Innovating Cities Policy Report for EU R&I Sustainable Urban Development

Cities P4P-Project for Policy: Policy Review Report from EU DG R&I funded urban projects under Framework Programme Seven (FP7)

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Innovating Cities Policy Report for EU R&I Sustainable Urban Development

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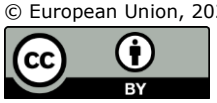

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edited by Maria Yeroyanni

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1 Introduction and Overview

Many of the economic, social and environmental challenges that Europe is facing have a strong urban dimension. Rapid population growth, aging population, shrinking and growing cities, climate change, biodiversity loss, disaster risks, migration, unemployment, and social exclusion are some of the major problems affecting citizens living in the urban environment. Thus, making cities inclusive, safe, resilient and sustainable is a global objective (Sustainable Development Goal, SDG no. 11) that requires innovative, holistic and citizen-centred solutions, by promoting a multi-stakeholder engagement within a multi-level and participatory governance framework.

Although the term smart cities has been extensively used for cities implementing new technologies in the fields of energy, mobility and Information and Communication Technologies (ICTs), truly smart and sustainable cities should be the reflections of the people who live, work, and create within them. Our cities and public spaces are indeed integral to the innovation, cultural heritage, arts, democracy and sustainability. Envisioning the future of our cities, implies synthesising the different perspectives and practices coming from a variety of urban players such as local authorities, planners and designers, practitioners, creative industries and SMEs, fab and living labs.

Cities are actors of open innovation and shapers of a sustainable and human-driven economic future. They foster regional growth to the well-being of citizens and create new jobs and market opportunities. They represent incubators of the future on the front lines of change in our society and the place where we are making the necessary progress on climate neutrality and where we show that social inclusion, social innovation, diversity, equity, justice and fairness are necessary ingredients for success.

Figure 1. © K.-U. Häßler

1.1 Aims and objectives of the report

The report capitalizes on 30 years of successful EU-funded research on sustainable urban development. It relies on the analysis of a critical mass of inspiring knowledge, ideas and practices coming from 41 projects funded under the Seventh Framework Programme (FP7) across the different thematic priorities, in conjunction with the evidence provided by initiatives supporting research and innovation towards transition to a more sustainable urbanisation (e.g. the Joint Programming and Partnering initiative JPI Urban Europe, the Energy Efficient Building Public-Private Partnership, the European Green Vehicles Initiative and the European Construction Technology Platform).

The report presents the results of almost 41 projects, and highlights, showcases and provides an EU-wide evidence base of the outstanding contributions of EU funded research and innovation in meeting urban societal challenges, notably those supported by the FP7 Research Framework Programme which deploy a systemic and integrated analysis of the urban ecosystem, and the interconnected nature of the urban challenges arising in our cities. The report highlights integrated policy research solutions to the societal challenges

that generate policy benefits and co-benefits simultaneously delivering socio-economic and environmental political objectives for regional, local city authorities, civil society, political representatives, the private sector and industry.

Figure 2. © pict rider

The EU Funded FP7 reviewed projects acknowledged the need to consider urban challenges in a wider perspective which promotes systemic solutions (e.g. nature-based, technological, digital, social, cultural, governance, financial and regulatory innovations) delivering new options and strategies for city managers and politicians for a sustainable Urban Design and planning towards a robust economy.

Horizon 2020 went beyond framework programme Seven (FP7) in scope and ambition, towards actions and implementation. However, FP7 had tackled many of the H2020 challenges, as it can be seen for the thematic chapters of the present report.

These thematic areas have been a significant source of inspiration for research and innovation under H2020, and have been integrated in the Horizon 2020 programmes on 'Smart and Sustainable Cities' and the policy agenda on Innovating Cities. This report constitutes a valuable evidence base of knowledge (research policy conclusions) for the Urban Agenda for the EU, its Urban Partnerships and the new Habitat III Global Agenda.

Figure 3. © Backwoodsdesign

It provides urban stakeholders with the inspiration of new ideas, factual information, as well a practical guide for dissemination and potential exploitation for innovating cities, and encouragement to deploy at large scale, upscaling and replicating these solutions, thus creating the opportunity for Europe to lead the global market of Innovating Cities with systemic solutions and contribute to sustainable, resilient, inclusive, healthy, creative and prosperous cities.

EU Research and Innovation on sustainable urban development is a strong component of Horizon 2020, the EU's current funding Programme for Research and Innovation, with emphasis on social innovation, and citizens' engagement towards open innovation, co-creation, co-design and co-implementation of systemic solutions with different actors in cities across the EU for Innovating Cities.

The reviewed projects provide ways to implement the proposed solutions to be adopted by city municipalities and highlight how the above projects which entail actual implementation of related actions to the proposed solutions, contributed to a new urban planning and design within city municipalities in Europe and in the World.

1.2 Structure of the Report

European research aims to devise and develop innovative solutions for city management, that can overcome the complexities of sustainable urban development and deliver on pan-European and global commitments on societal challenges and sustainable development goals. In this respect this report showcases the results of some EU funded multi-partner pan-European, and frequently global, research and innovation projects combining an urban ecosystem of stakeholder engagement, linking research skills to innovative city practice solutions.

The report highlights and presents the outputs of 41 EU projects thematically structured according to eight sections as follows:

- Climate Adaptation and Resilience
- Sustainable Land Use and Nature Based Solutions
- Resource Efficiency and Circular Economy
- Air Quality and Health
- Mobility
- Energy Transition including Energy Efficient Buildings
- Social Cohesion, Well-being and Diversity
- Social Innovation and Citizen Science

Each thematic section presents the results of a number of individual EU FP7 research projects. The thematic sections consider, amongst other issues, the extent to which the projects fostered and developed the following:

- Evidence-base for decision-making by cities. This could includes more information on the business cases for innovative solutions produced by the project.
- Cities as actors in a framework of open innovation. This includes technical and digital innovations for sustainable urban development.
- Stakeholder engagement in the design, development and deployment of solutions. This includes governance model innovations.
- Support of new local urban planning Instruments and policy.

2 Climate Adaptation and Resilience

2.1 Climate Adaptation Challenges

Extreme weather events like heavy rainfall, hail, violent storms and heat-waves are increasing in frequency and sea levels continue to rise. The effects of global warming and climate change are undeniable. Urban systems are highly vulnerable to these threats. However successful mitigation efforts prove to be, the impact of climate change will increase in the coming decades due to the delayed effects of past and current greenhouse gas emissions. Europe and other parts of the world therefore have no choice but to take adaptation measures to deal with the unavoidable climate impacts and their economic, environmental and social costs. Climate impacts vary significantly from region to region, and can fluctuate within defined geographical areas. Adaptation and resilience management is therefore required both on a regional and local scale to move towards more resilient communities. Building resilience is about helping communities withstand and recover from disasters, with the focus on tackling the root causes and dealing with the consequences. By prioritising coherent, flexible and participatory approaches, it will be much cheaper to take early, planned adaptation action than to pay a higher price of not adapting to climate change. Good planning and preparation can limit the scale of impacts, and risk management policies save lives and enable growth and sustainable development.

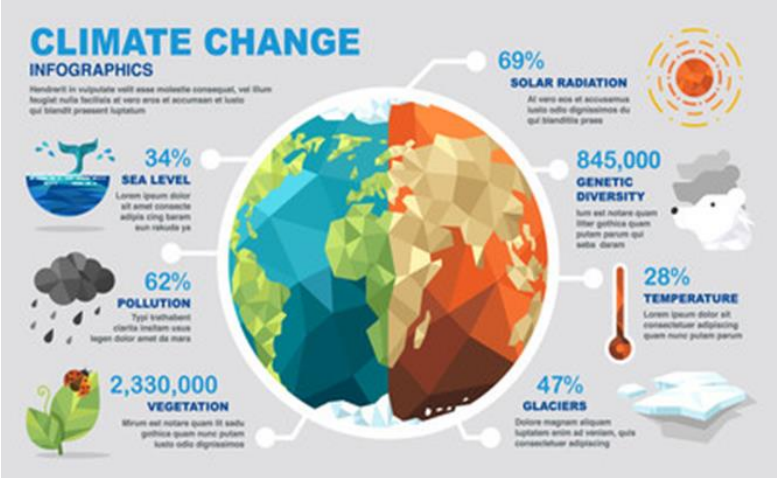

Figure 4. © antto

2.2 Resilience Solutions

The EU FP7 funded projects considered here include CLUVA, CORFU, SECOA, TRUST, PREPARED, BURBA and RAMSES. CLUVA and CORFU both address global problems on a trans-local scale – climate change in the Global South, Asia and Europe. In terms of integrated and systemic approach to societal challenges, CLUVA use urban morphology maps with other data to help predict and assess the risk for the most vulnerable communities in urban slums, whereas CORFU looked at cost effectiveness issues.

CLUVA (Climate Change and Urban Vulnerability in Africa) focused on five of Africa's most vulnerable cities: Saint-Louis in Senegal, Ouagadougou in Burkina Faso, Douala in Cameroun, Dar-es-Salaam in Tanzania and Addis Ababa in Ethiopia. The project supplied planners, managers and researchers within African cities with reliable forecasts of the local impact of climate change to strengthen the capacities of urban communities. Africa is considered a continent particularly vulnerable to the effects of climate change and its real impact, particularly on a local scale, is still poorly understood. Prediction of climate change impacts in Africa in the 21st Century are based on Global Circulation models with low resolution and a very broad scale which fail to represent two potentially important drivers of African climate variability, namely the El Niño/Southern Oscillation and land cover change. The task of developing reliable predictions of future climate change in Africa is further complicated by the lack of accurate baseline data on current climate and by the intricacies of climate space and time variations.

CLUVA developed methods and knowledge, which were uptaken and implemented to African cities to manage climate risks, to reduce vulnerabilities and to improve resilience towards climate change. The project improved the capacity of scientific institutions, local Councils and civil society to cope with climate change, and assessed the environmental,

social and economic impacts and the risks of climate change induced hazards anticipated to affect urban areas (floods, sea-level rise, storm surges, droughts, heat waves, desertification, storms and fires) over various time frames. The project also developed innovative climate adaptation strategies based on strong interdisciplinary components, and was delivered by a balanced partnership of European and African partners.

It worths mentioning the reliable forecasts of the local impact of climate change which CLUVA provided to planners, managers and researchers within the selected African cities and at the same time CLUVA offered concrete solutions by developing: Climate Change risk adaptation strategies; risk reduction strategies for the 38 per cent of Africa's population (280 millions); desertification maps to assess the sensitivity to desertification in peri-urban areas; provided an estimate of the impacts of Climate Change on African urban areas in the next 40 years and developed simple methods to be applied by the stakeholders of African cities; downscaled the Intergovernmental Panel on Climate Change (IPCC) scenarios to local urban and urban-rural regions; provided regional projections up to 2050 of climate change at high resolution (8km); conducted the first comprehensive assessment of green structures based on Urban Morphology Type (UMT) characteristics in sub-Saharan African cities; tailored a suite of methods developed in Manchester to the African urban context, including city-wide assessments of regulating urban ecosystem services; demonstrated that business-as-usual scenarios could result in the loss of around a third of Addis Ababa's agricultural land and a fifth of its other vegetated areas between 2011 and 2025; provided maps for Dar es Salaam, Addis Ababa and Ouagadougou to consider which particular communities are likely to be most impacted by flooding.

CORFU (Collaborative Research on Flood Resilience in Urban Areas) an interdisciplinary international project developed and applied novel strategies and measures for improved flood management in Barcelona (Spain), Beijing (China), Dhaka (Bangladesh), Hamburg (Germany), Mumbai (India), Nice (France) and Taipei (Taiwan). Flood impacts in urban areas--potential deaths, damage to infrastructure and health problems, and their consequent effects on individuals and communities were assessed by envisaging different scenarios of relevant drivers: urban development, socio-economic trends and climate changes. The project relied on differences in the perception of urban flooding problems in Asia and in Europe and created synergies offering new insights for flood management strategies globally. The latest technologies were cross-fertilised with traditional and emerging approaches to living with floods, enabling European and Asian institutions to learn from each other through joint development, implementation and dissemination of strategies towards scientifically sound management of the consequences of urban flooding, through cost-effective resilience measures and adaptable flood management plans.

In particular CORFU produced guidelines for the design and implementation of SUDS (Sustainable Drainage Systems) and flood management in Europe and China, which were adopted by local policy makers;developed and implemented real-time warning systems in Barcelona and Dhaka; applied the multi-cell model to Beijing City (area more than 1000 km2), and demonstrated it's applicability as it reproduced the observed location for the 21 July 2012 flood, when large parts of Beijing were seriously flooded causing 57 casualties. It also contributed to EU Floods Directive by developing urban flood scenarios, modelling and flood hazard mapping.

Figure 5. © lindacaldwell

SECOA tackled the issues of adaptation to climate change focusing on large coastal metropolitan areas in Europe and Asia, in order to provide sustainable urban planning solutions addressing conflicting uses of land and territorial resources (economic development vs environmental protection, preservation of natural sites and biodiversity; urban growth and restructuring; social cohesion and human mobility) by different stakeholders (i.e. residents, commuters, tourists, and enterprises).

These conflicts are multiplied by climate change affecting environmental conditions in coastal areas. In SECOA, an integrated ecosystem approach (Integrated Coastal Zone Management-ICZM) was adopted for understanding and dealing with the complex and dynamic problems that coastal urban environments are facing: economic factors, social features, natural and cultural resources, spatial organisation, resistance to sustainable development also linked to interests and pressure groups. SECOA integrated the ICZM perspective with the understanding of multi-dimensional environmental conflicts, with strategic outcomes in the application of a multi-criteria approach to analyse causes and effects of conflicts in a multi-dimensional perspective, in order to facilitate a shared, democratic and participatory approach to conflict resolution.

In particular, SECOA produced specific evidence base for decision making, including maps of the flood hazard in 15 of its case study coastal areas: Oostende and Brugge, Belgium; Mumbai and Chennai, India; Haifa and Tel Aviv, Israel; Rome and Chieti-Pescara, Italy; Lisbon and Algarve, Portugal; Gothenburg and Malmo, Sweden; Thames Gateway, United Kingdom; Hai Phong and Nha Trang in Vietnam.

SECOA delivered maps of natural resources sustainable use (through DPSIR framework) in all 17 case study areas, with a focus on conflict cases; it provided alternative development scenarios permitting consideration of both urban and metropolitan/regional scales, as well as peri-urban areas and directly interacted with on-going decision making processes, having an impact on their specific development.

The project delivered also a spatial decision support system capable of building and visualising plausible alternative futures, metadata, data, maps for Integrated Coastal Zone Management relying also on social resilience capacity to cope with catastrophic events.

TRUST dealt with the transition of urban water services and of their management, helping sector utilities and authorities (public and public/private enterprises) to formulate and implement appropriate urban water policies and achieve a sustainable, low-carbon quality water future.

Moreover, the project developed and tested a wide portfolio of tools (including nature-based solutions -NBS solutions and innovative technologies for optimised water treatment), guidelines, software and training material; their feasibility where demonstrated with city utilities in a variety of urban contexts across Europe and Africa. TRUST end products are online and available for free for the assessment of the impact of

interventions on the performance and sustainability gains of the overall urban water cycle; assessment water reclamation for non-potable-use, sustainable water demand and storm water management, energy-saving options and water-energy interventions. TRUST delivered tools for infrastructure asset management, helping utilities to perform targeted rehabilitation of infrastructures and to reduce leakage through integrated energy and pressure management in water distribution systems; for diagnosis of current and future status, ranging from tools for a very quick scan of the overall sustainability of urban water services (City Blueprint), to more complex web-based self-assessment tools;

RAMSES and PREPARED addressed the issue of climate change adaptation involving a variety of European and non-European cities, each facing different climate change problems, including heat stress and heat waves; pluvial and fluvial flooding, flash flooding; sea level rise, drought and water stress; snow diminishing; air and water quality; and urban agriculture and biodiversity management.

RAMSES provided standardised and transferable guidelines for cost-benefit assessment of different climate change impacts and of several adaptation measures, tools that are open access and available for hundreds of cities in the world. It also delivered a Transition Handbook and Training Package with a wide range of adaptation measures for cities to define transition pathways towards urban resilience and climate adaptation. It is worth noting the multi-stakeholder participatory approach, which RAMSES promoted and brought together urban planners, decision makers and practitioners, to share best practices and ensure their implementation in Europe and beyond.

The RAMSES results (e.g. cost assessments of different impacts (flooding, heat waves, simulation models, typology of heat waves on cities) have been implemented by the city of Antwerp where the municipality urban planners and urban designers used tools and knowledge delivered by the project to better plan climate adaptation measures (including nature-based solutions) and design innovative strategies for their city. Other project results such as the typology and indicators of resilient buildings are of great interest to insurance companies to calculate their premiums. For instance, the German Association of Insurance Companies has used RAMSES results in the calculation of insurance fees.

Figure 6. © Jbyard

PREPARED delivered to city municipalities and the construction sector solutions for the adaptation of European water supply and sanitation systems to climate change impacts, targeting risk assessment frameworks in respect to water scarcity, water quality, insufficient sewage system with combined outflows (sewage plus water flooding) and environmental problems created by wastewater (pollution, decrease in drinking water quality), real time modelling and monitoring systems and planning for resilience.

Tools and decision support systems helped water utilities to cope with the anticipated and uncertain impacts of climate change, especially the extremes ones and to make strategic investment decisions for the design and maintenance of their city infrastructures.

It was evidenced for the city of Berlin that integrated management reduces water overflows by 17% and discharged pollutants by 21-31% following extreme events; for the city of Genova - optimised management permits of water storage increases hydro energy produce by 43%, and reduces groundwater extraction by 20%; for the city of Barcelona - sediment monitoring and real time actions have considerably reduced the annual municipal sewer removal costs; for the city of Oslo- treating surplus wastewater during heavy rain events by chemical precipitation increases overall removal efficiency (including the untreated overflows) from 19 % to 32 % (total nitrogen) and from 36 % to 85 % (total phosphorous).

Research focused not only on the development of innovative technology but also on showing stakeholders how existing technology could offer innovative solutions to the anticipated problems: protect drinking water from the effects of climate change and extreme events; use alternative water resources (e.g. the integration of rainwater/stormwater into the water cycle as supplementary resource); make better use of water resources, to protect the population against flooding; protect buildings and infrastructure from damage; protect receiving water courses from pollution through better management of the sewer and drainage systems.

BURBA designed an IT method for waste management optimisation, as a new concept of waste service through the entire chain from production to disposal, based on handling of data from waste management. BURBA uses surveillance and feedback to create an optimised collection service, and a social game aspect to reward positive behaviour. The 3-year study is using cutting-edge low-cost RFID (radio frequency identification) and LBS (local based service) technologies for the separation and collection of waste at source. These are integrated into an intelligent waste container (IWAC) of 600 to 1.200--litre capacity for use in densely populated areas and eventually for industrial areas.The system delivered information that contributed to city sustainability improving the efficiency of waste management and recycling activities. The system also delivered information on individual user habits used for taxing or rewarding citizens, but also for motivational and educational purposes. To foster the systemic approach, the project worked in close collaboration with the end-users for each sector to define their requirements for the adequate design of the systems and to deliver outputs adapted to their needs.

Research centres, technology-provider companies, water utilities, and waste management companies worked with urban planners to deliver an integrated analysis of the problems and risk management options, and to propose innovative solutions.

Actors such as Acorde Technologies S.A.(Spain), Municipality of Camogli (Italy), Rzeszów Municipality (Poland), AOTO Company (Republic of China), Tekever SME (Portugal), Ayuntamiento de Santander (Spain), D'Appolonia S.p.a. (Italy), Politecnico di Milano (Italy). The project successfully addressed climate change problems, where cities need to reduce their emissions, andalso to be prepared for challenges, such as water shortage, heat stress, flooding, and waste recycling.

3 Sustainable Land Use and Nature Based Solutions

3.1 Sustainable Land Use Challenges

In the EU, 'land take' consumes more than 1,000 km² of land every year in development for housing, industry, roads or recreational purposes, every decade 'land take' consumes an area equivalent to Cyprus. About half of this surface is actually 'sealed', for other unsustainable land use patterns irreversibly eroded, or degraded through soil contamination or by reduction of organic matter. This 'land take' threatens security of food supply, health and more generally loss of natural capital and ecosystem services including

clean air, water and soil, adaptation to climate change and mitigation of natural disaster risks.

3.2 Nature-Based Solutions

There is growing recognition that nature can help provide viable solutions that use and deploy the properties of natural ecosystems and the services that they provide in a smart and sustainable way. These nature-based solutions provide, cost-effective, multi-purpose, multi-benefit and flexible alternatives for various objectives. Working with nature, rather than against it, can further pave the way towards a more resource efficient, competitive and greener economy. It can also help to create new jobs and economic growth, through the manufacture and delivery of new products and services, which enhance the natural capital rather than deplete it. Nature-based solutions to societal challenges are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Urban areas have a key role to play in the deployment of nature based solutions, as well as in the adoption of more sustainable land-use patterns, including the re-use of brownfields.

Figure 7. © Auguste Lange

HOMBRE and TIMBRE provided an in-depth analysis of redevelopment problems and potentials of a large variety of brownfield sites (BFs), for BF characterization and remediation towards a BF re-use and zero BF perspective both in urban and peri-urban contexts, usually of large dimensions i.e. former industrial, commercial, infrastructural, mining, military and housing areas, with the aim to show how to limit greenfield exploitation and urban sprawl, through an environmentally and economically sustainable re-use of land in already built-up areas.

Both projects delivered nature-based, hard and soft, technological solutions considering land resource as part of a continuous cycle of allocation of building land, development, use, abandonment and re-use to achieve a circular Land Management. Within this framework, the recognition of economic, social, environmental, policy-regulation enabling factors and constraints permits focus on review the re-use process, prioritizing BF regeneration sites and preventing redeveloped sites to become BF, through the assessment of different redevelopment options and remediation technological solutions.

TIMBRE focused on case studies from Central European Countries and delivered ready for commercial exploitation a Web based support toolkit for BF regeneration promoting an Expert Information System for BF Regeneration helping stakeholders to access and select information for regions, districts, cities or BF portfolios to distribute available resources to those sites that are assessed to be the most critical, urgent or profitable to regenerate.

In this way multiple societal challenges have been addressed such as :Sustainable use of Land and nature-based solutions - with a focus on greening strategies in cities; Energy efficiency - production of renewable energy; Climate change; Waste - and the reuse of waste from deconstruction of buildings and structures; Social inclusion, health and

wellbeing - with a focus on remediation of polluted sites and water pollution management; Development of jobs and skills in the local economy.

The projects' end products were uptaken among others by the Centre for Applied Geosciences at the University of Tübingen which in collaboration with a spin-off company proposed a feasibility study for SMEs to verify the technological /practical as well as economic viability of the tool. The remediation technology 'phytoscreening with tree coring' gained recognition by engineering companies and is now used in various projects in Denmark.

For example, Orbicon (Danish engineering company) used tree coring to identify the groundwater-surface water exchange at contaminated sites (Brede, Raadvad in Denmark) in the Region of Copenhagen. Today the technique is offered by engineering companies all across Europe and is taught to young environmental engineers at the Technical University of Denmark in the field course on contaminated sites.

Moreover, municipalities took up the project overall approach and the use of the decision support system. In particular, the Municipality of Solec Kujawski adopted the Zero Brownfield approach as an extension to policies the City had already started to implement, encouraged by project experience to mobilise financial resources to assess remediation options and redevelopment opportunities for the BF area.

The Municipality of Terni added HOMBRE experiences into its approach to regeneration; stakeholders expressed interest in the Brownfield Navigator and its updating and customisation, as a means of communication and supporting design strategies for regeneration, and as a way of keeping up to date with practice across Europe.

HOMBRE coordinator, Deltares, used the concept of the land use cycle in the research project Asset management of the subsurface, and tested it on cases in the Municipalities of Utrecht and Rotterdam. The concept was also used for projects on Resilient Cities in Rotterdam.

In Markham Vale, the Derbyshare Country Council endorsed the Brownfield Opportunity Matrix as a useful tool for on-going consideration of soft end-use options and the Brownfield Remit/Response. Moreover, the Brownfield Opportunity Matrix and the Brownfield Remit/Response Tool, was used by Formas (Sweden) in the frame of ERANET SNOWMAN network, with a first case study application to Rotterdam (Nederlands).

Figure 8. © aerial-drone

URBES and GREEN SURGE analysed the links between nature and urbanisation in urban spaces considering cities as social-ecological-technological systems where the different dimensions must be connected and careful planning of all is essential to address sustainability. The projects broadened the approach of urban planning by including the ecological dimension. Nature provides ecosystem services to sustain life, human welfare, health, security, and social relations, but also assists in addressing some of the most pressing societal challenges, such as climate change, air quality, water, food security, social inclusion and green economy.

These projects adapted the concept of biocultural diversity to urban areas, stressing the connections between nature and people in cities. Biocultural diversity represents a new way of thinking about biodiversity conservation by looking at culturally significant and valued biodiversity and by identifying cultural expressions of nature with local communities.

The projects addressed problems identified by city planners and citizens and facilitated engagement via the European Learning Alliance, an online community of practice in which planners, practitioners and other experts communicate through mailing lists and LinkedIn groups share knowledge, expertise and opinion on green infrastructure planning and implementation and learn from the knowledge and experience of others.

They were developed and implemented through integrative and transdisciplinary processes, building bridges between disciplines such as environmental modelling, urban planning and governance, economic valuation and socio-cultural studies at a European-wide scale.

They also identified good practice examples of urban green infrastructure planning in several cities and developed and implemented innovative urban green infrastructure planning, governance and valuation approaches to enhance biodiversity, ecosystem services and economic opportunities in Urban Learning Labs in several Euroepan cities (e.g. Milan, Bari, Ultrecht, Gliwice, Rotterdam, Malmö, Ljubljana,Barcelona, Berlin etc.) between different levels of governance and planning, focusing on the city regional and local levels, but delivering results useful at national and international levels.

URBES delivered outcomes to position urban biodiversity and ecosystem services as key assets supporting European cities to adapt to climate change, to provide urban ecosystem services that enhance human welfare and to reduce cities' ecological footprints.

Solutions and tools delivered from URBES were incorporated in the biodiversity and green infrastructure planning of several major cities including Berlin, Barcelona, Rotterdam and New York. The projects analysed the systemic influences of green spaces as key and multi-functional assets for cities to be incorporated in urban planning process as critical elements for citizens welfare, health, and aesthetic), and also to addressed challenges of climate change, energy efficiency, food security, etc.

For example, Barcelona's 161,423 trees not only reduce the local temperature and energy demand, they also offer habitats for urban wildlife, store CO2 and play an important role in filtering harmful substances from the air. In 2008, they offset around 19,000 net tonnes of CO2 from the atmosphere, and eliminated slightly more than 305 tonnes of air pollutants.

The projects results emphasized the relevance of nature-based solutions (NBS) and urban green infrastructures to address climate change impacts (local climate regulation and cooling, flood prevention, cost-effectiveness), as an emerging urban planning paradigm, as well as a relevant market opportunity.

For instance, investments in nature-based solutions offer a valuable return for cities and urban areas: A 10% increase in tree canopy cover may result in a 3-4°C decrease in ambient temperature and save large amounts of energy used in cooling buildings. In addition, there are multiple other benefits as urban green spaces contribute to filtering dust, storing CO2, serving as windbreaks, etc.

Policy impact for both projects is evident as URBES and GREEN SURGE results were not only used in the biodiversity and infrastructures planning of cities like Barcelona, Berlin, New York, Rotterdam, Malmö, Ljubljana but at global level, their City Biodiversity Outlook contributed to the UN Habitat III New Urban Agenda and the Sustainable Development Goals Agenda, namely (SDG11).

Figure 9. © Brian Kinney

URBES and GREEN SURGE positioned urban green spaces and infrastructures at different levels. At the city level, urban plans are backed up by project results, including : 2020 Barcelona Green Infrastructure and Biodiversity Strategy; PlaNYC (New York City's 20-year Economic and Environmental Sustainability Plan); Berlin and Rotterdam planning of green infrastructure planning; Malmö integrated green-grey infrastructure for stormwater management and the retrofitting of the housing area of Augustenborg, as part of Malmö Water Plan; Lisbon Action Plan for Biodiversity in 2015 including a landscape mosaic fostering biodiversity.

At the European level, the results fed the EU Green Infrastructure Strategy, the Urban Agenda for the EU, the EU 2030 Energy and Climate Package, the EU 2020 EU Biodiversity Strategy and the Thematic Strategy on the Urban Environment. At international level, these research results where essential contributions to the UN Convention on Biological Diversity (CBD) and UN Habitat III New Urban Agenda.

4 Resource Efficiency and Circular Economy

4.1 Resource Efficiency Challenges

Today in the EU, each person consumes 16 tonnes of material annually, of which 6 tonnes are wasted, with half going to landfill, notwithstanding rises in raw material and mineral prices. Measures such as better eco-design and reuse can bring EU wide net savings of up to 604 billion euros or 8% of annual turnover to businesses. Resource efficiency is essential if we aim to deliver greater value with less input, use resources in a sustainable way, delivering greater value with less input, using resources in a sustainable way and if we consider waste as a resource to be fed back into the economy as a raw material.

Resource efficiency is one of the core elements necessary to create a green economy in Europe and further afield, alongside waste prevention and, and more sustainable production and consumption patterns. The Circular Economy provides a range of new business opportunities based on services instead of products, such as leasing, sharing, repairing, upgrading or recycling, reducing corporate costs and contributing to the security of supply. The EU has designated resource-efficiency as one of the flagships of its Europe 2020 strategy and has developed a roadmap to pave the way - Roadmap to a Resource Efficient Europe. On this basis a Circular economy package has proposed revision of the 2008 Waste Framework Directive, the 1999 Landfilling Directive as well as the 1994 Packaging Waste Directive, as well as an EU action Plan for the Circular Economy (COM(2015) 614 final).

Cities are essential actors of open innovation in providing the conditions to stimulate the circular economy and increase ressource-efficiency, decoupling growth from natural resources consumption and degradation. Cities facilitate links between research, innovation and policy to:

- Encourage the most resource-efficient products and services, including sustainable local food chains based on green procurement policies, sustainable consumption campaigns and fiscal incentives;

- Develop innovative financial instruments to trigger the development of solutions by socio-economic stakeholders;

- Integrate resource efficiency and circular economy into planning policies and infratructures, in collaboration with other level of governance and across different services, for example, presenting alternatives to ordinary waste management by providing collection facilities for used products.

Figure 10. © SceneNature

4.2 Resource Efficiency Solutions

Resource efficiency and the circular economy was the broad focus of 6 FP7 funded projects including **Foodmetres** and **Supurbfood** (working on sustainable local food chains), **Pocacito** (working on the transition of cities to post-carbon models), and **Urban Nexus, Bridge and SUME** (on informed decision and policy making with a focus on resource-efficiency).

Foodmetres (Food planning and innovation for sustainable metropolitan regions) focussing on the spatial dimension of metropolitan regions, developed 3 footprint assessment tools:

- The Metropolitan Economic Balance Assessment (MEBA) tool applies an economic approach to assess the food demand-supply balance within a metropolitan region;

- The Metropolitan Area Profile and Scenario (MAPS) tool adopts a straightforward data-driven approach to applying different food production regimes (e.g. organic farming, food loss) and consumption patterns (e.g. vegetarian, healthy diets) or population scenarios; and

- The Metropolitan Foodscape Planner (MFP) allowing stakeholders to re-allocate up to 10 commodities on the basis of landscape-ecological principles while measuring the ecological footprint effects at the scale of 1 hectare-grids.

The tools allow stakeholders from agro-food business, governance and civil society organisations to enter a knowledge-driven debate on sustainable and innovative food chain planning and how to optimise the regional food supply of metropolitan areas around cities.

Furthermore, building upon the European Union approach towards sustainability impact assessment (CEC 2009), the project developed impact indicators around: (i) environment, (ii) economy, and (iii) society.

Examples of impact indicators in these different areas include food-miles (transport distance) environmental impact indicator, number of jobs along the food chain as an economic impact indicator, or the occurrence of pathogens along the food chain under the food safety domain. This list of food chain impact areas is one of the key outputs of the project as it fills an important gap in this emerging policy field.

The analysis undertaken in the case study city regions reveals the supplied and consumed amounts of primary agricultural products, reflecting on one hand the consumption pattern, and on the other hand the specialization of the productive system. The comparison between supply and food in a metropolitan region can contribute to rethinking agro-urban production and consumption by filling in gaps in terms of supply, or by reducing production when demand does not follow.

Foodmetres "innovation storylines", focussed on specific innovation domain(s) that are relevant to regional stakeholders (mainly entrepreneurs) for developing more sustainable food chains. Based on these storylines a 'quick-scan' procedure allows users to access a standard data set for communicating the key characteristics in a systematic way. These standard data sets allow cross-comparisons between food chains and positioning these food chains when undertaking sustainability impact and metropolitan footprint assessments. The policy analysis tool also measured the impact of European Rural Development Policies (RDP) on sustainability in the Metropolitan Agro-food System of the city regions and on the Short Food Chains Typologies (urban garden, direct sale, AgroPark, etc.).

The tool can help local administrators to adapt the RDP in order to respond to the needs of local stakeholders and (public bodies, farmers, consumers, associations, etc.). The tool also provides relevant information for European politicians about the impact of RDP on Local Short Food Chains in urban and metropolitan contexts.

Figure 11. © Ekaterina Belova

Critically the project contributed to the creation of a new local and regional planning instruments and governance models. In terms of short food chains, the research demonstrated that the new Rural Development Programme (RDP) of the Common Agricultural Policy should include new areas like metropolitan regions and new groups, not only farmers. The RDP should consider and support new food chain models, particularly short food chains, which benefit from a great interest in civil society.

Supurbfood (Towards sustainable modes of urban and peri-urban food provisioning), focusing on shortening nutrient, water and carbon cycles, organised city-region workshops to reflect on the role of institutional interaction and governance and foster the North-South Europe dialogue by sharing experiences and joint learning. Involved cities reviewed their own policies and governance and called EU, national, local governments to support independent, local specialist food retailers, SMEs and Civil Society Organisations through public procurement clauses, incubators, educational programmes, training and legal assistance, grants, connection with peers, etc.

In the case of short food chains, progress regarding efficient and sustainable biogenic waste management, as observed by the project, is hindered by regulatory constraints and difficulties in accessing finance. Laws and regulations still define some waste streams as waste in the sense of garbage to be disposed of. Ingredients that can be or have been up-scaled are not always officially recognised in their new role as valuable resources (i.e. kitchen wastes not recognised as animal feed).

This means substantial adjustments are needed in the respective regulations to enable initiatives following a blue economy. A waste targeted hierarchy, as used by the European Union Waste Directive, can give some orientation.

POCACITO (POst-CArbon CIties of TOmorrow – foresight for sustainable pathways towards liveable, affordable and prospering cities in a world context) also used a participatory approach that engaged local stakeholders through workshops in ten European cities (Barcelona, Copenhagen, Istanbul, Lisbon, Litoměřice, Milan, Turin, Rostock, Malmö and Zagreb) to create custom-made transition post-carbon strategies. These strategies were taken as the basis for an evidence-based EU 2050 Roadmap, a stakeholder-driven guide towards the model "Post-Carbon City of Tomorrow" that merges climate, energy and social urban transitions.

Figure 12. © Jenny Sturm

They were based on a preliminary assessment of each case study city using key performance indicators coupled with a quantitative analysis of the urban system and ongoing trends and changes (economic, demographic etc.). The key performance indicators aimed to evaluate the performance of cities during the transition process towards a post-carbon city, and were developed in an integrated way including social, economic and environmental dimensions. The environmental dimension covered the energy sector in general (energy efficiency but also resources depletion associated with energy consumption, including transportation/ mobility, buildings stock, biodiversity, air quality, waste and water).

Economic indicators focused on sustainable economic growth based on the wealth of the cities and their inhabitants. In this sense, factors taken into account-included labour market, life of the companies, public finances as well as the research and development expenditure as no city can become a post-carbon city without innovation. Finally, the social dimension covered standards of living related to education and health (for example, life expectancy and wellbeing), unemployment rates and poverty, public services and infrastructures, governance and civic society, culture and community.

Within participatory workshops case study cities followed five steps for developing their Post Carbon 2050 strategies: initial assessment (extensive analysis of the current situation in order to identify key challenges and opportunities); post- carbon visioning until 2050 based on facts; qualitative scenario building (how the transition to reach the respective post-carbon visions might be translated into single steps or actions; quantification and modelling process (holistic overview of the city, impact matrix, analysis of variables); roadmap building (discussed the impacts of the initial set of measures and identified additional actions necessary to close the gap towards the local 2050 post-carbon vision).

Following this process, two scenarios were developed: the Business As Usual (BAU) and the Post Carbon 2050 scenarios (PC2050). Where appropriate, the BAU considers progress made in relevant ongoing and planned projects. The PC2050 builds on the qualitative

scenarios. It is thus an interpretation and expansion of the visions, actions and milestones. As a next step, the impacts of the PC2050 scenarios are compared to the Business As Usual (BAU) outcomes across all three dimensions of Pocacito: environment, social and economic.

To evaluate the impact of these post-carbon visions Pocacito proceeded to an ex-ante assessment of the long-term impact of the post-carbon vision (PC 2050 scenario) and of the strategies being already implemented at local levels (Business as Usual scenario).

A semi-quantitative/qualitative indicator approach showed that nearly all cities will improve under Business As Usual scenarios for most indicators, but the performance is significantly improved under Post Carbon Cities 2050 scenarios. The analysis of the production based Greenhouse Gas emissions shows that most cities approach carbon neutrality under PC2050 but will not fully achieve it, with only 3 cities being below 1 tCO2eq/capita/year.

A benefit-cost analysis compared the reduced cost burden due to premature deaths from air pollution with investment costs for renewable energy and energy efficiency. It shows that under PC2050 the cost-benefits of reduced air pollution more than compensate for the investment costs. Investment costs are typically less than 1% of cumulative Gross Domestic Product from 2018 to 2050. According to Pocacito, public policies need to address not only immediate and concerted action on energy efficiency and localised renewable energy but the value of green space and the disparity between rich and poor if future cities are to be liveable, healthy and carbon neutral places. Although no direct policy implication in the cities was achieved, the project contributed to raising the attention and provided with the local roadmaps an input for future policy debates.

Pocacito findings outlined not only visions for post-carbon cities, but also created new insights concerning barriers, challenges and delivered key recommendations directed at national and European Union (EU) policymakers, as well as city-level decision makers. Pocacito promotes an approach for consulting stakeholders and advocates its widespread use, not only to develop strategies, but also to connect citizens with the future and place them clearly on the path to decarbonisation, changing them from takers of policy into shapers of the urban decision-making process.

Likewise, Pocacito findings advanced the knowledge base of policymakers, stakeholders and academics by providing a concise summary of important concepts and methodologies relevant to post-carbon transition in EU cities and by setting useful indicators to monitor progress within cities.

Similar participative or systemic approaches are also apparent in **Urban Nexus, Bridge, and SUME** supporting policy-decision making through assessment of scenarios and guidelines on urban development.

Urban Nexus (Furthering Strategic Urban Research) project's goal was to create partnerships between diverse stakeholders, combining different urban stakeholders across Europe with different geographical, cultural and professional backgrounds working on integrated urban development. The project brought together different types of actors, such as municipalities, business representatives, universities, national ministries, knowledge and lobby institutes and civil society organisations.

Over 3 years the project organised 5 international Dialogue Cafés (Bristol, Sofia, Goteborg, Barcelona and Glasgow bringing together different urban thinkers and practitioners on Urban Climate Resilience; Health and Quality of Life; Competing for Urban Land; Integrated Data and Information; and Integrated Urban Management. Conclusions and recommendations from the Dialogue Cafés were presented in the project's policy brief, and confirmed that it is absolutely necessary to have all stakeholders on board when it comes to decision making on sustainable urban development.

The project delivered key messages and recommendations related to urban climate resilience, health and quality of life, competing for urban land, integrated data and monitoring, integrated urban governance. It's findings on integrated data and monitoring

is closely related to the implementation of various EU activities and documents with relevance to the sustainable urban management, such as:

- The EU INSPIRE Directive on Infrustucture for Spatial Information in Europe;
- Directive on the re-use of public sector information (PSI Directive);
- A Digital Agenda for Europe;
- Joint Research Centre Report "Direct & Indirect Land use impacts of the EU Cohesion Policy"

It has also drawn on European Environment Agency's report on "Urban adaptation to climate change in Europe"1; the EC-funded DG CLIMA project on "Adaptation Strategies for European Cities"2; and on the European Environment Agency initiative, European Climate Adaptation Platform3 (CLIMATE-ADAPT). Furthermore, the partnership principles and main conclusions of the Urban Nexus project were taken up by JPI Urban Europe, successor projects and programmes that strive to engage society in urban research benefitting from the project's results.

Bridge (sustainaBle uRban Decision support accounting for urban mEtabolism) aimed to help policy makers take informed decisions and actions about water consumption, energy efficiency, carbon emissions and pollutants.

Bridge's contribution to these challenges was through the development of the Bridge Decision Support System (DSS) that combines Geographic Information System, local data and environmental and socio-economic indicators with the objective to assess different physical interventions proposed by cities and indicate the best in terms of multiple benefits in a specific area.

A bottom-up approach was adopted for the development of the Decision Support System indicators. The project set up a Community of Practice (CoP) in every case study city bringing together different departments of the municipality (urban planning, environmental office, and economic development office), scientists, and sometimes NGOs and local consultants. CoP aimed at making clear what aspects were important for the future users of the Bridge DSS software. CoP also collected datasets for the case studies (land use, infrastructure, socio-economic data, etc) that were integrated in the software.

The project helped policy makers take informed decisions and actions about water consumption, energy efficiency, carbon emissions and pollutants via the Bridge DSS, a prototype Geographic Information System gathering local data and environmental and socio-economic indicators with the objective to assess different physical interventions proposed by cities and indicate the best in terms of multiple benefits in a specific area.

The tool was tested in Helsinki (FI), Municipality of Egaleo (EL), Firenze (IT), London (UK), and Gliwice (PL). In addition, the project made in-situ measurements related to meteorology, fluxes of energy, CO2, aerosol particle number and concentrations of various trace gases and particles during the whole period of the project to feed in the DSS and provide more accurate assessment of the planning scenarios in each city.

Figure 13. © Renáta Sedmáková

The prototype support system was tested by key architects and Engineers in Europe and demonstrated the feasibility of assessing different planning interventions in specific areas of the cities and most importantly it contributed to sorting out the best-scored scenarios, meaning planning proposals with spin over effects for the area. However, it is up to the cities and the urban planners to choose the most appropriate scenario generated by these tools and implement it as such to contribute at local level. In this context, the support system prototype contributed to raising sustainability awareness in planning, by promoting an assessment culture in an integrated way allowing for pragmatic consideration of environmental, social and economic aspects.

SUME (Sustainable Urban Metabolism in Europe) focused on developing a spatially explicit approach to analyse the influence of urban form on urban resource use, to use it in scenario analyses, modelling, project and policy analyses, and to demonstrate how future changes in urban form could contribute to more resource-efficient European cities.

The integrated approach of the SUME project lies in the use of geographical Information systems integrating socio-economic and spatial data with the objective to propose an alternative long-term urban development perspective until 2050 in comparison to traditional urban development policies based on spatial expansion, a resource-minded development path versus a trend-type.

This integrated approach has been applied in a consistent way for seven case studies (Vienna, Stockholm, Oporto, Newcastle, Athens, Marseille and Munich), identifying land consumption and the spatial distribution of population and workplaces in 2050. The spatially explicit urban metabolism model allowed for systematic simulations of the functional relations between socio-economic development and their consequences for the urban metabolism. **SUME** assessment of two different planning approaches, demonstrated that the spatial expansion of the agglomerations analysed can be avoided to a large degree, even in dynamic and growing cities. Accommodating additional population does not have to result in huge urban sprawl: future land consumption in and around European cities could be reduced substantially.

For example, the spatial expansion of fastest growing agglomerations like Munich, Stockholm and Vienna can be greatly reduced by 2050 to 13%, 20% and 14% respectively. Similarly, the energy demand can be reduced by 60% to 80%, varying between cities and scenarios. In general, a SUME-scenario-type agglomeration development will reduce energy consumption between 10% and 40% by the year 2050 compared to the BASE scenario. A higher replacement or renovation rate of buildings and a better spatial focus of new developments with respect to public transport accessibility will reduce energy consumption by 30 to 40%. The main conclusion of the SUME was that the greatest potentials for saving energy – and the most relevant for policymakers – can be identified as the replacement of old building stock and the avoidance of urban expansion.

Both **Bridge** and **SUME** empirically confirm the importance and the benefits of an integrated approach in decision-making and in the implementation of actions taking into account social, economic and environmental perspectives at the same time. The concept of the integrated approach is not an innovation itself since it is part of the EU2020 strategy and of most EU initiatives, but the fact that the projects assess the impact of different planning proposals according to their integrated approach is the way forward. This kind of ex-ante evaluation should be part of the urban planners and local authorities' culture and way of working. Ex-ante evaluation using the BRIDGE DSS or similar tools could be part of future legislative proposals or urban programmes.

In addition, the SUME project developed 4 principles for EU, national and municipal levels, to integrate into urban policies, strategies, and plans related to Spatially-focused densification; High-density development only with high-quality public transport access; Functional mix in urban quarters; Combining urban and building (object) reconstruction. Both Bridge and SUME projects assessed the environmental and socio-economic impact of different planning scenarios in their case study cities. In addition, Bridge carried out in-situ measurements related to meteorology, fluxes of energy, CO2, aerosol particle number and concentrations of various trace gases and particles during the whole period of the project to feed in the DSS and provide more accurate assessment of the planning scenarios in each city. The main conclusion of the SUME project after comparing business as usual scenarios (BASE) with "SUME" low carbon scenarios was that that the greatest potentials for saving energy – and the most relevant for policymakers – can be identified as the replacement of old building stock and the avoidance of urban expansion.

5 Air Quality and Health Challenges

Globally, our climate is changing due to anthropogenic activity; this is already having, and will increasingly have, serious consequences for human and natural systems; urban areas are at a particularly high risk. However, urban areas are also responsible for producing more than 70 % of the greenhouse gas (GHG) emissions, which are changing the climate. Furthermore, urban road traffic alone contributes about 10% of all European carbon dioxide emissions, and at the same time is responsible for poor air equality in many European cities.

In addition to these local effects, this pollution is transported over regional scales, contributing to the pollution levels in other regions, as well as to the hemispheric background pollution. As a consequence when developing and implementing new sustainable development policies for our cities, it is vital to consider the effects on emissions of both greenhouse gases (GHG) and air pollutants. In many cases, implementing one policy strategy may reduce GHG emissions but instead increase emissions of air pollutants, bringing with them ill-effects on health and wellbeing.

Figure 14. © Sergey Nivens

5.1 Air Quality and Health Solutions

The projects featured here include **MEGAPOLI** which investigated the interactions among megacities emissions, air quality and climate, bridging spatial and temporal scales that connect local emissions, air quality and weather with global atmospheric chemistry and climate, to provide information on the effects on regional and global climate, and the feedbacks and mitigation potentials. **EURO-URHIS 2** addressing urban health analysis and specific challenges of health issues in urban areas, such as internationalisation of metropolitan regions, ageing populations, migration and poor environmental factors. **PURGE** examined the health impacts of greenhouse gas (GHG) reduction policies in urban settings in Europe, China and India, using case studies of 3-4 large urban centres and three smaller urban centres. Finally, **URGENCHE** developed and applied a methodological framework for the assessment of the overall risks and benefits of alternative greenhouse gas (GHG) emission reduction policies for health and well-being.

MEGAPOLI addressed the integrated approach dealing with air quality and its influence on climate change, pollution and health in cities (and specifically in megacities) by linking the multiple geographical scales to which the effects of air pollution and climate can be analysed.

The four most important Euroepan Megacities or conurbations (London, Paris, the Rhine-Ruhr region and the Po Valley) were researched in-depth, but also including Moscow and Istanbul as European megacities. Finally, extended simulations and satellite analysis for all the megacities in the world have been developed. The EU researchers worked with end-users (air quality monitoring facilities) and research centres from all these cities.

The research delivered integrated methodologies to assess the impacts of pollution within, and from megacities to global scales; assessed the feedbacks and interlinkages between air quality and climate change in megacities at urban, regional and global scales; delivered outputs that link city emissions and pollution with health, e.g. calculating the impact of pollution on DALY (disability adjusted life years).

The project also produced information on long-range transport and regional pollution, baseline scenarios and measures for improving air quality and climate change impacts in megacities; developed improved current and future emission estimates for natural and anthropogenic sources of air pollutants and analysed policy options to reduce megacity emissions.

Different results of MEGAPOLI have been incorporated in the air quality monitoring and emission reduction strategies of megacities in China, Mexico, several African cities (e.g., Accra, Cairo). At the European level, they influenced the EC Air Quality Policy (Air Quality Directive (2008/50/EC) and the National Emission Ceilings (NEC). The results have also been used for urban planning by the World Meteorological Organization, the World Bank and the OECD.

MEGAPOLI collaborated with the World Meteorological Organization and with end-users such as air quality monitoring facilities in various countries e.g. France, UK, Italy, Germany, Mexico, India, etc., environmental agencies and regional meteorological centres in China, Russia, USA, etc and attracted research centres and end-users from all over the world. In addition, companies and facilities specialised in aerospace monitoring and satellite technologies contributed to develop outputs and solutions.

The problems of all the megacities were analysed and the validity of the tools and methods validated at broader levels. The project also provided open datasets of health indicators that can be used by any interested stakeholder. The projects' results are widely regarded as inspirational and are used by the World Meteorological Organization, and the methods and tools produced have been transferred to other countries and cities in Africa, Asia and Latin America. The new concept of Integrated Urban Hydrometeorology, Climate and Environment Services, as an urban cross-cutting issue integrating these issues in city services has also been adopted by the World Meteorological Organization.

The European and Megacity Emissions Baseline Scenarios for 2020, 2030 and 2050 are being used by National and local governments, air quality monitoring facilities and the

European Environmental Agency. The results have been considered by the EC Air Quality Policy (Air Quality Directive 2008/50/EC) and the National Emission Ceilings (NEC) defined in the NEC directive (2001/81/EC)) and the EC Air Policy Review.

The Global Emission Inventory is of great interest for the World Meteorological Organization, the World Bank, UNEP and the World Health Organization. Furthermore, the project researchers have actively participated in international initiatives such as UNFCCC and the Paris COP-21 Agreement on Climate Change, the Habitat III New Urban Agenda and the IPCC.

Finally, several MEGAPOLI tools to monitor air quality are being used by many Chinese megacities, supported by the EU-China project MARCO POLO. At regional/megacity levels, the Exposure Maps for Greater London and Po Valley, and the impact assessment of mitigation and policy options are used for decision making by air quality monitoring facilities including Greater London Authority, AIRPARIFF and ARIANET.

EURO-URHIS 2 addressing urban health analysis and specific challenges of health issues in urban areas, such as internationalisation of metropolitan regions, ageing populations, migration and poor environmental factors. These factors are not captured by national datasets and normally are poorly investigated. The research developed methodologies and validated tools to collect comparable and reliable data in different countries on a wide range of determinants of health, specific to urban populations and provided evidence based information useful to policy makers at all levels to improve urban health conditions.

It harmonized indicators and methods; developed different cross-sectional surveys focusing on cross-thematic approaches e.g. environmental conditions, food and bioinformatics and displayed differentiated results for young and adults; built capacities in the health systems of Eastern countries; established benchmarking standards and analysed future trend in the status of urban health and in the costs associated to urban health services.

EURO-URHIS 2 worked in close collaboration with end-users (local and regional public health providers and urban planners) to foster the systemic approach. They worked in close collaboration with urban health systems to deliver outputs adapted to their needs, to do an integrated analysis of the problems and risk management options, and to propose adapted solutions. The results raised awareness about the higher health burden the cities will face in the future due to longer life expectancy, but with less healthy life years.

The project also worked with the World Health Organization, the city health planners and policymakers, and the national health services, as well as involved citizens e.g making surveys on the health status of schools, and supporting the school boards in developing strategies to address the problems identified.

Additionally, urban and national health services were mobilised from many different countries, to build capacities and raise awareness on the relevance of data collection with validated and comparable methods and the importance of benchmarking and learning from others.

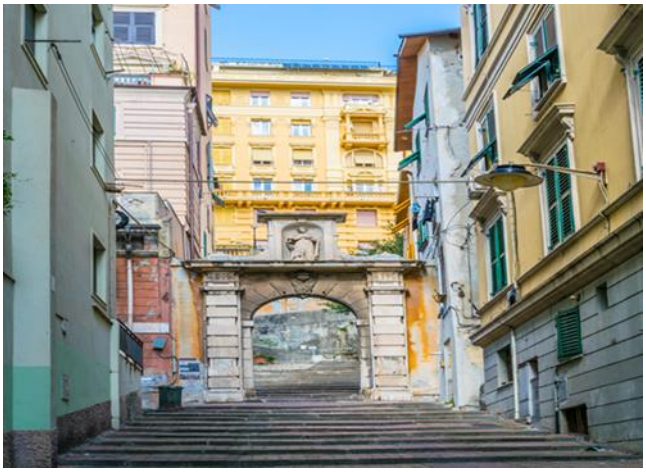

Figure 15. © dudlajzov

EURO URHIS 2 had important effects at policy level. The partner cities used the health indicators and the Health City profiles to adjust their health decisions. A network of urban health professionals was created to help with policy development and capacity building and benchmarking are now important issues in the urban policy agendas. At the European level, the European Public Health Association adopted the Urban Health Assessment method, and created an Urban Health Section, currently around 1500 members, that actively participates in research activity. At international level, the project contributed to the World Health Organisation (WHO) Healthy Cities programme.

The project delivered a harmonisation of urban health data methods and now over 15 countries have developed a common system for data collection and validation.

Furthermore, the instruments are available in all the local languages, and the system has been adapted to non-EU countries such as Vietnam, China, Kuwait and now is being validated for Nepal. Methods and instruments have been designed to be replicable and can be applied to any city in Europe and beyond.

Accordingly, Health Profiles have been developed for 26 European and non-European cities, providing policymakers with intersectoral analysis and comparable information on the health status of each city and delivering information on future trends that affect the future health burden.

A key success factor for EURO URHIS 2 was to include a strategic global partner, the World Health Organization, but the key point was to demonstrate to urban planners from very different European countries the importance of data collection at the urban level and the need to use validated, robust and comparable methodologies.

The main problems faced included the problems in harmonising data from different countries. They solved through thoroughly discussions to identify data available in the different countries that was relevant to analyse the health indicators and by delivering of common methods, indicator list and data validation instruments to be used.

Additionally, they found an important East/West divide in data availability and validity that they tried to solve creating capacities in Eastern countries. This project likewise faced important problems linked to the ethical approval requirements on sensitive individual health data that prevent the diffusion of particular results.

PURGE examined the health impacts of greenhouse gas (GHG) reduction policies in urban settings in Europe, China and India, using case studies of 3-4 large urban centres and three smaller urban centres.

Sets of realistic interventions were proposed, tailored to local needs, to meet published abatement goals for GHG Emissions for 2020, 2030 and 2050. Mitigation actions were defined in four main sectors: power generation/industry, household energy, transport,

food, and agriculture. The chief pathways by which such measures influence health were described, and models developed to quantify changes in health-related 'exposures' and health behaviours. Models included ones relating to outdoor air pollution, indoor air quality and temperature, physical activity, dietary intake, road injury risks and selected other exposures.

The project examined suites of policies options for achievement of the necessary GHG reduction strategies for urban populations as a whole. The assessments were focused on combinations of measures that together can achieve the required abatement trajectory overall. Accordingly, from an integration perspective assessment of the effects of different policy elements took account of the changes of other policy elements. This issue, and other joint effects of different sectoral policies where addressed through iterative cycles of model integration, which consider integration both with respect to exposures and also with respect to health impacts.

These integrated policy solutions for health (sometimes referred to as health 'co-benefits' if positive) arise from reduction of exposures to environmental pollutants (such as air pollution) and from the promotion of health-related behaviours (healthy diets, walking and cycling). They are additional to any impacts on health arising from the mitigation of climate change.

They are important because they can provide an additional rationale to pursue mitigation strategies, and demonstrate opportunities by which population health may be improved while pursuing environmental objectives.

PURGE innovations in terms of tools concerned the development and implementation of integrated quantitative models of health impacts associated with various policy choices. In addition, the project developed and applied Multi-Criteria Decision Analysis (MCDA) frameworks to compare different mitigation options. The focus being the process to examine uncertainty in the evidence and potential bearing on policy recommendations. The project sought and found evidence that measures to support the transition to a low carbon economy have the potential for securing appreciable benefits for population health. In particular, the primary message for policy is that there are important opportunities for health in almost all strategies aimed at reducing the emissions of GHG in urban environments. This observation provides added impetus for the acceleration of policies to reduce GHG emissions, and the creation of health co-benefits. The project thereby makes substantial contribution to the development and implementation of local, regional and high-level policy objectives supporting the evolution of the governance model. Moreover modelling of the health consequences of different greenhouse gas reduction strategies, and MCDA to assess the positive and negative impacts on health of policy actions, ensure policies maximise the opportunities for promoting health whilst minimising the adverse risks of unintended consequences.

PURGE developed evidence on the health impacts of greenhouse gas reduction strategies in transport, electricity generation, housing and food and agriculture in urban environments of Europe and Asia. Its findings:

- Extend the existing evidence on the health impacts associated with GHG reduction strategies. To date, health impacts have received comparatively limited attention in debates about the cost- benefit of 'decarbonization' by comparison with, say, economic considerations. For many mitigation strategies, the net consequences for health are positive, and so add to the rationale for an accelerated transition to low carbon (low GHG) economies, perhaps by helping to offset some of the perceived economic costs.

- Provide evidence on the types of GHG reduction strategy within each sector that are likely to have the greatest health dividend.

- Yield more detailed evidence on both the positive and negative consequences for health of such strategies, so that policies and regulation may be better tailored to ensure opportunities for promoting health are maximized and protective steps can be taken to avoid unintended adverse effects for health.

The project sought and found evidence that measures to support the transition to a low carbon economy have the potential for appreciable benefits to population health particularly in urban environments – an observation that gives added impetus to the acceleration of policies to reduce greenhouse gas emissions. The opportunities and optimal solutions for interventions in different sectors vary from setting to setting. In general, the potential co-benefits for health of GHG reduction policies are greater in India and China than for European populations largely because of the greater exposure to air pollutants.

According to the project analysis, European populations have diets, which are both less healthy and carry relatively high CO2e emissions, and there appears to be greater scope for environment and health gains from relatively modest adjustment to current dietary patterns. European populations are also relatively physically inactive, and sustainable transport policies, which promote active travel, may entail correspondingly large benefits for public health. Action in both Europe and Asia will be vital to meet GHG abatement targets to limit the risk of disruptive climate change. The use of tools to assess the positive and negative impacts on health of such actions could help ensure policies maximize the opportunities for promoting health while minimizing the risk of adverse unintended consequences.

URGENCHE scientists in the areas of health risk assessment, urban energy demand and supply scenarios, urban planning, environmental science and epidemiology - in close collaboration with city partners in both Europe and China considered how GHG reduction policies may affect public health in various ways, such as the choices made regarding the selection of fuels and means for space heating and transport, building codes to improve thermal efficiency, or urban development and zoning.

A methodological framework was developed and applied that considered GHG emission reductions of energy demand and supply and transport scenarios in urban areas, the effect of these policies, and subsequently the impacts on human health and well-being.

Figure 16. © stbaus7

The project delivered a validated, methodological framework to assess urban GHG policies with the greatest co-benefits for health and well-being in cities ranging in population from 50,000 to 10 million, across various climatological conditions and differences in socio-economic background.

The scope of the project was the public health and well-being impact of urban scale implementation of GHG-mitigation policies. The spatial scale of the project an urban area - a conurbation. For electrical power demand exceeding the power generated and supplied from within the metropolitan area, the scale was national electric power generation. The temporal scale was 10 years from 2010, to allow comparison to the EU and Kyoto-Copenhagen targets while also enabling realistic assessment of longer-term policies.

The methodological project objective was to develop a modelling platform and a related database for urban impact assessment. The platform had to be robust, easily transportable to new cities and usable for draft or detailed assessment depending on the availability of

data. The topics covered were urban energy generation and use, with GHG and other pollution release; urban spatial data including the urban spatial plan, building stock, transportation and population; socio-economic, demographic, exposure, health and well-being of the population.

URGENCHE outcomes from most policy scenarios showed marginal additional health benefits, with an example of a potential 1.5 million euros saved from total costs of 33 million per year caused by PM2.5 exposure in one EU city contemplating moves to biomass in combined heat and power, bio-fuels in transport and improvements to buildings insulation. Well-being effects of the policy scenarios were found to be positive but were generally expressed less strongly than health benefits.

In China, the impact of all scenarios on air quality was found to be negligible compared to that of ongoing economic development. However, as an example of other work carried out there, a Chinese survey on well-being indicated the importance given by local people to health, social life and safety, with implications noted for policy development for healthcare and communities.

The mobility policy implications of the case studies in the European and Chinese cities on air quality and noise are as follows: More stringent CO2 emission standards (zero-emission) for road traffic is the most effective measure to reduce CO2 emissions from urban road traffic.

This requires action at the level of the European Union and the central Chinese Government, and is beyond the control of local authorities; Support, facilitation and stimulation of physical (cycling, walking) and public transport provide the most effective local policies to reduce CO2 emissions and improve air quality, health and well-being.

These measures and local transport policies are within the control of local authorities.

URGENCHE impacts for exposure, health and well-being include:

- Sharing methodologies and international expertise to local policy decision-making processes.
- Building a broader community and debate for impact assessment of local policy interventions and indicating new directions on the assessment of the studied policies and on work being done by others, for example on wellbeing.
- Focusing on interventions that deliver the largest public health benefit and specifying interventions that could target large disparities among subpopulations.
- Identifying problems that are not acted upon and fostering knowledge transfer activities to engage the public and stakeholders and extending impact assessment methods from quantitative health assessments to qualitative well-being assessments.
- Being aware of the difficulty in measuring the impact of the work through its direct social benefits.

6 Mobility

6.1 Mobility Challenges

In many urban areas, increasing demand for urban mobility has created unsustainable urban patterns such as severe congestion, poor use of urban space, poor air quality, noise emissions and high levels of CO2 emissions from transport which are not only ruining the climate but also the citizens' quality of life.

Urban congestion also jeopardises EU objectives to achieve competitive and resource-efficient transport systems. European urban areas today face the dual challenge of providing the transport infrastructrure and services necessary to stimulate the growth needed to provide jobs and well-being for its inhabitants, while also ensuring that the quality of this growth leads to a sustainable future with less pollution and congestion, social inclusion, health and well-being.

By 2030, 60% of world population will live in cities; existing infrastructues will be inneficient and the congestion unbearable. People will die due to air pollution (WHO 2014: 7 million). Integrated and innovative solutions that combine technological, digital, business, governance, social, cultural and nature-based innovations are needed to foster sustainable environments in our cities (e.g. multimodal services and sharing transportation). Stakeholders' awareness should be promoted, so that they can design, develop and implement the appropriate interventions

The European Commission has actively promoted the concept of sustainable urban mobility planning for several years, notably though the development and implementation of Sustainable Urban Mobility Plans (SUMP) by local authorities. SUMP at the functional urban area level are applied across different levels of government and administration including rural and peri-urban areas, and across different policy areas and sectors (transport, land-use and spatial planning, environment, economic development, social policy, health, road safety, etc.) (Source: "Together towards competitive and resource-efficient urban mobility", COM(2013) 913 final).

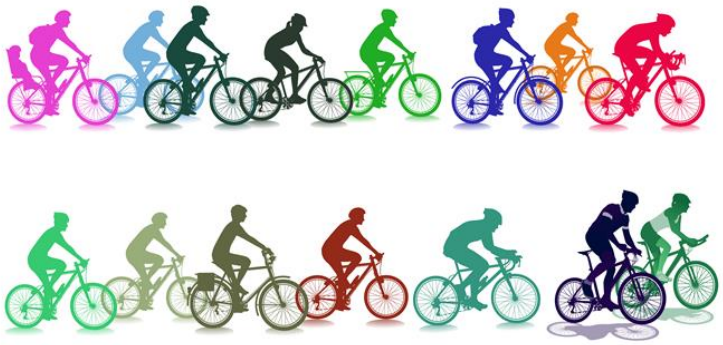

Figure 17. © scusi

The urban mobility projects under review tried to tackle the societal challenges of air pollution and quality of life by stimulating healthier lifestyles (promotion of cycling, jogging and walking), improving the environmental conditions (promotion of cleaner and more efficient alternatives of transportation), reducing congestion (reduction of the number of private vehicles), improving transportation security (improvement of infrastructures and introduction of new technologies), and increasing social inclusion (extension of Public Transport services to remote areas and improving first-mile/last-mile connectivity).

Cooperation between the different stakeholders was at the core of all the reviewed projects. While Universities mainly contributed with R&D, and SMEs and Industrial companies focused mostly on the development and implementation of the solutions, city Municipalities took the critical role of obtaining authorisations to perform real-life demonstrations and contributed to the dissemination of the results to citizens.

In order to ensure the replicability of the projects' outcomes, demonstration measures took place in cities with very different political, legal, social, cultural and climatic characteristics. Those differences helped to create a mobility innovation ecosystem, as each city looked to the same problem from a different point of view.

The reviewed projects contributed to (i) reduce air pollution and improve quality of life by stimulating new behaviors and healthier lifestyles as cycling, jogging and walking; (ii)

improve the environmental conditions, by proposing cleaner and more efficient transportation; (iii) reduce traffic congestion, by lowering the number of private vehicles; (iv) improve transportation through better infrastructures and new technologies; (v) foster social inclusion, by extending the public transportation to remote areas and improve connectivity.

The projects also contributed towards the New Urban Agenda, which was part of the Habitat III policy process. The Action Platform: Urban Electric Mobility Initiative (UEMI) was initiated by UN-Habitat and was launched at the UN Climate Summit in September 2014.

Moreover, all the above EU funded urban mobility projects promoted the concept of Smart and Sustainable cities encouraging green urban mobility solutions, which were considered as best practices. These solutions facilitated the dialogue between stakeholders and provided tailored guidance to city officials. The involvement of citizens in the project was mainly during the dissemination phases of the projects (i.e. co-implementation) and mostly as end users for the up-take of proposed solutions and tools.

The need to involve the users and concerned stakeholders since the start of the project to co-design, co-develop and co-deploy the proposed solutions was highlighted in all mobility projects. New local urban planning instruments and policy tools were applied by developing a methodology for the certification of fully automated road transport systems, which formed the basis of the legal framework proposal submitted to the European Commission.

All the above projects were multidisciplinary and this resulted in a high degree of synergies:

- Balance between the technical skills of partners to develop the project outcomes and the ability of municipalities and local policy makers to ensure places for the real-life demonstrations. The cities invested significant time in identifying the areas where they expected to give and receive expertise producing interesting results that allowed the determination of possibilities of cooperation that went well beyond the simple share of information to the point that they led to the actual joint development of projects.

- Combination and interaction of different disciplines, previous experiences in related research projects and complementary skills can help to perform the technical multi-tasking needed to achieve the objectives. Besides, a balanced geographical distribution, guarantee that the outcomes could be replicated at European scale

- External advisory members of the consortium helped to perform a proper development and a dissemination plan, as well as to guarantee that the projects results can be spread all over the EU. A holistic, integrated and systemic approach was employed. While the EU funded project **CityMobil2** tackled the thematic area of Automated Road Transportation Systems (ARTS), the EU funded project **CiViTAS MIMOSA** focused on thematic areas such as Alternative Fuels and Cleaning Vehicles, Collective passenger transport, Mobility management, Regulatory measures for road space optimization, Safety and security and Less Car Dependent Life Styles.

The EU funded project **SOLUTIONS** (Support coordinated Action) designed and implemented a methodology which provides guidance on how to transfer sustainable mobility solutions between cities. This innovative methodology helped to foster the adoption of innovative transport solutions by cities in Asia, Latin America and Mediterranean.

The project provided guidelines for policy development based on the exchange of knowledge and advice between city planners. Furthermore, the introduction of innovative technologies in these cities can motivate entrepreneurs and scientists to eplore these innovations and further adapt them to particularities in their countries. The transfer of these new technologies can be important to promote the competitiveness of the companies in the cities that share the innovations (i.e., leading cities), as it can provide critical financial resources for those companies. The implementation of these measures can bring awareness among policy makers towards the needs of being innovative regarding urban mobility, which can result in policies more friendly to this kind of novel solutions.

SOLUTIONS also contributed actively towards the New Urban Agenda, which was a part of the Habitat III policy process. The Action Platform: Urban Electric Mobility Initiative (UEMI) was initiated by UN-Habitat and was launched at the UN Climate Summit in September 2014.

The direct outcomes of the project (i.e. studies, guidelines and recommendations) were up-taken by cities and the results of such up-take (e.g. establishment of twining cities and the new SUMP in Belo-Horizonte, Brazil) lasted beyond the life-time of the project.

Overall, the implementation of these measures raised awareness among policy makers on the need for the development of innovative solutions on urban mobility.

In particular, during the project, the participating cities organised themselves in pairs of twin cities (one lead city for each take-up city). The dynamic that resulted from the creation of the twining cities mechanism facilitated the dialogue and exchange of information and allowed leading cities to promote successful policies and provide guidance and tailored advice to the officials of the take-up cities. A set of recommendations on cooperation between the EU and China and between EU and other Mediterranean countries was also developed.

As a direct result of the transferability methodology, the city of Belo Horizonte, in Brazil, has implemented an innovative Sustainable Urban Mobility Plan (SUMP), which includes comprehensive measures such as a NMT infrastructure – Zone 30 (30km/h zone) in cooperation with the twin city of Bremen in Germany; a Bus Rapid Transit (BRT) system and a cycling lane. A last-mile connectivity development in the Vytilla Mobility Hub (Kochi, India) that connects the metro corridor with a water transport network was created based on exchange and cooperation with the twin city of Hangzhou, in China.

Figure 18. © Laiotz

The replicability of the projects' outcomes was ensured through demonstration measures, which took place in cities with very different political, legal, social, cultural and climatic characteristics. These differences helped to create a mobility innovation ecosystem, as each city looked to the same problem from a different point of view.

Moreover, citizens played a key role in the project and especially in the implementation phase, since it was acknowledged that their behaviour towards mobility in a large extent dictates the success or failure of the initiatives.

CityMobil2 project developed and successfully inmeplemented the Automated Road Transportation System (ARTS). In particular, the project provided the following successful solutions:

a) CityMobil2 for Automated Road Transportation Systems (ARTS) provided the evidence base knowledge and tools to city municipalities and decision makers:

The ARTS demonstrations in Oristano (Italy), Vantaa (Finland), Sophia Antipolis (France), San Sebastian (Spain), Lausanne (Switzerland), La Rochelle (France) and Trikala (Greece), revealed the positive impacts of the implementation of ARTS: improved accessibility, social inclusion, traffic, comfort, safety, reduction of fares / parking fees and air quality (there will be less cars circulating and the ARTS is energetically more efficient than the current public transportation system. A safety and legal certification scheme for ARTS was also developed, as well as guidelines regarding how to integrate ARTS in cities (see question 6).

62199 rides were registered during the. Around 80% of the riders would have liked the temporary demonstrations to remain open and more than 70% wanted these systems to be extended all over the city. The demonstrations in La Rochelle, Vantaa and Trikala can be considered best practice examples of the deployment of ARTS due to the high number of passengers that tried the service.

b) CityMobil2 supported cities involved to become actors of open innovation.

The reviewed projected contributed to policy advancements by developing a methodology for the certification of fully automated road transport systems that forms the basis of the legal framework proposal submitted to the European Commission. Such proposal can be catalyst for innovation in the sector.

Furthermore, the review project predicted positive environmental, urban and socio-economic impacts of ARTS and evaluated its implementation costs. Policy makers can be motivated by the information provided to work towards the dissemination of ARTS.

The demonstration of ARTS in several cities also gave manufacturers the opportunity to thoroughly test their technologies and demonstrate the technical feasibility of automated last-mile transportation. It also increased awareness of citizens regarding these new transportation systems, which can promote the up-take of autonomous road vehicles by the market.

Despite the interest of habitants and municipalities in ARTS (the project provided evidence regarding the positive impacts of ARTS in economy, transportation, environment and social inclusion), once the project ended the demonstrations of ARTS were stopped.

c) CityMobil2 faced the following barriers of acceptance of innovative solutions and suggested the following mitigation measures:

- Initially there were problems in the acceptance of ARTS system. The suggested measures are to involve more citizens in the co-desifn, co-creation and co-deployment of ARTS and encourage dissemination to end-users.

- There was a lack of legal framework to conduct the demonstrations in proposed cities. For this reason, Municipalities had the responsibility of obtaining and finally obtained legal authorisations to perform the demonstrations.

d) **CityMobil2** created new local urban planning instruments:

The legal framework for the development of automated mobility in Europe is currently extremely fragmented or completely absent and makes it impossible, or incredibly unprofitable, for any economic operator to develop, produce or market automated vehicles in the European Union.

The review projects proposed two separate EC Directives: one to regulate the technical procedure for certification of Automated Road Transportation Systems (infrastructure, such as the different lanes, vehicles and all subsystems) and one to regulate the civil liability of Automated Road Transportation Systems' manufacturers, operators, and manually driven vehicles using the Automated Road Transportation Systems dedicated lanes.

Regarding the technical procedure, the legal framework proposed was to divide the road infrastructure in two independent (but connected) infrastructures. Automated Road

Transportation Systems can access dedicated/segregated lanes, which may intersect with lanes for manually driven vehicles (always with traffic lights and road-side sensors that control respect of lights), but it cannot access shared lanes (i.e. normal lanes).

In order to certify Automated Road Transportation Systems for legal and safety in EU, 9 technical steps were proposed to ensure that the vehicles are designed according to common specifications and tested for all safety situations:

1. The involved authorities must agree that the proposed procedure is acceptable to issue a certification for the described project.

2. Procedure foresees the compilation of a preliminary hazard list and makes proposals of mitigation measures, changing the project description until it is agreed that risks are mitigated and the final description approved.

3. Automated Road Transportation Systems need to be designed according to the specificities of the site and the agreed mitigation measures (e.g. changing the vehicle and sensor design could affect the mitigation measures).

4. The system engineering needs to pass a FMECA (Failure Mode, Effects, and Criticality Analysis)

5. The functional safety outcome of the FMECA must be ensured to work.

6. The system must reach the same safety in any operational conditions (e.g. weather conditions, as well as hours of operation and lighting conditions).

7. Manuals for the operators, their training program, the maintenance schedule and all the other conditions which might affect in time the effectiveness of the system safety need to be considered as well as emergency procedures in case of failure.

8. Define the operational safety cases on the basis of the approved procedures and devise tests.

9. Finally, last tests (dry runs) must be performed before the final approval to public opening.

Regarding the liability of the framework, Member States want to retain the framework for liability at national level.

The EU funded project **CiViTAS MIMOSA** helped shape a new mentality, promoting conscientious rewarding behaviors with citizen communication providing a key pillar of the strategy and contributing to improved mobility and quality of life in cities The project outcomes clearly linked radical change in urban mobility to the ability to convey the right message. Furthermore, it was demonstrated that citizens' behavioral change creates new markets for innovative urban mobility solutions, and fosters Research and Inovation (R&I) efforts in the sector. The inclusion of transportation industries in the innovative design, development and deployment process throughout the project contributed to the development of new ideas, new products and a stronger drive to replicate the most effective solutions in other markets. New ideas arose as key messages were disseminated and workshop/ training promoted.

The engagement and commitment of the local administrators and municipalities from the beginning of the project, in addition to the recognition and comprehension of the real benefits of the initiatives, were key to changing the mentality of policy makers towards more innovation-friendly legislation and policies for urban mobility.

The EU funded project CiViTAS MIMOSA developed a number of innovative transport solutions and provided the evidence base knowledge and tools to city municipalities and decision makers

a) **CiViTAS MIMOSA**: Alternative Fuels and Cleaning Vehicles

- A green tariff implemented in Funchal (Portugal) for owners of electric/hybrid vehicles i.e. 50% discount in parking meters) was used over 800 times. The dissemination campaigns of electric/hybrid vehicles resulted in a purchase increase of 650%. The increase of Accessibility of remote areas with mini-buses in Funchal resulted in a reduction of 1,2% of average fuel consumption of the overall fleet, 14% of CO2, 12% of PM10 and 22% - 26,3% of NOx. The number of urban buses able to transport wheelchairs has risen by 20%.

b) for Collective Passenger Transport:

- An increase of 44% in the offer of Park & Ride (P&R) parking spaces in Bologna (Italy) resulted in more 30% of occupancy rate. P&R with PT School Service in Funchal resulted in almost 6.000 new PT passengers, while In Tallinn the promotion of P&R resulted in more 9.1% of occupancy rate.

- Integrated PT Fare System in Bologna, ticketing on board and a recharging system for season tickets on contactless smart cards encourages the use of public transport (from Aug 2011 to Sep 2012, more than 5600 season tickets were renewed through ATMs).

- A new Online Ticketing System in Tallinn was well accepted by users, which is expected to increase the number of users of PT. The Green PT Line in Funchal, that provides high frequency Euro V buses in touristic areas, resulted in a reduction of pollutant levels of 13% (CO2eq) to 43% (PM10).

Figure 19. © kinwun

- The Control System for Dial and Ride Service in Funchal (a mini bus service based on a PT on-demand service in which citizens book their trips in advance) was used by a total of 1384 passengers, with an average of 1.5 passengers/ trip, between Oct 2011 and May 2012. Public Urban Transport Planning Centre implemented in Funchal managed information that was immediately available when planning or operational decisions needed to be made. The informatics system to manage complaints has reduced the response time to less than 1 month.

c) Regulatory Measures for road space optimization

- New regulation in Bologna regarding Limited Traffic Zones and access to semi-pedestrian areas, as well as the improvement of parking meters, lead to a 20% reduction of daily access to the city centre and a 42% reduction of vehicles entering semi-pedestrian areas. Limited Traffic Zone in Funchal achieved a traffic reduction of 56% of car entries in the city centre.

d) Mobility Management

- New parking rates and ticket machines improved parking management in the city of Utrecht.

- Policy planning and co-operation in Bologna lead to an increase in interactions with citizens (up to 3 000 participants in each European Mobility week).

- The implementation of a Mobility Management Office to elaborate the municipal mobility plan and to support companies in their mobility management resulted in an increase of

50% of Mobility Management agreements (7.603 units were sold in 2007 vs. 11,413 in 2011). As a result, emissions were reduced by 35% compared to 2008 (average value of all pollutant types), with 5 tons CO2 per year saved.

- The improvement of eco-driving habits in Funchal resulted in fuel savings (31.4% in 2010 and 31% in 2011) and less CO2 emissions (46.8% in 2010- 43.1% in 2011).

- Marketing activities in Gdansk between 2010 and 2012 resulted in an increase of 9% of bike regular use. Marketing activities in Tallinn resulted in a decrease of 1.5% in the share of personal car use.

- As a result of the Walking Bus initiative in Gdansk (a group of children walk to school escorted by one parent), there were around 20% less school-home trips by cars. A similar initiative in Bologna called Pedi-Bus achieved a participation of +20% of the students enrolled in 8 elementary schools.

- In Utrecht, 715 companies participated in the 'Utrecht Bereikbaar-pass (a free transportation pass for employees), with a total number of 19,120UB passes sold.

- Due to the hinder planning and communication in Utrecht, the traffic in peak hours on main roads increased by less 4% than what it had been previously expected.

- By distributing between rewards to car drivers that avoided the rush hour in Utrecht, the traffic level was reduced between 500 and 700 cars during the morning rush hours.

e) Safety and Security

- After participating in exercises on Road Control Due to their, more 19% students than before stated that they would not drive after drinking alcohol.

- The Urban Traffic Safety Plan for Bologna resulted in a 46% reduction of accidents at traffic islands crossings without traffic lights and a 34% reduction with traffic lights. A bundled indicator (including accidents, people injured and killed all over Bologna territory), show a reduction of 21.1% accidents in 2010 against 2007 and 21.6% fewer people injured over the same period.

- Measures to improve road Infrastructures, as well as a communication strategy to raise road safety awareness, resulted in a higher level of road safety for pedestrians and cyclists in Gdansk, especially along the coastal strip. Furthermore, an increase of 7% of cyclists driving along the strip was registered between 2010 and 2011. Another positive result was the raise of 8% of citizens practicing jogging several times a week along the strip between 2010 and 2012.

- Bus and tram drivers in Gdansk were taught to deal with vandalism and offenders, resulting in a 20% decrease of acts of vandalism and 25% increase in the perceived sense of security of PT users.

f) Less Car Dependent Life Styles

- In Bologna, a by-law on car sharing parking areas facilities lead to an increase in car sharing that resulted in a reduction of traffic, fuel consumption and emissions.

- The deployment in Bologna of four pilots of Mobimart, a reward mechanism tailored to the needs of the citizens of Bologna that converts desirable travel behavior into benefits such as free bus tickets or a free parking, were successful in terms of CO_2 savings and citizen participation.

- In Funchal, the buses equipped with Trafilog software to track down individual performances of drivers contributed to a decrease of the emission levels of CO2 equivalent by 2%. In Tallinn, because of the eco driving training, the fuel consumption was reduced by 3.9%. The driving style index was improved by 7.3% and the bus drivers' awareness on the environment by 29%.

- Funchal focus in a less vehicles dependent lifestyle resulted in an increase of 0.7 % in bike usage.
- The promotional measures "New Cycles" in Gdansk resulted in an increase of bike use for others than leisure.
- The development and dissemination of a successful consumer platform for car sharing in Utrecht.
- The improvement of parking facilities for bikes in Utrecht lead to an increase of 4% of residents cycling to city centre.

g) Urban freight logistics

- The Bologna´s City Freight Delivery Plan resulted in 123 journeys carried out through the Van Sharing system, covering 6 300 Km in a specific area of the 'Limited Traffic Zone' LTZ.
- Marking routes for better freight logistics in Tallinn was considered useful by 33% of truck drivers.
- Utrecht's City Distribution by electric Boat (Beer Boat), which supplied more than 60 catering businesses, resulted in a decrease of 13% of CO2, 6% of NOx and 10% of PM10.
- A Flexible access for cleaner freight traffic (e.g. Cargohopper) in the centre of Ultrecht resulted in a decrease of 4080 trips, which corresponds to less 88332 kilometres driven by diesel van or light truck and a reduction of 73% o CO2 , 27% NOx and 56% o PM10 emissions.

h) Transport telematics

- In Bologna, the introduction of SCOUT, an illegal street parking measure based on cameras that support municipal police officers, lead to a reduction of 53% of fines issued from 2008 to 2011.
- Cisium New Traffic Control Centre in Bologna resulted in a decrease of waiting times at traffic lights that improved the flow fluidity at intersections.
- The implementation of Stars in Bologna, an automatic enforcement system, resulted in a reduction of 21% of the accidents and 28% injuries at all crossings.
- The Urban Mobility Control and Monitoring Centre in Funchal was considered as a good contribution to the knowledge of the mobility dynamics and to support decision policy.
- Traffic Monitoring in Tallinn resulted in a decrease of 9.5 times of Red light infringements. PT lane infringements decreased 4.4 times and only 0.3% of drivers passing the two cross-sections were exceeding the speed limit.
- In Tallinn, the implementation of electronic real time PT information reached 37% of awareness and about 8% of improvement in comfort of PT usage.

SOLUTIONS Transferability conclusions for cooperation between EU and Mediterranean countries:

- Providing training to transport professionals and policy makers on ITS and their applications.
- Raising awareness regarding ITS applications and disseminating best practices in order to increase acceptance of these technologies among policy makers and the general public.

- Use of social media to collect traffic data and disseminate traveller information.
- Use of ITS to improve public transport services such as in vehicle monitoring systems, fleet management, traveller information services, smart ticketing and bus signal priorities.
- Support from EU in the preparation of a SUMP through the creation of exchange networks and workshops in order to foster the sharing of guidelines, knowledge and best practices.

Figure 20. © lcrribeiro33@gmail

- International knowledge exchange on innovative financing solution and cooperation of funding institutions and vehicle manufactures to provide attractive financing models.
- Sharing cost-effective non-motorized-modes infrastructure solutions and promote dialogue on the technical/economic feasibility of those infrastructure solutions to increase its introduction.
- Sharing international experience with integrated ticketing and revenue sharing.

Conclusions for Cooperation between EU and China:

- Exploit together the potential of current technologies, including alternative fuels (wheel-to-well emissions should be taken into account), expand vehicle electrification and develop common standards for batteries and charging infrastructure.
- RUC/traffic management system should be introduced as part of a comprehensive system, including improving other modes' attractiveness.
- Examine both the success and the failure of BRTs to understand BRTs' transferability. Exchange knowledge on technology and policy issues and operational and funding structures.
- Share of EU knowledge of interchange design and dialogue on the technical and economic feasibility and the specifications of the enabling policy and funding environment to increase the introduction of non-motorised transport infrastructure and services.
- Knowledge exchange on Sustainable Urban Mobility Plans, including local capacity building.
- Exchange between Europe and the target regions on Bus Rapid Transit (BRT) systems technology and policy issues, as well as on operational and funding structures.

7 Energy Transition including Energy Efficient Buildings

7.1 Energy Challenges

"Energy efficiency first" is a key element of the Energy transition of the "Energy Union", which aims to make energy more secure, affordable and sustainable for every European citizen. One of the best ways to improve energy efficiency is to tap the huge potential for

efficiency gains in the building sector, which is the largest single energy consumer in Europe, consuming 40% of final energy.

The European Union aims to promote energy efficiency in buildings and to support cost-effective building renovation with a view to the long-term goal of decarbonising the highly inefficient existing European building stock. This will also be a major contribution to reaching the EU's 2020 and 2030 energy efficiency targets. In this respect the 'Energy Performance of Buildings Directive' (EPBD) revised in 2010 required all EU member states to enhance their building regulations (new buildings have to be nearly zero energy by 2021), and inform consumers on the energy performance of buildings through a certification system.

The 2002 'Energy Performance of Buildings Directive' (EPBD) required all EU countries to enhance their building regulations and to introduce energy certification schemes for buildings (nearly zero energy by 2021). This enhancement is critical because by 2050 half of the buildings operational in 2012 will be still under use.

The EU funded projects under review mainly addressed the EU Urban Agenda Theme on Energy Transition and tried to tackle the selection of the best energy retrofitting strategies to increase the sustainability of an existing district, taking into account energy consumption, cultural heritage values, indoor air quality and air pollution.

Figure 21. © Studio Harmony

The European Commission proposal for a new revision of the Directive underlines the need to better link energy efficiency with performing buildings, so as to avoid possible adverse effects such as dampness and indoor pollution, affecting human well being and health particularlry for vulnerable groups, such as children and the elderly citizens.

Integrated innovative solutions are needed, to combine energy efficiency, while alleviating energy poverty and considering indoor air quality and renovation of buildings and districts of historic and cultural value. Once renovated, upgraded and ensuring consideration of embodied energy, buildings can also help to generate extra renewable-sourced power or provide key energy storage capacity.

Urban areas have been identified in the Accelerating Clean Energy Innovation Communication (COM(2016) 763 final, as most appropriate for the testing and implemention of integrated energy transition solutions. Europe's cities, towns and regions are instrumental in promoting ownership of the energy transition and in advancing climate and energy-related innovation from below. Accordingly the European Commision supports the Covenant of Mayors for Climate and Energy, which brings together thousands of local and regional authorities voluntarily committed to implementing EU climate and energy objectives.

7.2 Energy Solutions

The projects reviewed under this chapter include **EFFESUS** - "Energy Efficiency for EU Historic Urban Districts' Sustainability"; **FASUDIR** -"Friendly and Affordable Sustainable Urban District Retrofitting"; **ECODISTR-ICT** -"Energy Integrated Decision Support Tool for

Retrofit and Renewal towards Sustainable Districts"; **CETIEB** -"Cost-Effective Tools for Better Indoor Environment in Retrofitted Energy Efficient Buildings". These projects mainly address the EU Urban Agenda Theme on Energy Transition and aim to tackle the selection of the best energy retrofitting strategies to increase the sustainability of existing districts, taking into account energy consumption, cultural heritage values, indoor air quality and air pollution.

A district retrofitting approach to energy retrofitting is frequently the most sustainable and cost-effective strategy. However, the complexity of decision-making grows exponentially when the scale of the intervention increases. In order to reduce the complexity of district interventions, EFFESUS, ECODISTR-ICT and FASUDIR developed decision support tools to be applied at district level, with EFFESUS particularly focused in the inefficient-use of energy in historic districts (buildings pre-1945). CETIEB's challenge was to assure an adequate indoor environment quality in retrofitted energy efficient buildings at an affordable cost.

Overall a systemic and integrated approach to deal with the cross-cutting urban challenges was identified, undertaken through the geographical distribution and characteristics of the cities selected to conduct the case studies, and the engagement and participation of multi-stakeholders in the co-deployment of the innovative solutions (materials, products and Decision Support System tools).

Local governments and municipalities were critical to obtain the legal authorisation to set up the demonstrations. Even though citizens were not asked their opinions and ideas regarding the solutions implemented, they were still engaged during the dissemination process.

7.3 Systemic Decision Support Tool : evidence base for decision making

Integrated assessment regarding the implementation of energy retrofitting policies at a district scale is possible through the development of decision making (DSS) support software tools deployed and tested in the cities case studies by the projects. The projects considered simultaneously heritage values, technological aspects, technology integration, cost effectiveness and environmental and social impact of the solutions. In particular, CETIEB explored the interconnection between energy efficiency retrofitting and indoor air quality issues, to avoid the "the sick building syndrome" i.e. the lack of ventilation due to the high levels of insulation adopted to reduce energy consumption leading to a degradation of the indoor air quality.

EFFESUS, ECODISTR-ICT and FASUDIR developed different Decision Support System (DSS) software tools to assist decision making on the difficult energy retrofitting and renewal process for existing districts and their constituent buildings. The DSS developed by **EFFESUS** was implemented in Santiago de Compostela (Spain), Visby (Sweden) and Genoa (Italy), and provided evidence for decision making by the cities based on both its direct positive impacts (economic, cultural heritage, energy consumptions and environmental) and the interests of the municipality and citizens.

In particular, **EFFESUS** focused on historic districts and provided the following evidences:

Efficient window improvement solutions of indoor temperature preservation: Prototypes with "thermal shade" or "adhesive low emissivity films" or with "air sandwich" keep the temperature on 0.77oC, 0.14oC and 1.68oC higher than reference window respectively. Spacefill Aerogel insulation for use in historic buildings with existing solid wall construction where lath and plaster finishes are present result in a reduction of Transfer of Heat between indoor and outdoor (the lower Thermal Conductivity λ =0.0255 W/mK vs λref =0.0287 W/mK while keeping the Moisture Absorption below requirements means lower heat losses).

New radiation selective coating compatible with historic buildings result in a reduction of the transfer of heat in façades, with an indoor temperature reduction of 1.3oC to 2.7oC in comparison with a no-coating situation, the reversibility and transparency of the product were not achieved.New hydraulic lime-based mortar with optimal insulating properties for

use as plaster and render application resulted in reduction of 5oC of indoor temperature during summer.

In addition, it worths mentioning the intelligent indoor climate solutions: Building Automation Systems and Building Energy Management Systems using already available concepts for improving indoor climate and reducing energy efficiency combined with the innovative windows were developed within the EFFESUS project.

The DSS developed by EFFESUS was implemented in Santiago de Compostela (Spain), Visby (Sweden) and Genoa (Italy), and provided evidence for decision making by the cities based on both its direct positive impacts (economic, cultural heritage, energy consumptions and environmental) and the interest of the municipality and citizens. EFFESUS methofologies were tested and successfully applied in four buildings in Old Town Santiago de Compostela: Rua Nova 22, Rua Nova 46, Toural 3, and Caldeireira 34.

EFFESUS DSS and proposed solutions achieved:

- - a reduction of energy demand of 45% up to 72% for heritage protection degree 3-4;
- - reduction of CO2 emission of 91% up to 95% for heritage protection degrees 3-4;
- - savings of 2.369.972,66€.

Finally, the retrofit Investment Calculator that developed within a Sustainable Community Business Model for the citizens of Santiago de Compostela demonstrated that there are sufficient resources to generate renewable energy for the whole city and provide 100% renewable energy to the historic centre to achieve a carbon neutral sustainable future. A retained surplus of 12.09 million€ in 10 years is enough to repay loans (13M €) and investors, or to continue investing in more projects to achieve 100% renewable energy production for Santiago more quickly.

CETIEB focused on the IAQ of retrofitted building and developed the Infrared Thermal Comfort Monitoring System (Comfort Eye): The monitor system achieved a 15 % energy savings in testing.

Air Biofilter active control systems prototype: Nedlaw Ltd. in Ontario (Canada) is the developer of the concept of this system and calculated energy savings of up to 60% on ventilation energy when their system is installed and operating at optimum efficiency. It can also educe VOC concentrations by up to 50%.

Multi-Functional Passive Plaster System: Reduces indoor temperature and humidity and through photo-catalytic activity removes indoor air pollutants. In a further development it was able to reach a thermal conductivity of 0.060 W/(mK), which is lower than the 0.066 W/(mK) of conventional polystyrene containing plasters.

Two years after CETIEB, the team at Schwenk developed further the Multi-Functional Passive Plaster System. The company was acquired by QuickMix in 2015.

ECODISTR-ICT followed a different approach to gather and process data and exploited state of the art developments in the fields of GIS (geographic information systems), BIM (building information models) and UIM (urban information models), to efficiently gather huge amounts of detailed data on individual buildings, and use them in simulations at district level. By linking existing tools and indicators at the level of the individual building to frameworks for urban simulation, the DSS closed the gap between current building performance simulation tools used for the design and renovation of single buildings, and the simulation tools which focus at a macro level of a district or city.

The DSS developed by ECODISTR-ICT was tested in Stockholm (Sweden), Rotterdam (Netherlands), Valencia (Spain), Warsaw (Poland) and Antwerp (Netherlands). Rotterdam set up an approach to link energy efficiency with different local challenges, enabling the uptake of energy efficiency measures in districts where local residents are hardly or not able to invest.

The concept of BIM (Building Information modelling) has advanced the built environment industry paradigm (through the projects EFFESUS, FASUDIR, and ECO-DISTRICT). In fact, BIM envisages virtual construction of structure/neighbourhoods, prior to physical construction, in order to reduce uncertainty, improve safety, work out problems, and simulate and analyze potential impacts, informing the model before construction.

Energy performance-based project delivery methods focused on environmental methodologies are being implemented and advanced; instruments are being used to achieve more efficient and well performing buildings, city neighbourhoods and cities. Some of these combined technological and nature-based solutions to offer model visualization, and advanced functionalities by considering not just the optimisation of single buildings, but cooperation and collaboration in managing entire urban environments.

The city of Rotterdam has set up an approach to link energy efficiency with different other local challenges, enabling the uptake of energy efficiency measures in districts where local residents are hardly or not able to invest. This approach is, among others, based on the workshop and testing approach of ECODISTR-ICT. The method has been called 'social approach' to underline the role of social innovation and related interventions.

In the Hovsjö district in Stockholm case study, the tool provided comprehensible reports and visualizations to assist in understanding the effects of 5 different scenarios for the different buildings in the district and the following options to reduce energy consumption were identified. The projects created new local urban planning instruments in implementing energy retrofitting measures at district level including:

1. Integrated planning for energy retrofitting process

To guarantee the fulfilment of sustainability targets in a district renovation process, urban scale plans and tools were connected to those at the building scale adopting an integrated multi-scale approach. Achievement of this integrated multi-scale approach required involvement of different stakeholders and policy makers, and furthermore public and private cooperation was part of the planning process from the beginning. The e-collaboration platform of FASUDIR allowed the active involvement of the stakeholders but also was supported by public users with different levels of access to information. The open source nature of ECODISTR-ICT modules also provide an excellent example of how citizens and companies can participate in retrofitting projects at district scale.

In order to achieve an integrated approach on energy retrofitting it is also important to take into consideration other urban sustainability themes (e.g. Cultural Heritage or Mobility) besides energy efficiency. Accordingly, EFFESUS designed the following five categories of indicators for a proposed EU-harmonized holistic certification methodology that integrates heritage values in the assessment of the districts: a) IEQ; b) Embodied energy; c) Operational energy; d) Economic return; e) Heritage urban level.

2. Business plans and urban planning

Financial issues are one of the key obstacles to retrofitting across Europe, particularly in the current economic climate. Policy makers need ways to identify retrofitting plans that not only have a low cost for owners, but that can also support local businesses, energy service companies and SMEs, to create self-sustaining virtuous cycles within local markets.

3. Integration of assessment systems in urban plans

Policies, strategies and planning activities at urban scale have to be supported by contextualized assessment tools and indicators to evaluate the sustainability of districts. The assessment tools have to define and communicate in an intelligent and objective way the performance targets. The use of measurable objective indicators, and of a tool that allows the automatic calculation of those indicators was considered as fundamental not only for the decision making process but also for monitoring and evaluating the expected benefits of the interventions applied in the districts. The assessment tools have to be used in the whole life cycle of an urban area to verify the level of performance during

construction and operation. In the planning phase, assessment systems support the decision making process to identify the optimal design solution.

4. Multilevel governance in urban district retrofitting

Multi-level governance models based on assessment tools and KPIs are very important for an effective energy retrofitting process. This ranges from legally binding partnership and participatory planning activities, to the joint development of regional and local structures and tools.

5. Indoor Environmental Quality (IEQ) Guidelines

Indoor environmental quality is of concern for projects dealing with energy efficiency. In particular indoor comfort is improved with systems using VOC sensors, and low-cost infrared vision system to monitor comfort and health related parameters (i.e. CETIEB). CETIEB research project aimed at devising innovative ways of both monitoring and controlling the IEQ in a cost-effective way, so that Europe can achieve the 'best of both worlds' – highly energy efficient buildings with optimal indoor air quality and indoor climates avoiding sick building syndrome.

Energy Efficiency projects (e.g. **EFFESUS, ECODISTR-ICT and FASUDIR**) covered a vast range of relevant and related subjects essential to help Europe reduce its carbon emissions. The topics covered by the design projects refer to neighbourhoods and mainly addressed retrofit solutions and advanced decision support tools.

These projects applied innovative technologies to achieve a more sustainable built environment. The importance of getting the design right is emphasised throughout all projects. All projects are targeting reducing energy consumption and/or making buildings more sustainable. Projects have energy targets ranging from 20% energy savings to net zero-energy buildings. Other projects use scenarios (a 3D graphic user interface (i.e. FASUDIR) to analyse user consumption behaviour, increase acceptance by users and achieve more holistic solutions.

Renovation solution packages & deep energy renovation strategies have been developed to grow the renovation rate of EU building stock. Historic buildings whose renovation is affected by architectural value were maintained as functional living and working spaces (i.e. 3ENCULT). Internal insulation issue is investigated with rsolutions offering hygrothermal performance and not harming existing constructions (i.e. RIBuild).

All projects realised innovative and groundbreaking outcomes with major impact in respect of both product and policy including:

EFFESUS focused on historic districts delivered:

Efficient window improvement solutions of indoor temperature preservation:

Prototypes with "thermal shade" or "adhesive low emissivity films" or with "air sandwich" maintaining temperatures 0.77oC, 0.14oC and 1.68oC higher than reference windows.

Spacefill Aerogel insulation for use in historic buildings with existing solid wall construction with lath and plaster finishes, resulting in a reduction of Transfer of Heat between indoor and outdoor (the lower Thermal Conductivity λ =0.0255 W/mK vs λref =0.0287 W/mK while maintaining Moisture Absorption below requirements means lower heat losses).

New radiation selective coatings compatible with historic buildings resulting in reduction of the transfer of heat in façades, with an indoor temperature reduction of 1.3oC to 2.7oC in comparison with a no-coating situation.

New hydraulic lime-based mortar with optimal insulating properties for use as plaster and render applications resulting in reduction of 5oC of indoor temperature during summer.

Intelligent indoor climate solutions:

Building Automation Systems and Building Energy Management Systems using already available concepts for improving indoor climate and reducing energy efficiency combined with the innovative windows.

Retrofit Investment Calculator:

Developed within a Sustainable Community Business Model for Santiago de Compostela demonstrated that sufficient resources generate renewable energy for the whole city and provide 100% renewable energy to the historic centre to achieve a carbon neutral sustainable future. A retained surplus of 12.09 million€ in 10 years is enough to repay loans (13M €) and investors, or to continue investing in more projects to achieve 100% renewable energy production more quickly.

FASUDIR compiled knowledge and technologies developed in previous projects, in particular regarding sustainability indicators of EU related FP7 projects, in relation to:

a) Energy Efficiency at Building and District Scale;

b) Retrofitting Technologies and Tools;

c) Energy Retrofitting Market Uptake;

d) Cultural Heritage.

FASUDIR DSS was tested in Frankfurt (Germany), Santiago de Compostela (Spain) and Budapest (Hungary). The scores for the FASUDIR indicators identified domains where the district of Heinrich Lübke Siedlung in Frankfurt was poorly performing. These aspects were visualized using a scoring system for district indicators and meaningful color codes.

ECODISTR-ICT - For the Hovsjö district of Stockholm, the tool provided comprehensive reports and visualizations to assist understanding the effects of 5 different scenarios for the different buildings in the district, identifying the following options to reduce energy consumption:

- Changes to exhaust and supply air ventilation with heat exchangers, more insulation on the roofs, new windows and hot tap water saving devices resulting in an average reduction of energy consumption of 16%;
- Energy efficiency package focuses on energy use per heated area with 31% average reduction of energy consumption;
- New buildings on top of parking garages providing a saving of around 7% in energy consumption;
- PV cells installed on roofs with reduction of energy consumption of 11% and electricity production of 13 kWh/m2;
- Ground source heat pumps in row houses and an energy saving of 10%.

In the Kiel-West district of Antwerp collaboration between the social housing corporation, the City of Antwerp and local actors, developed a district retrofit strategy delivering a cost-effective reduction of energy demand up to 60%, while introducing renewable energy production and increasing liveability and comfort.

As actors of open innovation the consortium partners published the foreground methods and tools of the DSS as open source software in the public domain. As a result, other players are able to both use the free software tool, and also further improve the DSS.

CETIEB focused on the IAQ of retrofitted buildings, and delivered:

Infrared Thermal Comfort Monitoring System (Comfort Eye):

The monitor system achieved 15 % energy savings.

Air Biofilter active control systems prototype:

Nedlaw Ltd, Ontario (Canada), developed the concept and calculated energy savings up to 60% on ventilation energy when the system is operating at optimum efficiency.

Multi-Functional Passive Plaster System:

Reduces indoor temperature and humidity and through photo-catalytic activity removing indoor air pollutants. In a further development it was able to reach a thermal conductivity of 0.060 W/(mK), which is lower than the 0.066 W/(mK) of conventional polystyrene containing plasters.

The materials and products developed by CETIEB have generated substantial market interest. UNIVPM is currently collaborating with a company that produces glazed facades to develop an innovative building envelope management system that makes use of the Comfort Eye to derive indoor surfaces temperatures and comfort conditions that can optimize the control of glazed facades.

Indoor Environmental Quality Guidelines for Retrofitting:

Provide a step by step process for retrofitting any building for energy efficiency and improved indoor environmental qualities. The Guidelines support the creation of new legislation that can boost innovation by imposing new requirements that must be met with innovative solutions that ensure either an adequate IEQ for energy retrofitted buildings or an adequate retrofitting process that does not harm the IEQ.

Guidelines set out by CETIEB provide a step by step process for retrofitting any building for energy efficiency and improved indoor environmental qualities. The Guidelines are followed by a list of the multiple benefits of retrofitting which may apply to the stakeholder. Depending on the stakeholders' interests they may be missing the significant added value of some of the other benefits. As a result of the ground-breaking work of CETIEB, Europe is taking a major step towards a new generation of innovative 'intelligent' buildings, able to regulate their own indoor environment in a cost-effective way and helping the world move closer to its energy efficiency targets.

Open stakeholder engagement was evident in the design, development and deployment of all project innovative processes and solutions, and in particular the role of Municipalities within the consortiums created several synergies between cities and private companies that were critical for projects to reach their goals. The following synergies contributed to deliver innovation:

- Balance between the technical skills of partners to develop the project outcomes and the ability of municipalities and local policy makers to ensure places for the real-life demonstrations.

- Municipalities provided information to the technical partners of the consortium that was critical to the proper development of the project.

- Previous experience in related research projects e.g. Santiago de Compostela and complementary skills that helped to perform the technical multi-tasking needed to achieve the objectives. Besides, a balanced geographical distribution of cities during the demonstrations guaranteed that the outcomes could be replicated at European scale and upscale worldwide.

CETIEB contributed to the Advanced Material and Nanotechnology Cluster (AMANAC) Coordination Support Action that brought together FP7 projects that use Nanotechnology to develop high-performance insulation materials/products and HVAC systems to significantly enhance the energy efficiency of buildings. CETIEB was included in the group "Technologies and materials for a healthier indoor environment".

The Indoor Environment Quality sector is highly trans-disciplinary from advanced sensing, materials and systems to health assessment as well as behavioural and socio-economic issues. The IEQ cluster initiated by University of Stuttgart – Materials Testing Institute in behalf of the CETIEB consortium contributed with research ideas to the European roadmap within EU Horizon 2020 for "Renaturing Cities" and "Materials & Technologies for improved Indoor Environment Quality".

CETIEB also contributed with the results for comfort and health related parameters to identify a research agenda for the cluster Smart Home and Living with respect to comfort issues of Smart Homes for elderly. Regarding the up-take and up-scaling of solutions, some policy makers and some members of the consortiums aim to commercialize and/or use the DSS in future projects: ECODISTR-ICT DSS tool by Flemish Regional Administration and FASUDIR DSS tool by Calcon Deutschland AG.

The materials and products developed by CETIEB have created a lot of interest from the market. UNIVPM is currently collaborating with a company that produces glazed facades to develop an innovative building envelope management system that makes use of the Comfort Eye to derive indoor surfaces temperatures and comfort condition that can optimize the control of glazed facades and other EU funded projects are also planning to use the Comfort Eye. In addition following the completion of CETIEB, Schwenk (Partner) further developed the Multi-Functional Passive Plaster System, including all certifications and full scale application tests. QuickMix, who acquired Schwenk in 2015, and aim to further develop the product.

Figure 22. © rudi1976, #116337570, 2020, stock.adobe.com

In the Hovsjö district in Stockholm case study, the tool provided comprehensible reports and visualizations to assist in understanding the effects of 5 different scenarios for the different buildings in the district and the following options to reduce energy consumption were identified:

Changes to exhaust and supply air ventilation with heat exchangers, more insulation on the roofs, new windows and hot tap water saving devices result in an average reduction of energy consumption of 16%. Energy efficiency package focuses on energy use per heated area resulted in a reduction of energy consumption of average 31 %. New buildings on top of parking garages lead to a saving of around 7 % in energy consumption. PV cells installed on roofs lead to a reduction of energy consumption of 11 % and electricity production of 13 kWh/m2. Ground source heat pumps in row houses lead to an energy saving of 10 %

The DSS developed by FASUDIR was tested in Frankfurt (Germany), Santiago de Compostela (Spain) and Budapest (Hungary). The scores for the FASUDIR indicators in the current state allowed identifying domains where the district of Heinrich Lübke Siedlung in Frankfurt was poorly performing. These aspects were the same as the ones identified by the detailed study from AS&P and can be easily visualized on the FASUDIR tool thanks to the scoring system for district indicators and meaningful color code. Regarding the cross-linkages with other relevant EU platforms/databases, it is worthy to note that most of the technologies, systems and protocols developed in the projects reviewed are based in previous developments of EU related projects.

Regarding the energy efficiency of buildings, the preliminary database, information and glossary from all over Europe was developed in the Project BRITA-in-PuBs and provided a good basis for adding additional information to the information obtained by EFFESUS.

FASUDIR compiled knowledge and technologies developed in previous projects, in particular regarding sustainability indicators of EU related FP7 projects, in the following thematic areas:

a) Energy Efficiency at Building and District Scale;

b) Retrofitting Technologies and Tools;

c) Energy Retrofitting Market Uptake;

d) Cultural Heritage.

Regarding the creation of communities of practice of innovating cities, the following Europeans initiatives/networks were relevant to the reviewed projects where some of the consortium partners were involved: ECTP (European Construction Technology Platform); E2BA (Energy Efficient Buildings Association); EERA (European Energy Research Alliance); Smartcities; KIC-InnoEnergy; Sustainable Building Alliance; BuildingSmart and KIC-Climate.

Moreover, the DSS developed within EFFESUS, FASUDIR, ECODISTRICT-ICT, is a valuable tool to inform Municipalities and construction companies about best retrofitting strategies to improve the energetic efficiency of urban districts and the real urban conditions of historic districts. If municipalities decide to up-take the new innovations proposed by the DSS they will be fostering innovation by supporting the development of those markets and, as a result, providing private companies with the necessary resources to continue their R&D efforts.

In the case of ECODISTR-ICT, the partners of the consortium took an extra step to become actors of open innovation by publishing the developed foreground methods and tools of the DSS as open source software in the public domain. As a result, not only other players will be able to use a free software tool, as they will also be able to further improve the DSS.

The Kiel-West district in the City of Antwerp (BE) is a multi-cultural district with around 6 000 inhabitants or 2 500 housing units including about 80 % social housing.

In collaboration with the social housing corporation, the City of Antwerp and local actors, a district retrofit strategy has been developed, aiming at cost-effective reduction of the energy demand up to 60 %, while introducing renewable energy production and increasing liveability and comfort.

As a theoretical concept (only TLR2 level), the strategy developed by EFFESUS to match the supply and demand for heat, cooling and electricity has contributed for the general advancement of knowledge in several different areas:

- Concept for Energy analysis using geographic information systems (GIS), for historic districts;
- Development of Indicators for district heating systems;
- Heat flux measurement for wall constructions with increased moisture content;
- Concept for Application of interior lime mortar;

Since this strategy works at the district level and not at building level, its implementation by municipalities could lead to the development and introduction of other innovative solutions.

Due to the fluctuation of the renewable energy supply, the energy systems have to be transformed from demand-oriented energy generation to generation-oriented energy consumption. This was achieved within EFFESUS focusing on Smart Grids.

This requires demand side management (DSM) and intelligent storage technologies. In this context, the building sector has huge potential. Therefore, EFFESUS evaluated the fraction of residential heat demand that can be expected to be covered by using electric heat pumps coupled with a heating system for variable loads, and to improve the utilisation of surplus electricity from renewable energy sources in space heating and to stabilise the indoor temperature within a given comfort interval.

The deployment of a smart grid can foster the development of innovative solutions allowed by the existence of a smart grid (e.g. grid-connected renewable energy systems).

The Urban Energy Laboratory, created as a dissemination strategy of EFFESUS co-organized with the municipality of Santiago de Compostela, contributed to improve the knowledge on how buildings are used, managed and transformed to meet modern comfort requirements, as well as to collect information on energy consumption and housing environmental management strategies.

The laboratory will also explain citizen how to handle the permanent transformation processes in historic centres without endangering the urban heritage values they represent.

The EFFESUS proposed Business Model can provide new ways of thinking about business potentials of cities in general and historic urban districts in specific. This business model, which is strongly based on clean energy, can entail a higher involvement of municipalities in the selection of the sources of sustainable energy to be used at the city level, thus developing the sustainable energy market and promoting further innovations in the sector.

EFFESUS recommended the creation of REScoops (Renewable Energy Source co-ops), which are co-operatives created to implement Community Energy Projects. Community energy projects use grassroots participation and local funding to build a sense of community and trust through engagement with people in their community.

The expertise and value created by these projects remains within the community, and surplus value is used to fund further investment in energy efficiency, renewable energy and other community initiatives.

By proposing a more comprehensive methodology for energy retrofit at the district level, EFFESUS helped municipalities to gain more often the acceptance of both citizens and national governments when proposing energy retrofit investments, which will develop the market and foster the creation of new innovative solutions.

8 Social Cohesion, Well-being and Diversity

8.1 Social Cohesion Challenges

At the European level, social and economic policies are currently ordered and organised around achieving the goals of the Europe 2020 strategy – high levels of employment, productivity and social cohesion. It is widely recognised, however, that social cohesion is declining or at least under new pressure as a consequence of the economic and employment crisis, but also due to longer-term trends including growing inequality, immigration and increasing cultural diversity. Social disparities in the EU are increasing in relation to poverty, labour market access, health, equitable education as well as intergenerational justice. At the same time, social cohesion is generally valued in and of itself, as it reflects solidarity and social harmony, while also being regarded as an important resource for economic success and quality of life.

Figure 23. © Igor

DIVERCITIES focuses on the case-study of hyper-diversity and urban communities as a whole, spreading horizontally to 14 cities and their local challenges and opportunities. While **CITISPYCE** is thematic and focuses on youth and inequality challenges, which yield socially innovative practices, even if less attention was given to the sociological portrait of each city.

Finally, **WILCO** investigated how social needs where addressed by social innovations in cities, working with local policymakers, welfare service providers, social agents, third sector organizations and vulnerable citizens, and focused on three policy fields (child care, employment and access to housing) and 3 target groups (single mothers, youngsters and first generation migrants) in several European countries with very different welfare systems and cultural values regarding social exclusion and integration.

ARTS, GLAMURS and TESS common assessment was that, for a sustainability transitions to occur, the local level needs to be transcended so that innovations are able to diffuse and become part of institutional policies and politics. The identified ingredients of processes of bottom-up creation of sustainability transition pathways through grassroots initiatives included:

- Accelerating (the phase when visible structural changes take place through an accumulation of socio-cultural, economic, ecological and institutional changes that react to each other);
- Upscaling (the growth of members, supporters or users of a single transition initiative in order to spread new ways of thinking, organizing and practising);
- Replicating (the take up of new ways of doing, organizing and thinking of one transition initiative by another transition initiative or different actors in order to spread these alternative way);
- Partnering (the pooling and/or complementing of resources, competences, and capacities of local transition initiatives in order to exploit synergies to support and ensure the continuity of the new ways of doing, organizing and thinking);
- instrumentalising (the tapping into and capitalizing on opportunities provided by the multi-level governance context of the city-region in order to obtain resources);
- embedding (the alignment of new ways of doing, organizing and thinking in order to integrate them into city-regional governance patterns).

8.2 Social Cohesion Solutions

The projects considered here include **ARTS, GLAMURS and TESS** which provide in-depth description of a large variety of Transition Initiatives (TIs) which are active in many transition domains including biodiversity and ecosystem services, resource efficiency, energy use and supply, with a focus on household energy (local renewable energy production and supply systems), and urban living and built environment, with a focus on housing (social innovations like intergenerational co-housing models). SEISMIC addresses the broader challenge of connectivity and network-building for mutual learning. It thus operates vertically between different scales linking local actors to EU agenda and JPI Urban Europe.

Focusing on these ingredients, ARTS, GLAMURS and TESS explored the complex interactions among economic, social, cultural, political and technological factors influencing and supporting change towards sustainable lifestyles and sustainable systems of consumption-production at the individual and societal level. Their common working method was based on the creation of a multitude of dialogue spaces for knowledge sharing and knowledge co-production including scientists, communities and TIs, local governments. Through continous interaction, these projects showed how to connect science, social practice, policy and politics, and how to enable debates on good governance and new forms of participation in cities future visions and strategies.

The overall assumption is that evidenced impact and the innovations that these TIs bring in social, ecological and economic terms makes them a promising starting point for triggering and catalysing wider transitions towards sustainable low-carbon European societies – both, as a valuable source of transferable ideas, and as frontrunners that unveil key barriers and opportunities for innovation. As such, these initiatives can potentially contribute to achieving EU policy goals, but also they also show their potential wider and integrated effects.

ARTS, TESS and GLAMURS produced a large variety of tools to assess TIs multi-domain performance and to foster and build participatory processes, aimed to co-produce acceleration pathways and networking:

- Single Transition Initiative Model and Multi Transition Initiative Model Simulation Game focusing on qualitative and quantitative assessment of acceleration and interaction dynamics, Acceleration Roadmapping Workshops format (ARTS); Backcasting Methodology for Visions and Pathways Workshops, three methodological modelling approaches (Micro-economic Models, Macro-economic Models and Agent-based Models) and one Integrated Model for Environmental Impact Assessment and Footprinting of present and potential future lifestyle and economic alternatives (GLAMURS); Carbon Reduction Scoreboard and Track-it! self-assessment on line tool to benchmark GHG emissions, Community Impact Scoreboard and Resilience Compass self-assessment on line tool dealing with multiple factors that determine community resilience, a synthetic and scientific Multi-Criteria Analysis for carbon efficient projects tool (TESS).

- Integrated theory on the complex relationships between institutional, social, economic, political, technological and environmental determinants of lifestyle change;

- Quantified relationships and developed models of lifestyle change that consider different and integrated pathways to achieving transition (initially developing in niches, then becoming regimes and landscapes, as defined by theories on transition);

- Supporting Cities to become Actors of Open Innovation

- ARTS, GLAMURS and TESS outcomes contributed to the generation of new approaches and ideas that considerably advance the transition theory debate and practices:

- They produced significant impacts on the public debate and knowledge on transitions initiatives for sustainability, by collecting a wide range of empirical data;

- In particular ARTS and GLAMURS produced a remarkable impact on advancing the use of gaming simulation and backcasting scenarios to support collective learning;

- An important impact on civil society was reached by means of a well-balanced set of numerous engagement actions (i.e. in the case of ARTS: workshops, transition talks, local cultural events and communication campaigns, online platforms and tools - social networks, citizens blogging, the Resilience Connections Network);

- As for assessment and self-assessment of environmental and resilience performance by Tis, TESS in particular elaborated innovative frameworks and tools to compare carbon-reduction potentials, which can be further developed by the market;

- The impacts on local Tis and on establishing stronger and more durable relations among Tis, local public institutions and research centres public was remarkable. The cities and TIS involved in the projects learnt how to improve their management and decision making capacities thanks to the participation to the research activities; TIs gained awareness about their role and interdependences with the context as well as a wider scientifically-grounded vision of their transformative role in society.

- Many of ARTS outputs produced concrete networking and policy making results in case study cities and city-regions:

- In Brighton: the roadmap included a range of next steps to be taken by a number of local stakeholders which will contribute to the further acceleration of the transition in Brighton and Hove. One of the follow up action will be the settlement of a sustainable city working group which will ensure that the lessons learned from the project will continue to have local impact. The stakeholder workshops also produced a variety of intermediate impacts directly. Participants reported how the opportunity to hear, first-hand, about contemporary issues facing the City Council and their proposed response was particularly valuable to them.

- In Budapest: the creation of a mutual sense of understanding and of opportunity for group interaction between transition initiatives resulted in the creation of a structured on line platform for future cooperation, with the function to assist in spreading the impact of each organization. Budapest research team is going to continue and extend the work of ARTS with transition initiatives in order to connect the 'Dream Budapest' dialogue (resulted from roadmapping process) to other ongoing debates on degrowth and sustainability in the city.

- In Dresden: with the support from ARTS team (PP IOER), in 2015 the City of Dresden won the "Future-City" project (national competition by the German Federal government, 2015-2018) aiming to develop a public vision for an "Open City Dresden – Sharing Responsibilities for Sustainable Development". In co-operation with this project, ARTS team organized the stakeholder workshops on Acceleration Roadmaps. ARTS activities also contributed to the replication of the SUKUMA film competition in the city.

- Also in the case of GLAMURS, concrete networking (and further development of some Tis), policy making and research follow-ups results can be highlighted:

- Backcasting workshop results from the Rome case study were presented to the Municipality of Rome North. Links were established between the University Roma Tre team and the Municipality, Roma Resiliente (part of the 100 Resilient Cities Programme of the Rockfeller Foundation), and the Urban Centre Committee, involving citizens, politicians and institutions in decisions regarding urban transformation and regeneration;

- In the Galician case study, the leader of Zocamiñoca food cooperative approached the PP Universidad da Coruña research team to collaborate on launching a social platform pressing governments to start work on transitioning to more sustainable lifestyles;

- Project impacts also derived from the interaction with the case study initiatives. Some were related to the case study exchange itself, such as the example of members of one of the Romanian ecovillages starting a Repair Café in Cluj-Napoca as a direct result of having met with the Dutch Repair Café case study participants at the case study exchange meeting;

- A pilot study on city residential waste rules and regulations which helped to focus on macro-economic models was developed in the city of Tilburg, by the local project patner University with the Municipality;

- The fruitful collaboration between psychological and economic theory was formalized as a new research stream at the Department of Economics of the University of Bath,

on behavioural sciences and economic. This new research avenue was called "psychonomics" in order to stress the integrative research approach.

- In the case of TESS, the delivered Visual Interactive Platform showed concrete possibilities for further development and exploitation;

- The Platform functionalities were discussed with other ongoing European projects, which showed interest in using TESS platform (e.g., GLAMURS, PATHWAYS, ECOLISE, EU-INNOVATE and ARTS). During the project implementation TESS team interacted with the German bottom-up initiative TransforMap to map the alternative community. This initiative is documented on the page www.14mmm.org. TESS team was also studying the possibility to integrate the platform with Project Dirt (http://www.projectdirt.com/), a UK-based company offering a custom-made social network already used by a significant number of initiatives in the UK. This further development is in fact necessary to keep the platform lively and updated.

- DIVERCITIES (ethnic hyper-diversity), CITISPYCE (integration of youth), and SEISMIC (mutual learning and dialogue all foster a systemic approach albeit of different kinds. On the broadest level, SEISMIC (Societal Engagement in Science, Mutual Learning in Cities) engages the very challenge of communication and collaboration in and between cities. SEiSMiC created national networks (NatNets) in Austria, Belgium, the Czech Republic, Germany, Hungary, Italy, the Netherlands, Sweden, Turkey and the United Kingdom, bringing together a wide variety of social initiatives, grassroots movements, social innovators, social entrepreneurs, citizens, NGOs, interest groups, freelancers, educators, scientists and policy makers. SEiSMiC built national and international bridges for mutual learning between society, the scientific community and policy makers.

- The aims were to mobilise a wide range of urban actors to identify research and innovation needs; contribute to the social dimension of JPI Urban Europe's research and innovation agenda; develop policy recommendations that address real social needs; and create a platform for dialogue and mutual learning among citizens and urban actors to strengthen social innovation in a local context.

- SEiSMIC - networking urban social innovation

- It initiated a multi-stakeholder, mutual learning dialogue that allowed the setup of ten national forums in urban social innovation

- It built on extensive previous EU funding under "Science in Society" in FP6 and FP7 of multi-actor participation and mobilisation and mutual learning processes and methodologies, which are key to social innovation, proving the added value of European intervention

- It served as a living, lively laboratory for urban, social and open innovation that diminished existing discourse barriers

- It bridged different national cultures (EU15 and EU13)

- It demonstrated that involvement of grassroots organisations in innovation related debates can make a difference and generate innovative ideas, even in countries that lack a pro-innovation culture

- It provided the public authorities involved in the JPI Urban Europe with cross-border interdisciplinary and trans-disciplinary insights into the urban innovation dynamics

- It embraced a plurality of social perspectives in a constructive experimentation

- It contributed significantly to the definition of JPI's Strategic Research and Innovation Agenda (SRIA)

Figure 24. © Frank Gärtner

- It always remained close to EU policy developments and through its Policy Watch deliverable it diffused these developments to its partnership and to the JPI Urban Europe
- Introduced to JPI Urban Europe the innovative, idea of the Living Lab Approach, now followed by many
- It is a sustainable project, with forward looking legacy and outlived by its 10 national forums that have now constituted the AGORA of the JPI Urban Europe
- Organized educational training of activists, educators and city planners across Europe.
- The two other projects were action-research projects focusing on specific themes, rather than coordinating support actions as with SEISMIC. DIVERCITIES (Governing Urban Diversity: Creating Social Cohesion, Social Mobility and Economic Performance in Today's Hyper-diversified Cities) focused on the question of how to create social cohesion, social mobility and economic performance in today's hyper-diversified cities. The project promotes urban diversity as an asset, to inspire creativity and innovation, and make cities more liveable and harmonious.
- In this way socio-economic, socio-demographic, ethnic and cultural diversity positively affect social cohesion, economic performance and social mobility of individuals and groups. The project highlights how and under which circumstances European's urban diversity can be turned into social and economic advantages.

DIVERCITIES – engaging Europe's future and most urgent problem

- Orchestrated the Diversity Festival
- Conducted a comparative analysis of cities and how to deal with hyper-diversity
- Initiated a successful Educational Program for Diversity in 20 Schools
- Provided a road map for European cohesion and diversity management in cities
- Conducted collaborative research in 14 cities and published the Handbook for Governing Hyper-Diverse Cities
- Policy Platforms have been formed in all countries, generally comprising about 6-10 stakeholders

CITISPYCE (Combating inequalities through innovative social practices of, and for, young people in cities across Europe) addresses the challenge of understanding and dealing with urban inequality among youth in European cities (aged 16-25). It builds on research that

shows the disproportionate impact of the economic crisis on young people across Europe, including excessively high rates of youth unemployment and threats to the social provision enjoyed by previous generations.

This is compounded by the 'coming of age' of the descendants of recent migrant communities, who now form significant proportions of the young population in major European cities. They are Europeans in language, social habit and cultural repertoire, yet continue to face longstanding barriers as a result of membership of communities already marginalised from mainstream labour markets and civic life.

The outcomes reflect the projects' integrated approach. For SEISMIC the major outcome was the NatNet (national network) itself. It initiated a multi-stakeholder, mutual learning dialogue that allowed the setup of ten national forums in urban social innovation. For DIVERCITIES, in addition to the goal of raising awareness and revaluing diversity it focuses on an educational program in school and Policy Forums in 10 cities.

It conducted a comparative research of urban diversity in 14 cities and published the path breaking Handbook for Governing Hyper-Diverse Cities Finally, CITISPYCE brought together a range of academic disciplines -- anthropology, sociology, economics, governance, public policy -- from seven universities, as well as social policy expertise and practice and two non-profit social NGO to study innovation, inequality and youth inclusion. It highlighted the role of active and involved youth in making the innovative city of tomorrow.

CITISPYCE – valuing the role of youth and fighting inequalities

- Research has shown that the global economic crisis of 2008 has had a disproportionately adverse impact upon young people in urban areas. Not only are they experiencing excessively high rates of unemployment but threats to the social provision enjoyed by previous generations. When linked to other indicators of deprivation, it is clear that young people in the 16 to 24 age group are amongst the hardest hit and face more social and economic inequalities than any other group in society

- Mapped Socially Innovative Practices (SIPs) in 10 different cities against the backdrop of the rapid redrawing of social inequalities across Europe

- Gave voice to young people suffering from marginality and inequality

- Engaged with more 600 young people, and created a platform for young people across Europe get together online and put forward their views and ideas

- Created new forms of networking and mobility for young people who might live in deprived neighbourhoods.

- Involved Roma youth in artistic projects

WILCO investigated how social needs are addressed by social innovations in cities, and worked with local policymakers, welfare service providers, social agents, third sector organizations and vulnerable citizens. It focused on three policy fields (child care, employment and access to housing) and 3 target groups (single mothers, youngsters and first generation migrants) and elaborated the patterns of social inequality and social cohesion in European cities across ten countries that provided information on how local politics enable or disable the emergence and development of social innovation.

The project produced a Policy Review Social Innovation Research in the European Union: Approaches, findings and future directions commissioned by the European Commission that was inspirational in incorporating social innovations in the EU research and policy agendas.

Equally it elaborated a Chart of Patterns of Social Inequality and Social Cohesion in European cities across 10 countries that provided information on the emergence and development of social innovations; created innovative instruments and practices including

an interpretative framework for local welfare systems across different European contexts; raised awareness on the importance of citizen-led initiatives for effective local welfare systems combating social exclusion; and developed policy recommendations, offering innovative interdisciplinary and comparative findings for evidence-based policy making in key areas of the European social model.

WILCO's overall success was linked to its effectiveness in repositioning the concept of social innovation in Europe, from a buzzword in policy circles to a high position in the policy agenda, building on the solid evidence-based constructions of the project, and the mapping of the social innovations existing in European cities.

The project also underscored and highlighted the critical links between social innovation, the dynamics of urban welfare governance models and the social exclusion problems and patterns in Europe.

Key messages include:

- Social innovations are not only innovations in social services, but also changes in rules and regulations (e.g. concerning the access to financial benefits) and in governance (forms of democracy and decision making on priorities in welfare and cohesion politics);

- Social innovation in cities is not a disconnected phenomenon, but an element in the traditional European welfare system that is differently expressed according to the particular socio-economic models and the specific national and local cultures;

- Most social innovations do not fit a pattern of growth and upscaling nor are easily translated to other contexts. They emerge in specific contexts, to address existing needs and do not aim to wider diffusion or upscaling.

9 Social Innovation and Citizen Science

9.1 Societal Challenges

Citizen science is both an enabler of open innovation and can involve citizens 'doing science', for example, through crowdsourcing, as well as involving the public engaging in policy-making through, for example, agenda-setting for research systems. These are typified by 'gathering data', 'analysing data' and 'co-production of knowledge'. Citizen science also involves greater understanding of science by the public madeood to possible through greater access to information about the research process such as the ability to use open research data or download open access journal articles. Citizen science may also refer to the ability of the public to understand science and engage with scientists, through more 'open' communication in the form of blogs and social media. Overall this framework highlights the importance of contributions from people who might not be considered scientific experts, but do have specialist knowledge of particular habitats and skills, particularly in relation to local environments, addressing societal challenges.

9.2 Citizen Science Solutions

The citizen science projects considered here include CITI-SENSE involving development of sensor-based Citizens' Observatory Community for improving quality of life in cities, focusing on air and noise pollution. The project enabled citizen participation in community decision-making and planning relating to these issues, through use of personal microsensors and mobile devices. CITYZEN (megaCITY - Zoom for the Environment) both addressing the impact of urban pollution on climate change, air quality and emission hotspots.

CITI-SENSE: Empowering the citizen to participate in environmental governance.

Figure 25. © william87

WeSenseIT (Citizen Water Observatory) which aimed to establish citizen observatories for water monitoring in three case study cities, Doncaster (United Kingdom), Delft (The Netherlands) and Vicenza (Italy), focused on supporting agencies, such as emergency services and policy makers, to deal with natural phenomena such as floods and droughts.

CITI-SENSE addressed the challenge of air quality in public and institutional urban spaces in Barcelona, Oslo, Haifa, Vienna, Ostrava and Silesia region, Beograd, Edinburgh, and Ljubljana. It developed "citizens' observatories" to empower citizens to contribute to and participate in environmental governance, to enable them to support and influence community and societal priorities and associated decision making.

CITI-SENSE develops, tests, demonstrates and validates a community-based environmental monitoring and information systems using innovative and novel earth observation applications. To achieve this, the project: (i) raises environmental awareness in citizens, (ii) raises user participation in societal environmental decisions and (iii) provides feedback on the impact that citizens had in decisions. It addresses EU's need for effective participation by citizens in environmental stewardship, based on broad stakeholder and user involvement in support of both community and policy priorities. The project aims to learn from citizen experience and perception and enable citizenship co-participation in community decision making and co-operative planning.

The impact of CITI-SENSE rests on three pillars: technological platforms for distributed monitoring; information and communication technologies; and societal involvement. Three case studies focused on a range of services related to environmental issues of societal concern: combined environmental exposure and health associated with air quality; noise and development of public spaces, and indoor air at schools. Attention was given to the representativeness of citizen participation. The case studies were designed in collaboration with citizens' groups and decision makers. They were based on distributed data collection using innovative static, portable and personal devices (low-cost reliable microsensor packs) that communicate with data repositories through mobile phones or other devices. Development of participatory methods, data management strategies, and applications to facilitate exploitation of the data and information for policy, and society, was achieved in strong collaboration with private innovation firms.

The systemic approach manifests itself chiefly by the explicit multi-stakeholder, multi-sectoral approach, involving industry, academia, individual environmental specialists, NGOs and public organizations. It also engages citizens in research and data-collections across regions and cities.

Integrated solutions:

- High technology environmental sensors, innovative data fusion methods and communication paired with scientific analysis and efficient communications with users and the public;

- Deployment of static (fixed) and mobile (personal) sensors to monitor various environmental components;

- Combination of new sensing technology, ICT Cloud platform with IoT, Big Data and App/Portal services and participatory methods, to create useful products and services.

The concept of CITI-SENSE is based on realization of the chain "sensors-platform-products-users": technologies for distributed monitoring (sensors); information and communication technologies (platform); information products and services (products); and citizen involvement in both monitoring and societal decisions through participation and empowerment (users). Products and services (exploitable by the market) include:

- AQ (Air Quality) maps by applying new methods for spatial interpolation and visualisation of environmental data;

- AQ perception mobile applications and questionnaires ;

- Novel static and mobile AQ sensor platforms;

- Real-time environmental information with alert services for delivery of timely knowledge of pollution hot- spots;

- Local CO web portals to facilitate and promote public participation and engagement;

- Common CO web portal to access, upload and exchange data and information.

- Developed the new approach of "Citizens' Observatories" (COs): a collaborative concept that focuses on the empowerment of citizens to influence their community policy and decision-making

- Combined new sensing technology, ICT Cloud platform with IoT, Big Data and App/Portal services and participatory methods in products and services

- Involved multiple stakeholders including innovation firms which developed business models following products (the Personal Air Monitoring Toolkit, tools for remote sensing, and mobile apps)

- Studied the motivations and barriers to citizen involvement with environmental decision making

- Deployed low-cost micro-sensor devices and innovative data fusion and scientific analyses

- Contributed to European air pollution (or, alternatively, air quality, AQ) legislation by supplying local authorities with comparability of measurements across Europe, and standardized methods and comprehensive quality control and quality assurance systems

- Developed and evaluated the mechanisms needed to implement the two-way interaction between policy makers and citizens that is fundamental to empower the citizen and allow him/her to influence environmental governance

- With the inclusion of KICT and SALTLUX in the consortium, CITI-SENSE realized the intentions in the Agreement on Scientific and Technological Cooperation between the European Community and the Government of the Republic of Korea

- By help of a business plan, the project identified 17 knowledge items that were considered "exploitable", i.e., presenting a clear and significant potential for exploitation (both in terms of commercial activities as well as further research ones)

- CITYZEN determines the air pollution distribution and change in and around hotspots in megacities over the last decade from extensive satellite and in-situ observations. It

employs a series of different scale models in order to analyze the impacts of air pollution hot spots on regional and global air quality including potential future changes for various climate scenarios. Focus is on ozone and particulate matter with chemical and physical characterization, and their precursors. The eastern Mediterranean (Istanbul, Athens, Cairo), the Po Valley, the BeNeLux region, the Pearl River Delta in China (with megacities Guangzhou and Hong Kong) and the hot and polluted European summer 2003 were chosen for intensive case studies. The consortium included groups from China, Turkey, Greece and Italy, in addition to France, Germany, UK and Norway, including experts on observations, emission data and models.

- The project addressed the challenge of the increasing number of megacities (with populations over 10 million), where regional air pollution hot spots have developed as a result of anthropogenic emissions and changes in land usage that have large environmental implications, both in the regional hot spots themselves and on larger scale. A scientific challenge in this project is the multi-scale character of the issue. As megacities have the potential to impact both their local environment but also the regional to global scales, scale-bridging data sets and model systems have to be used. Bringing together academic and public agencies generates a systemic approach both in terms of geographic scale and institutional collaboration.

CITYZEN considered 5 policy scenarios:

- No policy change ('GEA Frozen':This scenario assumes that there is no change in future air pollution policies after 2005 which implies that the combustion technologies and abatement measures penetration remains at the level of 2005 for the entire modelling period.

- Current legislation AQ Policy: This scenario is identical to the case described above in terms of energy. However, it assumes full implementation of all current and planned air pollution legislation world-wide to 2030.

- Current legislation AQ+Climate Policy: This scenario assumes implementation of a stringent climate policy corresponding to a 2 degree global temperature target. In addition, it assumes a moderate energy access policy corresponding to microfinance and 20% fuel subsidy well as full implementation of all current and planned air quality legislation until 2030.

- Very ambitious AQ+Climate Policy: This scenario varies from the above one in that it assumes global implementation of extremely stringent pollution policies (SLE) until 2030. These stringent air quality control strategies assume fast implementation of low emission measures in all sectors.

- The observational and modeling studies conducted within CITYZEN resulted in a better understanding and in better tools to assess air pollution and to design air quality control policies. The 4 work packages provided improvements to input data, modeling tools and observational methods. The development, validation and subsequent application of the new tools, useable under different circumstances and for different areas inside and outside the EU contributes to more effective measures to prevent increased air pollution and climate change. The co-ordination of the evaluation of the actual available knowledge in Europe has already resulted in a better knowledge. The further improvement based on new observational methods and models to study air pollution and climate change, and interactions and the development of new diagnostic tools will support European decision makers.

CITYZEN: Mega-cities and Emission Hotspots

- The modelling of the impact megacities on air pollution has highlighted hotspots in the East Mediterranean around Istanbul, Athens and Cairo, as well as the Pearl River Delta in China

- Provided extensive sets of global satellite observations of air pollutants and established a new measurement network in Turkey

- Downscaled the EMEP European emission inventory to 0.1°x0.1° lon/lat resolution for the period 1998-2006

- Merged the European emission data into a global emission data set (the so-called 'RCP' scenario being used in the IPCC process) and developed mitigation scenarios based on the new RCP scenarios

- Improved the modelling capability with scale interactions and 10-year trends

- Wrote an assessment of megacities in collaboration with other colleagues worldwide, published by IGAC (International Global Atmospheric Chemistry) and WMO (World Meteorological Organization)

- Supported together with the Chinese Ministry of Science and Technology and Guangdong province specification of science-based control policies for regional pollution in the Pearl River Delta. PKU conducted a research program on regional air pollution in the PRD for years, in terms of both fundamental research and policy

- Organized (PKU) a science team to design the air quality assurance plan for the 16th Asian Games held in Guangzhou in November 2010. Regional multi-pollutants control strategy was used as guideline for control scenarios design. The assurance plan was adopted and implemented by GD-EPB and Guangzhou EPB.

- Planned (FRIUUK) science-based control policies for regional pollution used by the North Rhine Westphalia State Agency for Nature, Environment and Consumer Production (LANUV-NRW) in planning of air quality improvement in North-Rhine-Westphalia.

WeSenseIT interdisciplinary concept was developed on the basis of 3 different aspects of community participation in water governance:

- environmental non-structured data collection via optimized networks of sensors as well as information provided directly by citizens (measurements, images, messages) and via mining of social media portals;

- development of descriptive and predictive models (both physical/natural and social) and decision-making tools that are able to optimally assimilate both social and physical data;

- two-way feedback and exchange of environmental knowledge/experience between citizens and authorities for decision-making, planning and governance.

The project applied the concept of citizen observatories for water management and monitoring in three case study cities, Doncaster (UK), Delft (NL), and Vicenza (IT). The project developed and tested technological solutions such as heat and moisture sensors, connected acoustic rain gauges, urban umbrella rain gauge (prototype), smartcams for long-term water monitoring, wireless soil moisture and temperature measurement, satellite derived soil moisture maps, platforms for smart irrigation planning, river discharge estimation with mobile phone, web portals connecting citizens and local authorities, citizen video communication, crowd activity monitoring, social media monitoring, and augmented reality tools. All solutions aimed to support monitoring and modelling with applications and sensors, and communication components that form the observatory. Two-way feedback and exchange of environmental information and experience between citizens and authorities aimed to support decision making and governance within an e-collaboration framework.

The project demonstrated the importance of bringing together different stakeholders at the local level to co-design and co-produce integrated and resource-efficient strategies for the future. Working closely with the local level provided on the ground information, challenges and success factors, which add value to the research project. Local workshops also enabled local authorities to better understand and explain the challenges faced and

therefore provide a solid baseline for study and options for building more sustainable and resource-efficient futures.

Real world scenarios specified as follows:

- Doncaster (UK) WeSenseIt installed physical sensors on the river Don, providing an efficient and effective alert system, complemented by citizen observations via citizen apps. In all, five gauge boards have been installed in Doncaster, four weather stations, five radar bridge sensors, and a community portal was created.

- Delft (NL) WeSenseIt project became part of the Digital Delfl and policy providing citizen information to the digital hydrological cycle information system of Delft. In order to test the technologies of the soil moisture sensors and Lizard Boxes developed by the project, thirty sensors and fifteen boxes were installed spread as homogenously as possible over the Delfland region.

- Vicenza (IT) a civil protection exercise was organised by the Alto Adriatico Water Authority and the Municipality, involving 134 volunteers and fifty technicians and researchers. The exercise, had dual objectives to test the new mobile barriers for the hydraulic safety of the city, and test the applications that exchange information between citizens and the Civil Protection Authorities.

WeSenseIT legacy deployed:

- GroundTruth2.0, a 3-year H2020 project on Environmental knowledge discovery of human sensed data;

- SETA, another H2020 project on Big Data for Mobility in Smart Cities (2016-2019); Tracking Health in a Large Population project, funded by the UK government, to support the National Health Service (NHS) strategic vision to healthier lifestyle in the areas of smoking, drinking, eating, moving, sleeping and stress reduction;

- Football Whispers, a project which has now been running for 1 year that provides information to users and some of the main media outlets (e.g. SkySports);

- beAWARE, a H2020 project working on potential of current and new measures and technologies to respond to extreme weather and climate events and teaching;

- KidronNar a 3-year UNESCO-IHE project on the topics of improved catchment area management and safe deltas, access to clean drinking water and basic sanitation, water governance and diplomacy;

B-Putra, a 1-year project funded by the World Bank and led by Antea Group ; and the H2020 GROW Observatory project.

10 Summary of Project Highlights

10.1 Climate Adaptation and Resilience

CLUVA

provided urban planners and researchers within five of Africa's most vulnerable cities (Saint-Louis in Senegal, Ouagadougou in Burkina Faso, Douala in Cameroun, Dar-es-Salaam in Tanzania and Addis Ababa in Ethiopia) reliable forecasts of the local impact of climate change, in the next 40 years. This research improved the understanding of the impact of climate change and the costs and benefits of adaptation and mitigation measures in cities, and provided comparable data and specific solutions for adaptation to climate change impacts, such as flooding, droughts, changes in temperature and more extreme events. The projects developed tools to quantify risks, vulnerabilities, damage from climate change and a detailed cost assessment of the effectiveness of adaptation measures to

different hazards (i.e. flooding, heat waves, wind damage) that support policymakers in the planning of the above African cities. The project also tailored a suite of methods developed in Manchester to the African urban context. CLUVA provided concrete solutions by developing Climate Change risk adaptation strategies and risk reduction strategies for the 38 per cent of Africa's population (280 millions); It also developed a desertification map to assess the sensitivity to desertification and land degradation in local peri-urban areas. It downscaled the Intergovernmental Panel on Climate Change (IPCC) scenarios to local urban and urban-rural regions; provided regional projections up to 2050 of climate change at high resolution (8km).

CORFU

created successful synergies relying on differences in the perception of urban flooding problems in Europe and China, and delivered new insights for flood management strategies globally. The latest technologies were cross-fertilised with traditional and emerging approaches to living with floods, enabling European and Asian institutions to learn from each other through joint development, implementation and dissemination of strategies towards sound management of the consequences of urban flooding, and cost-effective resilience measures and flood management plans. Barcelona (Spain), Beijing (China), Dhaka (Bangladesh), Hamburg (Germany), Mumbai (India), Nice (France) and Taipei (Taiwan) applied in their flood management strategies the CORFU guidelines for the design of urban drainage systems. The project also developed flood hazard scenarios (potential deaths, damage to infrastructure and health problems, and their effects on communities), prevention policies, and methodologies and guidelines for the design and implementation of a new Sustainable Drainage Systems (SUDS) and flood management in Europe and in China, which were adopted by local policy makers. CORFU evidenced the importance of social resilience in improving flood hazard management and prevention. It also contributed to the development and implementation of real-time warning systems in Barcelona and Dhaka and to the application of the multi-cell model to Beijing City (area more than 1000 km2). The applicability of the latter was demonstrated, as it reproduced the observed location for the 21 July 2012 flood, when large parts of Beijing were seriously flooded causing 57 casualties. CORFU also contributed to the EU Floods Directive by developing urban flood scenarios, modelling and flood hazard mapping.

SECOA

tackled the issues of adaptation to climate change focusing on large coastal metropolitan areas in Europe and Asia and provided sustainable urban planning solutions. The project delivered an integrated ecosystem approach (Integrated Coastal Zone Management-ICZM) together with a Spatial decision support system for urban planners and policy makers for integrated coastal management based on real time input and considering existing conflicts (eg. economic development versus environmental protection, preservation of natural sites and biodiversity; urban growth and restructuring; social cohesion and human mobility) by different stakeholders (i.e. residents, commuters, tourists, and enterprises). These conflicts are multiplied by climate change affecting environmental conditions in coastal areas. In particular, SECOA produced specific evidence base for decision making, including maps of the flood hazard in 15 of its case study sites: Oostende and Brugge, (Belgium), Mumbai and Chennai (India), Haifa and Tel Aviv (Israel), Rome and Chieti-Pescara (Italy),Lisbon and Algarve (Portugal), Gothenburg and Malmo (Sweden), Thames Gateway (United Kingdom), Hai Phong and Nha Trang (Vietnam) have been the case study coastal areas. These cities used the SECOA evidence, scenarios, and applied the SECOA maps of flood hazard into local urban planning and flood management strategies. SECOA provided alternative development scenarios permitting consideration of both urban and metropolitan/regional scales, as well as peri-urban areas and directly interacted with on-going decision making processes, having an impact on their specific urban development.

TRUST

dealt with the transition of urban water services and of their management, helping sector utilities and authorities (public and public/private enterprises) to formulate and implement appropriate urban water policies and achieve a sustainable, low-carbon quality water

future. The project developed and tested a wide portfolio of tools (including Nature-based solutions -NBS solutions and innovative technologies for optimised water treatment), guidelines, software and training material; their feasibility where demonstrated with city utilities in a variety of urban contexts across Europe and Africa. For instance, the Urban Water Cycle Systems (UWCS), a key approach developed within TRUST, supports an integrated and sustainable planning and management of urban water services (e.g. water supply and distribution, water demand, wastewater and cyclic water recovery and resource recovery). TRUST delivered for free tools and e-learning materials available to city Municipalities (Amsterdam, Hamburg, Istanbul, Melbourne, Quito) and any other city, for the assessment of the impact of interventions on the performance gains of the overall urban water cycle; assessment tools of Nature-based solutions and innovative technologies for optimised water treatment, water reclamation for non-potable-use, sustainable water demand and storm water management, energy-saving options and water-energy interventions; mobile and software tools for infrastructure asset management, helping city utilities in the above mentioned cities to perform targeted rehabilitation of infrastructures and to reduce leakage in water distribution systems. The project findings contributed to the goals of the European Innovation Platform on Water (EIP Water Action Group) and to the Urban Water Atlas for Europe.

RAMSES

provided standardised and transferable guidelines for cost-benefit assessment of different climate change impacts and of several adaptation measures to the cities involved such as London, Anwerp, Bilbao, Rio De Janeiro, Bogota, Skopje. The project focused on how climate change might affect buildings, infrastructure, health and living conditions and the economy. Using several climate change scenarios, the project analysed the impacts on the cities due to several climatic and non-climatic drivers (e.g., heat to human health; heat to urban comfort; heat to work productivity; flood to traffic disruption or flood to built environment) and assessed the cost and benefits of different adaptation strategies. The RAMSES tools are open access and available for hundreds of cities throughout the world. The research delivered a Transition Handbook and Training Package to support cities to define transition pathways towards urban resilience and the necessary adaptation measures. Other project results such as the typology and indicators of resilient buildings, are of great interest to insurance companies (e.g., the German Association of Insurance Companies) to calculate their premiums. In addition, the RAMSES results (e.g. cost assessments of different impacts of flooding, heat waves, simulation models, typology of heat waves on cities) have been implemented by the city of Antwerp (Belgium) where the municipality urban planners and urban designers used tools and knowledge delivered by the project to better plan climate adaptation measures (including nature-based solutions) and design innovative strategies for their city.

PREPARED

delivered to city municipalities and the construction sector solutions (tools and decision support systems) for the adaptation of European water supply and sanitation systems to climate change impacts, targeting risk assessment frameworks in respect to water scarcity, water quality, insufficient sewage system with combined outflows (sewage plus water flooding) and environmental problems created by wastewater (pollution, decrease in drinking water quality), real time modelling and monitoring systems and planning for resilience. For instance, PREPARED findings helped water utilities to cope with the anticipated and uncertain impacts of climate change, especially the extremes ones. It also helped the urban planners and decision makers to make strategic investment decisions for the design and maintenance of their city infrastructures. It was evidenced for the city of Berlin (Germany) that integrated management reduces water overflows by 17% and discharged pollutants by 21-31% following extreme events; for the city of Genova (Italy) - optimised management permits of water storage increases hydro energy produce by 43%, and reduces groundwater extraction by 20%; for the city of Barcelona (Spain) - sediment monitoring and real time actions have considerably reduced the annual municipal sewer removal costs; for the city of Oslo (Norway)- treating surplus wastewater during heavy rain events by chemical precipitation increases overall removal efficiency (including

the untreated overflows) from 19 % to 32 % (total nitrogen) and from 36 % to 85 % (total phosphorous).

BURBA

Designed an IT method for waste management optimisation, as a new concept of waste service through the entire chain from production to disposal, based on handling of data from waste management. The system delivered information that contributes to cities sustainability by improving waste management and the recycling activities. The system also delivered information on individual user habits used for taxing or rewarding citizens, but also for motivational and educational purposes. To foster the systemic approach, the project worked in close collaboration with the end-users for each sector to define their requirements for the adequate design of the systems and to deliver outputs adapted to their needs. Research centres, technology-provider companies, water utilities, and waste management companies worked with urban planners in the Municipality of Camogli (Italy), Rzeszów Municipality (Poland) and with Acorde Technologies S.A.(Spain), AOTO Company (Republic of China), Tekever SME (Portugal), Ayuntamiento de Santander (Spain), D'Appolonia S.p.a. (Italy), Politecnico di Milano (Italy) to deliver an integrated analysis of the problems and risk management options. The project addressed problems faced by each of these sectors especially in scenarios of climate change, where cities need to reduce their emissions, and also to be prepared for challenges, such as water shortage, heat stress, flooding, and waste recycling.

10.2 Sustainable Land use and Nature Based Solutions

HOMBRE

focused on Soft Re-use technology solutions and showed how Brownfield remediation can offer the opportunity to develop green open space networks in densely built urban areas, and to generate renewable energy through non-food biomass production. In Genoa and Terni (Italy), Markham Vale (United Kingdom), Halle/Salle (Germany), Solec Kujawski (Poland), the HOMBRE Brownfield Navigator created a focus point for stakeholders' consensus for BF (Brownfield) strategies and regeneration for both urban and peri-urban contexts (i.e. former industrial, commercial, infrastructural, mining, military and housing areas), with the aim to show how to limit greenfield exploitation and urban sprawl, through an environmentally and economically sustainable re-use of land in already built-up areas. Case study Municipalities took up the project overall approach and the use of the decision support system. For example, the Municipality of Solec Kujawski adopted the Zero Brownfield approach as an extension to policies the City had already started to implement, encouraged by project experience to mobilise financial resources to assess remediation options and redevelopment opportunities for the BF (Brownfield) area. The Municipality of Terni added HOMBRE experiences into its approach to regeneration. Municipalities of Utrecht and Rotterdam (Netherland) implemented the concept of the land use cycle in the research of the subsurface.

TIMBRE

Three components of the TIMBRE Web based support toolkit for brownfield (BF) regeneration include an expert Information System for BF regeneration which helps stakeholders to share, access and select the most suitable and available information on national and international projects, programmes and initiatives, and on technological solutions supporting economically and socially beneficial BF regeneration. The Prioritization Tool helps stakeholders to be responsible for wider territories (regions, districts, cities) or BF portfolios to distribute available resources to those sites that are assessed to be the most critical, urgent or profitable to regenerate, on the base of the evaluation of their redevelopment potential, marketability, environmental risk or other perspectives specified by end-users. The Site Assessment and Re-use Planning Tool is an open-source web based instrument aimed at supporting participatory planning and assessment of re-use options by offering to invited users the access to data and allowing them to get involved in the planning process. The project focused on integrated solutions for BFs characterization and remediation, towards a zero BF perspective on case studies from Central and European Countries.

TIMBRE outcomes contributed to the implementation of site-specific BF regeneration projects and processes in a variety of case study cities and regions, spread across European countries such as Germany (Dortmund, Gelsenkirchen, Halle/Saale, Meerane, Postdam, Berlin), Poland (Solec Kujawski, Katovice, Szprotawa, Zielona Gora), Romania (Hunedoara, Craiova, Bucharest), Nederland (Rotterdam), France (Orléans), Czech Republic (Brno, Ostrava, Hrušov, Ústí nad Labem). Technologies developed for integrated site characterization and remediation and phytoscreening with tree coring gained recognition by several engineering companies and are used in various projects in Denmark. For example, Orbicon (Danish engineering company) used tree coring to identify the groundwater-surface water exchange at contaminated sites (i.e. Brede, Raadvad, Copenhagen in Denmark). Today the technique is offered by engineering companies all across Europe and is taught to young environmental engineers at the Technical University of Denmark in the field course on contaminated sites.

URBES

Delivered outcomes to position urban biodiversity and ecosystem services as key assets supporting European cities to adapt to climate change and to reduce cities' ecological footprints. At the city level, several city plans were supported by project results, including the 2020 Barcelona Green Infrastructure and Biodiversity Strategy, the PlaNYC (New York City's 20-year Economic and Environmental Sustainability Plan), as well as Berlin and Rotterdam green infrastructure planning. Other examples include the Malmö integrated green-grey infrastructure for stormwater management in the design of the new residential neighbourhood Bo01, and the retrofitting of the housing area of Augustenborg, as part of the Malmö Water Plan. Lisbon (Portugal) in its Local Action Plan for Lisbon Biodiversity in 2015 was also inspired to take a comprehensive approach which includes the creation of a municipal allotment garden network established in existing or new green spaces and planned to create a landscape mosaic with strong potential to foster biodiversity.

GREEN SURGE

Adapted the concept of biocultural diversity to urban areas, stressing the connections between nature and people in cities. Biocultural diversity refers to a new way of thinking about biodiversity conservation by looking at culturally significant and valued biodiversity and by identifying cultural expressions of nature with local communities. The research identified indicators and typologies of urban green infrastructures that provide nature-based solutions and ecosystem services and contribute to human wellbeing and climate change resilience. Project results were used in the biodiversity and infrastructures planning of cities including Barcelona, Berlin, New York or Rotterdam. Further, at global level, their City Biodiversity Outlook contributed to the UN Habitat III New Urban Agenda and to support the inclusion of a goal for sustainable cities (SDG11) in the Sustainable Development Goals Agenda.

10.3 Resource Efficiency and Circular Economy

Foodmetres

Focused on sustainable local food chains. The impact of European Rural Development Policies (RDP) on sustainability was measured through policy tools in the Metropolitan Agro-food System of the city regions and on the Short Food Chains Typologies (urban garden, direct sale, AgroPark, etc.).

The tool also provides relevant information for local administartors and European politicians about the impact of RDP on Local Short Food Chains in urban and metropolitan contexts.

In terms of short food chains, the research demonstrated that the new Rural Development Programme (RDP) of the Common Agricultural Policy should include new areas like metropolitan regions and new groups, not only farmers. The RDP should consider and support new food chain models, particularly short food chains, which benefit from a great interest in civil society. FOODMETRES developed also impact indicators around: (i) environment, (ii) economy, and (iii) society. Examples of impact indicators in these different areas included food-miles (transport distance) for the environmental impact area,

or number of jobs along the food chain as an economic impact indicator, and the occurrence of pathogens along the food chain under the food safety domain. Assessment reveal distinct differences between the experts' and the practitioners' perspective as well as between the different case study sites, highlighting the importance of regional situation-adjusted strategies and solutions to short food supply innovation.

Supurbfood

Focused on sustainable local food chains and sustainable modes of urban and peri-urban food provisioning and succesfully shortened nutrient, water and carbon cycles. Supurbfood promoted a stakeholder participatory approach through city-region workshops that highlighted the strategic role of institutional interaction and governance and fostered the North-South Europe dialogue by sharing valuable experiences and joint learning. Involved cities reviewed their own policies and governance and called EU, national, local governments to support independent, local specialist food retailers, SMEs and Civil Society Organisations through public procurement clauses, incubators, educational programmes, training and legal assistance, grants, connection with peers, etc.

The Supurbfood policy brief formed the driving force of setting the Milan Food Pact, and the project's working methodology with stakeholders and the policy recommendations produced, formed the basis for the Horizon 2020 project Robust (June 2016- 2020) which focuses on urban rural relations.

POCACITO

Advanced the evidence knowledge base for sustainable pathways towards liveable, affordable and prospering cities. Pocacito engaged stakeholders, policymakers, and academics in Barcelona, Copenhagen, Istanbul, Lisbon, Litoměřice, Milan, Turin, Rostock, Malmö and Zagreb who together with the citizens defined key performance indicators (focusing on energy consumption, urban mobility, air quality, resources depletion, waste, water, building stock,economic growth, health and well being, etc.) to monitor and evaluate the performance of these cities during the transition process to the post carbon cities of tommorow. This participatory approach resulted in custom-made transition post-carbon strategies, that were then taken as the basis for an evidence-based EU 2050 Roadmap, a stakeholder-driven guide towards the model "Post-Carbon City of Tomorrow" that merges climate, energy and social urban transitions. POCACITO successfully developed the 'Post Carbon 2050 scenarios'that was comparted against the 'Business As Usual (BAU)' and proved that nearly all cities will improve under Business As Usual scenarios for most indicators, but the performance is significantly improved under Post Carbon Cities 2050 scenarios where most cities approach carbon neutrality under PC2050. Moreover, under the PC2050 scenario, the cost-benefits of reduced air pollution more than compensate for the investment costs. Investment costs are typically less than 1% of cumulative Gross Domestic Product from 2018 to 2050.

URBAN NEXUS

Combined different urban stakeholders (municipalities, businesses, universities, national ministries, civil society) across Europe (Bristol, Sofia, Goteborg, Barcelona and Glasgow) with different geographical, cultural and professional backgrounds to advance strategic urban research on Urban Climate Resilience, Health and Quality of Life, Governace, Land Management and inform policy decision. The project's policy brief confirmed the strategic importance of having all stakeholders on board when it comes to decision making on sustainable urban development.

It's findings contributed to the implementation of various EU Directives, policy agenda and reports, such as the EU INSPIRE Directive on Infrustucture for Spatial Information in Europe; the Directive on the re-use of public sector information (PSI Directive); the Digital Agenda for Europe; the Joint Research Centre Report "Direct & Indirect Land use impacts of the EU Cohesion Policy"; the European Environment Agency's report on "Urban adaptation to climate change in Europe"; the European Environment Agency initiative, European Climate Adaptation Platform3 (CLIMATE-ADAPT). Furthermore, the partnership principles and main conclusions of the Urban Nexus project acted as an important catalyst

in the development of the Strategic Agenda of research priorities of the Joint Programic Innitiative (JPI Urban Europe) and also provided feedback for the development of the Urban Agenda for the EU.

BRIDGE

Compared and assessed the urban planning scenarios of (Helsinki (FI), Athens (EL), London (UK), Firenze (IT), Gliwice (PL). BRIDGE demonstrated to the European Community and Association of Engineers and Architects that these scenarios depend on environmental indicators related to meteorology, fluxes of energy, CO2, aerosol particle number and concentrations of various trace gases and particles in the cities in question. BRIDGE accurate planning scenarios were fed in a decision support system which helped urban planners and policy makers to adopt a sustainable urban planning for the urban metabolism of the above cities for water consumption, energy efficiency, carbon emissions and pollutants and be replicated in other European cities.

BRIDGE delivered a prototype decision support system that was tested by key architects and Engineers in Europe and demonstrated the feasibility of assessing different planning interventions in specific areas of the cities and most importantly it contributed to sorting out the best scored scenarios, meaning planning proposals with spin over effects for the area. This research resulted also in the ERA.Net projects GEOURBAN and SEN4RUS. Furthermore, based on the BRIDGE approach to energy fluxes in the urban environment, a Horizon 2020 project URBANFLUXES was developed focusing on estimation of Urban Energy Budget and the anthropogenic heat flux using Copernicus Sentinels observations.

SUME

Confirmed the importance and the benefits of an integrated approach in decision-making and in the implementation of actions taking into account social, economic and environmental perspectives at the same time. SUME analysed the influence of urban form on urban resource use and demonstrated how future changes in the urban form could contribute to more resource-efficient European cities. This integrated approach was applied in Vienna, Stockholm, Oporto, Newcastle, Athens, Marseille and Munich and provided scenarios on the land consumption and the spatial distribution of population and workplaces in 2050. The urban metabolism model demonstrated that the spatial expansion of the agglomerations can be avoided even in dynamic and growing cities, where accommodating additional population does not have to result in huge urban spraw: future land consumption in and around European cities could be reduced substantially.SUME also evidenced that the spatial expansion of fastest growing agglomerations like Munich, Stockholm and Vienna can be greatly reduced by 2050 to 13%, 20% and 14% respectively.

Similarly the energy demand can be reduced by 60% to 80%, varying between cities and scenarios. SUME-scenario-type agglomeration development could reduce energy consumption between 10% and 40% by the year 2050 compared to the BASE scenario. A higher replacement or renovation rate of buildings and a better spatial focus of new developments with respect to public transport accessibility could reduce energy consumption by 30 to 40%.

10.4 Air Quality and Health

MEGAPOLI

Investigated the interactions among megacities emissions, air quality and climate, bridging spatial and temporal scales that connect local emissions, air quality and weather with global atmospheric chemistry and climate, to provide information on the effects on regional and global climate, and the feedbacks and mitigation potentials. Delivered integrated methodologies to assess the impacts of pollution within, and from megacities to global scales; assessed the feedbacks and interlinkages between air quality and climate change in megacities at urban, regional and global scales; delivered outputs that link city emissions and pollution with health, e.g., calculating the impact of pollution on DALY (disability

adjusted life years); produced information on long-range transport and regional pollution, baseline scenarios and measures for improving air quality and climate change impacts in megacities; developed improved current and future emission estimates for natural and anthropogenic sources of air pollutants and analysed policy options to reduce megacity emissions.

EURO-URHIS 2

Analysed the specific challenges of health issues in urban areas, such as internationalisation of metropolitan regions, ageing populations, migration and poor environmental factors. It harmonized indicators and methods; developed different cross-sectional surveys focusing on cross-thematic approaches e.g. environmental conditions, food and bioinformatics and displayed differentiated results for young and adults; built capacities in the health systems of Eastern countries; established benchmarking standards and analysed future trend in the status of urban health and in the costs associated to urban health services. The project delivered a harmonisation of urban health data methods for over 15 countries, offering a common system for data collection and validation. The system has also been adapted to non-EU countries such as Vietnam, China, Kuwait and now is being validated for Nepal. Methods and instruments have been designed to be replicable and can be applied to any city in Europe and beyond.

PURGE

Developed evidence on the health impacts of greenhouse gas reduction strategies in transport, electricity generation, housing and food and agriculture in urban environments of Europe and Asia. Its findings extend the existing evidence on the health impacts associated with GHG reduction strategies. For many mitigation strategies, the net consequences for health are positive, and so add to the rationale for an accelerated transition to low carbon (low GHG) economies, by helping to off-set some of the perceived economic costs.

The project also provides evidence on the types of GHG reduction strategy within each sector that are likely to have the greatest health dividend, and yields more detailed evidence on both the positive and negative consequences for health of such strategies, so that policies and regulation may be better tailored to ensure opportunities for promoting health are maximized and protective steps can be taken to avoid unintended adverse effects for health.

URGENCHE

Innovation is evident in respect of both the policy contributions to the regulatory and legislative frameworks for sustainable development, as well as tool development, adaptation and application in the urban planning context. The project developed and applied a methodological framework for the assessment of the overall risks and benefits of alternative GHG emission rate reduction policies for health and well-being. The GIS based modelling platform and related database for urban impact assessment, assessed GHG policies with greatest cost benefit for health and well-being, with particular focus on energy demand and supply as well as transport. URGENCHE policy themes together with other urban planning inputs e.g. green space and water management, permit the generation of a cohesive set of strategies to maximise health and well being in a sustainable city. The project thereby makes substantial contribution to the development and implementation of local, regional and high-level policy objectives supporting the evolution of the governance model.

10.5 Mobility

CityMobil2

The demonstrations in La Rochelle, Vantaa and Trikala can be considered best practice examples of the deployment of ARTS due to the high number of passengers that tried the service. A total of 62,199 rides were registered during the. Around 80% of the riders would have liked the temporary demonstrations to remain open and more than 70% wanted

these systems to be extended all over the city. The project contributed to policy advancements by developing a methodology for the certification of fully automated road transport systems that formed the basis of the legal framework proposal submitted to the European Commission. Such proposal can be catalyst for innovation in the sector. Furthermore, CityMobil2 predicted positive environmental, urban and socio-economic impacts of ARTS and evaluated its implementation costs. Policy makers can be motivated by the information provided to work towards the dissemination of ARTS. The demonstration of ARTS in several cities also gave manufacturers the opportunity to thoroughly test their technologies and demonstrate the technical feasibility of automated last-mile transportation. It also increased awareness of citizens regarding these new transportation systems, which can promote the up-take of autonomous road vehicles by the market.

CiViTAS MIMOSA

Implemented a green tariff in Funchal (Portugal) for owners of electric/hybrid vehicles (i.e. 50% discount in parking meters) was used over 800 times. The dissemination campaigns of electric/hybrid vehicles resulted in a purchase increase of 650%. The increase of Accessibility of remote areas with mini-buses in Funchal resulted in a reduction of 1,2% of average fuel consumption of the overall fleet, 14% of CO2, 12% of PM10 and 22% - 26,3% of NOx. The number of urban buses able to transport wheelchairs has risen by 20%. A new Online Ticketing System in Tallinn was well accepted by users, which is expected to increase the number of users of PT. Bus and tram drivers in Gdansk were taught to deal with vandalism and offenders, resulting in a 20% decrease of acts of vandalism and 25% increase in the perceived sense of security of PT users. The deployment in Bologna of four pilots of Mobimart, a reward mechanism tailored to the needs of the citizens of Bologna that converts desirable travel behavior into benefits such as free bus tickets or a free parking, were successful in terms of CO_2 savings and citizen participation. Utrecht's City Distribution by electric Boat (Beer Boat), which supplied more than 60 catering businesses, resulted in a decrease of 13% of CO2, 6% of NOx and 10% of PM10.

SOLUTIONS

Developed a transferability methodology that fostered the adoption of innovative transport solutions by cities in Asia, Latin America and Mediterranean. The project outcomes provided guidelines that can be used for policy advancements regarding the exchange of knowledge and advices among city officials. Furthermore, the introduction of innovative technologies in these cities can motivate entrepreneurs and scientists to explore those innovations and further adapt them to the particularities of their countries. As a direct result of the transferability methodology, the city of Belo Horizonte, in Brazil, has implemented an innovative SUMP, which includes comprehensive measures such as a NMT infrastructure – Zone 30 (30km/h zone) in cooperation with the twin city of Bremen in Germany; a Bus Rapid Transit (BRT) system and a cycling lane. A last-mile connectivity development in the Vytilla Mobility Hub (Kochi, India) that connects the metro corridor with a water transport network was created based on exchange and cooperation with the twin city of Hangzhou, in China. SOLUTIONS also contributed actively towards the New Urban Agenda, which was a part of the Habitat III policy process. **The Action Platform: Urban Electric Mobility Initiative (UEMI)** was initiated by UN-Habitat and was launched at the UN Climate Summit in September 2014.

10.6 Energy Transition Including Energy Efficient Buildings

EFFESUS

Focused on historic districts in Visby (Sweden) , Genoa (Italy) and Santiago de Compostela (Spain), developed the following innovations. Efficient window improvement solutions of indoor temperature preservation: Prototypes with "thermal shade" or "adhesive low emissivity films" or with "air sandwich" keep the temperature on 0.77oC, 0.14oC and 1.68oC higher than reference window respectively. Spacefill Aerogel insulation for use in historic buildings with existing solid wall construction where lath and plaster finishes are present, result in a reduction of transfer of heat between indoor and outdoor (the lower Thermal Conductivity λ =0.0255 W/mK vs λref =0.0287 W/mK while keeping the Moisture Absorption below requirements means lower heat losses). New radiation selective coating

compatible with historic buildings result in a reduction of the transfer of heat in façades, with an indoor temperature reduction of 1.3oC to 2.7oC in comparison with a no-coating situation, the reversibility and transparency of the product were not achieved. New hydraulic lime-based mortar with optimal insulating properties for use as plaster and render application resulted in reduction of 5oC of indoor temperature during summer. The Decision Support System inputs developed by EFFESUS, were successfully applied in four buildings in Santiago de Compostela. Performance improvement included a reduction of energy demand of 45% up to 72% , in particular for historic buildings; reduction of CO2 emission of 91% up to 95% for Cultural Heritage protection, resulting in economic savings of 2.369.972,66€.

ECODISTR-ICT

Developed Decision Support Systems that were tested and applied in Stockholm (Sweden), Rotterdam (Netherlands), Valencia (Spain), Warsaw (Poland) and Antwerp (Netherlands). The city of Rotterdam set up an approach to link energy efficiency with different other local challenges, enabling the uptake of energy efficiency measures in districts, where local residents are hardly able to invest. This approach is, among others, based on the workshop and testing approach of ECODISTR-ICT. The method has been called 'social approach' to underline the role of social innovation and related interventions. In the Hovsjö district in Stockholm, the tool provided comprehensible reports and visualizations to assist in understanding the effects of five different scenarios for the different buildings in the district, including changes to exhaust and supply air ventilation with heat exchangers. More insulation on the roofs, new windows and hot tap water saving devices result in an average reduction of energy consumption of 16%. Energy efficiency package focused on energy use per heated area resulting in a reduction of energy consumption of average 31 %. The ECODISTR-ICTconsortium published the developed foreground methods and tools of the DSS, as open source software in the public domain. As a result, not only other players will be able to use a free software tool, but they will also be able to further improve the DSS. The Kiel-West district in the City of Antwerp (BE) is a multi-cultural district with around 6 000inhabitants or 2 500 housing units including about 80 % social housing. In collaboration with the social housing corporation, the City of Antwerp and local actors, a district retrofit strategy has been developed, aiming at cost-effective reduction of the energy demand up to 60 %, while introducing renewable energy production and increasing liveability and comfort. In the Hovsjö district in Stockholm case study, the tool provided reports and visualizations to assist in understanding the effects of five different scenarios for the different buildings in the district, resulting in key benefits with regard to energy consumption (i.e. New buildings on top of parking garages lead to a saving of around 7 % in energy consumption; PV cells installed on roofs lead to a reduction of energy consumption of 11 % and electricity production of 13 kWh/m2; Ground source heat pumps in row houses lead to an energy saving of 10 %.

FASUDIR

Developed Decision Support Systems for engineers, architects and urban planners. The DSS is a valuable tool to inform Municipalities and construction companies about best retrofitting strategies to improve the energetic efficiency of urban districts and the real urban conditions of historic districts.

These systems were tested and demonstrated in Frankfurt (Germany), Santiago de Compostela (Spain) and Budapest (Hungary). The scores for the FASUDIR indicators in the current state allowed identifying domains where the district of Heinrich Lübke Siedlung in Frankfurt was poorly performing. These aspects can be easily visualized on the FASUDIR tool thanks to the scoring system for district indicators and meaningful color code.

FASUDIR demonstrated that to address successfully energy retroffiting complexity, many actors and resources need to be mobilized, including a strong coordination between diffrenct stakeholers. In this context, FASUDIR's platform was not configured as a "single user", but as an interaction mechanism between different stakeholders involved in a sustainable urban retrofitting project.

CETIEB

Focused on the IAQ (Indoor Assessment Quality) of retrofitted buildings and supported product developments such as the Infrared Thermal Comfort Monitoring System (Comfort Eye): The monitor system achieved a 15 % of energy savings. Moreover, the Air Biofilter active control systems prototype edivenced energy savings of up to 60% on ventilation energy when the system is installed and operates at optimum efficiency. The Air Biofilter reduces also VOC concentrations by up to 50%. The Multi-Functional Passive Plaster System Reduces indoor temperature and humidity and through photo-catalytic activity removes indoor air pollutants. In a further development it was able to reach a thermal conductivity of 0.060 W/(mK), which is lower than the 0.066 W/(mK) of conventional polystyrene containing plasters. Two years after CETIEB, the team at Schwenk developed further the Multi-Functional Passive Plaster System. The involved partner company was acquired by QuickMix in 2015.

10.7 Social Cohesion, Well-being and Diversity

ARTS

Explored the complex interactions among economic, social,cultural, political and technological factors influencing and supporting change towards sustainable lifestyles and sustainable systems of consumption-production at the individual and societal level. ARTS managed to successfully integrate natural and social sciences research, quantitative and qualitative approaches, bringing together interdisciplinary teams of researchers and developing methodologies and tools for

monitoring and reporting the social, political, economic, technological and environmental impacts of urban transition pathways. ARTS used participatory methodologies/tools such as the Multi Transition Initiative Model Simulation Game that was designed to enable regional teams to create and simulate Tis networking configurations, varying in terms of initiative ecosystem (e.g. number and type of active initiatives), and contextual conditions (e.g. limited financial support, large volunteer base, low sustainability awareness, etc.). During ARTS implementation, Acceleration Roadmapping Workshops were conceived as the setting of a variety of participatory events, aimed to facilitate direct knowledge transfer between research, (local) policy, business and practice in the five transition regions through a strategic engagement process and providing real life laboratories for developing science and policy-relevant knowledge.

GLAMURS

Produced Carbon Reduction Scoreboard and Track-it self-assessment on line tools to benchmark GHG emissions and Community Impact Scoreboard tools in two different fields: participatory workshops, scientific and desktop assessment models. The Backcasting Methodology for Visions and Pathways Workshops provided support for the organization of two series of workshops: the first one aimed to produce and discuss visions for transitions towards sustainable lifestyles and green economy; the second one aimed to outline specific transition pathways and agendas of actions. Agent-based Models of behavioural interaction analysed the combined effects of workplace flexitime arrangements, building new infrastructures and urban concentration on both commuting time and GHG emissions.

TESS

Developped tools produced with a special focus on the carbon reduction potential, aiming to integrate evaluation of environmental, political, economical, social and technological impacts, through a better understanding of both internal factors e.g. social dynamics, and external factors e.g. institutional settings and political support, which make initiatives work and upscale. The Carbon Reduction Scoreboard assesses the Greenhouse Gas (GHG) reduction potential achieved by Transition activities in different domains (Transport, Waste, Food, Energy).TESS produced tools successfully integrated theory on the complex relationships between institutional, social, economic, political, technological and environmental determinants of lifestyle change;Quantified relationships and developed models of lifestyle change that consider different and integrated pathways to achieving urban transition (initially developing in niches, then becoming regimes and landscapes);tested models of transition to sustainable lifestyles and a green economy

through a combination of empirical research and participatory simulation approaches, including micro- and macro-economic models and environmental assessment tools, as well as interactions between them and case-study research. TESS successfully tested and evaluated the feasibility and costs of different governance designs and policy mixes.

DIVERCITIES

Orchestrated the Diversity Festival conducted a comparative analysis of cities and how to deal with hyper-diversity. The project initiated a successful educational program for diversity in 20 schools, provided a road map for European cohesion and diversity management in cities, conducted collaborative research in 14 cities and published the Handbook for Governing Hyper-Diverse Cities. The handbook proposed new and innovative policy instruments and governance arrangements that (a) recognise urban diversity as a positive aspect; (b) increase interaction and communication between the diversity of groups; and (c) increase participation meeting the needs of communities.

CITISPYCE

Mapped Socially Innovative Practices (SIPs) were identified across 10 cities and included in a menu of innovative practices as a basis for discussion by stakeholders engaging with more than 600 young people, and creating a platform for young people across Europe to get together online and put forward their views and ideas, so giving voice to young people suffering from marginality and inequality. The project created new forms of networking and mobility for young people living in deprived neighbourhoods, especially the Roma youth via an artistic project. CITISPYCE research showed that the global economic crisis of 2008 has had a disproportionately adverse impact upon young people in urban areas. Not only did they experiencei excessively high rates of unemployment but threats to the social provision enjoyed by previous generations. When linked to other indicators of deprivation, it was clear that young people in the 16 to 24 age group are amongst the hardest hit and faced more social and economic inequalities than any other group in society.

SEISMIC

Initiated a multi-stakeholder, mutual learning dialogue that promoted the setup of ten national forums in urban social innovation. The project served as a living, lively laboratory for urban, social and open innovation overcoming existing discourse barriers, bridging different national cultures, and demonstrating that involvement of grassroots organisations in innovation related debates can make a difference and generate innovative ideas, even in countries that lack a pro-innovation culture. It provided public authorities with cross-border interdisciplinary and trans-disciplinary insights into the urban innovation dynamics, and introduced the idea of Cities Living Labs approach. It also promoted urban diversity as an inspiration approach towds creative, liveable anf harmonious cities. The project highlights contributed significantly to the definition of JPI's (Joint Programming Initiative) Strategic Research and Innovation Agenda (SRIA).

10.8 Social Innovation and Citizen Science

CITI-SENSE

Developed the new approach of "Citizens' Observatories" (COs), a collaborative concept that focused on the empowerment of citizens to influence their community policy and decision-making, combined with new sensing technology, ICT Cloud platform with IoT, Big Data and App/Portal services and participatory methods in products and services. Developed and evaluated the mechanisms needed to implement the two-way interaction between policy makers and citizens that is fundamental to empower the citizen and allow him/her to influence environmental governance. The project involved multiple stakeholders including innovation firms which developed business models for a Personal Air Monitoring Toolkit, and tools for remote sensing, studied the motivations and barriers to citizen involvement with environmental decision making, and deployed low-cost micro-sensor devices and innovative data fusion and scientific analyses. In total the project identified 17 exploitable knowledge items, presenting a clear and significant potential for exploitation (both in terms of commercial activities as well as further research ones). It thereby

contributed to European air pollution and air quality legislation by supplying local authorities with comparability of measurements across Europe, and standardized methods and comprehensive quality control and quality assurance systems.

CITYZEN

Addressed the challenge of the increasing number of megacities with populations over 10 million and determined the air pollution distribution in and around hotspots in megacities over the last decade from extensive satellite and in-situ observations. The focus of the project was in the East Mediterranean around Istanbul, Athens and Cairo, as well as the Po Valley, the BeNeLux region, the Pearl River Delta in China (with megacities Guangzhou and Hong Kong). It established a new measurement network of air pollutants in Turkey. Furthermore, it downscaled the EMEP (European Monitoring and Evaluation Programme under the Convention on Long-range Transboundary Air Pollution (CLRTAP) to solve transboundary air pollution problems) emission inventory to 0.1°x0.1° lon/lat resolution for the period 1998-2006, merged the European emission data into a global emission data set (the so-called 'RCP' scenario being used in the IPCC process) and developed mitigation scenarios based on the new RCP scenarios, improved the modeling capability with scale interactions and 10-year trends, and wrote an assessment of megacities in collaboration with other colleagues worldwide, published by IGAC (International Global Atmospheric Chemistry) and WMO (World Meteorological Organization). Parts of the work carried out in CityZen have been used by the North Rhine Westphalia State Agency for Nature, Environment and Consumer Production (LANUV-NRW) for the planning of air quality improvement in North-Rhine-Westphalia including aspects of the notification process for the air quality directives of the European Commission (2008/50/EC). Results from the EURAD model have been delivered to LANUV on a 5 km grid basis for North Rhine Westphalia and on a 25 km basis for Germany. These results have been distributed further by LANUV-NRW for decision making within urban administrations and on a national basis.

WeSenseIt

Applied the concept of citizen observatories and local governance for water management and monitoring in three case study cities, Doncaster (UK), Delft (NL), and Vicenza (IT). It developed and tested also technological solutions like sensors and gauge boards with information notices on how to read and submit the sensor data with QR codes, low-cost sensible heat flux sensors, soil moisture measurement systems, and river discharge estimation with mobile phone, web portals connecting citizens and local authorities, citizen video communication and crowd activity monitoring. All solutions aimed to support monitoring and modelling with applications and sensors, and communication components that form the observatory. These tools have been used in real world scenarios such as the support to the evacuation of 30,000 people from the city of Vicenza in Italy and the support to emergency control rooms during events involving over a million people. Doncaster (UK) WeSenseIt installed physical sensors on the river Don, providing an effective alert system, complemented by citizen observations via citizen apps. In all, five gauge boards have been installed in Doncaster, four weather stations, five radar bridge sensors, and a community portal was created.

Delft (NL) WeSenseIt project became part of the Digital Delfl and policy providing citizen information to the digital hydrological cycle information system of Delft. In order to test the technologies of the soil moisture sensors and Lizard Boxes developed by the project, thirty sensors and fifteen boxes were installed spread as homogenously as possible over the Delfland region. Moreover, the WeSenseIt activity and outputs produced around Citizen Observatories have been accepted by the Italian Government as a key measure for the European Flood Directive (2007/60) and Water Framework Directive (2000/60) in the Italian Eastern Alps District.

11 Overall Lessons learnt

Figure 26. © Thaut Images

- Cities are on the front lines of change in our society and the place where the economic expansion, the new ideas, and the cultural advances happen, where we are making the necessary progress on climate change and where we show that inclusion and diversity are necessary ingredients for success, as cities are incubators of the future and actors of open innovation.

- Truly smart cities are reflections of the people who live, work, and create within them. Our cities and public spaces are integral to the arts, innovation, culture, democracy and sustainability.

- Cities are the places with the need and urgency to take actions as they are the places that are already home to 75% of the people on the planet, on track to reach 85 % by 2050[1]. So they are the places where national and international policies on climate change, climate adaptation, air quality, disaster risks, health and well-being, social inclusion, energy efficiency, urban mobility, urban poverty, migration, social cohesion, social innovation and other issues need to be implemented.

- Innovating cities should happen by envisioning the future of our cities together with citizens, urbanists, entrepreneurs, designers, architects, engineers, industries, storytellers, Local Authorities who will bring more promise of building solutions that work for everyone and leave no one behind, create a dialogue about the opportunity and potential cities hold and lead to Climate Neutral and Smart Cities of the future, fostering the EU Green Deal Initiative of the European Commission President Ursula Von der Leyen.

- Cities are the major contributors to challenges related to climate change, air quality, waste, health, transport, the economy, social cohesion, immigration, natural disasters and natural resources consumption (energy, water, food security). The complex nature of urban contexts calls for innovative and sustainable solutions developed through participatory, people-centric approaches and social innovation to create resilient, sustainable, safe , inclusive, healthy and prosperous cities.

- Since the early 1990s, the multi-faceted nature of urban contexts has made visible the need to support research on sustainable urban development. Through the different themes of the Seventh Framework Programme for Research and Technological Development (FP7), the EU contributed to this research with a total investment of about EUR 1.9 billion. The investment in FP6 and FP5 were EUR 0.4 billion and EUR 0.5 billion, respectively. This investment has continued in Horizon 2020, the EU's current R&I programme with EUR 3.1 billion. Europe should take stock on over 30 years of investment in transnational EU Research and Innovation (R&I) on Sustainable Urban development.

[1] Source: United Nations (World Urbanisation Prospects) and Eurostat

- The report illustrates the need for an integrated Research and Innovation Framework for Sustainable Urban Development to better co-ordinate, streamline and focus the existing and future research and innovation activities and initiatives on urban issues across the R&I arena on cities at EU and Global Level (e.g. across future Framework Programmes).

- The report showcases EU-funded projects that are transforming our cities into European and global R&I actors, dealing with Climate resilience and adaptation, energy efficicency, urban mobility, health and well-being, circular economy and food, social innovation and inclusion. It takes a closer look at facts and figures in the reviewed projects and the impact created to participating stakeholders, cities and citizens, as well as the contribution to city related policies and actions, to the implementation of the Urban Agenda for the EU and the Habitat III new Urban Agenda.

- It is in line with international targets and agreements such as Paris Agreement COP21, 1.5 IPCC report, Sendai framework for the Reduction of Natural Disasters, SET Plan, Sustainable Development Agenda Goals 2030.

- It represents a pilot policy review exercise and assessment of facts, and impact of EU investments related to Sustainable Urban Development though EU FP7 funding to urban/cities related projects. In this respect, the need for multidisciplinarity and creating bridges between different academic disciplines have been addressed by all the research projects reviewed. In some projects the links have been between the natural and the social sciences (e.g.URBES and GREEN SURGE), in others urban researchers worked with climate modellers, practitioners and health specialists (e.g. RAMSES, PREPARED, EUROURHIS2, MEGAPOLI) and engineers worked with IT specialists (e.g. BURBA). In other projects (e.g. WILCO) focus on social innovation and humanities' scientists interacted. All of them connected scientific excellence and social impacts, and worked with urban planners, designers and citizens (to a lesser extent). This demonstrated the need to reinforce the participation of key urban stakeholders, urban planners, city municipalities and citizens in the projects through a co-design, co-creation and co-implemetation approach, using cities as test beds and living labs of proposed tools and solutions.

- The report envisages adaptation as primarily people-centred, meaning that the well-being of the urban population and the rights of vulnerable people have to be respected as critical elements of sustainable cities. Several projects have worked from detailed models useful for city planning, to large-scale assessments, since problems and decision making often takes place on large scales, for instance when dealing with risk assessment and the definition of general guidelines.

- The report highlights that to achieve a sustainable Urban Development in the years to come, we need to unlock the capacity and potential in cities, by enabling action having citizens as key actors. New instruments of urban governance based on strong public-private-people partnerships need to be explored and implemented, in order to facilitate the interplay between science-policy-making, market-driven actions, grassroots initiatives and upscale the deployment of systemic solutions combining nature-based-innovations with technological, digital, cultural, social,governance and financial innovations.

- To make this possible we have to be creative and capitalise on the existing stock of EU funded R&I projects, existing business cases, governance models that cities use and when developing new ones to aim to multi-stakeholder solutions that provide benefits and co-benefits.

- There is also the need to recognize urban knowledge and social diversity as a capital. Acceleration towards Sustainable Urban Development requires engaging with all stakeholders and citizens and capitalising on existing and diverse knowledge in the city-region.

- Cities are to be considered as systems of systems and functional units and not only as administrative boundaries. For instance RAMSES project analysed the impacts on the

cities due to several climatic and non-climatic drivers (e.g., heat to human health; heat to urban comfort; heat to work productivity; flood to traffic disruption or flood to built environment) and assessed the cost and benefits of different adaptation strategies.

- Other projects dealing with air quality and health issues fostered the systemic approach by analysing how the impacts of air pollution created at local scale (1-100 km2) affect to the regional scale (1.000 km2) and to the global (10.000km2) scale. Important conclusions were that ecosystems strengthen the ability of cities to adapt to climate change and accelerate transition to healthier, happier, more sustainable and low-carbon societies.

- Indeed, different policy makers at the international, national, regional and city level provide several examples of how ecosystems offer solutions to many challenges cities face by offering numerous services such as clean air, water filtration, flood prevention, noise reduction, recreation, as well as climate change mitigation and adaptation.For instance the network of cities from very different countries with different health status and different approaches to health provision systems created an important added value through sharing knowledge, establishing benchmarking, delivering innovative training and creating capacities in the less developed health systems of Eastern countries.

- Most of the analysed projects have gone from research, to implementation and to policy. They have delivered indicators, typologies, frameworks, handbooks and guidelines that have been integrated in cities planning and management, supporting the operational working and the policymaking in green infrastructures planning, air quality, emission reduction, water supply and sanitation management, waste management, health indicators, social innovations and climate change adaptation and resilience strategies.

- Several issues addressed by these projects have been the precursors which have promote changes in the policy vision (From FP7 Research Programme to H2020 Research and Innovation Actions). Their outputs have been several years later included in the EU research and innovation policy agenda for city/urban related issues. For instance, some projects (e.g.URBES and GREEN SURGE) positioned the concept of Nature-based solutions and its role in addressing climate change and other environmental challenges faced by cities. Other projects (e.g.WILCO) delivered solid evidences about social innovations by identifying novel views of what was going on cities and the steaming bottom-up initiatives emerging. MEGAPOLI also created a new concept: Integrated Urban Hydrometeorology, Climate and Environment Services that is now considered as an urban cross-cutting issue that integrates joint measuring of meteorology, climate and environmental services in cities and has been taking by the World Meteorological Organization to be applied en several cities in the world. EURO URHIS 2 backed up the inclusion of the health issues in the urban agenda to sustainability, shifting from an urban health agenda to all urban agendas considering health.

- As it was acknowledged in the majority of reviewed projects, city planning is a complex issue involving management of the interconnected socio-economic and environmental characteristics of the city region in a spatial framework. This demands the creation and deployment of multi-stakeholder, cross-sectorial and multi-benefit solutions in a multi-layered framework of governance for securing optimal solutions. Complex and interconnected facets of the urban ecosystem demand systemic and integrated assessment of spatial impacts in terms of socio-economic and environmental indicators in order to secure the essential "win-win" policy co-benefit that are central to the delivery of the transformation agenda adopted by city politicians globally. Policies targeting the socio-economic and environmental dimensions of sustainable development address the global societal challenges driving and defining the urban transition. Integrated assessment is central and essential combined with behavioural change and social innovation to accelerate transition to a sustainable urban development and cities of the future.

- To this aim the required city planning and governance model is based on an integrated assessment of complex urban challenges and the definition of integrated "win-win" solutions allied with a participatory engagement with all stakeholders in the co-production of a spatial plan that defines and delivers the political will necessary to implement the plan transition.

- Clearly the challenge of securing the transformation of an innovative governance process according to an architecture of integrated and participatory governance is substantial. Meeting this, requires harnessing the collective skills of city planners promoting dialogue amongst all stakeholders, including citizens on the most effective solutions for Innovating Cities promoting an enhanced urban governance and planning.

- As also evidenced in the reviewed projects under the social innovation chapter the effort is essential if we are to deliver the climate neutrality policy agenda, as well as all other political goals set by cities in meeting the challenges of urbanisation today. Solving the problems of urban living enabled by a new democratic, transparent and effective urban governance model, also creates a set of solutions that can be applied to the definition, development and delivery of sustainable and connected cities globally.

- As it was acknowledged in the projects reviewed under the 'Climate Adaptation Chapter' and advocated by international city agreements, common global and regional drivers of change (climate change, economic crisis and urbanisation) are defining and generating a shared set of problems in cities throughout the world for which common solutions are evident, taking into account the necessary adaptation to local contexts.

- As highlighted by the majority of reviewed projects the socio-economic architecture of the city-region defined in a territorial context determines the extent to which the cities of Europe positively contribute to Europe's global commitments to mitigate climate change and achieve climate neutrality by reducing greenhouse gas emissions, and deliver on a range of associated policy research and innovation objectives. The overall shape and structure of the city-region, the extent of urban sprawl, the density of population and the dominant mode of transport between homes and work, and recreational and cultural facilities substantially determine the level of greenhouse gas emissions, air quality, energy efficiency, and the health and well-being of both society and the economy. Furthermore, the form of the city-region and its physical connectivity and interaction with its hinterland substantially determines the wider impact of the city on the natural environment, and the conservation or loss of biodiversity. This spatial and multi-layered governance structure of the city-region generates a complexity which can be dealt with only through an integrated and multi-dimensional framework for policy development and implementation.

- According to the projects assessment, urban governance is further complicated by the number and the variety of actors, private and public operating at different territorial levels e.g. Municipalities, Urban-Rural Region, Metropolitan area, City-Region, with various competences e.g. agencies, services providers and objectives. Besides public and semi-public sectors, the policy-making process involves heterogeneous actors from private sector, third sector and citizens. These private sector including firms and companies operate at national e.g. infrastructure providers, regional, city and individual e.g. property development companies, levels of activity. Third sector agencies including NGOs, civil society organisations, non-profit-making organisations e.g. interests groups, ecological associations, neighbourhood committees, are also engaged with a mix of both intensity and territorial focus.

- As a consequence of the various challenges identified above governance, driving the socio-economic and environmental transformations necessary to deliver the sustainable development objectives adopted by the cities of Europe, is confronted with the limitations of the policy instruments that are inadequate to deal with urban complexity. Furthermore, current governance models are insufficiently agile to cope with the entrepreneurial environment encountered, and to respond to the pace of change in demography, societal expectations, and new technological paradigms.

- Transformational and innovative governance seeked solutions in integrated, participatory and multi-level urban governance, an arrangement for making binding decisions that engage a multiplicity of politically independent and interdependent actors, private and public, at different levels of territorial aggregation. Coordination, cooperation, participation and integration are the key principles of the multi-level urban governance approach. Urban governance is particularly characterized by the need for cooperation between a large variety of actors of many domains e.g. utilities, housing, urban planning, health, and the necessity to engage stakeholders e.g. citizens, business, NGO's in the decision-making process.

- In addition to the integration model of governance outlined above, the involvement of civil society and citizens in the decision-making process proved to be essential. For policy-makers and decisions-makers, dialogue with citizens is not only a way to understand society's expectations, and to elicit a qualified demand for innovation, but also to identify barriers and opportunities for transformation, supporting the effective implementation of research and innovation policies related to cities and regions.

- As evidenced by the reviewed projects, to achieve transition towards sustainable cities it is necessary to critically examine institutions e.g. global markets, the scale e.g. district, municipality, city, city-region, region, the values and norms, and daily practices e.g. commuting by car, as well as the characteristics of the place e.g. territorial capital. Change needs to occur at many levels, at small and large scales, and among many stakeholder groups.

- In the area of Climate Adaptation and Resilience, it was evidenced that the business-as-usual scenarios to mitidate the risk of catastrophic effects, could result in substantial economic damages and loss of human lifes. For instance, a businee-as-usual scenario could provoque a considerable loss of agricultural land (e.g. around a third of Addis Ababa's agricultural land and a fifth of its other vegetated areas between 2011 and 2025) took adaptation measures to deal with the unavoidable climate impacts and their economic, environmental and social costs. Climate impacts vary significantly from region to region, and can fluctuate within defined geographical areas. Adaptation and resilience management is therefore required both on a regional and local scale to move towards more resilient communities. Building resilience is about helping communities withstand and recover from disasters, with the focus on tackling the root causes rather than dealing with the consequences. Good planning and preparation can limit the scale of impacts, and risk management policies save lives and enable growth and sustainable development.

- Reliable weather forecasts of the impact of climate change and the risk for the vulnerable urban communitites can be assessed,only through an integrated and systemic approach to societal challenges. In fact, the EU funded project CLUVA suggested cost- effective adaptation measures (e.g. EU project CLUVA for African most vulnerablecities (Saint-Louis in Senegal, Ouagadougou in Burkina Faso, Douala in Cameroun, Dar-es-Salaam in Tanzania and Addis Ababa in Ethiopia). CLUVA provided to planners, managers and researchers concrete solutions by developing Climate Change risk adaptation strategies; risk reduction strategies for the 38 per cent of Africa's population (280 millions); desertification maps to assess the sensitivity to desertification in peri-urban areas; provided an estimate of the impacts of Climate Change on African urban areas in the next 40 years and developed simple methods to be applied by the stakeholders of African cities; downscaled the Intergovernmental Panel on Climate Change (IPCC) scenarios to local urban and urban-rural regions; provided regional projections up to 2050 of climate change at high resolution (8km); conducted the first comprehensive assessment of green structures based on Urban Morphology Type (UMT) characteristics in sub-Saharan African cities; tailored a suite of methods developed in Manchester to the African urban context. For instance, the EU funded project RAMSES delivered a Transition Handbook and Training Package to support cities to define transition pathways towards urban resilience and the necessary adaptation measures.

- It was evidenced that to investigate the vulnerability of cities to Climate Change, an integrated, holistic and multi-stakeholder approach to main impacts should be considered including heat stress and heat waves, pluvial and fluvial flooding, including flash flooding, sea level rise, drought and water stress, snow diminishing, air and water quality, and urban agriculture and biodiversity management. London, Anwerp, Bilbao, Rio De Janeiro, Bogota, Skopje used the set of standardised and transferable guidelines from EU funded project RAMSES for cost-benefit assessment of different climate change impacts and several adaptation measures, tools that are open access and available.

- Under the Disaster risk management chapter, it is highlighted that Flood impacts in urban areas (potential deaths, damage to infrastructure and health problems and their consequent effects on individuals and communities) can be concretely assessed by envisaging different scenarios of relevant drivers: urban development, socio-economic trends and climate changes. New insights for flood management strategies globally were obtained by using differences in urban flooding problems in Asia and in Europe and creating synergies between potentially affected stakeholder communities. European and International institutions need to learn from each other through joint investigation, development, implementation and dissemination of strategies that will permit more scientifically sound management of the consequences of urban flooding in the future.

- To this aim, the latest technologies obtained from the EU projects investigated under this review were cross-fertilised with traditional and emerging approaches to living with floods and novel strategies and measures were applied for improved flood management in cities (Barcelona in Spain, Beijing in China, Dhaka in Bangladesh, Hamburg in Germany, Mumbai in India, Nice in France, and Taipei in Taiwan). The cost-effectiveness of resilience measures and flood risk management strategies was quantified and guidelines for design of urban drainage systems and flood management in Europe and China adopted by local policy makers;developed flood hazard scenarios and prevention policies for implementation of SUDS (Sustainable Drainage Systems);provided evidenced how social resilience can improve flood hazard management; brought together Asian and European stakeholders (involving industry) and contributed to EU Floods Directive by developing urban flood modelling and flood hazard mapping; developed and implemented real-time warning systems in Barcelona and Dhaka; applied the multi-cell model to Beijing City (area more than 1000 km2), and demonstrated it's applicability as it reproduced the observed location for the 21 July 2012 flood, when large parts of Beijing were seriously flooded causing 57 casualties.

- Under the Urban metabolism chapter and in particular for urban water management, it was highlighted that in order to achieve a sustainable, low-carbon water future, without compromising service quality and sustainable planning and management of urban water services, the water supply and distribution, water demand, wastewater and cyclic water recovery and resource recovery have to be addressed all together and in an integrated way and this requires several levels of detail, from long-term to short-term, and from national/regional to local level, in an aligned way. It should take into account not only the economic, social and environmental aspects of sustainability, but also the governance of services, the quality of civil society's information and knowledge, as well as the infrastructure assets. Understanding the metabolism of the urban water systems helps choosing the best options to pave the way towards more sustainable services for city water utilities, decentralised storm water/waste water management and recovery and use of treated wastewater.

- EU funded projects under review (e.g.TRUST) delivered for free tools and e-learning materials - online available to city Municipalities (Amsterdam, Hamburg, Istanbul, Melbourne, Quito) for the assessment of the impact of interventions on the performance gains of the overall urban water cycle; assessment tools of Nature-based solutions and innovative technologies for optimised water treatment, water reclamation for non-potable-use, sustainable water demand and storm water management, energy-saving options and water-energy interventions; mobile and software tools for

infrastructure asset management, helping city utilities to perform targeted rehabilitation of infrastructures and to reduce leakage in water distribution systems.

- EU Reseach contributed to the goals of the European Innovation Platform on Water (EIP Water Action Group) and to the Urban Water Atlas for Europe by sharing best practices, creating awareness among cities and networking synergies. EU Research on integrated waste management successfully delivered new concepts of waste service through the entire chain from production to disposal, based on handling of data from waste management. For instance, the EU funded project BURBA delivered information that contributed to city sustainability improving the efficiency of waste management and recycling activities, through a systemic and multi-stakeholder approach, with the direct involvemenbt of end-users for each sector to define their requirements for the adequate design of the systems and to deliver outputs adapted to their needs. Actors such as research centres, technology-provider companies, water utilities, and waste management companies worked with urban planners to deliver an integrated analysis of the problems and risk management options, and to propose adapted solutions. The projects addressed problems faced by each of these sectors especially in scenarios of climate change where cities need to reduce their emissions, and also to be prepared for challenges, such as water shortage, heat stress, flooding, and waste recycling.The networks of end-users and cities created an important added value through sharing knowledge, incorporating solutions already tested in other areas, and broadening the options of impact.

- In the area of Sustainable Land Use and Nature Based Solutions it was highlighted that in the EU, 'land take' consumes more than 1,000 km² of land every year in development for housing, industry, roads or recreational purposes. About half of this surface is 'sealed', for other unsustainable land use patterns irreversibly eroded, or degraded through soil contamination or by reduction of organic matter. This 'land take' threatens security of food supply, health and more generally loss of natural capital and ecosystem services including clean air, water and soil, adaptation to climate change and mitigation of natural disaster risks. It has been recognised that nature-based solutions can help provide viable solutions that use and deploy the properties of natural ecosystems. These nature-based solutions provide sustainable, cost-effective, multi-purpose and flexible alternatives for various objectives.

- Working with nature, rather than against it, can further pave the way towards a more resource efficient, competitive and greener economy. It can also help to create new jobs and economic growth, through the manufacture and delivery of new products and services, which enhance the natural capital rather than deplete it. The reviewed projects analysed the systemic influences of green spaces as key and multifunctional assets for cities that need to be included in the urban planning due to the roles they play in citizens' life (welfare, health, aesthetic), but also to face challenges like climate change, energy efficiency, food security, etc. For instance, Barcelona's 161.423 trees not only reduce the local temperature and energy demand. They offer habitats for urban wildlife and store CO2 and play an important role in filtering harmful substances from the air. It is estimated that, they offset around 19,000 net tonnes of CO2 from the atmosphere, and eliminated slightly more than 305 tonnes of air pollutants. Some projects (e.g.GREEN SURGE) have been developed and implemented through integrative, iterative and transdisciplinary processes, building bridges between disciplines such as environmental modeling, urban planning and governance, economic valuation and sociocultural studies at a European-wide scale. Transdisciplinary outcomes have been fostered, providing sound relations between science, policy and practice.

- Green and water areas evidenced a clear spatial pattern that overlapped with social but also health-related patterns of overweight in children. Sub-districts with a relatively large proportion of natural space cover also show low percentages of children being overweight or living in single parent households. The results from the spatial distribution of sub-districts are, however, not conclusive as to whether natural space cover or natural space per capita is the most appropriate variable to use to indicate health and inequalities.

- In view of the increasing rate of land take for new buildings and infrastructures all across Europe, soil has been recognised as a scarce and non-renewable resource, stressing the need for more efficient land use and innovation in land management. Brownfield regeneration is a multi-dimensional issue, which has to be addressed referring to a variety of problems: scarce water resources, environmental and health risks, as well as economic and social costs for local communities. However, Brownfield regeneration can also be an opportunity to make a step beyond, towards urban resilience and energy transition.

- Starting from these considerations, the EU funded projects HOMBRE and TIMBRE offered a broad definition of nature-based BF regeneration in urban planning, management and design processes; environmental, social and economic assessment; integrated solutions for BFs characterization and remediation, towards a zero BF perspective. For example, in the case of the EU funded project HOMBRE, case study Municipalities took up the project overall approach and the use of the decision support system. In particular, the Municipality of Solec Kujawski adopted the Zero Brownfield approach as an extension to policies the City had already started to implement, encouraged by project experience to mobilise financial resources to assess remediation options and redevelopment opportunities for the BF area. The Municipality of Terni added HOMBRE experiences into its approach to regeneration; stakeholders expressed interest in the Brownfield Navigator and its updating and customisation, as a means of communication and supporting design strategies for regeneration, and as a way of keeping up to date with practice across Europe. Municipalities of Utrecht and Rotterdam implemented the concept of the land use cycle in the research of the subsurface. This integrated scientific and technical perspective, was achieved through a systemic and multi-stakeholder approach (where researchers, public authorities and SMEs providing industrial products and technical services were represented), with the testing and customisation of project results in case studies, through the engagement of local stakeholder, in particular policy makers and developers.

- On one hand, innovative technology combinations (Technology Trains) showed how to connect aquifer thermal energy storage with groundwater bioremediation, convert the contaminated soil and demolition waste into construction materials to be used on site, and reinforce unstable soils through the removal of contaminants from groundwater. On the other hand, a focus on Intermediate and Soft Re-use technology solutions shows how BF remediation can offer the opportunity to develop green open space networks in densely built urban areas, and to generate renewable energy through non-food biomass production.

- According to HOMBRE project conclusions, Europe's urban BF sites are valuable resources and Urban land use decision should be expected to deliver a clear "return of investment". Understanding urban systems in terms of their environmental, social, economic and governance performance is an essential part of sustainable urban land management.

- The URBES, GREEN SURGE projects considered cities as social-ecological-technological systems and analysed the links between nature and urbanisation in urban spaces , where the different dimensions must be connected and careful planning of all is essential to address sustainability. The projects broadened the approach of urban planning by including the ecological dimension. Nature provides ecosystem services to sustain life, human welfare, health, security, and social relations, but also assists in addressing some of the most pressing societal challenges, such as climate change, air quality, water, food security, social inclusion and green economy.

- All EU funded projects with same context as the above two projects positioned urban biodiversity and ecosystem services as key assets supporting European cities to adapt to climate change, to provide urban ecosystem services that enhance human welfare and to reduce cities' ecological footprints. The concept of biocultural diversity was adapted to urban areas, stressing the connections between nature and people in cities. Biocultural diversity represents a new way of thinking about biodiversity conservation by looking at culturally significant and valued biodiversity and by identifying cultural

expressions of nature with local communities. The research identified indicators and typologies of urban green infrastructures that provide nature-based solutions and ecosystem services and contribute to human wellbeing and climate change resilience.

- Solutions were incorporated in the biodiversity and green infrastructure planning of several major cities including Berlin, Barcelona, Rotterdam and New York. The projects analysed the systemic influences of green spaces as key and multi-functional assets for cities to be incorporated in urban planning process as critical elements for citizens welfare, health, and aesthetic), and also to address challenges of climate change, energy efficiency, food security, etc.

- The projects' results emphasized the relevance of nature-based solutions (NBS) and urban green infrastructures to address climate change impacts (local climate regulation and cooling, flood prevention, cost-effectiveness), as an emerging urban planning paradigm, as well as a relevant market opportunity. For instance, investments in nature-based solutions offer a valuable return for cities and urban areas: A 10% increase in tree canopy cover may result in a 3-4°C decrease in ambient temperature and save large amounts of energy used in cooling buildings. In addition, there are multiple other benefits as urban green spaces contribute to filtering dust, storing CO2, serving as windbreaks, etc.

- Policy impact from these reviewed projects is evident as results were not only used in the biodiversity and infrastructures planning of cities like Barcelona, Berlin, New York,Rotterdam, Malmö, Ljubljana, but at the global level, their City Biodiversity Outlook contributed to the UN Habitat III New Urban Agenda and to support the inclusion of a goal for sustainable cities (SDG11) in the Sustainable Development Goals Agenda.

- URBES and GREEN SURGE positioned urban green spaces and infrastructures at different levels. At the city level, urban plans are backed up by project results, including:2020 Barcelona Green Infrastructure and Biodiversity Strategy;PlaNYC (New York City's 20-year Economic and Environmental Sustainability Plan);Berlin and Rotterdam planning of green infrastructure planning;Malmö integrated green-grey infrastructure for stormwater management and the retrofitting of the housing area of Augustenborg, as part of Malmö Water Plan;Lisbon Action Plan for Biodiversity in 2015 including a landscape mosaic fostering biodiversity. At the European level, the results fed the EU Green Infrastructure Strategy, the EU Urban Agenda, the EU 2030 Energy and Climate Package, the EU 2020 EU Biodiversity Strategy and the Thematic Strategy on the Urban Environment.

- In the Resource Efficiency and Circular Economy chapter it was highlighted that**,** today in the EU, each person consumes around 16 tonnes of materials annually, of which 6 tonnes are wasted, with half going to landfill, and this even as raw material and mineral prices are rising. Measures such as better eco-design and reuse can bring EU wide net savings of up to 604 billion euros or 8% of their annual turnover to businesses.

- Resource efficiency is essential if we aim to deliver greater value with less input, use resources in a sustainable way, and if we consider waste as a resource to be fed back into the economy as a raw material. Resource efficiency is one of the core elements necessary to create a green economy in Europe and further afield, alongside waste prevention and , and more sustainable production and consumption patterns.

- Cities are essential actors of open innovation to provide the conditions to stimulate the circular economy and increase ressource-efficiency, decoupling growth from natural resources consumption and degradation. An integrated and systemic approach to societal challenges is needed with active stakeholder engagement in the design, development and deployment of solutions to create evidence base for decision-making by cities towards Innovative, resilient, safe, healthy and inclusive cities.

- During the last decades scientific evidence has shown that, in the affluent world, patterns of consumption and production based on intensive resource use and increasing Greenhouse Gas Emissions are leading to rising resource scarcity, loss of biodiversity

and climate change, with numerous and disastrous effects. Materialistic lifestyles have failed to deliver wellbeing, as evidenced by indicators of physical and mental health, happiness and subjective perceptions of life satisfaction.

- Furthermore, the recent economic crisis has led to a deep recession in many parts of Europe and highlighted the need for a profound transformation of our economic and governance institutions in a direction that is smart, sustainable and inclusive. Finding the appropriate pathways to sustainable change has therefore become a priority for European citizens and policy-makers.

- Resource efficiency and the circular economy was the broad focus of several FP7 funded projects including Foodmetres and Supurbfood (working on sustainable local food chains), Pocacito (working on the transition of cities to post-carbon models), and Urban Nexus, Bridge and SUME (on informed decision and policy making with a focus on resource-efficiency).

- The impact of European Rural Development Policies (RDP) on sustainability was measured through policy tools in the Metropolitan Agro-food System of the city regions and on the Short Food Chains Typologies (urban garden, direct sale, AgroPark, etc.). The findings and tools help local administrators to adapt the RDP in order to respond to the needs of local stakeholders and (public bodies, farmers, consumers, associations, etc.). The tool also provides relevant information for European politicians about the impact of RDP on Local Short Food Chains in urban and metropolitan contexts.

- In terms of short food chains, the research demonstrated that the new Rural Development Programme (RDP) of the Common Agricultural Policy should include new areas like metropolitan regions and new groups, not only farmers. The RDP should consider and support new food chain models, particularly short food chains, which benefit from a great interest in civil society.

- It was also highlighted (e.g. EU project POCACITO) that sustainable transition towards liveable, affordable and prospering cities was achieved through participatory approaches that engaged local stakeholders through workshops in ten European cities (Barcelona, Copenhagen, Istanbul, Lisbon, Litoměřice, Milan, Turin, Rostock, Malmö and Zagreb) to create custom-made transition post-carbon strategies.These strategies were then taken as the basis for an evidence-based EU 2050 Roadmap, a stakeholder-driven guide towards the model "Post-Carbon City of Tomorrow" that merges climate, energy and social urban transitions.

- Economic indicators focused on sustainable economic growth based on the wealth of the cities and their inhabitants. In this sense, factors taken into account included labour market, life of the companies, public finances as well as the research and development expenditure as no city can become a post-carbon city without innovation. Finally, the social dimension covered standards of living related to education and health (for example, life expectancy and wellbeing), unemployment rates and poverty, public services and infrastructures, governance and civic society, culture and community.

- EU Research findings outlined not only visions for post-carbon cities, but also created new insights concerning barriers, challenges and delivered key recommendations directed at national and European Union (EU) policymakers, as well as city-level decision makers. A multi-stakeholder approach is promote s and advocates its widespread use, not only to develop strategies, but to connect citizens with the future and place them clearly on the path to decarbonisation, changing them from takers of policy into shapers of the urban decision-making process.

- Post-carbon visions were evaluated by Pocacito and in particular the long-term impact of the post-carbon vision (PC 2050 scenario) and of the strategies being already implemented at local levels (Business as Usual scenario). A semi-quantitative/qualitative indicator approach showed that nearly all cities will improve under Business As Usual scenarios for most indicators, but the performance is significantly improved under Post Carbon Cities 2050 scenarios. The analysis of the production based Greenhouse Gas emissions shows that most cities approach carbon

neutrality under PC2050 but will not fully achieve it, with only 3 cities being below 1 tCO2eq/capita/year.

- A benefit-cost analysis compared the reduced cost burden due to premature deaths from air pollution with investment costs for renewable energy and energy efficiency. It shows that under PC2050 the cost-benefits of reduced air pollution more than compensate for the investment costs. Investment costs are typically less than 1% of cumulative Gross Domestic Product from 2018 to 2050. According to Pocacito, public policies need to address not only immediate and concerted action on energy efficiency and localised renewable energy but the value of green space and the disparity between rich and poor if future cities are to be liveable, healthy and carbon neutral places. Although no direct policy implication in the cities was achieved, the project contributed to raising the attention and provided with the local roadmaps an input for future policy debates.

- Other useful conclusions with regard to urban planning and development, based on SUME project, highlighted that the spatial expansion of fastest growing agglomerations like Munich, Stockholm and Vienna can be greatly reduced by 2050 to 13%, 20% and 14% respectively. Similarly the energy demand can be reduced by 60% to 80%, varying between cities and scenarios. In general, a SUME-scenario-type agglomeration development will reduce energy consumption between 10% and 40% by the year 2050 compared to the BASE scenario. A higher replacement or renovation rate of buildings and a better spatial focus of new developments with respect to public transport accessibility will reduce energy consumption by 30 to 40%. The main conclusion of the SUME was that the greatest potentials for saving energy – and the most relevant for policymakers – can be identified as the replacement of old building stock and the avoidance of urban expansion.

- In the Air Quality and Health chapter, it was evidenced that globally our climate is changing due to anthropogenic activity; urban areas are at a particularly high risk. However urban areas are also responsible for producing more than 70 % of the greenhouse gas (GHG) emissions which are changing the climate. Furthermore, urban road traffic alone contributes about 10% of all European carbon dioxide emissions, and at the same time is responsible for poor air equality in many European cities. As a consequence when developing and implementing new sustainable development policies for our cities, it is vital to consider the effects on emissions of both greenhouse gases (GHG) and air pollutants. In many cases, implementing one policy strategy may reduce GHG emissions but instead increase emissions of air pollutants, bringing with them ill-effects on health and wellbeing.

- Research delivered integrated methodologies to assess the impacts of pollution within, and from megacities to global scales; assessed the feedbacks and interlinkages between air quality and climate change in megacities at urban, regional and global scales; delivered outputs that link city emissions and pollution with health, e.g. calculating the impact of pollution on DALY (disability adjusted life years); produced information on long-range transport and regional pollution, baseline scenarios and measures for improving air quality and climate change impacts in megacities.

- The reviewed projects (e.g. MEGAPOLI) investigated the interactions among megacities emissions, air quality and climate, bridging spatial and temporal scales that connect local emissions, air quality and weather with global atmospheric chemistry and climate, to provide information on the effects on regional and global climate. Specific challenges of health issues in urban areas, such as internationalisation of metropolitan regions, ageing populations, migration and poor environmental factors were addressed (e.g. EURO-URHIS 2 addressing urban health analysis and PURGE examining the health impacts of greenhouse gas (GHG) reduction policies in urban settings in Europe, China and India).

- EU megacities or conurbations (e.g. London, Paris, the Rhine-Ruhr region and the Po Valley) were researched in-depth, but also including Moscow and Istanbul as European megacities. Finally, extended simulations and satellite analysis for all the megacities in

the world have been developed. The EU researchers worked with end-users (air quality monitoring facilities) and research centres from all these cities.

- Different results of MEGAPOLI have been incorporated in the air quality monitoring and emission reduction strategies of megacities in China, Mexico, several African cities (e.g., Accra, Cairo). At the European level, they influenced the EC Air Quality Policy (Air Quality Directive (2008/50/EC) and the National Emission Ceilings (NEC). The results have also been used for urban planning by the World Meteorological Organization, the World Bank and the OECD.MEGAPOLI collaborated with the World Meteorological Organization and with end-users such as air quality monitoring facilities in various countries e.g. France, UK, Italy, Germany, Mexico, India, etc., environmental agencies and regional meteorological centres in China, Russia, USA, etc and attracted research centres and end-users from all over the world.

- In the "Energy Transition Including Energy Efficient Buildings" chapter, the Building Automation Systems and Building Energy Management Systems, were discussed and highlighted the benefits from using already available concepts to improve indoor climate and energy efficiency combined with the innovative windows.

- The concept of a retrofit Investment Calculator (developed under the EFFESUS project) within a Sustainable Community Business Model for Santiago de Compostela demonstrated that sufficient resources generate renewable energy for the whole city and provide 100% renewable energy to the historic centre to achieve a carbon neutral sustainable future. A retained surplus of 12.09 million€ in 10 years is enough to repay loans (13M €) and investors, or to continue investing in more projects to achieve 100% renewable energy production more quickly.

- A district retrofitting approach to energy retrofitting is frequently the most sustainable and cost-effective strategy. However, the complexity of decision-making grows exponentially when the scale of the intervention increases. In order to reduce the complexity of district interventions, EFFESUS, ECODISTR-ICT and FASUDIR developed decision support tools to be applied at district level, with EFFESUS particularly focused in the inefficient-use of energy in historic districts (buildings pre-1945). CETIEB's challenge was to assure an adequate indoor environment quality in retrofitted energy efficient buildings at an affordable cost.

- The positive impact in urban design and renovation of historic cities was demonstrated by EFFESUS athrough the development of a Decision Support System (DSS) implemented in Santiago de Compostela (Spain), Visby (Sweden) and Genoa (Italy). The DSS provided evidence for decision making by the cities based on both its direct positive impacts (economic, cultural heritage, energy consumptions and environmental) and the interest of the municipality and citizens. EFFESUS methofologies were tested and successfully applied in four buildings in Old Town Santiago de Compostela: Rua Nova 22, Rua Nova 46, Toural 3, Caldeireira 34.

- EFFESUS DSS and proposed solutions achieved a reduction of energy demand of 45% up to 72% for heritage protection degree 3-4; reduction of CO2 emission of 91% up to 95% for heritage protection degrees 3-4; savings of 2.369.972,66€.

- Finally, the retrofit Investment Calculator which developed within a Sustainable Community Business Model for the citizens of Santiago de Compostela demonstrated that there are sufficient resources to generate renewable energy for the whole city and provide 100% renewable energy to the historic centre to achieve a carbon neutral sustainable future. A retained surplus of 12.09 million€ in 10 years is enough to repay loans (13M €) and investors, or to continue investing in more projects to achieve 100% renewable energy production for Santiago more quickly.

- In the Urban Mobility chapter, it was highlighted that:

- Sustainable Urban mobility R&I can succesfully address the societal challenges of air pollution and quality of life by stimulating healthier lifestyles (promotion of cycling, jogging and walking), improving the environmental conditions (promotion of cleaner

and more efficient alternatives of transportation), reducing congestion (reduction of the number of private vehicles), improving transportation security (improvement of infrastructures and introduction of new technologies), and increasing social inclusion (extension of Public Transport services to remote areas and improving first-mile/last-mile connectivity). In particular air Quality policy scenarios in relation to urban mobility (e.g. coming from URGENCHE) showed marginal additional health benefits, with an example of a potential 1.5 million euros saved from total costs of 33 million per year caused by PM2.5 exposure in one EU city contemplating moves to biomass in combined heat and power, bio-fuels in transport and improvements to buildings insulation. Well-being effects of the policy scenarios were found to be positive but were generally expressed less strongly than health benefits. In China, the impact of all scenarios on air quality was found to be negligible compared to that of ongoing economic development. However, as an example of other work carried out there, a Chinese survey on well-being indicated the importance given by local people to health, social life and safety, with implications noted for policy development for healthcare and communities.

- The mobility policy implications of the case studies in the European and Chinese cities on air quality and noise showed that more stringent CO2 emission standards (zero-emission) for road traffic is the most effective measure to reduce CO2 emissions from urban road traffic. This requires action at the level of the European Union and the central Chinese Government, and is beyond the control of local authorities.

- Support, facilitation and stimulation of physical (cycling, walking) and public transport provide the most effective local policies to reduce CO2 emissions and improve air quality, health and well-being. These measures and local transport policies are within the control of local authorities.

- In the Social Cohesion, Well-being and Diversity Chapter, it was highlighted that social innovations are not only innovations in social services, but also changes in rules and regulations (e.g. concerning the access to financial benefits) and in governance (forms of democracy and decision making on priorities in welfare and cohesion politics).

- Social innovation in cities is not a disconnected phenomenon, but an element in the traditional European welfare system that is differently expressed according to the particular socio-economic models and the specific national and local cultures. Most social innovations do not fit a pattern of growth and upscaling nor are easily translated to other contexts. They emerge in specific contexts, to address existing needs and do not aim to wider diffusion or upscaling.

- Social Innovation and Citizen Science are both an enabler of open innovation and can involve citizens 'doing science', for example, through crowdsourcing, as well as involving the public engaging in policy-making through, for example, agenda-setting for research systems. These are typified by 'gathering data', 'analysing data' and 'co-production of knowledge'. Citizen science also involves greater understanding of science by the public madeood to possible through greater access to information about the research process such as the ability to use open research data or download open access journal articles. Citizen science may also refer to the ability of the public to understand science and engage with scientists, through more 'open' communication in the form of blogs and social media. Overall this framework highlights the importance of contributions from people who might not be considered scientific experts, but do have specialist knowledge of particular habitats and skills, particularly in relation to local environments, addressing societal challenges.

- In the Social Innovation and Citizens Science chapter, the development of sensor-based Citizens' Observatory Communities was acknowledged for improving quality of life in cities, notably focusing on air and noise pollution. It also supported the empowerment of citizens and multiple stakeholderes (e.g. from Academia, Public and Private Sector, NGOs, Civil Society) to influence their community policy and decision-making. Several business models and barriers to citizens' involvement were developed and analysed, such as the Personal Air Monitoring Toolkit, tools for remote sensing, and mobile

apps.Thanks to EU funded projects, Local Authorities were supplied with comparability of measurements across Europe, standardized methods and comprehensive quality control and assurance systems.

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Today, more than half of the world's population lives in urban areas and this is expected to rise to just over 80 % by 2050 (Source: United Nations (World Urbanisation Prospects) and Eurostat). In addition to demographic growth, cities and metropolitan regions are centres of economic activities and increased resource consumption. Cities are the home of complex, inter-linked challenges related to climate change, pollution, energy efficiency, urban mobility, water, waste, food and resource efficiency, health and well-being and social innovation. Cities are key actors for meeting the targets set out by international frameworks.

For 30 years, Europe has been investing in transnational EU research and innovation on urban-systems-related issues, with providing financing from the Framework Programmes FP5, FP6 and FP7 of €2.8 billion and even in Horizon 2020: €3.1 billion. Horizon Europe plans to continue similarly to invest in these issues. For this, we need to take stock of where we are and what are the options we have for the future.

This report capitalizes on 30 years of successful EU-funded research on sustainable urban development. It relies on the analysis of a critical mass of inspiring knowledge, ideas and best practices coming from 41 projects funded under the Seventh Framework Programme (FP7) across the different thematic priorities. It showcases and provides an EU-wide evidence base of the outstanding contributions of EU funded research and innovation in meeting urban societal challenges, notably those supported by the FP7 Research Framework Programme which deploy a citizen-centric, systemic and integrated analysis of the urban ecosystem. The report highlights the need for integrated policy research solutions to the societal challenges that generate policy benefits and co-benefits simultaneously delivering socio-economic and environmental political objectives for regional, local city authorities, civil society, political representatives, the private sector and industry.

The report spreads expertise across Europe and paves the way to future European cities being climate-proof, resource-efficient, smart as well as more resilient, healthy, inclusive, prosperous, safe and sustainable and contributes to the European Green Deal to make Europe the first climate-neutral continent.

Research and Innovation policy

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