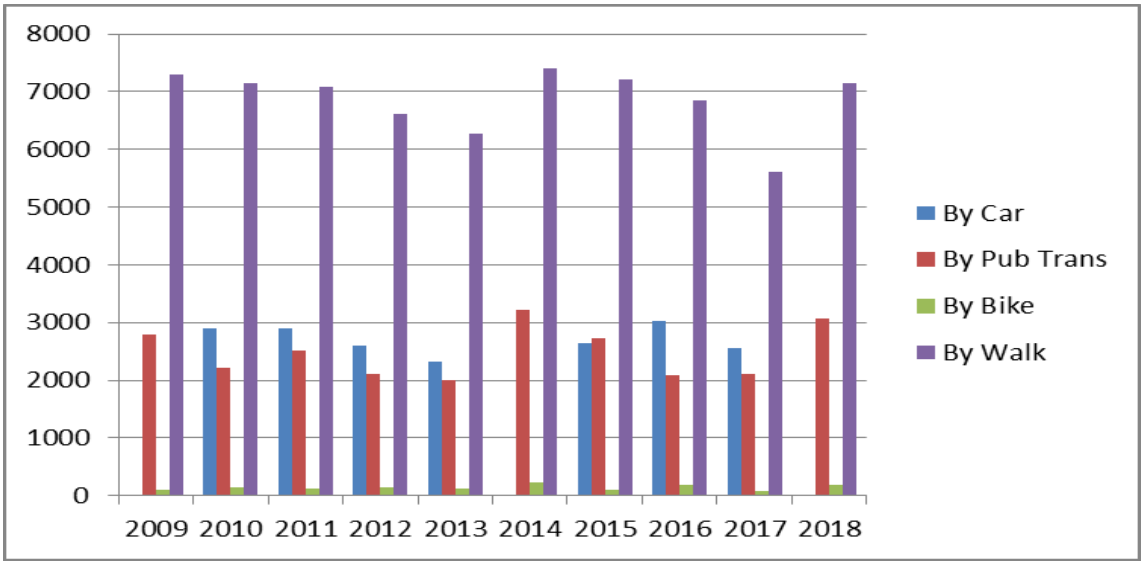


Med Gross Rent (USD)

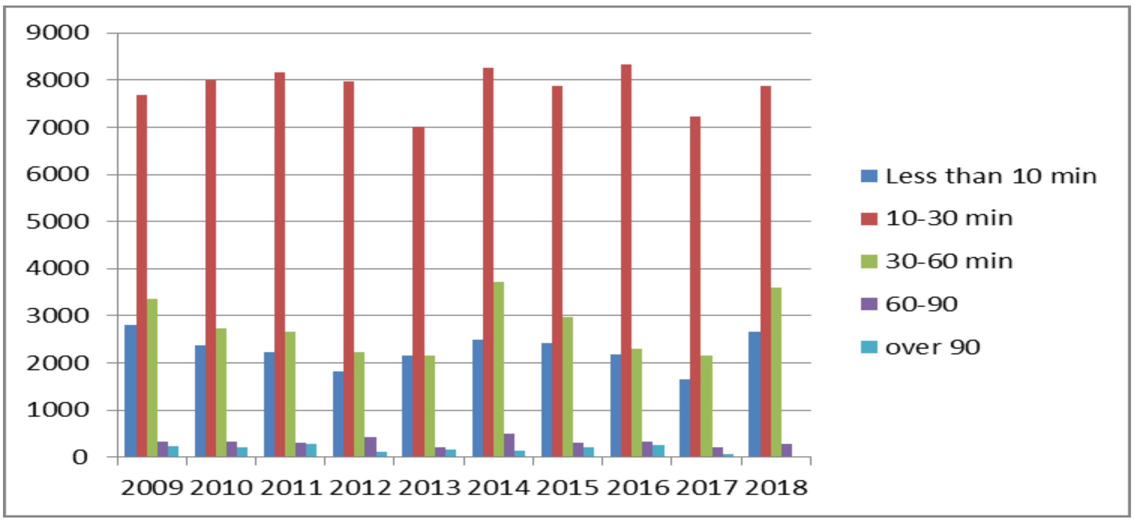


	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
By Car	0	2909	2900	2611	2320	0	2654	3019	2557	0
By Pub Trans	2791	2223	2518	2107	1997	3218	2721	2088	2106	3076
By Bike	108	152	129	147	131	225	99	188	89	194
By Walk	7291	7159	7092	6616	6278	7405	7205	6853	5622	7140
COMMUTING TIME										
Less than 10 min	2813	2369	2224	1816	2163	2500	2425	2188	1658	2671
10-30 min	7683	7993	8154	7959	7007	8259	7886	8332	7231	7869
30-60 min	3365	2738	2669	2221	2155	3718	2967	2303	2151	3603
60-90	337	321	312	426	203	505	304	325	217	294
over 90	233	223	285	118	152	129	200	251	62	0

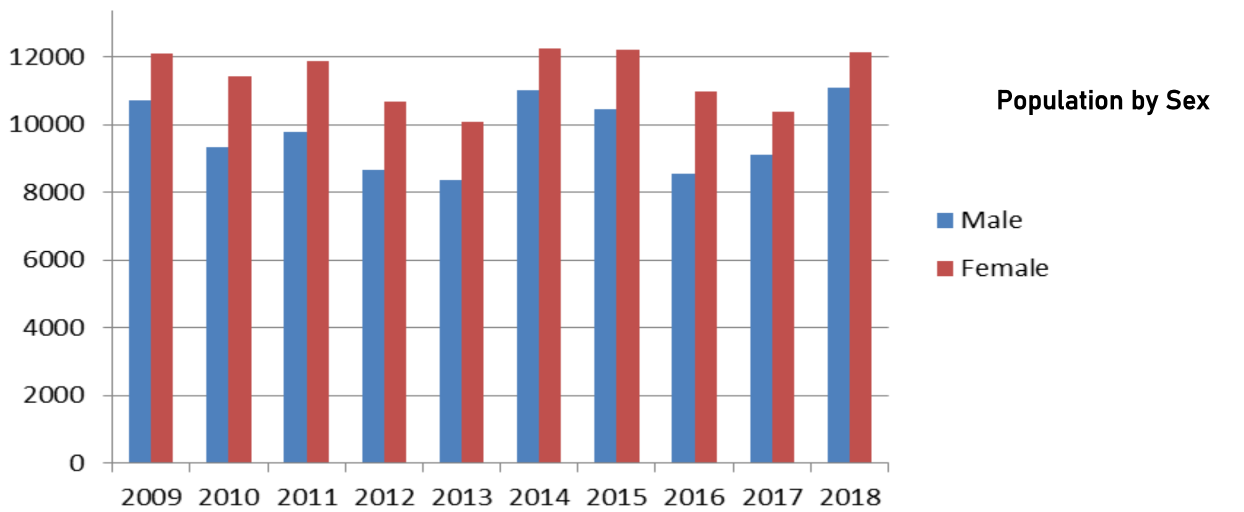
Commuting by

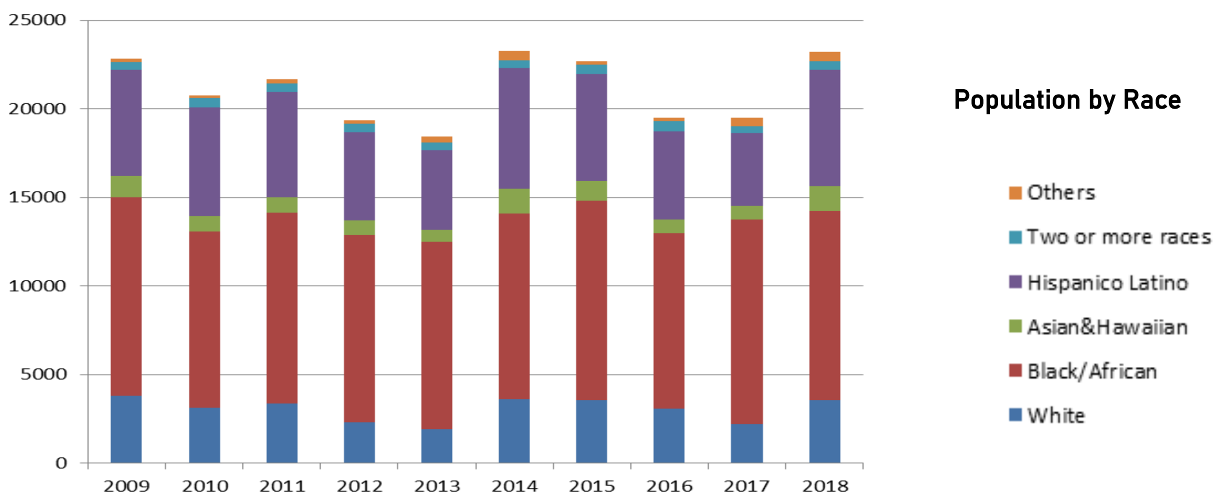


Commuting time



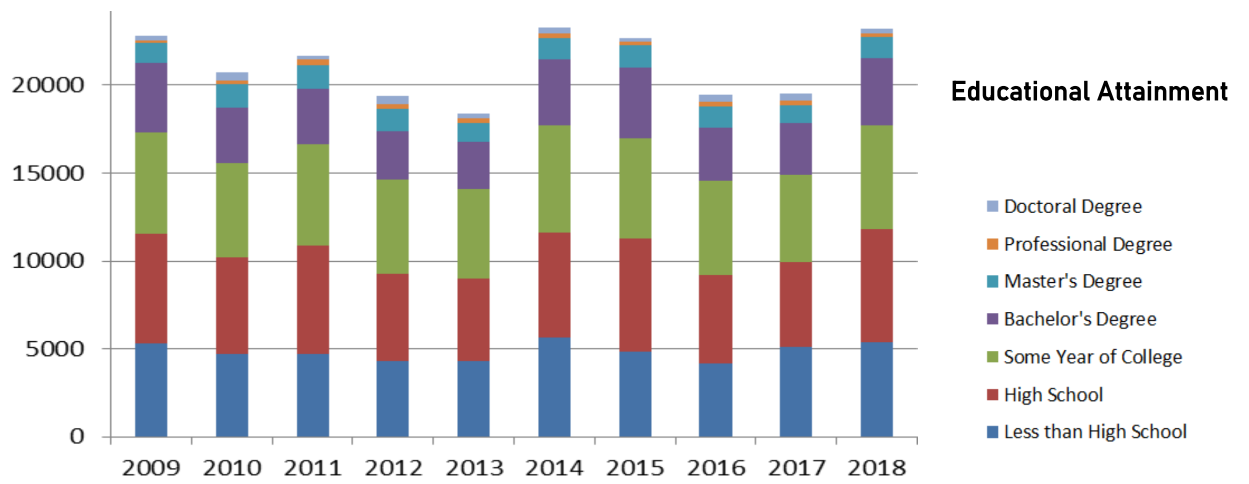
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
POPULATION BY SEX										
TOT	22819	20767	21655	19369	18429	23273	22680	19500	19507,71	23227
Male	10731	9350	9765	8672	8354	11030	10473	8531	9125	11079
Female	12083	11410	11884	10690	10070	12237	12201	10962	10377	12141
	%									
Male	47,0	45,0	45,1	44,8	45,3	47,4	46,2	43,7	46,8	47,7
Female	112,6	122,0	121,7	123,3	120,5	110,9	116,5	128,5	113,7	109,6
POPULATION BY RACE										
White	3796	3135	3367	2287	1908	3622	3575	3049	2208	3566
Black/African	11232	9940	10762	10597	10574	10458	11254	9944	11542	10686
Asian&Hawaiian	1205	881	891	803	691	1401	1087	764	766	1359
Hispanico Latino	5967	6139	5931	5015	4493	6824	6029	4992	4132	6591
Two or more races	448	505	500	469	410	428	545	540	379	474
Others	171	167	204	198	353	540	190	211	480,71	551
	%									
White	16,6	15,1	15,5	11,8	10,4	15,6	15,8	15,6	11,3	15,4
Black/African	49,2	47,9	49,7	54,7	57,4	44,9	49,6	51,0	59,2	46,0
Asian&Hawaiian	5,3	4,2	4,1	4,1	3,7	6,0	4,8	3,9	3,9	5,9
Hispanico Latino	26,1	29,6	27,4	25,9	24,4	29,3	26,6	25,6	21,2	28,4
Two or more races	2,0	2,4	2,3	2,4	2,2	1,8	2,4	2,8	1,9	2,0
Others	0,7	0,8	0,9	1,0	1,9	2,3	0,8	1,1	2,5	2,4

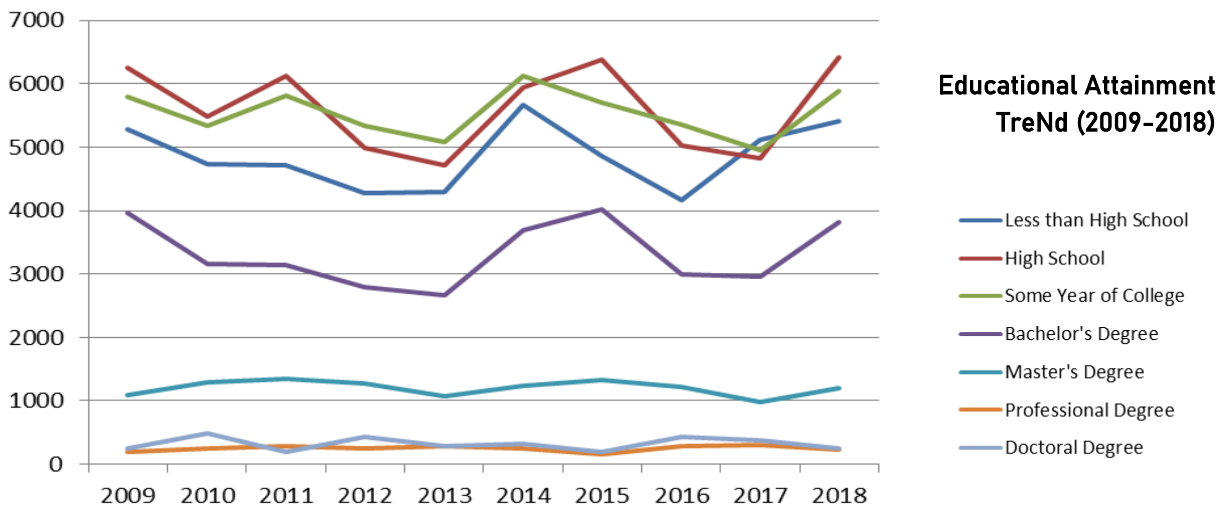




TA5_Educational Attainment Analysis

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TOT POPULATION	22819	20767	21655	19369	18429	23273	22680	19500	19507,71	23227
EDUCATION										
Less than High School	5290	4739	4716	4273	4292	5675	4856	4173	5123	5409
High School	6244	5492	6123	4992	4716	5938	6386	5026	4820	6408
Some Year of College	5788	5335	5821	5330	5084	6124	5695	5361	4951	5880
Bachelor's Degree	3956	3154	3148	2793	2671	3699	4024	2987	2949	3823
Master's Degree	1088	1300	1343	1275	1068	1242	1331	1224	976	1207
Professional Degree	190	245	290	256	281	248	164	277	299	225
Doctoral Degree	241	480	191	429	295	324	199	427	369	255
%										
Less than High School	23,2	22,8	21,8	22,1	23,3	24,4	21,4	21,4	26,3	23,3
High School	27,4	26,4	28,3	25,8	25,6	25,5	28,2	25,8	24,7	27,6
Some Year of College	25,4	25,7	26,9	27,5	27,6	26,3	25,1	27,5	25,4	25,3
Bachelor's Degree	17,3	15,2	14,5	14,4	14,5	15,9	17,7	15,3	15,1	16,5
Master's Degree	4,8	6,3	6,2	6,6	5,8	5,3	5,9	6,3	5,0	5,2
Professional Degree	0,8	1,2	1,3	1,3	1,5	1,1	0,7	1,4	1,5	1,0
Doctoral Degree	1,1	2,3	0,9	2,2	1,6	1,4	0,9	2,2	1,9	1,1

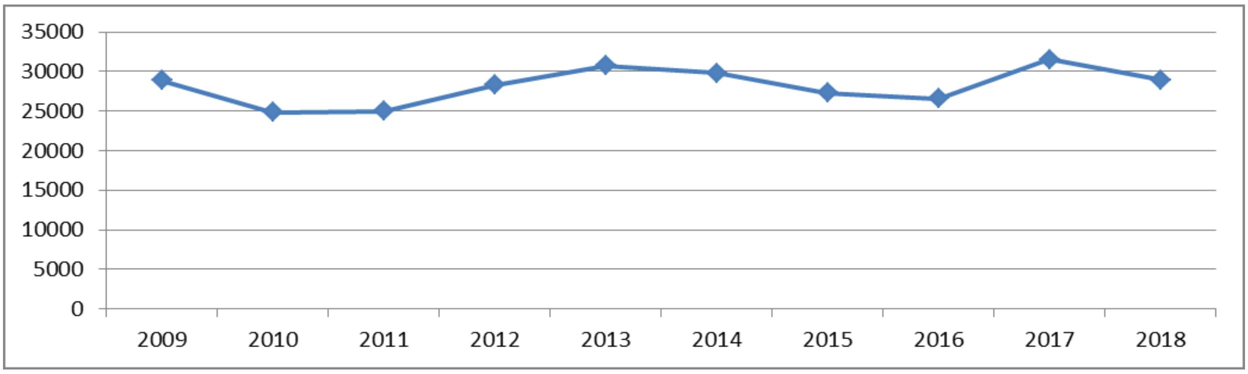




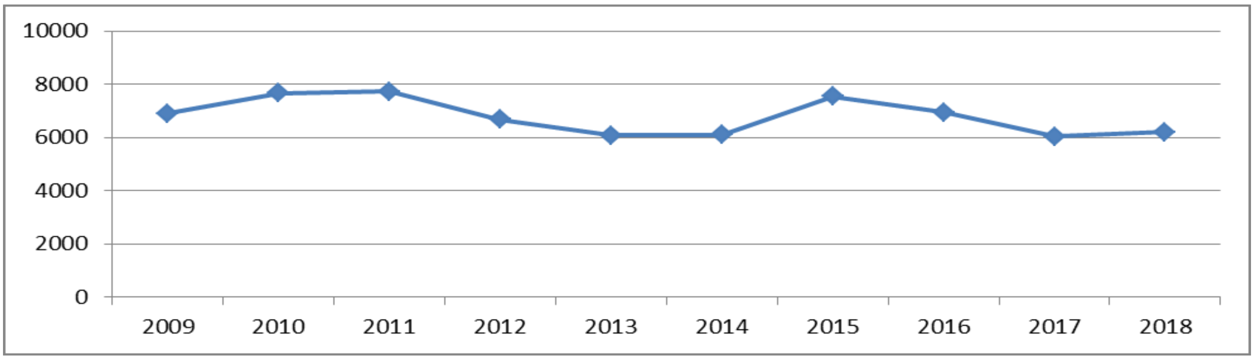
TA5_ Economic Analysis

ECONOMY											
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**CHANGE 2009-2018**
TOT POP	22819	20767	21655	19369	18429	23273	22680	19500	19507,71	23227	
Median Household Income ($)	28837,9	24852,7	24976,6	28328,29	30758,9	29773,9	27323	26561	31505,1	28923	0,30
Public Ass	1476	1516	1746	1547	1498	1585	1687	1510	1718	1550	11,16%
Public Ass %	6,47	7,30	8,06	7,99	8,13	6,81	7,44	7,74	8,81	6,67	
Family Poverty	6899	7665	7718	6675	6071	6093	7537	6934	6037	6197	-14,82%

Median Household Income

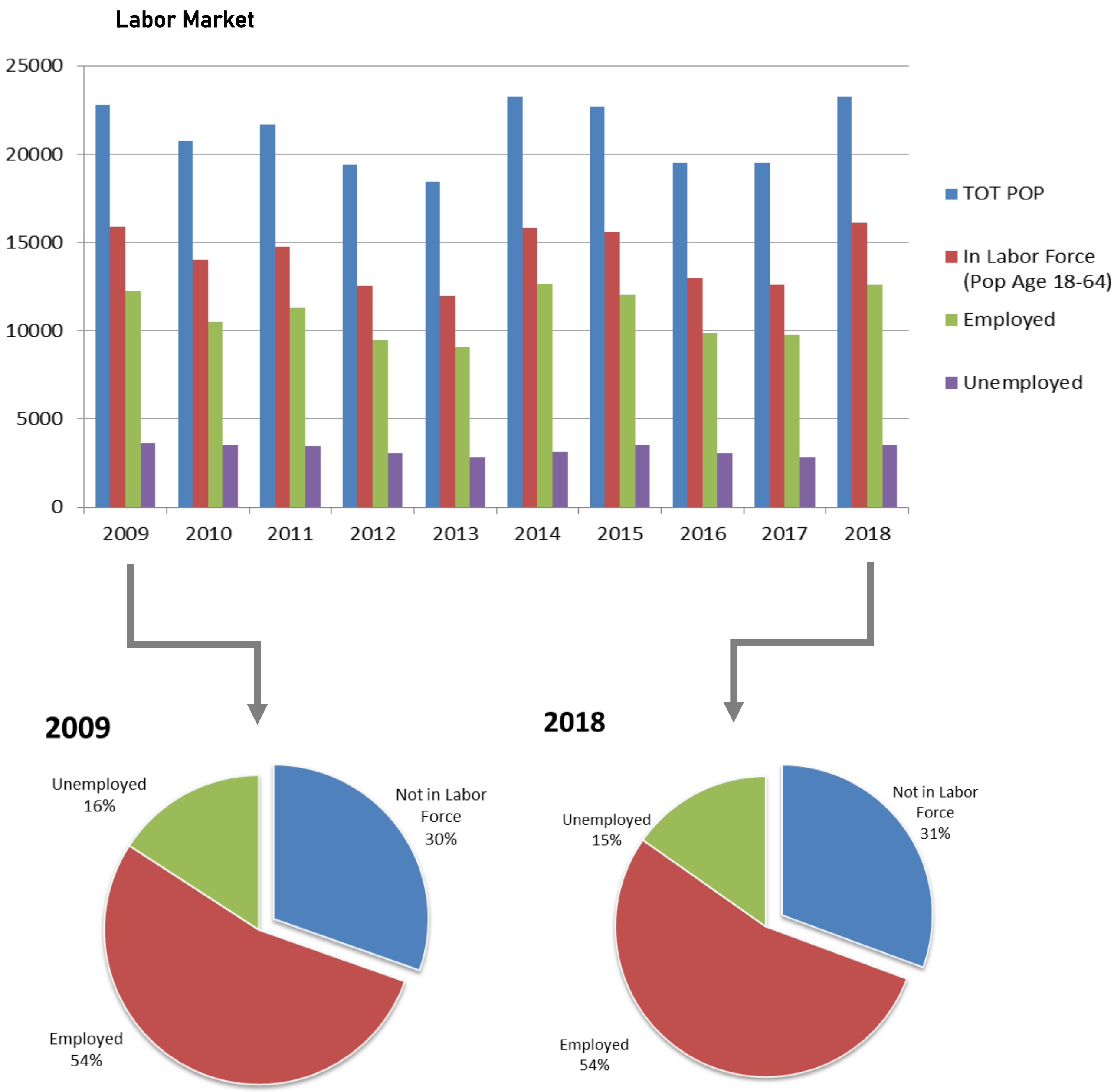


Family Poverty



CT_ID	GINI										CHANGE 2009/2018
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
25025080300	0,543	0,551	0,571	0,450	0,440	0,496	0,554	0,636	0,452	0,460	-0,083
25025080401	0,547	0,513	0,530	0,545	0,514	0,593	0,562	0,523	0,495	0,574	0,026
25025080500	0,538	0,524	0,534	0,520	0,564	0,540	0,505	0,548	0,510	0,529	-0,009
25025080601	0,551	0,490	0,521	0,474	0,467	0,595	0,542	0,481	0,472	0,580	0,029
25025081400	0,514	0,531	0,516	0,513	0,512	0,536	0,494	0,522	0,476	0,527	0,013
25025081700	0,577	0,550	0,545	0,488	0,487	0,584	0,555	0,524	0,467	0,555	-0,022
25025081800	0,496	0,499	0,507	0,460	0,398	0,557	0,520	0,486	0,464	0,553	0,057
VAL MEDIO	0,538	0,522	0,532	0,493	0,483	0,557	0,533	0,531	0,477	0,540	0,002

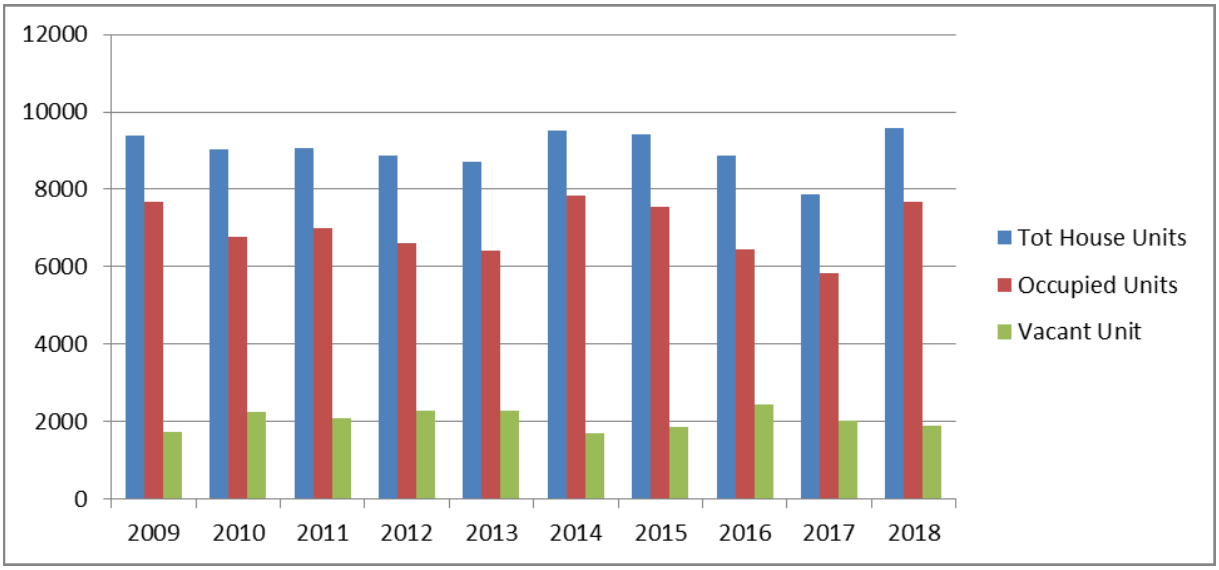
LABOR MARKET										
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
TOT POP	22819	20767	21655	19369	18429	23273	22680	19500	19507,7	23227
In Labor Force (Pop Age 18-64)	15883	14010	14752	12541	11948	15819	15575	12992	12606,1	16106
In Labor Force %	70	67	68	65	65	68	69	67	65	69
Employed	12269,9	10490,2	11276,6	9448,922	9096,99	12670	12047	9893,9	9736,55	12573,8
Employed %	77	75	76	75	76	80	77	76	77	78
Unemployed	3613	3520	3475	3092	2851	3149	3528	3098	2870	3532
Unemployed %	23	25	24	25	24	20	23	24	23	22



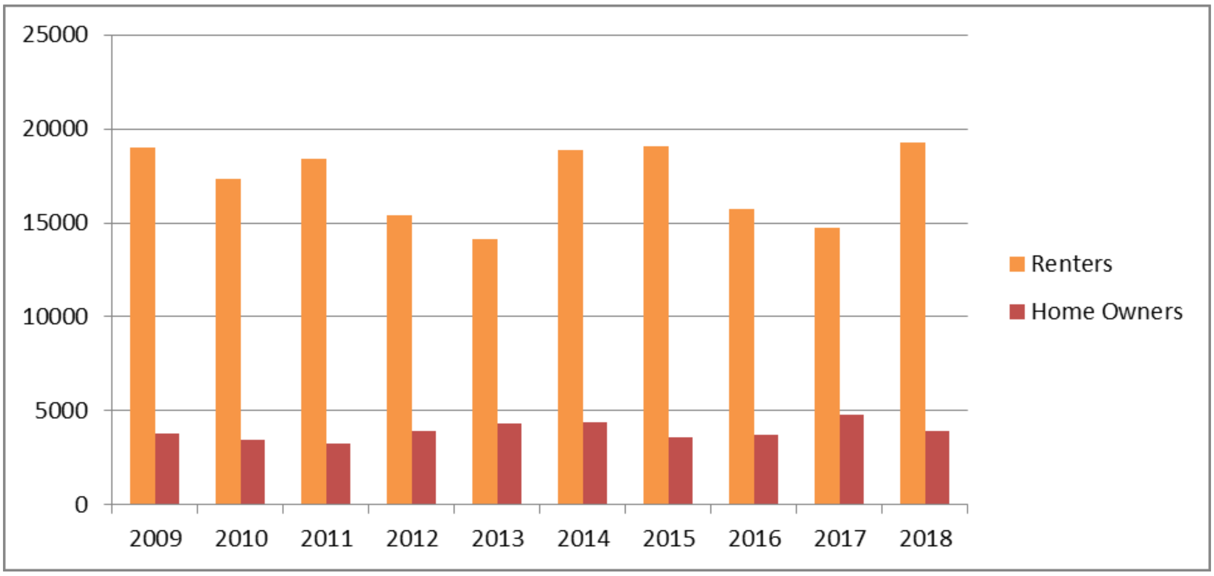
TA5_ Housing Stock

HOUSING STOCK										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Tot House Units	9399	9028	9062	8875	8696	9520	9409	8880	7866	9570
Vacant Unit	1725	2243	2073	2276	2274	1691	1873	2445	2031	1893
TOT POP	22819	20767	21655	19369	18429	23273	22680	19500	19508	23227
Renters	19010	17303	18396	15412	14102	18878	19050	15763	14731	19303
Renters %	83	83	85	80	77	81	84	81	76	83
Home Owners	3802	3457	3252	3950	4320	4388	3623	3730	4768	3917
Home Owners%	17	17	15	20	23	19	16	19	24	17
US $										
Med Gross Rent	2095	1893	1958	1794	1619	2307	2082	1924	1539	2205
Med Home Value	738800	704366	694766	657633	666133	916733	713666,7	707000	673900	796800

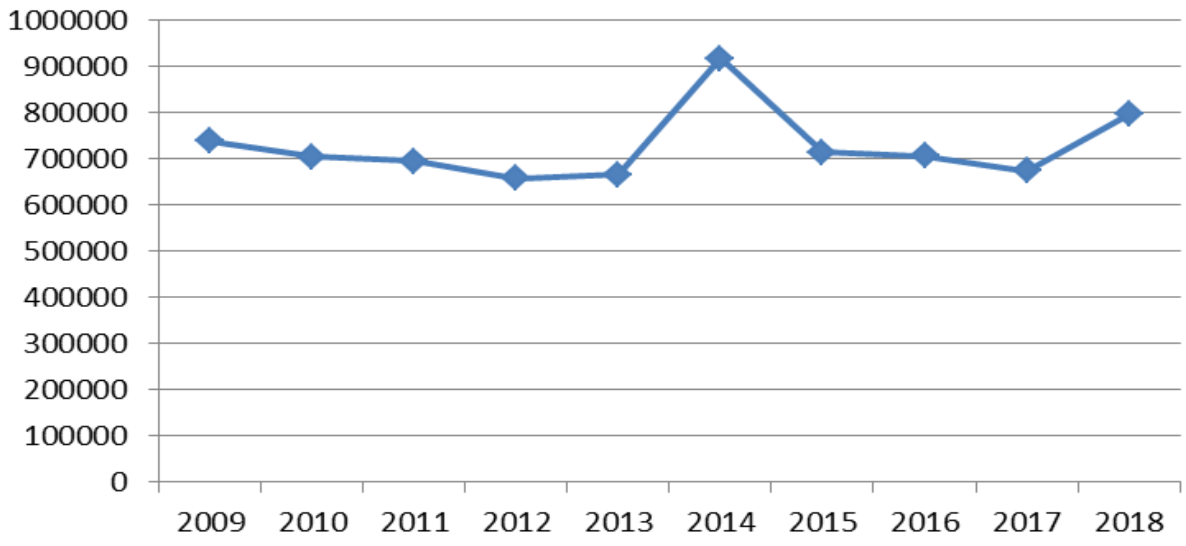
House Units



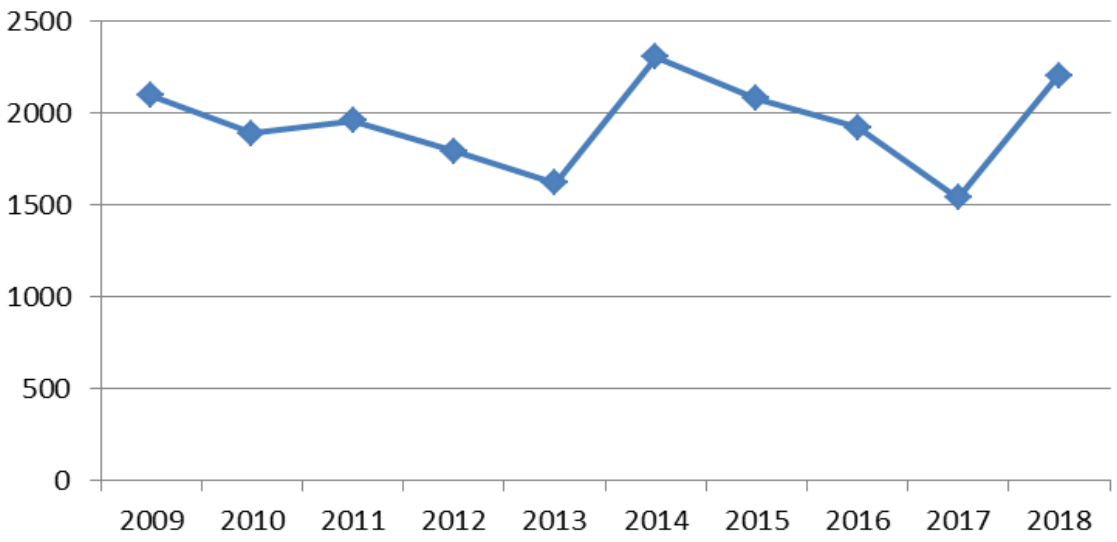
Renters & Home Owner



Med Home Value (USD)

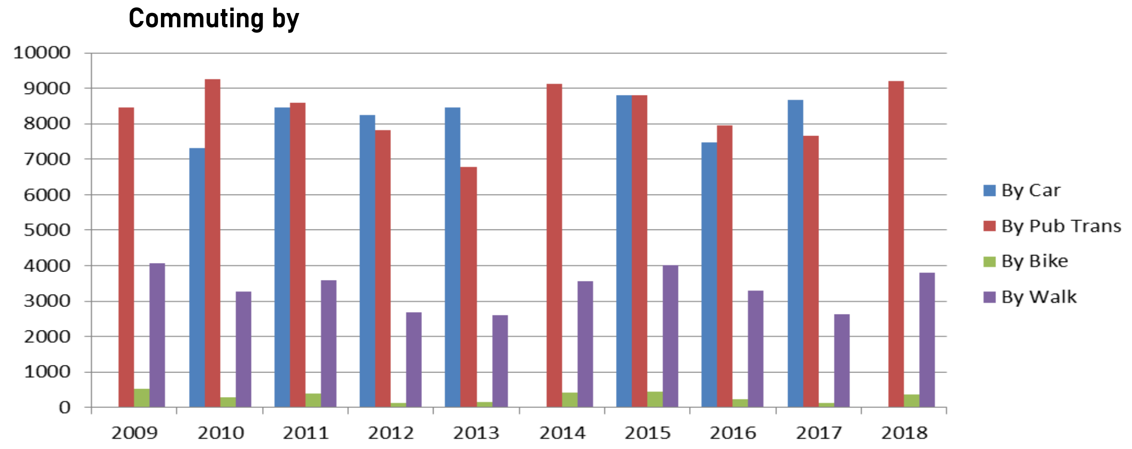


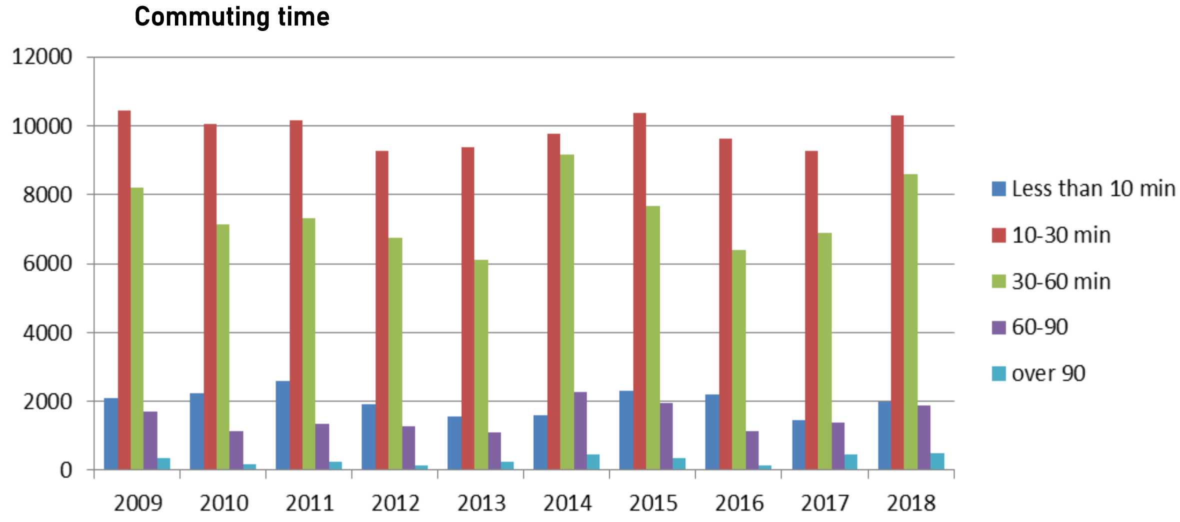
Med Gross Rent (USD)



TA5_ Transport

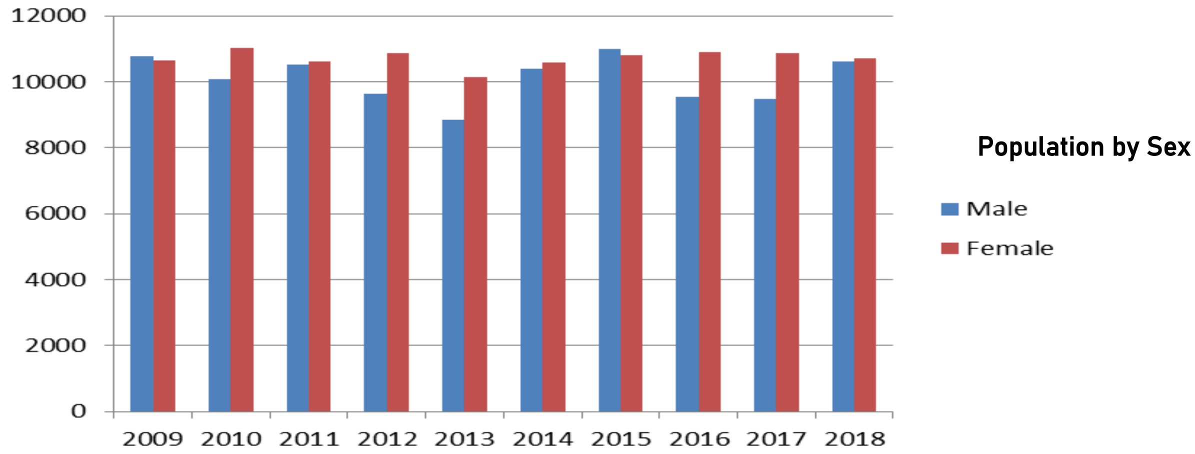
TRANSPORT										
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
By Car	NA	7325	8463	8237	8454	NA	8805	7483	8680	NA
By Pub Trans	8472	9270	8586	7828	6773	9121	8796	7948	7648	9217
By Bike	529	276	404	134	142	429	435	246	119	363
By Walk	4077	3269	3587	2683	2589	3563	4022	3287	2623	3800
COMMUTING TIME										
Less than 10 min	2097	2252	2574	1930	1564	1611	2301	2210	1457	1971
10-30 min	10425	10053	10165	9260	9393	9761	10387	9627	9286	10302
30-60 min	8207	7128	7315	6753	6095	9153	7657	6405	6874	8577
60-90	1711	1151	1351	1267	1114	2286	1968	1121	1398	1864
over 90	363	165	234	142	248	447	347	123	476	494

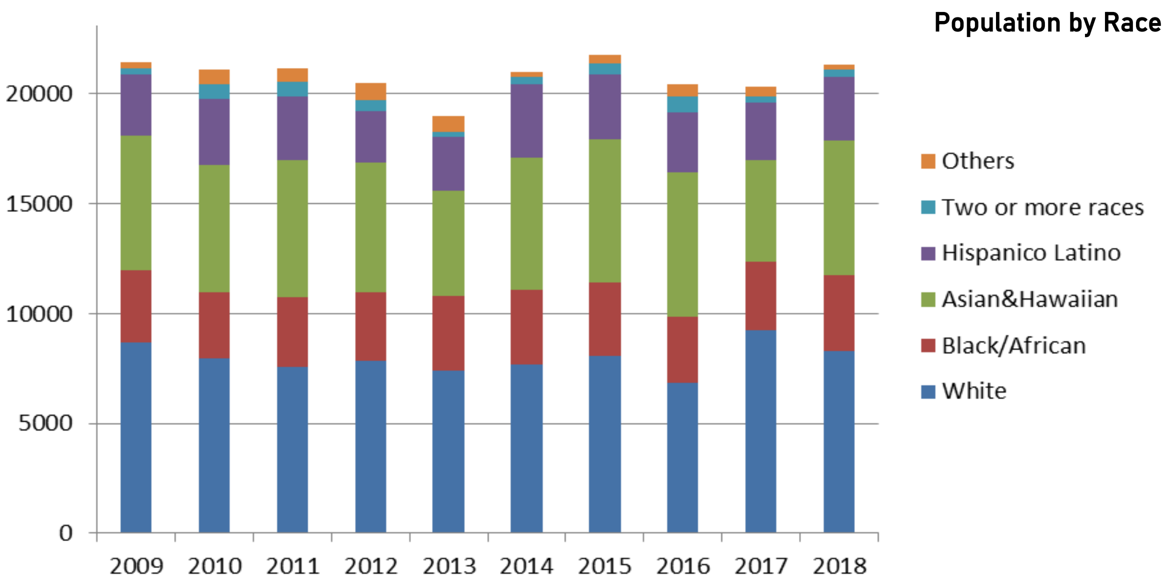




TA6_ Venture Development Center Socio-Demographic Analysis

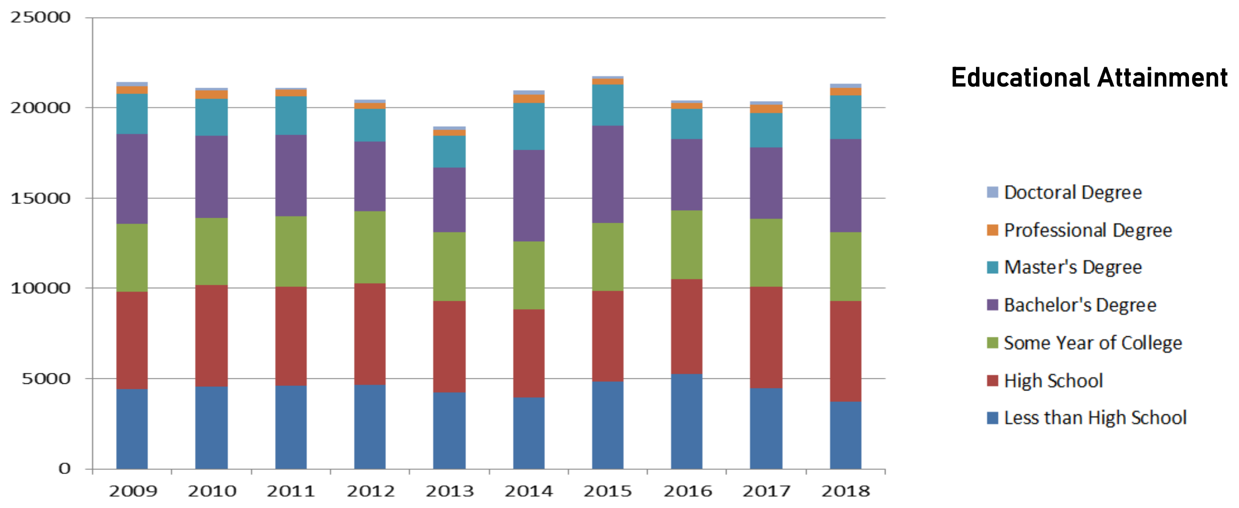
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
POPULATION BY SEX										
TOT	21429	21114	21137	20492	18998	20992	21793	20438	20356	21347
Male	10786	10087	10523	9627	8856	10408	10980	9544	9485	10626
Female	10638	11022	10609	10860	10138	10581	10809	10889	10867	10717
	%									
Male	50	48	50	47	47	50	50	47	47	50
Female	50	52	50	53	53	50	50	53	53	50
POPULATION BY RACE										
White	8706	7975	7592	7868	7407	7661	8081	6859	9259	8292
Black/African	3271	3021	3174	3099	3419	3441	3329	3013	3103	3465
Asian&Hawaiian	6113	5750	6225	5886	4747	5991	6523	6585	4642	6110
Hispanico Latino	2796	3001	2898	2387	2448	3346	2930	2708	2625	2891
Two or more races	262	677	660	503	242	363	510	691	240	339
Others	281	690	588	749	735	190	420	582	487,36	250
	%									
White	40,6	37,8	35,9	38,4	39,0	36,5	37,1	33,6	45,5	38,8
Black/African	15,3	14,3	15,0	15,1	18,0	16,4	15,3	14,7	15,2	16,2
Asian&Hawaiian	28,5	27,2	29,5	28,7	25,0	28,5	29,9	32,2	22,8	28,6
Hispanico Latino	13,0	14,2	13,7	11,6	12,9	15,9	13,4	13,2	12,9	13,5
Two or more races	1,2	3,2	3,1	2,5	1,3	1,7	2,3	3,4	1,2	1,6
Others	1,3	3,3	2,8	3,7	3,9	0,9	1,9	2,8	2,4	1,2

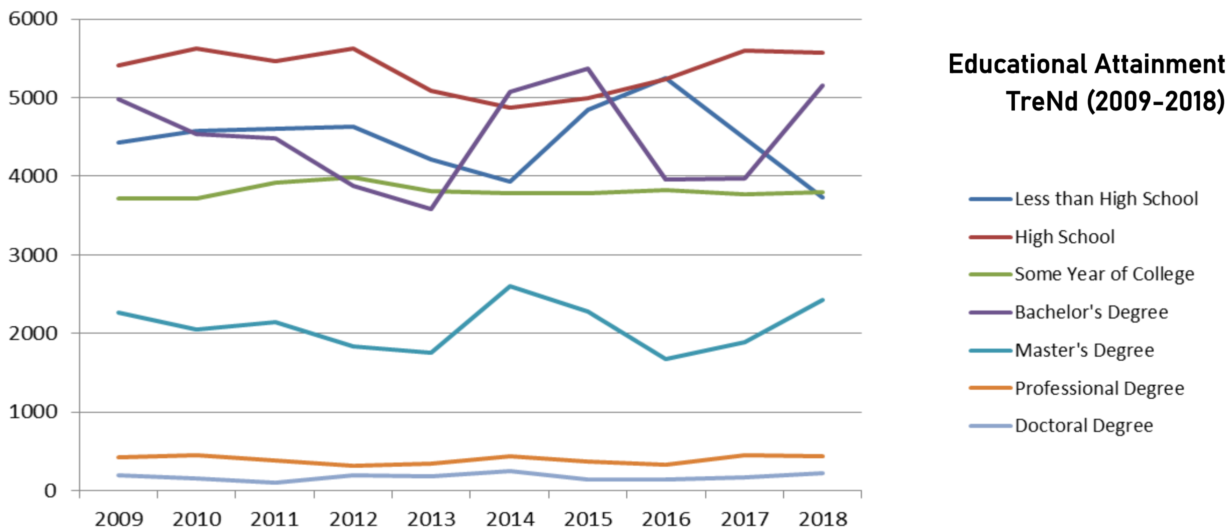




TA6_Educational Attainment Analysis

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TOT POPULATION	22819	20767	21655	19369	18429	23273	22680	19500	19507,71	23227
EDUCATION										
Less than High School	4425	4572	4609	4631	4215	3939	4843	5249	4477	3733
High School	5409	5625	5464	5626	5089	4878	4994	5240	5602	5568
Some Year of College	3720	3718	3921	3993	3812	3790	3786	3827	3770	3800
Bachelor's Degree	4974	4531	4490	3876	3584	5074	5366	3956	3971	5152
Master's Degree	2264	2048	2145	1830	1758	2596	2279	1675	1892	2422
Professional Degree	421	453	388	322	341	444	366	331	452	433
Doctoral Degree	201	151	104	197	183	252	141	144	174	224
%										
Less than High School	19,4	22,0	21,3	23,9	22,9	16,9	21,4	26,9	22,9	16,1
High School	23,7	27,1	25,2	29,0	27,6	21,0	22,0	26,9	28,7	24,0
Some Year of College	16,3	17,9	18,1	20,6	20,7	16,3	16,7	19,6	19,3	16,4
Bachelor's Degree	21,8	21,8	20,7	20,0	19,4	21,8	23,7	20,3	20,4	22,2
Master's Degree	9,9	9,9	9,9	9,4	9,5	11,2	10,0	8,6	9,7	10,4
Professional Degree	1,8	2,2	1,8	1,7	1,9	1,9	1,6	1,7	2,3	1,9
Doctoral Degree	0,9	0,7	0,5	1,0	1,0	1,1	0,6	0,7	0,9	1,0

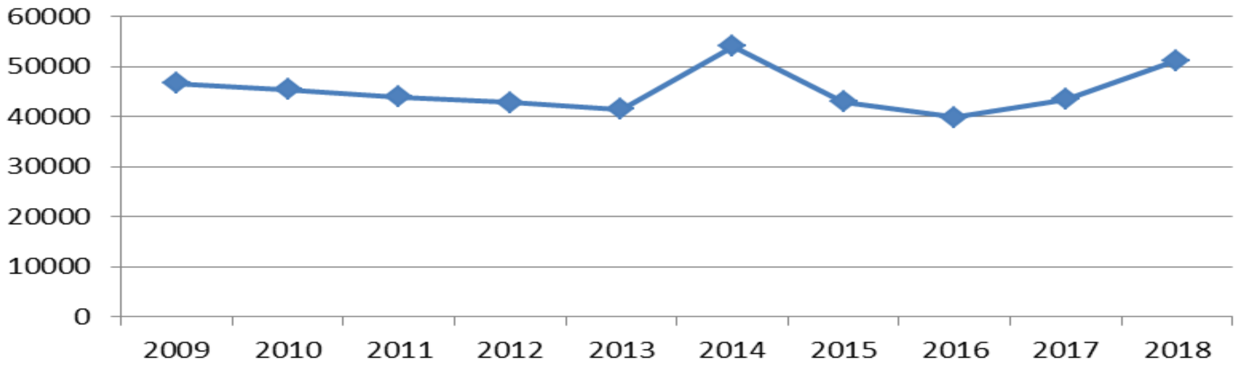




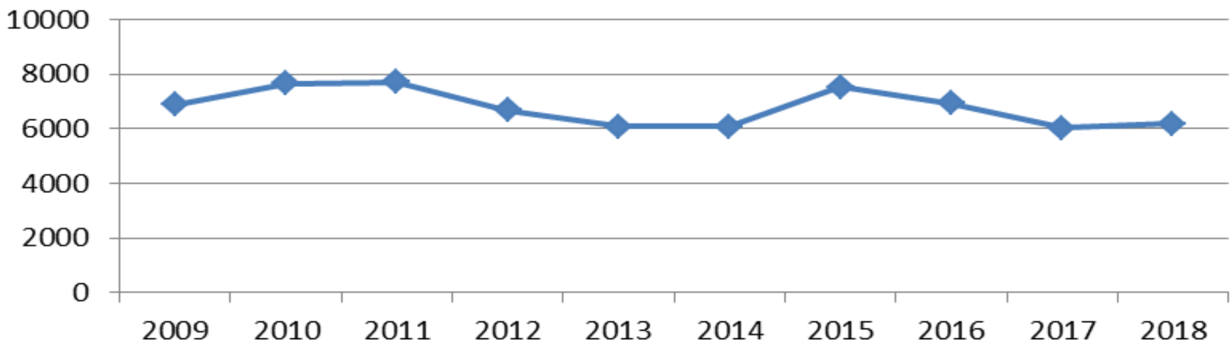
TA6_ Economic Analysis

ECONOMY											
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**CHANGE 2009-2018**
TOT POP	22819	20767	21655	19369	18429	23273	22680	19500	19507,71	23227	
Median Household Income ($)	46600	45412	43976	42812	41410	54078	42963	39843	43448	51188	9,84
Public Ass	875	1209	1187	1553	1477	662	898	1674	1401	653	-25,37
Public Ass %	3,83	5,82	5,48	8,02	8,01	2,84	3,96	8,58	7,18	2,81	
Family Poverty	5242	5640	5165	6124	5033	4894	5799	5877	5321	5179	-1,20

Median Household Income



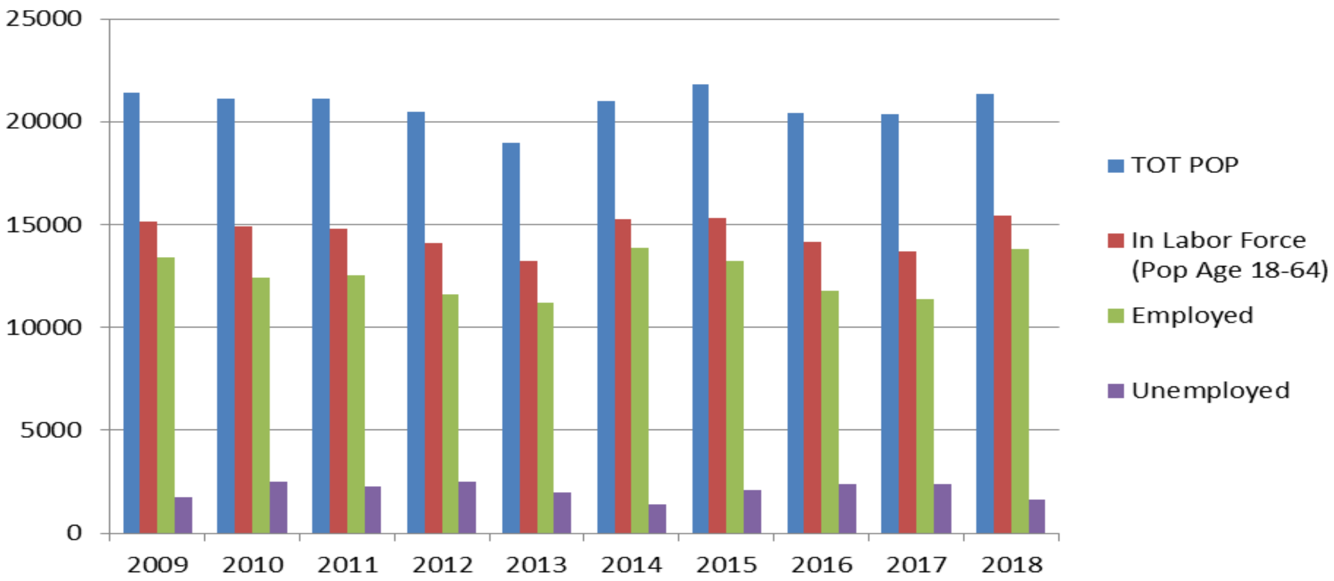
Family Poverty



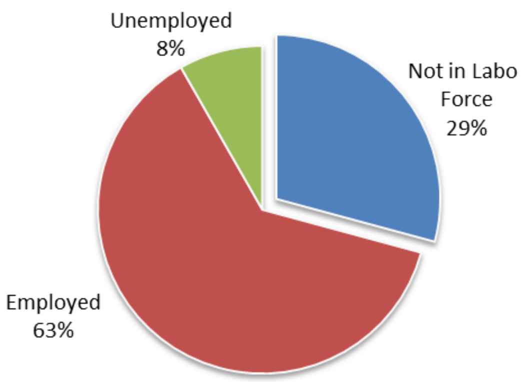
CT_ID	GINI									
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
25025981201	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
25025090901	0,5845	0,5412	0,5713	0,5225	0,489	0,5828	0,5709	0,544	0,475041	0,571
25025091001	0,431	0,4742	0,4378	0,5013	0,527	0,4304	0,4665	0,5011	0,514717	0,4215
25025092101	0,5441	0,496	0,4742	0,5046	0,483	0,5077	0,5415	0,489	0,497	0,5195
25025061101	0,5882	0,522	0,555	0,5094	0,462	0,5543	0,569	0,5142	0,5	0,6036
25025091100	0,4274	0,4337	0,4502	0,4306	0,413	0,4349	0,4439	0,4676	0,372	0,4349
VAL MEDIO	0,5150	0,4934	0,4977	0,4937	0,4748	0,5020	0,5184	0,5032	0,4718	0,5101

LABOR MARKET										
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
TOT POP	21429	21114	21137	20492	18998	20992	21793	20438	20356,4	21347
In Labor Force (Pop Age 18-64)	15172	14912	14788	14074	13215	15260	15302	14172	13707,1	15431
In Labor Force %	71	71	70	69	70	73	70	69	67	72
Employed	13399	12400	12513	11593	11227	13883	13206	11773	11349	13822
Employed %	88	83	85	82	85	91	86	83	83	90
Unemployed	1773	2512	2275	2481	1988	1377	2096	2399	2358	1609
Unemployed %	12	17	15	18	15	9	14	17	17	10

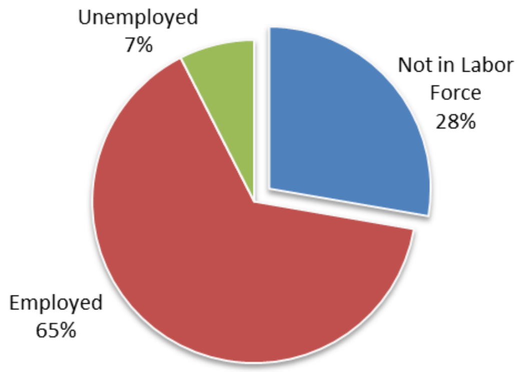
Labor Market



2009



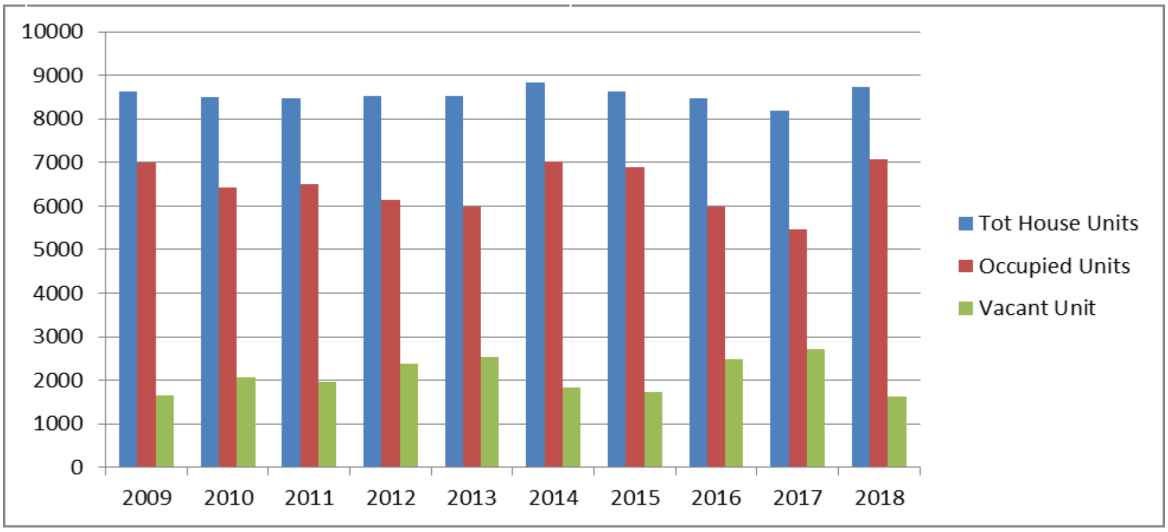
2018



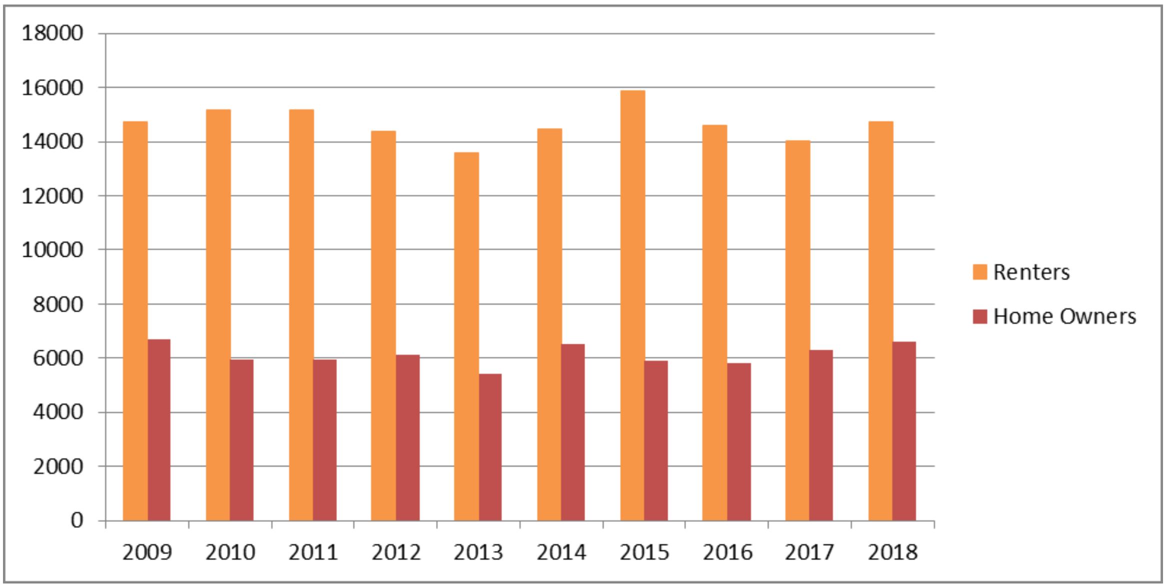
TA6_ Housing Stock

HOUSING STOCK										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Tot House Units	8779	8025	8233	7661	7331	9490	8398	7924	6990,2	9275
Vacant Unit	2430	1558	2053	1663	1321	3178	2252	1474	1338	3197
TOT POP	14439	13653	13651	12549	11687	15118	13789	13406	11326	14650
Renters	9775	8756	8379	7499	7064	9535	9049	8086	6534	9587
Renters %	67,70	64,13	61,38	59,76	60,44	63,07	65,62	60,32	57,69	65,44
Home Owners	4661	4894	5269	5047	4620	5580	4737	5317	4789	5060
Home Owners%	32,28	35,85	38,60	40,22	39,53	36,91	34,35	39,66	42,28	34,54
US $										
Med Gross Rent	2095	1892,7	1957,7	1794,3	1619	2307,3	2082	1923,7	1539,3	2205
Med Home Value	738800	704367	694767	657633	666133	916733	713667	707000	673900	796800

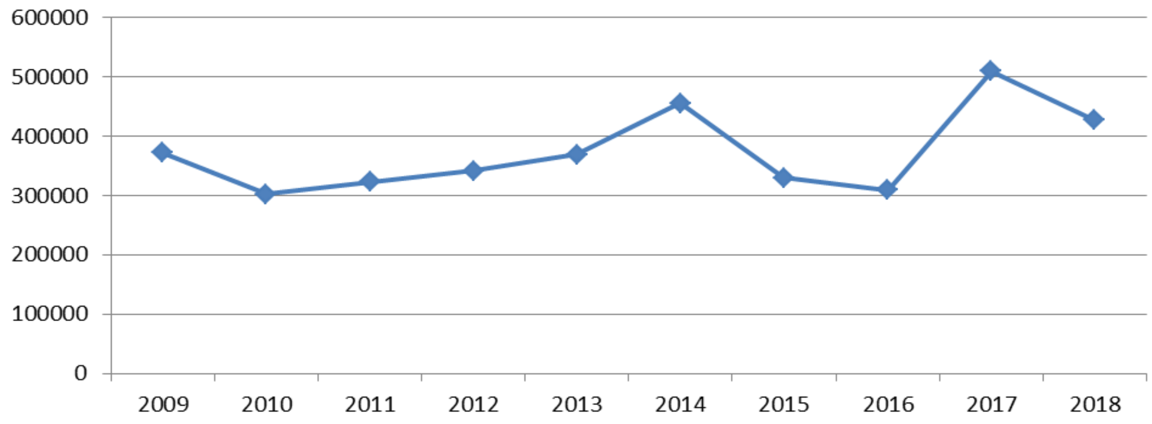
House Units



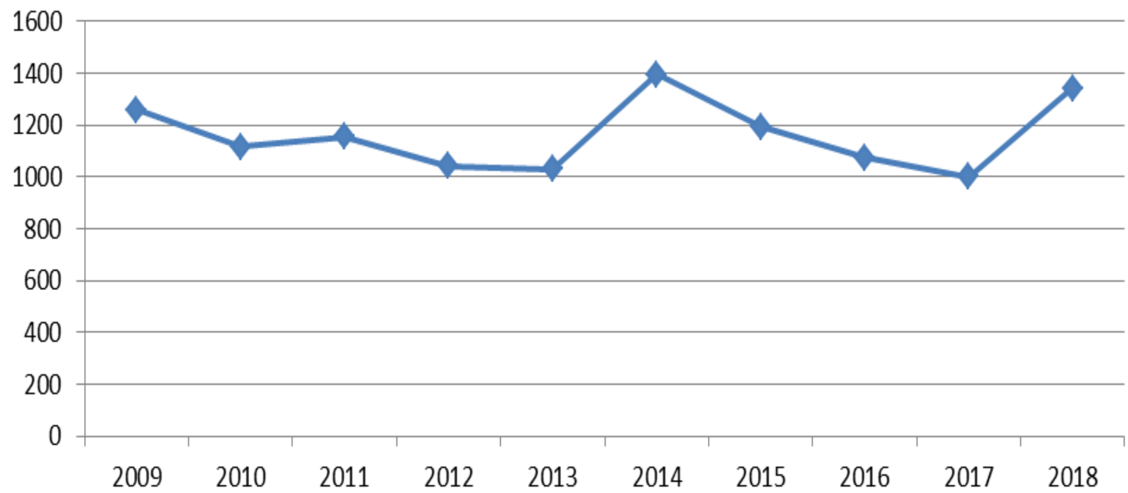
Renters & Home Owner



Med Home Value (USD)



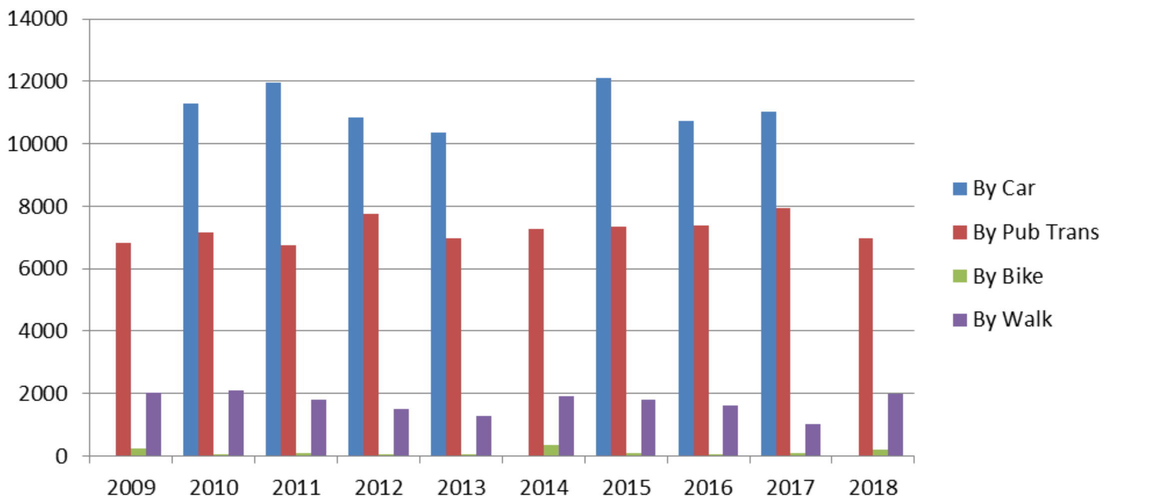
Med Gross Rent (USD)



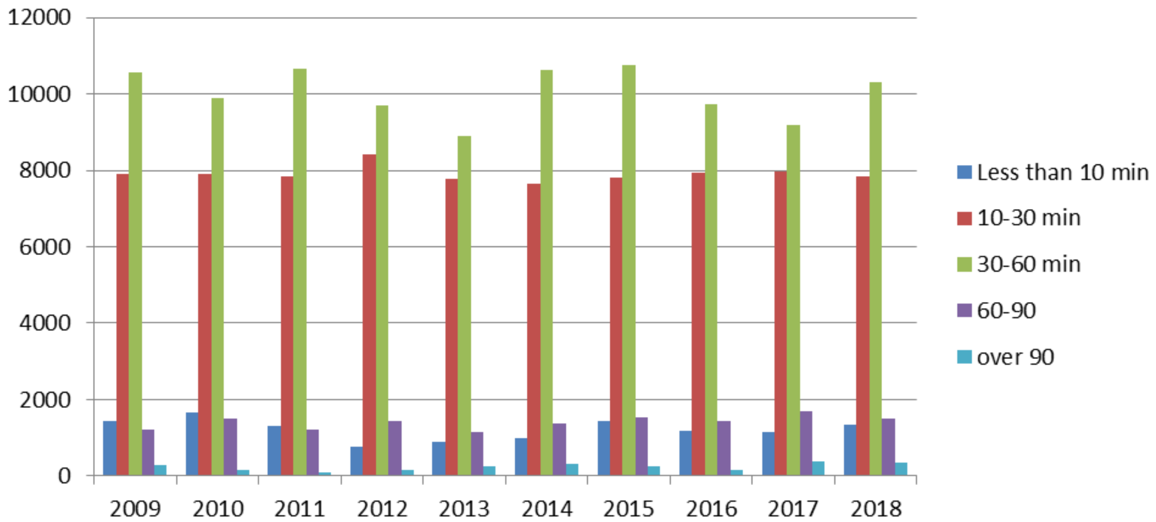
TA6_ Transport

TRANSPORT										
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
By Car	0	11284	11945	10852	10343	0	12115	10738	11010	0
By Pub Trans	6834	7158	6746	7771	6969	7275	7348	7398	7926	6986
By Bike	236	64	94	52	58	337	89	63	73	206
By Walk	2025	2116	1782	1514	1277	1928	1805	1628	1021	1969
COMMUTING TIME										
Less than 10 min	1436	1675	1308	776	876	1001	1434	1192	1151	1354
10-30 min	7889	7897	7842	8407	7788	7661	7823	7927	7953	7826
30-60 min	10572	9884	10664	9708	8902	10630	10756	9734	9184	10306
60-90	1221	1494	1219	1449	1159	1384	1517	1422	1680	1512
over 90	297	154	94	140	261	302	253	154	377	336

Commuting by



Commuting time



Note

[1] https://www.cluds.unirc.it/project/project_trend/
[2] https://cordis.europa.eu/project/id/823952
[3] https://cordis.europa.eu/project/id/645651/it
[4] https://www.peoplesworld.org/article/turning-point-what-will-be-the-post-pandemic-new-normal/
[5] "Fire Statistics". CAL FIRE. January 2, 2021. https://www.fire.ca.gov/incidents/2020/
[6] https://www.ecowatch.com/extreme-weather-climate-2020-2649628910.html
[7] CRED & UNDRR. 2020: The Non-COVID Year in Disasters. Brussels: CRED; 2021. https://emdat.be/sites/default/files/adsr_2020.pdf
[5] https://www.climatewatchdata.org/ghg-emissions?end_year=2018&start_year=1990
[6] The annual growth rate reached its peak in the late 1960s, when it was at around 2%: in 40 years from 1959 to 1999, world population has doubled, increasing from 3billion to 6 billion (100%increase). Currently (2021) annual growth rate is estimated around 1.05%, with an average population increase of 81 million people per year. According to the most recent estimates by Worldometer, as April 2021 the world population is 7.9 billion. The latest world population projections indicate that world population will reach 10 billion persons in the end of 2050s. (source: www.Worldometers.info)
[7] https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS
[8] The document was proposed by the Union of Concerned Scientist (UCS) under the coordination of Dr. Henry Kendall (Nobel in Physics, 1990). The UCS is a nonprofit science advocacy organization founded in 1969 by the Massachusetts Institute of Technology, with the involvement of scientists, economists, engineers and a majority of the Nobel-prize winners. It is part of the Sustainable Energy Coalition, supporting renewable energy, energy efficiency, GHG emission reduction and other climate-related activities.
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[15] Thomas Friedman, "We Need Herd Immunity From Trump and the Coronavirus", *The New York Times*, 25 April 2020. https ://www. nytim es.com/2020/04/25/opini on/coron aviru s-immun ity-trump .html
[16] GCIP: www.cityindicators.org/Default.aspx
[17] CDB: www.adb.org/publications/urban-indicators-managing-cities
[18] GUI: http://unhabitat.org/books/global-urban-indicators-database/
[19] SPI: https://www.socialprogress.org/framework
[20] WCCD: https://www.dataforcities.org/about-wccd
[21] Census Quick Facts, https://www.census.gov/quickfacts/fact/table/bostoncitymassachusetts
[22] Source: *Go Boston 2030,* https://www.boston.gov/sites/default/files/file/document_files/2017/03/go_boston_2030_-_6_boston_in_2030_spreads.pdf
[23] The county government was disbanded on July 1999, but many data still refer to this geographic definition.
[24] Greater Boston can be described either as a Metropolitan Statistical Area (the Boston-Cambridge-Newton MSA), or as a broader combined statistical area (Boston-Worcester-Providence CSA) that involves also the metropolitan areas of Providence, Manchester, Worcester and Cape Cod.
[25] https://worldpopulationreview.com/us-cities/boston-ma-population
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[30]https://www.mass.gov/info-details/ghg-emissions-and-mitigation-policies#greenhouse-gas-emissions-trends-
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