Centre for Logistics and Traffic

UNIVERSITÄT DUISBURG ESSEN

Offen im Denken

Sustainable and Smart Cities

Transformation challenges and chances

Connective Cities

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PD. Dr. habil. Ani Melkonyan

Private Docent at the Joint Centre of Urban Systems

Executive Director of Centre for Traffic and Logistics

International Expert at NASA LCLUC program

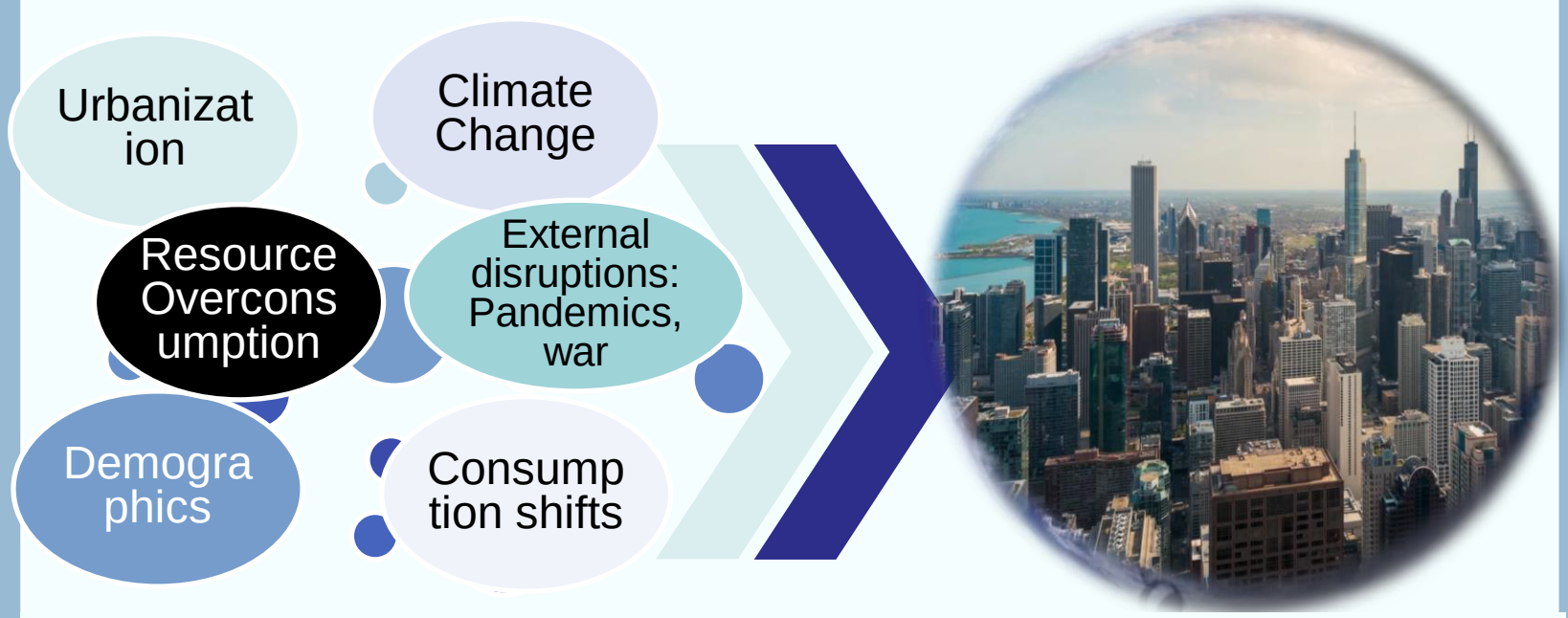
Visiting Professor at the University of Oklahoma

Outline

1. **Background and Motivation**
2. Definitions of sustainable cities
3. Transformation to Sustainable/Smart Cities: Best Practices
4. Results of the project NEMO

Background

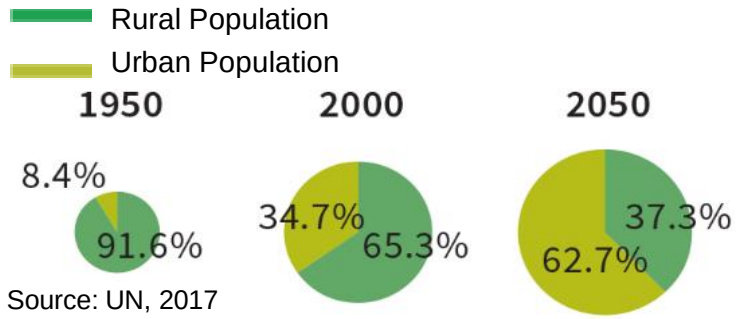
Humans as dominant force in the bio-physical living conditions



The urban setting represents a challenge and an opportunity for transformation towards net zero-carbon.

Why do Cities matter in Global Climate?

Over **62 %** of the world pop. will live in cities by 2050, increasing energy use



Source: UN, 2017

Urban infrastructure accounts for **70 %** of global energy use

Cities account for **37- 49 %** GHG emissions

Urban Group	Projected base case emissions growth from 2012-2030 megatonnes of CO_2	Projected population in 2030 bns	Per Capita emissions in 2030 tonnes of CO_2
Emerging Cities	3230	~1.3	~7
Small Urban Areas	1220	~2.2	~4.6
Established Cities	390	~0.4	~12.1
Global Megacities	1050	~0.6	~7.1

Source: Oxford Economics Global 750 Cities database, 2018

Cities play and will continue to play a significant role in the future carbon emissions out to 2030, while being vulnerable towards climate change.

The main issues associated with citties

1. Urban Heat Island
2. Urban Sprawl

Urban Heat Island (I)

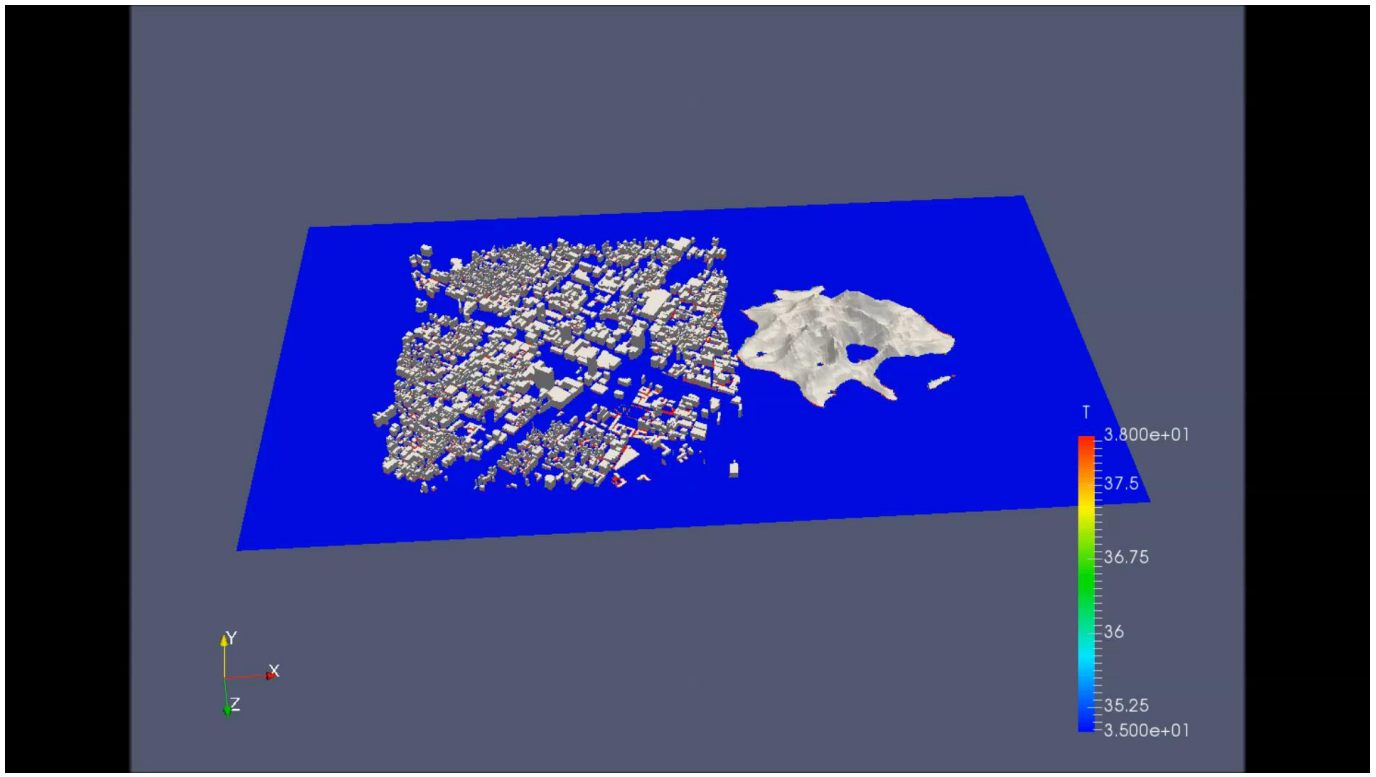
The most important features of “Urban Climate” are:

1. Changes in the radiation balance of the urban air and surfaces
2. Higher air temperatures
3. Lower atmospheric exchange and
4. Higher degree of atmospheric turbidity

Urban Heat Island (UHI)

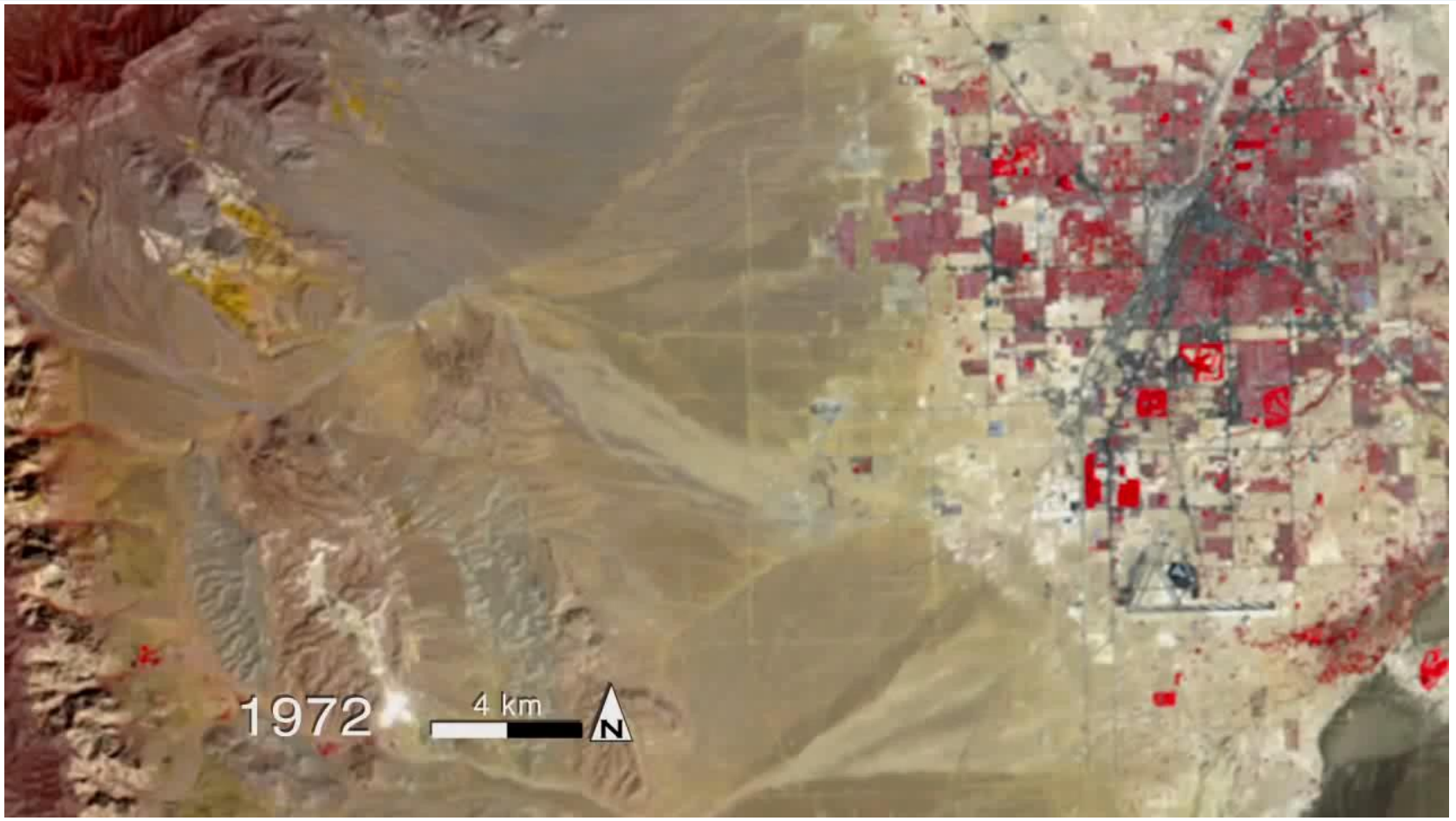
Urban Heat Island refers to urban air and surface temperatures that are higher than nearby rural areas. This temperature difference could be varied from *1-5 K or sometimes even more*.

Urban Heat Island (UHI) in Montreal



UHI is modeled for downtown of Montreal with more than 4000 buildings and a mountain. The simulation has been done with CityFFD which is a semi-Lagrangian model equipped with turbulence model. The domain has more than 10 million grids and the running time is around 5 hours on a personal computer with 12 GB RAM.

Urban Sprawl (II): Las Vegas



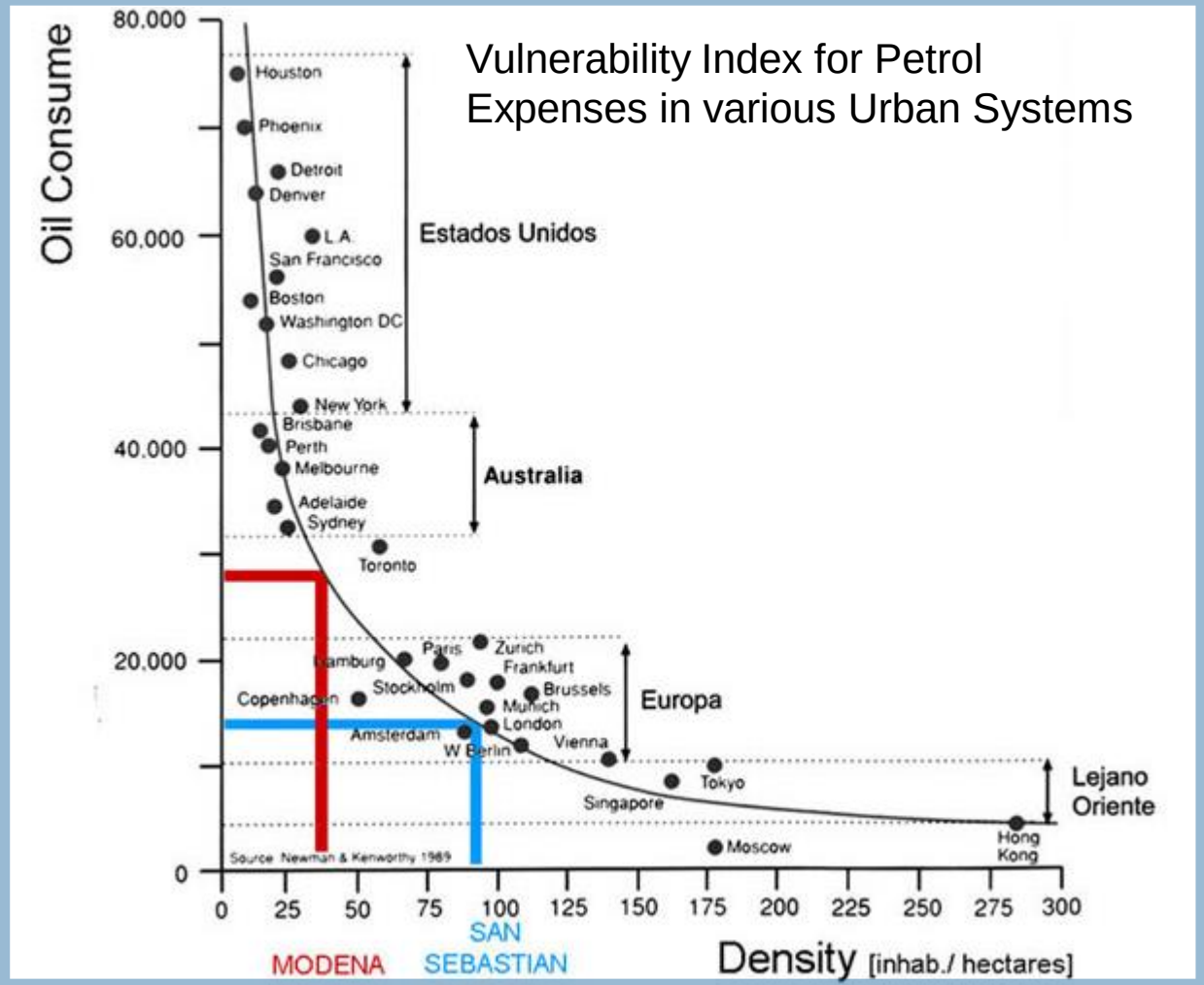
Source: LANDSAT Images of NASA, 2019

Urban Sprawl

as "the uncontrolled spreading of urban developments (such as houses and shopping centers) on undeveloped land near a city".

Why is ECO-COMPACT CITY more efficient than SPRAWL CITY?

1. it consumes less territory
2. it allows a correct density
3. it allows small retail to be on street and on square
4. it maximizes investment
5. it allows the creation of an efficient network of public utilities
6. it allows the creation of an efficient public transit system



http://www.ecocompactcity.org/home.html

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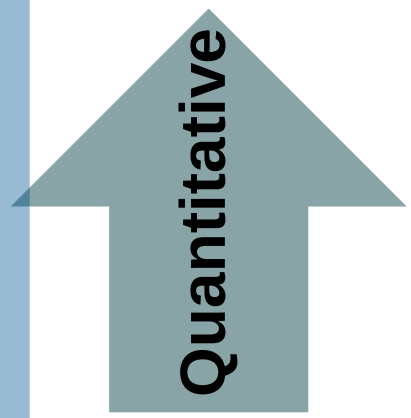
Cities/Urban Areas are Ecosystems

So instead, Cities, we speak about Urban Systems



Urban areas are the areas in which the human population reaches or exceeds densities of 186 people/km^2

Urban ecosystems comprise suburban and hinterland areas linked by corridors (transportation, utilities) or affected by the urban core

A **sustainable city** makes use of opportunities from current trends (e.g., digitalization, clean energy, sustainable finance), as well as innovative transport and mobility patterns, thus providing options for inhabitants to make more environmentally friendly choices, boosts sustainable economic growth, enabling cities to improve their service delivery.

Sources: Savic et al., 2005, Böschen, 2013; UN HABITAT III, 2017

Sources: Irwin et al., 2011; Zhou et al., 2014; Pan et al., 2018

Sustainable Urban Area provides various functions/services

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Transformation Process towards Sustainable/Smart Cities (I)

- New working market and working patterns
- Pollution, Climate Change, Resilience
- Good Governance
- Transparency, market openness
- Reputation, creating a brand attract business, talent and visitors

Reasons for transformation towards Sustainable Urban Areas worldwide

Analysis of context variables for Sustainable Urban Areas

- Structural factors (size and demographic density of cities)
- Economic development of the cities (attract human capital)
- Technology development (Investments in R&D)
- Environmentally friendly policies

- Demographic Change
- Immigration
- Urbanization
- Online Commerce
- Shared Economy Models
- Digital Divide
- Employment Trends
- Mobility trends
- Industry 4.0

Understanding the Trends and Influencing Factors

Transformation Process towards Sustainable Urban Areas (II)

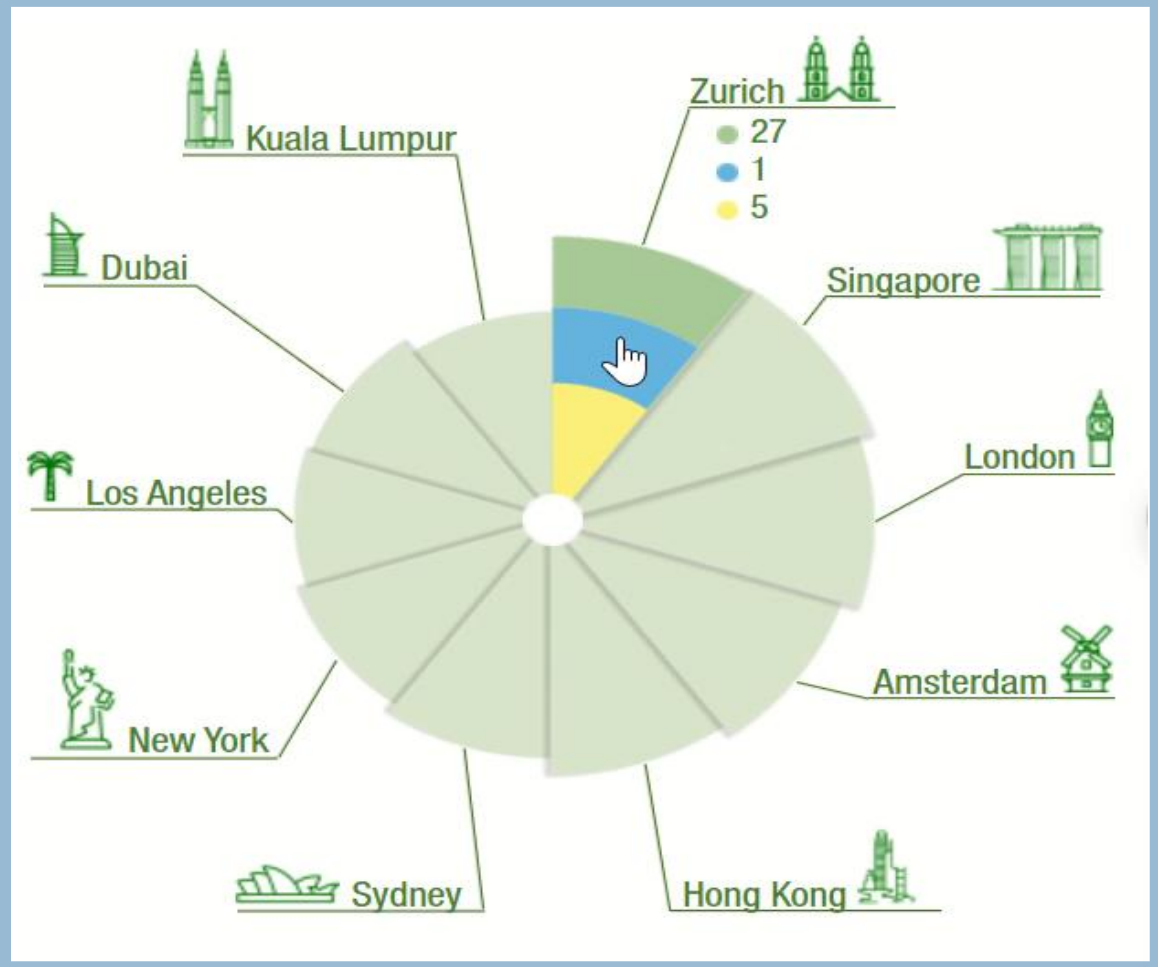
- **Hard Domains**
  Energy Networks, Air, Water, Waste, Natural Resources, Mobility and Transport, Buildings and Districts
- **Soft Domains**
  Government, Cultural Heritage, Education, Public Safety and Security, Healthcare, Social Inclusion

Understanding the domains

Categories of Actions Integrated Planning

- Community Building (inclusive collaborative environment, citizen participation)
- Strategic Framework (action plans, programs, guidelines, roadmaps, recommendations)
- Services and Applications (New IT technologies)

Best practices of Sustainable Urban Areas



The social factors related to the quality of life of a city's inhabitants — health, work, and education.

The environmental factors related to the conditions which give a city its **'green label'** such as its level of pollution, its initiatives to promote recycling, the extension of green zones.

The economic prerequisite: The economic health enjoyed by the inhabitants of a city.

Best practices of Sustainable Urban Areas
Cross-Country Comparison

- Asian Cities (China, India, Taiwan, Sing, Korea) focus on hard domains because of (a) high level of pollution and (b) considerable economic development
- EU Cities on soft domains – human capital investments
- American cities are not driving the changes because of still low environmental regulation
- Small cities are good ecosystems to launch new experiments (Living Labs)
- Large cities usually face more critical needs and problems that entail digitization endeavors and they can attract technology vendors easily

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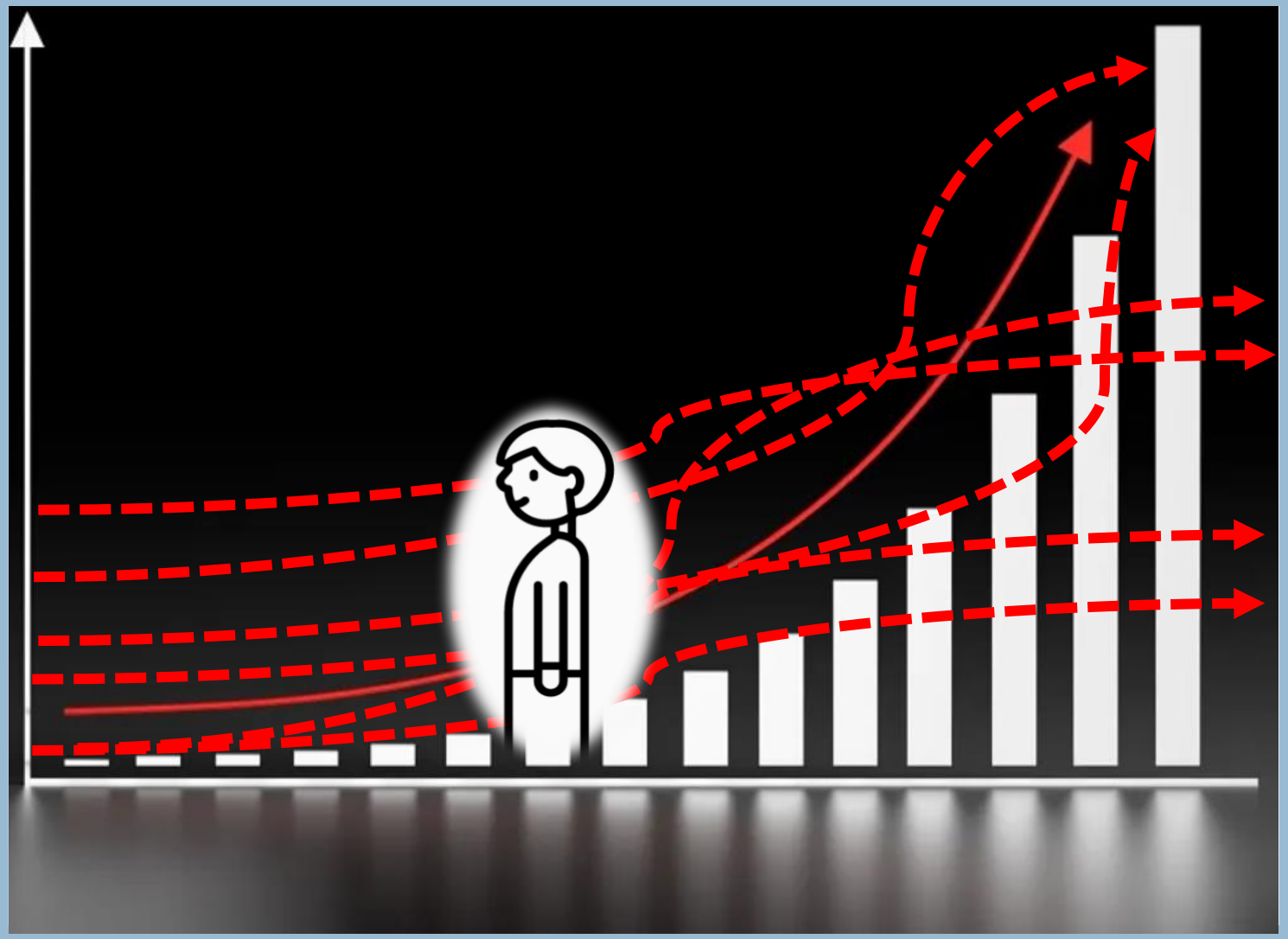
Sustainable Urban Systems

Project New Mobility in Metropolitan areas (NEMO)



‘Urban Nexus’ perspective

- Links (a) critical urban infrastructures and (b) all relevant stakeholders into **participative governance** structure through
- Horizontal and vertical Integration within **multi-layer, multi-criteria decision making systems**
- Societal issues are characterised by complex time evolutionary behaviour on multiple dimensions

Sustainable Urban Systems

Project New Mobility in Metropolitan areas (NEMO)

Economic Viability of Public Investments

Net cash flow
investment
revenue
Cost per ton
Current parking fare
Public transport attractiveness
Parking fare attractiveness
Withdrawal
Fuel

Mobility dynamics

leaving customers
obsolescence time
seed customers
Potential Customers
Customers
new customers
Market Size
sales size
would be word of mouth sales
customer sales effectiveness
sales
c advertising spending
fraction would be with real prospects
would be advertising sales
advertising effectiveness
Customer perception about sustainable practices
Implementation of sustainable practices
Adjustment Delay
Business sustainability
Productivity at workplace
Reduced cost of operations
Competitor fraction
Comp delay
Competitor effect
Profit per unit
Profits
Profit multiplier
Fraction invested towards sustainibility
Capital investments towards Sustainability
Energy

Melkonyan et al., 2017

female
Immigration
net immigration rate
Net Immigration
Population bet. 18-65
Geriatric rate
Population above 65
Adult deaths
Geriatric deaths
Adult mortality rate

Population dynamics

<Immigration>
Population density
Total cumulative distance traveled
<Livable area in Ruhr>
Area needed factor
Requirement
New area needed
Additional distance travelled per person
Effective city area

stments in astructure, Land use

Source: Melkonyan et al., 2019

Sustainable Urban Systems: *NEMO Scenarios (I)*

Smart City

- Interactive digital networks strengthen integrated multi-modal transport system: ***Cyber Infrastructure***
- Autonomous driving leads to a better public transportation: ***Public Transport Attractiveness***
- Intelligent parking reduces searching time causing reduced traffic: ***Parking Fare Attractiveness***
- Multi-purpose areas enhance social interaction: ***Social attractiveness of mixed-land use***
- Increased renewable energy production and its use in the mobility sector: ***Renewable Energy produced***

Sustainable/Healthy City

- Environmentally aware citizens reduce consumption of energy-intensive products/services: ***Energy requirement/Capita***
- Sustainable lifestyles and high level of social interaction public participation in creating new urban planning concepts for more public room in the cities: ***mixed-used public spaces***
- Fossil fuels and parking in urban cores are expensive or banned, internalization of externalities as fiscal policy: ***CO_2 price***
- Soft mobility is dominant: ***Investment in public transport or bike infrastructure***
- Shared mobility business models are efficiently developed and accepted: ***Effect of car sharing***

Sustainable Urban Systems*: NEMO Scenarios (II)*

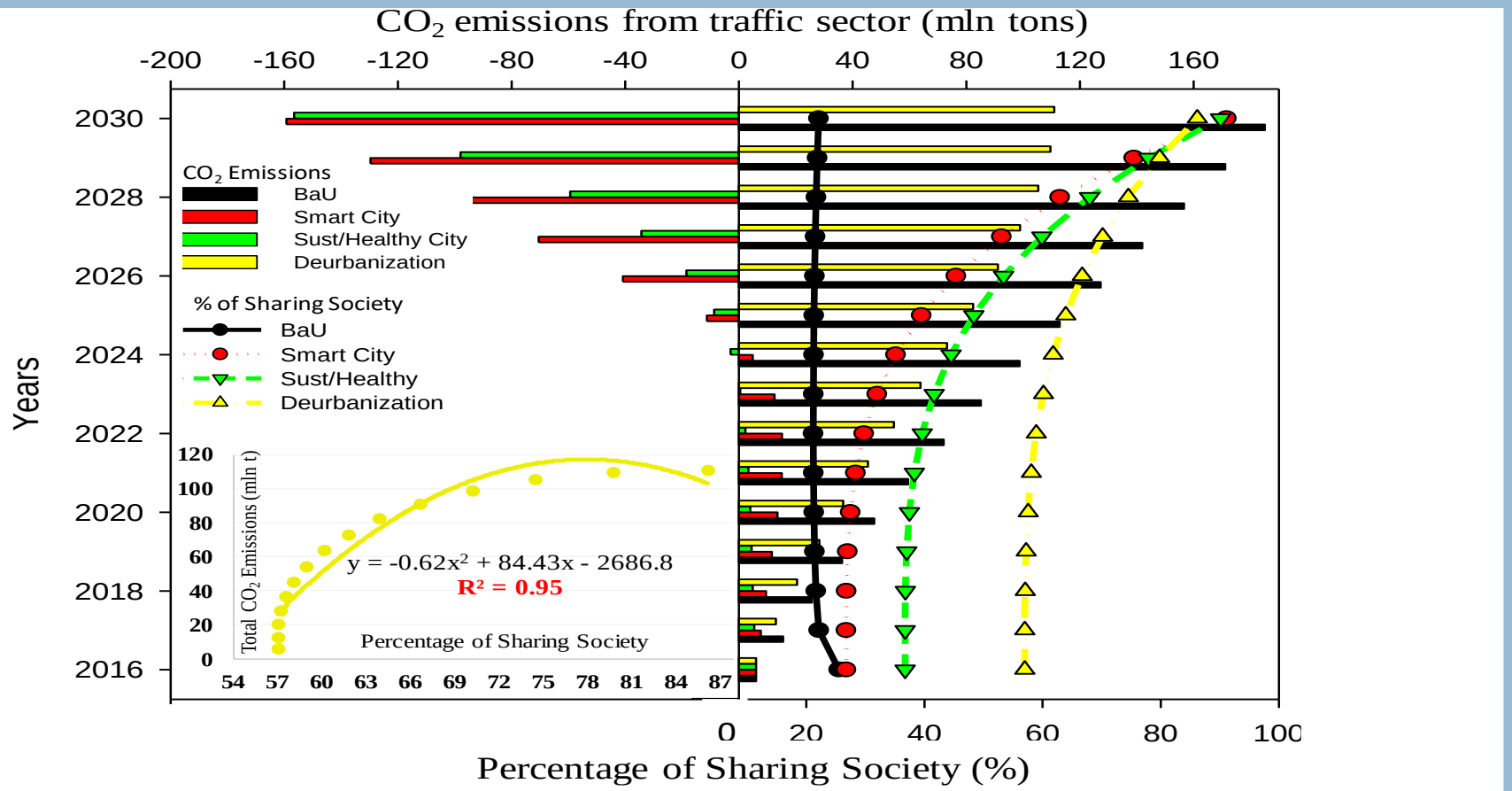
Peri-Urbanization

- Lack of investment in urban cores: ***Fraction of investments in urban infrastructure***
- Less economic growth accompanied with high living prices in urban cores: ***Development index***
- New digital technologies lead to more remote working job models and less commuting distances: ***Total cumulative distance travelled***
- Local actors are better off: ***Daily distance by car***

Business as Usual

- Focus on private transport: ***Cars per person***
- No shared mobility concepts and less investments in public transport: ***high level of Air Pollution***
- High share of unemployment: ***Unemployment Rate***
- Inefficient spaces: ***Conversion to City area***
- Social disturbance: ***Unrest due to people problems***

NEMO Simulation Runs; Carbon Emissions

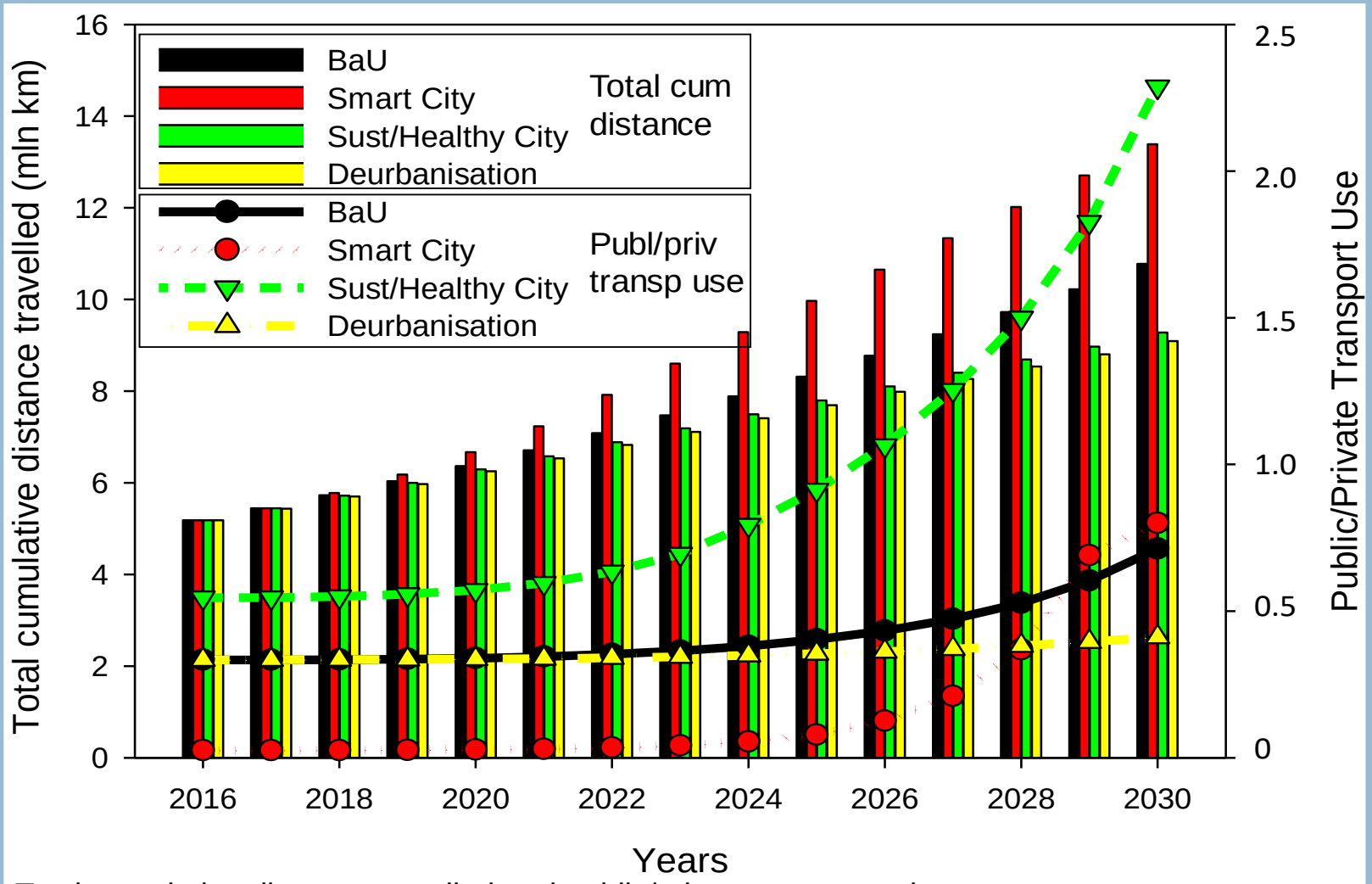


Percentage of sharing society and its impact on CO_2 emissions for scenarios BaU, Smart City, Sustainable/Healthy City, and Deurbanisation. Development of sharing society is presented as a scatter and line plot on the right-hand side. The inset graph displays the correlation between total CO_2 Emissions and the percentage of sharing society as simulated for the Deurbanization scenario.

Source: Melkonyan et al., 2019

1. The percentage of sharing society is the highest in the deurbanization scenario, but the increase of the percentage in the sharing population is the highest in the smart city scenario.
2. CO_2 emissions decrease sharply in Smart and Sustainable City scenarios.
3. CO_2 emissions increase in the scenario deurbanization, showing a positive correlation

NEMO Simulation Runs; Total cumulative distance travelled

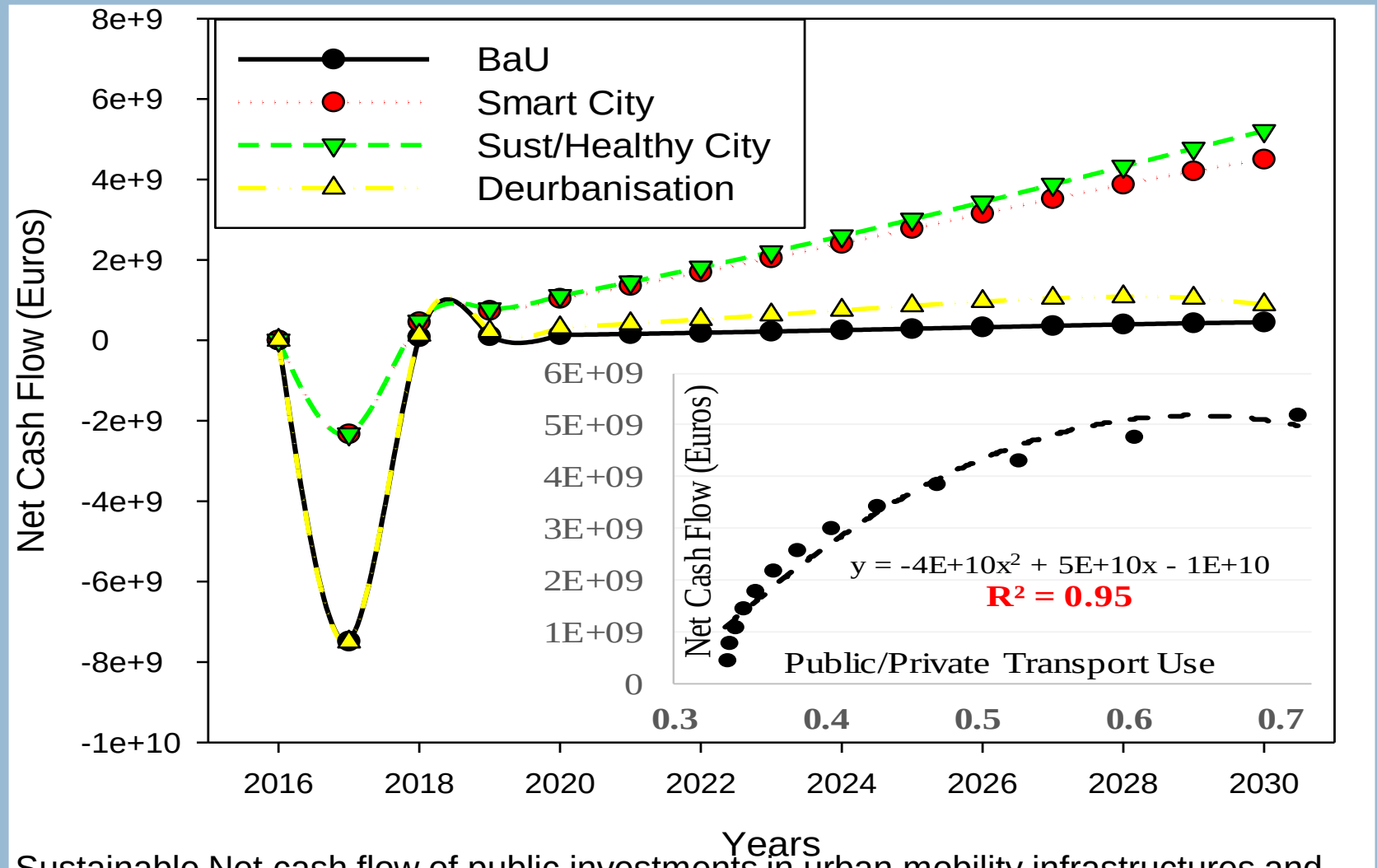


Total cumulative distance travelled and public/private transportation use

Source: Melkonyan et al., 2019

1. Due to the expansion of urban areas in the Smart City scenario, the distance driven increases significantly.
2. However, CO_2 emissions are saved in Smart City and Sustainable City scenarios. This is explained by
3. (a) modal - split: increasing, high share of public transport relative to private transport.
   b) efficient and targeted investments in urban systems

NEMO Simulation Runs; Sustainable Net Cash Flow



Sustainable Net cash flow of public investments in urban mobility infrastructures and the correlation with the modal split for the Business-as-Usual scenario

Source: Melkonyan et al., 2019

1. SNCF depends on tax agreements of the state and CO_2 emissions saved.
2. Once the investment is made, it initially only leads to capital expenditures, then the SNCF increases significantly. This is particularly evident in the Smart City and Sustainable/Healthy City scenarios, where the most CO_2 emissions are saved.

Sustainable Urban Systems*:* Project NEMO: Recommendations

1. The fraction of **renewable energy use in motorized** vehicles should be 80 %.

2. An increase from currently 1,000 Euros/person in public infrastructures investment to 3,500 Euros/person could lead to a decrease in total cumulative CO_2 emissions from 60 million tonnes to 20 million tonnes. A public infrastructure investment of **4,000 Euros/person** could lead to the mobility sector becoming CO_2-neutral.

3. Increasing the **attractiveness of public transportation** by improving quality, coverage, price, and timing of services could lead to direct savings of all the CO_2 emissions, making the transportation sector CO_2 neutral by the mid-2030s.

4. Transportation and Mobility sector along with Building and Energy sector is the key lever for transformation

Source: Melkonyan et al., 2019

There are many good Best case examples for Sustainable/Smart Cities reflecting on Urban Logistics, Mobility, Energy, Construction, Education, Policy Making.

BUT……

There are only a few circular activities in several Cities
and no Circular Cities

Ani Melkonyan
Executive Director of ZLV

ani.melkonyan@uni-due.de
www.uni-due.de/zlv