



How Smart Cities can help to fight climate crisis

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Altogether more than 524.000 people died worldwide as a direct result of extreme weather events between 1997 and 2016, and economic losses of US\$ 3.16 trillion were incurred in the same period. These devastating figures related to climate change, have pushed the adoption of measures and international compromises, such as Paris Agreement, of states all over the world to fight climate change and implement environmentally friendly and sustainable strategies, which will lead into a lower environmental impact. International experts consider that if measures are taken and implemented urgently the climate change's effects might be limited.

For the first time in history, over the half of world's population lives in cities. It is expected that the inhabitants in cities rise up to the 70% by 2050. Today, cities consume approximately the 75% of world's energy and generate almost the 70% of the CO₂ global emissions. The abrupt increase of population in urban areas will contribute to increase the demand of infrastructures and services provided by both, public and private sector, generating new business opportunities. Along with these opportunities, our political leaders face the challenge of designing the cities of the future.

Traffic jams, pollution and abandoned areas are some of the main problems that must be solved in this era of cities. Basic commodities such as water supplies, electricity or urban mobility must be rethought in order to identify clean, green and environmentally respectful alternatives that will help, on one side, to fight against climate change and, on the other side, to foster competitive and socially inclusive urban environments.

The Public Administrations cannot face the fight against climate change alone and the cause needs the involvement of all the different stakeholders implicated: political stakeholders, Administrations, companies and citizens. Although every citizen in the globe must fight climate change individually, it is important to foster joint actions and policies from the main decision centres.

In addition, the impact of technological megatrends and their impact in the fight against climate change must be analysed. Trends such as Internet of Things or Artificial Intelligence are changing abruptly the way of managing energy or mobility within smart cities. Smart meters, smart grids and connected and electric shared vehicles are totally modifying life and well-being models for citizens.



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A global view regarding climate change

The fact that the climate is changing among the world is undeniable in the 21st Century. The scientific community has concluded that the impact of the economic activity carried out by humans affects directly on the pollution of the air and oceans, being directly related with the climate change and the global warming of the Earth¹.

Recently, some of the consequences that the climate change has brought to certain areas in the world have already been discovered, being especially remarkable the case study of Jakarta, capital city of Indonesia. The sinking of Jakarta, due to the sea level rise, has already forced some of the citizens to leave the city, being, along with Bangladesh and several islands in Oceania, the cause for which the term “climate refugees” was forged.

As mentioned, some of the consequences that the climate change brings are already being visible and noticeable in certain areas. For instance, there are locations, which are already suffering from climate changes, such as desertification, sunk lands that are located above the sea level, etc.

In addition, the most recent data and research carried out by climate experts show that the climate change will become a global issue if we do not take action in the short term².

As far as it concerns to the Civil Sector, most of the international organizations and the Governments are defining strategic plans in order to face this situation and approach it in a non-reversible way. In this sense, it is worth to mention the Paris Agreement, which, for the very first time in history, achieved the agreement between different countries. Thanks to this agreement and political compromise, all of the countries in the globe acquired the same commitment, without making differences between developed and undeveloped countries. This has shown the world’s population that the climate change affects all of us equally and it must be faced with a common and joint approach.

At European level, the new European Commission has proposed the achievement of a European Green Deal, which will have to, at least, stand to the criteria agreed on the Paris Agreement, because all of the Member States took part on it. Although the content of this deal is still

¹ (Greenpeace, 2009)

² (Matthew T. Ballew, 2019)

unknown, it is supposed to be based on and the introduction of new taxes related to products and services that can affect the climate change.

Less developed countries suffer more from climate change than industrialized countries

Contrary to what could be thought, less developed countries are generally more affected by climate change than industrialized countries, according to the Global Climate Risk Index 2018. In this sense, a red flag has been risen by researchers and experts, appointing that the already existing vulnerability of certain regions may increase in the future, when extreme eventualities will become more frequent and more severe due to the climate change.

Table 1. The 10 most affected countries by Climate Change in 2016

1	Haiti
2	Zimbabwe
3	Fiji
4	Sri Lanka
5	Vietnam
6	India
7	Chinese Taipei
8	Former Yugoslav Republic of Macedonia
9	Bolivia
10	United States of America

Haiti, for example, was severely devastated by two hurricanes in 2016, which affected over one million people³. Zimbabwe, for instance, held extreme droughts associated to El Niño, which caused record-breaking heatwaves and acute agricultural losses⁴.

The appearance of a European country among the most affected countries can be attributed to an extraordinary number of fatalities. Although some of the developed countries are sometimes hit by extreme events, this situation is more exceptional.

³ Information provided by the Federation of the Red Cross and Red Crescent Societies

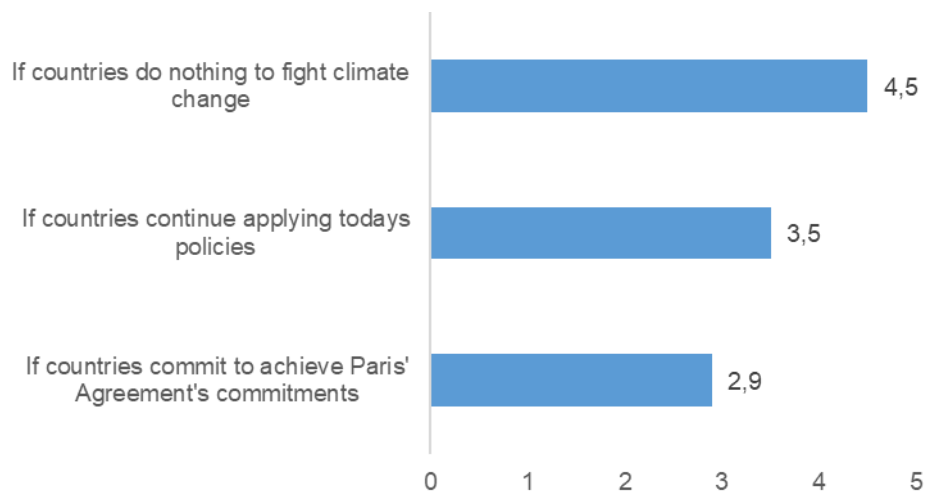
⁴ Food and Agriculture Organisation of the United Nations, 2016

In relative terms, **the climate change effects hit poorer developing and less industrialized countries harder**. Poor countries are therefore more vulnerable to climatic risks than richer countries, although monetary losses are much higher in richer countries when a climatic risk materializes.

The Earth's global temperature will rise 4° Celsius by 2100

Among the last years, experts and scientists have been redefining what a secure warming of the Earth could be, in order to be sustainable and assure the continuance of life, as we understand it today. These experts maintain that the global warming should not increase more than 2° Celsius before 2100.

Illustration 1. Degrees Celsius in which global warming will rise in the 2018-2100 period depending on the policies implemented by countries



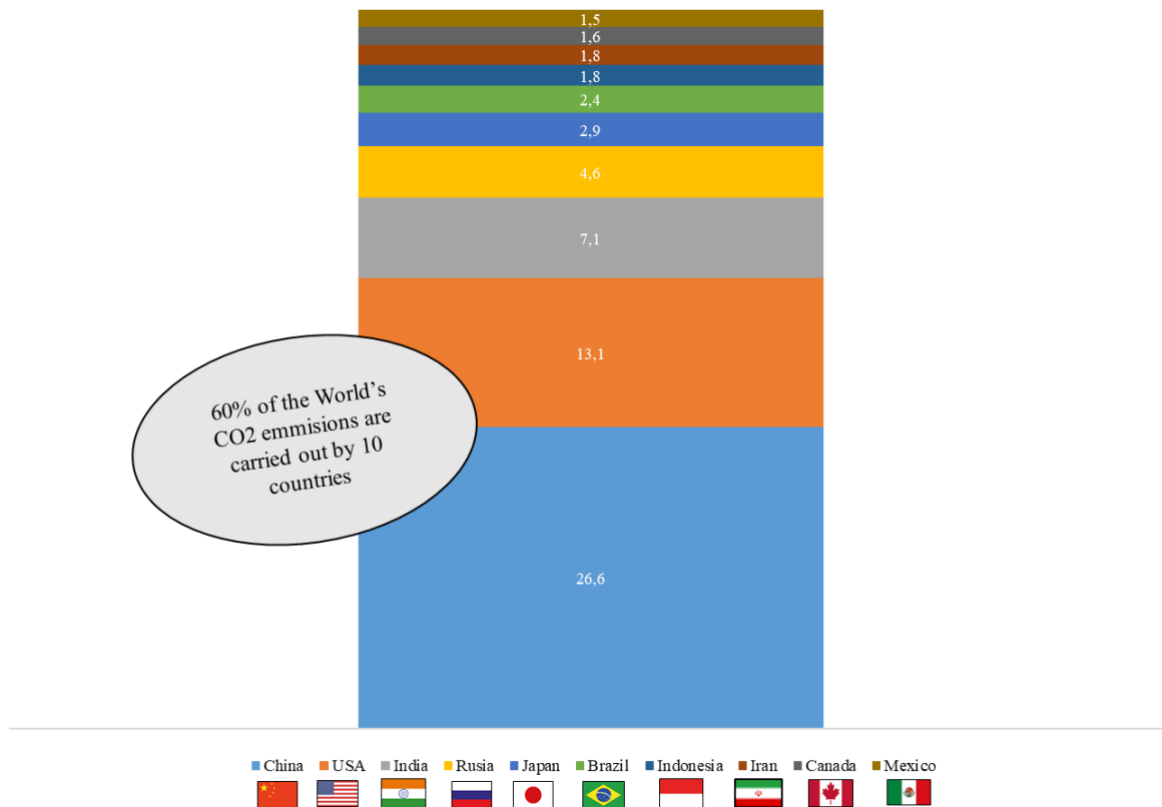
Source: Climate Action Tracker

As it can be noticed in the chart above, the situation is challenging and if drastic measures are not taken soon, the Earth will not be able to recover. In this regard, the agreement of Paris, to which all the member states of the United Nations committed, establishes a limit of 2° Celsius to be increased up to 2050, and pursue efforts in order to maintain the levels below a temperature or heat increase of the 1,5°, if possible.

The 60% of world's CO2 emissions are carried out by 10 countries

Although China and the United States of America are liable of the 40% of the world’s CO2 emissions, this percentage reaches the 60% only taking into account the world’s most polluting ten countries.

Illustration 2. Distribution of the 60% of CO2 emissions of the World by countries



Source: EC Joint Research Centre/PBL Netherlands Environmental Assessment Agency

In this regard, also, the Paris Agreement establishes the commitment of decreasing global emissions by 45% by 2030 (compared to 2010 levels).

What is next for international resilience policy?

The great success of diplomacy which ended with the adoption of the 2015 Paris Agreement by all the member states of the United Nations (hereinafter, UN) is the core policy of the international resilience to face climate change.

The resilience agenda to be adopted includes a rulebook that will help to implement Paris Agreement in every country and a new five year strategic work plan to fight loss and damages caused by climate change.

Decarbonisation: Transition to sustainable mobility and cleaner fuels

The decarbonisation of energy systems plays a key role as a solution to face climate change effects. Although in the last years there has been a stable decrease of the carbon dioxide emissions, there has been a slight increase in 2018, mainly due to a growth in the primary energy demand of fossil fuels (petrol or coal, for instance).

Nevertheless, there are encouraging signs that a global energy transition is under way. In 2017, the world faced the most important increase in the generation of renewable energies, representing solar energy generation alone more than the net additions of coal, gas and nuclear combined.

Emerging economies as well as developing countries continue to play an increasingly crucial role in the global energy transition with Asia, accounting for 64% of new capacity of generating renewable energies in 2017.

Improving a supportive and transparent policy framework will be key to maintain the positive developments in renewable energies and to exploit the full spectrum of renewable energy potential.

Urban areas are also in risk

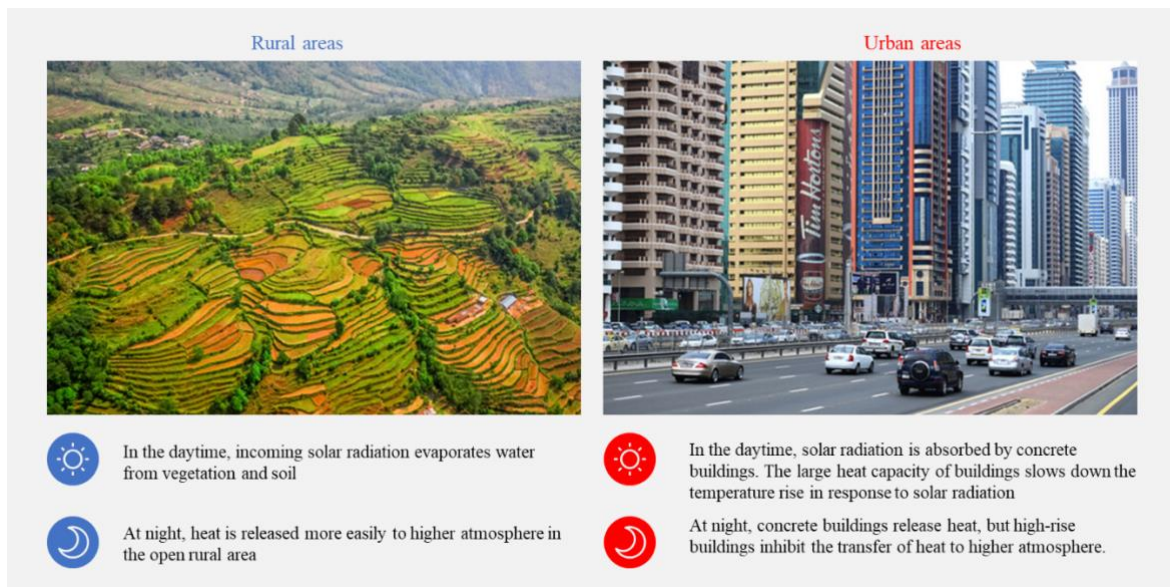
Nowadays, cities attract over half of the world's population and this proportion will continue increasing, not only because of the migration of citizens from rural areas, but also due to the increase of the population.

During the next 25 years, world's population will increase from the actual 7.300 million, up to 9.500 million, and urban population will represent the 66% of its. Europe's situation is even more drastic, with a projection of the 85% of the population being urban by 2050.

The concentration of population in urban areas, consequence mainly of the efficiencies arising of the sharing of resources, will directly contribute to the centralization and urbanisation of the political power, economic forces, workforce and even culture, which inevitably leads to the increase of urban population and the broad development of cities.

⁵ Smart Cities – Documento de Visión 2030. ICI (Grupo Interplataformas de Ciudades Inteligentes) 2017

Urban development, including the change of land uses from agriculture to industry or living, the more dense building developments, heat emissions related to the activity, etc. has a great impact in the local climate of the cities. The main effect is known as Urban Heat Island effect (hereinafter, UHI effect) which implies slower cooling rates in urban than in rural areas.



In order to sustain all the activity carried out in cities, energy is required. This implies, only in Europe, the 70% of energy consumption and over the 75% of the emission of CO₂ to the atmosphere. Therefore, working in the optimisation of the energetic consumption in cities has become one of the main challenges for politicians.

Additionally, in a broader sense, cities must face the climate change challenge though the implementation of measures related to circular economy, mainly meaning the re-using of resources, recycling and optimizing the logistics related to the movement of citizens and goods, which will have a direct impact in the living standards of the urban population.

Long story short, the need of reaction to ensure the existence of the Earth, as we know it, shows us some of the challenges that all of the countries will have to face in order to reduce their impact on the Earth, and tackle the climate change. Therefore, in the next pages the most facing challenges related to climate change will be explained.

High consumption of resources

The fact that the 7.7 billion people living on the Earth nowadays are consuming more resources than the Earth can provide has become undeniable. On the current situation, the human being is using the resources of 1.7 Earths, and it is estimated that by 2050 this consumption level will reach up to three Earths per year⁶.

The increasing consumption levels have brought us to a situation where the earth is reliant of its finite resources. The levels of consumption of fossil fuels, iron and other kind of metals and minerals are lower than ever, according to the United Nation's International Resources Panel analysis carried out in yearly basis. The consumption rates are directly related with the birth rate, which has also globally shown a rising trend, adding more consumers to the global sum and making resources run out faster.

On the other hand, the consumption of renewable resources such as timber, water or vegetable and animal food is not granted either. The consumption rate is almost the double of the replacement capacity that the Earth shows currently, and the United Nation's International Resources Panel has projected that the rate regarding resource use per person will reach up to 71 per cent in 2050.

This idea leads us to the concept of overconsumption. Overconsumption must be understood as consuming more than we need and more than what we generate, due to a higher demand, with which the planet cannot cope with.

The overconsumption of energy, water and raw materials worsens and affects negatively the climate change and increases air pollution. The overuse of the planet's resources leaves humans short of materials, which is critical for our health and quality of life.⁷

The most critical issue related to the overconsumption of natural resources comes from the hand of the most basic needs, mainly, food and water. Water is the most basic human necessity, and the shortage of water in certain areas is becoming more and more critical. A study carried out by the MIT in collaboration with the Water Footprint Networks shows that Water Stress will affect

⁶ Global Footprint Network

⁷ (UN Environment 2018)

⁸ (Water Footprint Network and MIT 2019)



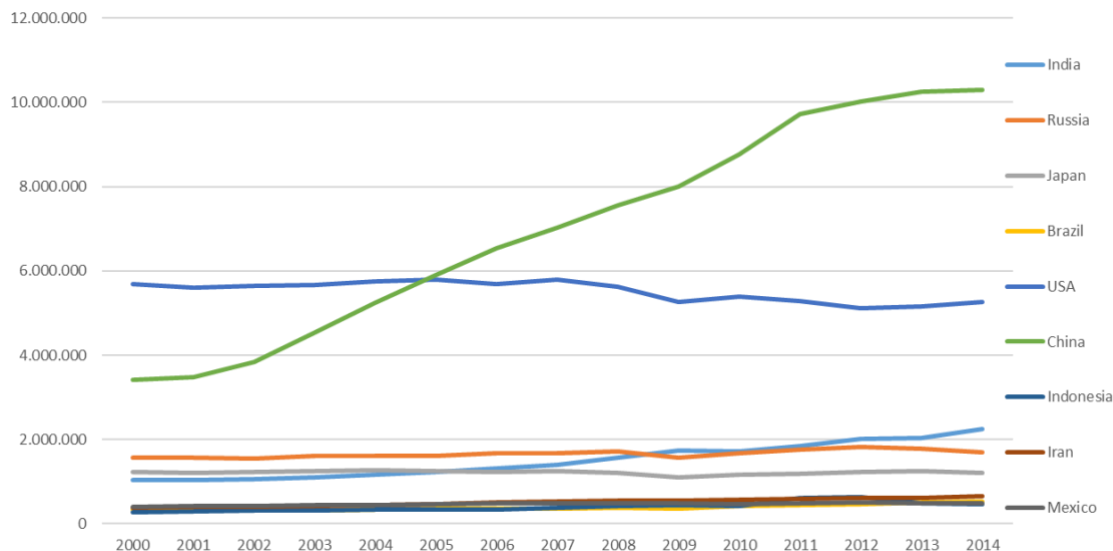
almost the 52% of the global population by 2050. This same study shows that by 2050 we will need 70% more food in order to feed the humankind.

Increase of CO2 emissions

As it has been previously mentioned, almost all of the countries have taken part in the diplomatic agreements created to tackle the climate change. Most of these agreements are fundamentally based on commitments acquired by the member states of the United Nations in order to decrease the CO2 emissions or the pollution rates, as well as on the increase related to investment directed to reduce the impact of climate change on cities' inhabitants on this global climate crisis. In this sense, and taking into account that the main and primary cause of global warming is related to the burning of fossil fuels, most of the commitments acquired through the Paris Agreement by the signing member states are related to the reduction of the emissions of the Carbon dioxide, the gas created as a consequence of the process of burning fossil fuels.

Despite all of these agreements, The Met office (Official Climate Predictions UK office) has published that the level of climate-warming carbon dioxide (CO2, henceforth) is forecasted to achieve a record amount level in the atmosphere in the approaching years. Globally, the CO2 emissions have increased a 2.7% since the Paris Climate Change agreement has been signed (only four years ago) and this growth has been notorious, once again, in the three most polluting countries of the Globe (China, United States of America and India).

Illustration 3. Historical emissions of CO₂ of the nine countries with highest CO₂ emissions (measured in CO₂ tones)



The increase of CO₂ emissions on China (5%), USA (2.5%) and India (6%) are directly related with the economic growth of these countries. That is one of the reasons for which the Stanford University's (USA) professor Rob Jackson predicts that during the 2019 and 2020, unless a new crisis hits the financial system once again, the CO₂ emissions will continue growing, maintaining the trend of the global temperature on a growing path.

Nevertheless, the idea of the relation between greenhouse gas emissions, where CO₂ is sorted as the first and most consumed one, and economic growth has been questioned during 2018. Nineteen countries all over the world have been able to grow economically and reduce their greenhouse gas emissions at the same time. Countries like France, Ireland, Sweden or the United Kingdom are some of the most relevant economies on the list of sustainable and clean growth.

It is worth to mention that the CO₂ emission sources do not only include fossil-fuel combustion, but many other goods, which are related with the increasing emissions of CO₂ among which flaring of waste gas during gas and oil production, cement clinker production and other limestone uses, feedstock and other non-energy uses of fuels are some of the most relevant.

This idea shows the breaking point of the direct impact that the industrial production and other activities have on the CO₂ emissions, regardless of the impact that consumption does also have.

⁹ (Caldeira 2010)

This impact also contributes to show that a big part of the emissions related to transport are directly related to the consumption of determined goods and services, and cannot be related to a determinate country.

In this sense, in 2004, the 23% of the global emissions were related directly to the international trade, primarily to exports from developing countries that offer many products and services to wealthy and more developed countries. Therefore, a way to solve the ineffective deals that have been agreed up to date, which are not able to share the liability among the consumers, but just on the producers, might be sharing liability for CO₂ emissions between producers and consumers, aiming to a more equal and shared approach.

The situation that we are facing nowadays requires a drastic change on our consumption and economical models and habits. According to the Tyndal Centre for climate change investigation, the emission of CO₂ must be reduced in a 50% in order to maintain the global temperature levels of the Earth until 2030.

Low environmental awareness

Environmental awareness is the capability to understand the fragility of our environment, the importance of its protection and the impact that the human being has on it. This idea is based on the education and sensitization of the need that we have as a society to protect our planet and to tackle the consequences that the climate change will have on the upcoming generations.

The awareness on environmental issues has been rising for the last years, leading to the demand of both environmental-friendly business practices and the creation of ecologically friendly legislation or green legislation.

However, the facts show that even if business owners or managers have strong green attitudes, the implementation of environmental-friendly practices is still low nowadays¹⁰. As a matter of fact, it has been proved that the influence exercised on the productive industrial companies has usually as a consequence a reduction of the waste created among the production processes, but does not really introduce a new environmental management system or anything but an environmentally friendly marketing campaign on goods and services.

¹⁰ (Gadenne 2008)

In addition to the low awareness on the industrial companies, results show that some of the organizations that have engaged in environmentally friendly and green management initiatives have finally achieved both, not only a more sustainable and ecological organization, but also an organization with higher benefits. This benefits are mainly related to financial savings and reductions on the liabilities related to environmental impacts that the company could cause.

Therefore, the implication of the organizations and the growth of the environmental awareness on them has to be reached in two ways. On the one hand, the pressures made by legislative and executive powers and the civil society, and, on the other hand, related to the economic impact of the green economy.

For this final aspect, it will be necessary to do cases of study; the organizations should have the capability to know the economic and financial impact that the implementation of these ecological management systems will have on their own organizations.

In addition to what has been explained, environmental awareness is not a criteria that only affects organizations or industrial companies, but is directly connected with citizens and individuals. Scientific education is the mainly what brings knowledge regarding environmental issues and pro-environmental behaviour to students.

In this sense, studies made on Open Spaces as Learning Places program¹¹ show that the inclusion of Environmental Awareness on Science education bring as a result the creation of a high awareness on the local environment and an augment on the knowledge of different environmental concepts. This improvement has no correlation with the socioeconomic situation or economic status of the students, which shows that the daily environmental impact of future generations might be reduced by only increasing the environmental awareness of new generations.

Finally, environmental awareness is one of the main challenges to which the public civil sector can make an addition. On the one hand, the creation of educational campaigns that enforce the campaigns that have been previously mentioned. These campaigns should focus on concrete actions that can be shown and taught to the youngest population. For instance, campaigns related to recycling quotes, techniques to avoid water wasting or campaigns associated to the prevention on the use of private transport in detriment of the public or collective one. On the other hand,

¹¹ (Fisman 2010)

sensitization campaigns should be elaborated and published on different mass media, social networks and advertising marketplaces. The main aim of these campaigns should be teaching and rising the awareness of the society regarding the environmental issues and the climate change. This campaigns should show in an easy way the direct impact that our actions have on the Earth and what we can do to prevent or reduce our impact on the environment with our daily activities and actions.

Recycling and waste treatment

Recycling has always been considered one of the most effective actions to tackle the climate change. One of the reasons that justifies the effectiveness of recycling as a policy to mitigate the climate change is its transversal being¹². Recycling enables and improves the quality of the solution for many of the problems that derived as a consequence of environmental dangers and climate change.

First of all, recycling reduces both, the energy waste, but also the waste of many of the natural resources. A good recycling policy leads to the reduction on the production, transport and elaboration of new products and the use of raw materials, and this also carries along a reduction on the energy currently used in the production. The natural resources are the ones that are more likely to be impacted by the recycling. In this sense, if glass, paper or plastic are recycled there is no need of using new raw materials on the production of products which contain those elements.

In addition, it has been proved that recycling reduces the CO₂ emissions. This reduction has its bases on two main reasons. On one side, the reduction of the energy consumption related to recycling compared to new production and, on the other side, the surveillance of the forests, seas, and other natural resources, which are not used for the extraction of raw materials.

The surveillance of forestall resources not only reduce the CO₂ emissions, but also help to reduce the CO₂ that is already in our atmosphere. According to the United Nation´s Organization for Alimentation and Agriculture, every tree has the capacity to capture 150 kilograms of CO₂, and

¹² OXFAM Intermón

big forests do also act a stabilizers of the global temperature (as mentioned before); and in urban areas, the trees act as natural filters of the particles that pollute the air.

Accordingly to what has been previously mentioned, a study carried out by the United Nations shows that the spilling of waste and its incineration are the two most impacting activities regarding climate change. Therefore, recycling would help to reduce huge amounts of emissions and polluting activities, as an example, a unified European recycling policy would achieve to reduce 235 tons of CO₂, which is similar to take 40 million cars out of the roads during a whole year¹³.

Innovation arises as the main solution to the Cities' challenges.

The development and application of the new technologies to approach the optimization of the citizens needs contribute to the acceleration of sustainable innovation, making Smart Cities arise as the solution to Climate Change among other challenges that cities face.

The European Commission considers that “Smart cities should be regarded as systems of people interacting with and using flows of energy, materials, and services and financing to catalyse sustainable economic development, resilience, and high quality of life. These flows and interactions become smart through making strategic use of information and communication infrastructure and services in a process of transparent urban planning and management that is responsive to the social and economic needs of society”¹⁴.

Therefore, a Smart City must be understood as a city, which, by incorporating new technologies, processes and innovative services guarantees its energetic, environmental, economic and social sustainability, with the purpose of assuring and improving the life quality standards of the citizens.

Smart cities approach climate change and environmental sustainability in several ways. For instance, one of the most relevant issues, the energy consumption, will be faced by Smart Cities through self-production and consumption. In this regard, citizens will be more involved in

¹³ Municipality of Santa Cruz de Tenerife

¹⁴ European Commission

energetic markets and the efficiency will become the most important premise. The new buildings will consume less energy as well as the new electrical gadgets.

In addition, Smart cities will take advantage of natural resources by stocking rainwater and through the valuation of urban wastes.

Urban mobility will tilt towards new alternative fuels, will reduce the pollution and will release less greenhouse gases. A more efficient organisation of the means of transport will contribute to the optimisation of displacements and the avoidance of traffic congestions, being the last, one of the main causes of pollution in cities.

The optimization of cities will also include the monitoring of the use of resources through the implementation of Internet of Things in order to improve public services and reduce both, costs associated to the use of resources and the waste of them. For instance, Internet of Things gadgets will be installed to control illumination, pollution, traffic, etc.

Information and communication technologies (hereinafter, ICTs) will play an important part in the transmission and processing of the information arising from connected Internet of Things gadgets, but will also contribute to the quality living standards of urban population.

In order to sum up, technological improvement will contribute to make sustainable, sure and attractive environments out of cities, where citizens will be able to achieve their goals and build their own vital projects.

Smart cities and technological megatrends to fight climate change

We refer to a smart city as a city that has implemented technological measures that collect useful data to know in real time the problems that the city is facing and, therefore, its main needs. In few words, Smart Cities are cities that seek to increase the quality of life of their inhabitants by managing their resources in a sustainable way. Smart cities are born as a result of a series of innovative advances that allow them to boost the development of the municipality with a responsible and intelligent environmental management of the resources.

To determine if a city is intelligent and smart or not, generally, a model around six Features is analysed: Economy, Government, Citizenship, Environment, Quality of Life and Mobility. The main idea of using these features is to determine if the city is modern enough on the management

and the interaction between institutions, citizens and computer systems and technologies. An intelligent and smart city uses ICTs and other technological means to improve not only the decision-making and management, but also the efficiency of operations, urban services and their competitiveness, while ensuring an effective attention and approach related to the needs regarding economic, social and environmental issues that a city can face.

One of the main factors that is developed in Smart Cities is Mobility. Urban mobility arises as a catalyst of change in the cities of the future. It is essential to note that given the recent increase in awareness related to the environmental issues and the improvement of the quality of life in the world, new ways of ordering mobility in cities is very relevant. The arising use of the bicycle, shared vehicles and electric means of transport contributes to a cost reduction and economically more sustainable way of commuting within cities. In addition, new low polluting alternative means of transport contribute to the environmental sustainability. In this sense, the use of new apps, shared electric vehicles and a sustainable urban mobility management contribute to the reduction of CO₂ emissions, proving to be efficient to transform the traditional infrastructure of cities into sustainable ecosystems, providing benefits to people who live and work there.

Therefore, a new concept has been created when referring to the mobility in the smart cities: the Smart Mobility. This concept refers to mobility systems that supported by new technologies, pursues the application of smart solutions that are somehow related to a more environmentally sustainable cities, such as:

- Report and monitoring of traffic jams in cities thanks to the installation of sensors that permanently provide data, thanks to the implementation of models supported by Big Data and Internet of Things. The traffic reports at real time can be used by the traffic authorities contributing to the diversion of traffic at certain conflictive points. Consequently, the traffic would be more fluid, reducing the CO₂ emission and their impact in a significant way.
- Use of sensors for intelligent parking systems that communicate directly with the citizens through mobile apps (thanks to 5G) or panels installed in the most crowded points of the city, at a real time. Sensors would detect free parking spots and inform cars and citizens, reducing the time they waste parking, and therefore, reducing the CO₂ emissions.

- Bet on the shared use of vehicles (Ride-Sharing, Car Sharing or carpooling) and the Mobility as a Service concept that, supported by mobile technology, drives a model that allows citizens to combine different urban transport systems to reach their destination in the most efficient and direct way. This would reduce significantly the use of private vehicles, contributing to the reduction of CO2 emissions and pollution.
- Creation of an infrastructure network that, supported by ICTs, encourages more efficient and real-time management of the elements related to traffic management in cities that also would contribute to energy savings thanks to the installation of smart gadgets such as intelligent light signals that detect movement and stop working after a few seconds of inactivity.
- Mobility management through mobile devices and applications that allow citizens to be informed of everything that affects their mobility and the solutions they can adopt in real time to avoid unnecessary waiting, such as, public transport schedules and frequencies.
- Bet on the technology of the connected car that optimizes routes and consumptions and that are an impulse of smart culture and entrepreneurial solutions in the field of sustainable mobility in Smart Cities.

Out of the Mobility factor, the consumptions and management of natural resources is other of the topics that smart cities can help to deal with, among which the water management is the most relevant.

In a context like this, smart cities must offer solutions aimed at improving efficient management of water in urban environments, ensuring a supply of quality water and a rational use of resources according to the real demand of citizens and industries. In this regard, through the implementation of smart water solutions, the smart cities use and implement the most advanced technology aimed at optimizing integral management processes of water, achieving:

- The decrease in water consumption, influencing both the improvement of the networks and the individual savings, as well as the application of water regeneration and reuse mechanisms. In the field of distribution networks and drinking water supply, smart systems are key that guarantee the increase of their efficiency, keeping in mind both the resource itself and the energy consumed, adapting the operation to the patterns of demand and enabling the detection and reduction of breakdowns, leaks, frauds, etc. It is also

necessary to incorporate smart water supply and management systems in the homes of citizens. For instance, some of the smart solutions are the following: the installation of differentiated domestic water networks according to the type of use of each individual, reuse systems or installation of smart meters for automated readings, allowing all consumers to know their daily consumption patterns, rates and network services and generate suggestions for improving habits through custom tips.

- The minimization of energy consumption associated with the processes of purification and desalination, increasing the efficiency of distribution networks and sanitization.
- Improving the quality of wastewaters. The establishment of control systems of pollution in water in sanitation networks, advanced drainage management systems for the prevention and protection of urban floods, construction of water tanks rainwater based on the integration of the forecast.
- In the field of urban irrigation, remote management systems for the control of the optimal irrigation of parks and gardens are the basis of intelligent management, together with the use of groundwater and reused water for irrigation and street cleaning.

In addition, the use of Big Data and analytics, together with Internet of Things has also been used as a solution for other main problems on the urban areas, among which it is necessary to mention the following ones:

- **Parking:** One of the main problems of large urban areas, as well as small cities, is undoubtedly the issue of parking. Indeed, the amount of projects that can be carried out within the city does not matter, because they will never be able to support such a large number of vehicles. The right way to act in order to solve and give a smart solution to this issue is to build smart parking lots outside the city, with important connections to the city centre itself. It would then be places of connection for sustainable mobility, which would significantly reduce vehicle traffic and, more importantly, would be responsible for lowering the level of pollution.

In this regard, it must also be pointed out the arising phenomenon of car sharing, which means to share the means of transport (among friends, work colleagues or individuals

with a dedicated App). Today it is a very popular option in smart cities, being an economical and efficient solution.

- **Building planning:** One of the points to take into account to define a smart city is the quality of the buildings that conform the city. In this sense, modern structures must be built, capable of maintaining a low environmental impact and obtaining certificates according to energy efficiency standards.

Buildings with high-energy efficiency standards grant a reduction of water expenditure up to 70%, consequently also reducing CO₂ emissions over that percentage, even reaching the 90%. Obviously, the advantages are multiple, being able to repay the construction costs in distress 5 years of life of the building.

- **Energy sources:** Another fundamental factor to be able to define smart a city turns out to be without a doubt the use of renewable energies. Smart cities should significantly reduce dependence on fossil sources. In this sense, clean energy must be used as much as possible, especially within the urban centre, in order to cover most of the city's energetic demands.
- **Digital communications and computer systems:** According to studies¹⁵, the use of specific Apps for tablets and smartphones could help to control and anticipate the management of traffic in the cities, offering faster routes to drive. In addition, parking could be managed through these kind of apps too. This would obviously reduce the CO₂ emissions of vehicles, in addition to avoiding unpleasant and stressful queues, traffic jams and wastes of time.

In addition, a Smart City must be able to tell about different “computer brains”, capable of monitoring energy consumption in real time to reduce eventual waste, and to know how to improve efficiency.

On the other hand, new government models have been created, known as smart government models. Smart cities took their first steps by placing sensors, smart traffic lights or public internet access points. However, the ecosystem has been gaining in complexity. The role of local

¹⁵ Innovotics study, Smart Cities (2019)

governments, as drivers, dynamizers and active part of the projects has become key to foster the development of this new city models. Thus, smart government would be the cornerstone of a complete and holistic smart city.

“We must move from the old smart city debate, understood as the use of technology to develop urban centres, towards a new paradigm based on smart governance that allows for a lasting and comprehensive economic, social, environmental and institutional urban development,” they explain from the IESE Cities in Motion centre.

Looking to the future, smart city models will also be a catalyst for enabling technologies related to different resources and strategies, among which we could underline, smart and efficient public service management, like the lighting management, waste collection, traffic management, etc. impacting directly in the reduction in consumption of energy and emissions of greenhouse effect gases.

Finally, it is necessary to mention that citizens play a determinant role on the creation and development of their cities into smart or smarter cities. It is necessary to foster awareness on the need of becoming greener cities and cities that are more efficient as a solution to the climate change.

Certain European cities are leaders in the smart city movement, fostering and promoting greener, cleaner and more efficient urban environments

At a European level, there are many smart city models that are worth to mention. These city models have already proved to be efficient. In this context, Smart solutions on the resources management and data collection, brings as a result a new solution to tackle climate change at a local level. Among all of these city models, some of the most relevant are explained below:

- **London (United Kingdom):** The capital of the United Kingdom is the largest city in Europe. Its metropolitan area, known as Greater London, is now close to 20 million inhabitants. Ensuring access to health and transportation services, energy and water management, and reducing traffic congestion are pressing challenges for London.

The city has decided to bet strongly on technological innovation in search of solutions, and is now on top of the ranking of the European Smart cities. Thus, according to Smart

City Press analysts, the developments that have cemented London's intelligence are, among others:

- a) Creation of the London Data store in London. It is an open data platform that more than 50,000 citizens, companies, researchers and developers already use each month. This data store is a data bank, where all kind of information is stored so that experts can build new intelligent models and solutions.
 - b) Innovation in the transport network; For example, the creation of transport capsules that interconnect Heathrow Airport, one of the busiest on the planet. They are called Heathrow Pods. These pods have managed to eliminate the carbon emissions on the transports made to the airport, which represents nowadays more than 10% of the daily transports on London.
- **Paris (France):** The future of the French capital has a marked environmental accent. The city has endorsed the sustainability objectives set internationally and manages several construction and innovation projects for the next decades that almost seem like science fiction. However, what has led Paris to lead the global rankings of smart cities is the revitalization of an open innovation environment.
"The method chosen by Paris to advance as a smart city is open innovation: granting inhabitants and other actors in the city control and access to data flows," said Energy Cities, a European association of local governments to strengthen the transition to a new energy model.
Thus, ongoing projects enhance the use of clean transport means, such as bicycle and electric vehicles and the optimization of the flows of people and vehicles through applications of the Internet of Things. However, as they recognize from the association, Paris did not wait until the 21st century to become a smart city.
The French capital accumulates centuries of experience in people management, energy, waste and urban planning. In addition, it is an economic center of his country and of Europe. In fact, Paris obtains the best scores in the IESE index in international projection, transport, urban planning and economics.

- **Copenhagen (Denmark):** Copenhagen, classified as one of the cities with the highest standard of living in the planet, has the objective of becoming a Carbon Neutral city by 2025. This smart city has set numerous and ambitious goals in the field of energy efficiency and in the use of renewable energy. By 2020, all regulations regarding construction will include a zero energy profile.

The “Copenhagen Connecting” connects the wireless data emitted by cell phones and the GPS systems of the means of public transport. It also manages to connect the sensors of the sewers and garbage containers, to significantly reduce the dimensions through intelligent management of waste and its displacements.

- **Amsterdam (Holland):** Undoubtedly, the Dutch capital is an example for the whole world, being the only city where there vehicle traffic is no longer one of the biggest issues to be solved, since every day millions of individuals use bicycles to get around. The idea of bike sharing was born in this city, idea that we can now find in countless cities around the world.

Like Copenhagen, Amsterdam also has a culture on the use of technology, and with its public-private partnerships, it was able to create more than 40 urban projects. The latter were able to open the doors to new solutions in terms of mobility, in the use of renewable energy and the use of common spaces, for instance, they created an open source laboratory where you can experience new energetic alternatives, designed to improve the quality of life of citizens and tourists.

- **Wien (Austria):** For many years, the Austrian capital has been developing smart city-oriented strategies. Undoubtedly, among the best projects carried out, there is the Citizen Solar Power Plant, which outstands. Citizens can buy solar panels that after, are directly rented to the Wein Energie power company.

This initiative has led into great improvements in the city: The city has been able to promote electric mobility with the creation of 440 charging stations, with the objective of covering over the 50% of the energy needs with renewable sources. This has been focused in remodeling densely populated old neighborhoods, transforming them into examples of smart cities.

In addition, thanks to new technologies, some buildings have installed and implemented bio-solar roofs, capable of combining solar energy and plant cultivation. Green roof systems offer a perfect habitat for pollinating insects, smarter irrigation and, at the same time, excellent roof care. If we add to all this the reduction of the maintenance expenses derived from this new roofs, we can easily understand how this system works.

- **Barcelona (Catalunya):** Apart from being a city rich in culture, this multi-ethnic and cosmopolitan city has been able to adapt to the energetic progress and implement new initiatives in the recent years. The city has given birth to a series of initiatives and organized events such as the Smart Cities Expo World Congress, focused in the smartest cities. This has led into Barcelona reinventing itself with a mix of smart planning and business innovations.

During these congresses organized in the city in the last years, there is a reciprocal exchange of information between world capitals, dealing with crucial issues such as air pollution, noise pollution and urban waste management. It should be added that, nowadays, Barcelona is one of the cities with the highest life expectancy in the world, with an average life expectancy of 83 years.

- **Santander (Spain):** The city of Santander (Spain) has implemented an intelligent city strategy that was approved in 2015. This strategy consisted in connecting all the public services and important information of the city (such as, traffic, weather, monitoring of the street furniture in poor condition) and making it available to all the citizens of Santander and surrounding municipalities. Thanks to this initiative, several things were achieved, such as making city council service faster and more efficient to detect, be informed, plan and fix any problem arising.

Over 20,000 sensors have already been connected and installed throughout the Smart Santander, and they are almost anywhere that could be imagined: water fountains, wastebaskets, parks, banks and any other public infrastructure. These sensors are capable of measuring almost anything: road traffic and parking, waste management, etc.

Santander does not store the information in a simple “real-time information bank”, but has also created an intelligent “brain” that can anticipate certain actions before they

happen. For example, if it rains a certain amount of rain it can foresee that there will be flooding in the road that will hinder the traffic of cars, and therefore, plan reactive actions that can be implemented.

- **Nice (France):** This French city has become the reference on investigation and development of Smart City models. On the one hand, they have a large network of sensors that record data related to pollution, sound levels, waste management, and energy expenditure or water quality. From its analysis, different real time measures and actions are carried out by the civil government to improve many services of the city and face and fix any arising issues.

On the other hand, this city hosts the Innovation Center for Smart Cities, a platform from which progress is taught, researched and disseminated in this area, an institution made up of universities, public institutions and organizations and private companies.

With similar vocation, Nice also hosts the Mediterranean Institute of Risks, Environment and Sustainable Development, an institution that seeks to define a new way of cooperating between companies, researchers and the territory in order to advance in areas such as green technology and smart cities. Among its many advances, we find the redefinition of San Isidoro, a completely CO₂ zero impact neighbourhood that serves as a paradigm of what the cities of the future should be.

- **Malaga (Spain):** The origin of this initiative to become a Smart City arose from the need to address the European energy policy established in 2007 and known as “20-20-20”, whose objectives must be met in 2020.

The first steps of the initiative were launched in 2009 in the La Misericordia neighbourhood of Malaga. This is a beach area and it has become a place where public and private sectors’ cooperation has led to execute different smart initiatives as:

- Implementation of digital energy counters at houses. They allow measurement in real time, so that the citizens can adapt their consumption to save on their own electricity bill. The users know their curve of daily consumption, and therefore can adapt their consumption behaviour in order to reduce the use of electricity and energy in the hours in which the energy is more expensive.

- Efficient management of public lighting with the replacement of conventional lights with LED lights, saving over the 65% in public lighting expenses, since its implementation.
- Installation, management and control of alternative energy generators (photovoltaic, mini eolic, cogeneration, etc.). This kind of energy generators allow to improve the planning and foster the use of alternative energies.
- Battery management and storage facility for generators. The smart grid also makes possible to take advantage of surpluses of electricity production from other suppliers, and thus, creating more efficient energetic supplies in which the demand and offer are met easily and more efficiently.
- Technical reforms to optimize the use of energy in public and private buildings. This has led users and citizens to have greater energy awareness.
- Automatization of the control systems of the power grid, contributing to the reduction of breakdowns of the energy systems. The power grid's disconnection time in case of breakdowns has been reduced and the use of the entire system has been optimized.
- Implementation of electric cars and research in V2G Vehicle to Grid technology.

This great initiative of eco-efficient city, has invested over 31 million euros from European funds and the private companies that have developed it in collaboration with the public sector. Thanks to this experiment, valuable lessons in the efficient use of energy have been obtained and learnt. Smart City Málaga has meant for the city the implementation of a large real laboratory of Smart Grid technologies of the future, which has meant that Malaga has become a window into the world of these technologies.

Conclusions

Therefore, taking into account both, the technological trends that nowadays affect and influence in the economy and living and the high risk in which the Earth's sustainability is, measures should be adopted in order to fight climate change with a smart and collective approach, including the participation of the public sector, companies and citizens. Only a joint approach will be able to face climate change with a smart, intelligent and sustainable approach. Only by understanding the real problems and megatrends associated to the climate change, such as the

great increase of population in cities, the problem can be identified and fought. In this sense, the strategic lines of action are defined and required:

- Public Administrations should be ambitious in the compliance of the environmental measures and commitments, fostering the introduction of innovation and technological development across the distinct sectors of the economy in order to reduce energy consumption.
- Moreover, Public Administrations should carry out a joint analysis with the economic sectors regarding how climate change will affect, in order to establish a common and integrated approach to fight the consequences arising at every different scenario.
- Energy companies must continue in their path towards a low carbon economy, working in a less carbon intensive way of electricity generation, fostering cleaner fuels and the use of new technologies.
- Citizens must make changes in their way of living and consumption habits. For instance, citizens must change the way of commuting, moving towards a more sustainable clean and shared transport, which will contribute to save and will be more efficient. Living standards should be separated from energy consumption, and new technologies and developments should be adopted in order to be more efficient and green.