Resilient Cities

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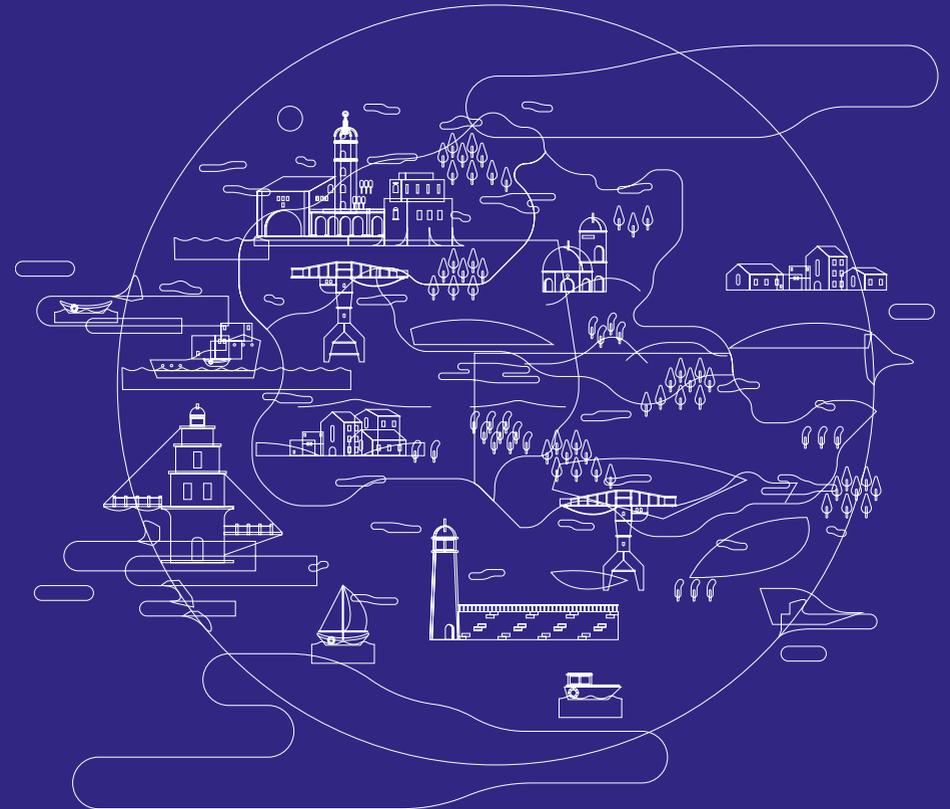**Mass urbanization**

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Editorial

There is an urgent need to examine the ways in which cities can maximize resilience

Today, 54% of the world's population is living in cities, by 2050 this number will reach 70%.
This ever-growing concentration of population and economic value will occur in areas exposed to natural disasters and generates new risks by itself (e.g. pollution). These trends demand a vigorous mobilization to strengthen cities resilience to ensure a safe, sustainable and successful future for their inhabitants. That is why we must promote research on several key areas, such as spatial planning, infrastructure, exposure to floods and earthquakes, and the impact of pollution on health.

Understanding, preventing and containing risks

There are many ways to help cities plan for the future. First, we need to understand risks at stake to allow anticipation.

Second, we must foster awareness so that populations, governments and private organizations are well informed and can make the right decisions. And third, we need to share research data to help governments and city planners build appropriate solutions, including infrastructure.

Supporting Academia and Public Policies: at the heart of tomorrow's resilient cities

At AXA we are convinced that research is key to effectively tackle the global challenges facing our societies. Scientists are central to the production of knowledge that is essential for the design and implementation of successful prevention and mitigation strategies.
That's why we are supporting around twenty best-in-class researchers who work on various resilience fields including urbanization, climate hazards, migration flows, impacts on human health, and infrastructure.

We are very proud to support such research through the AXA Research Fund, which not only provides financial backing for researchers

but also encourages them to take part in the public debate. By fostering scientific exchanges and knowledge sharing, we can influence decision-makers and bring about the behavioral changes needed to create the resilient cities of tomorrow.

"We are supporting around twenty best-in-class researchers"

Cross-sector collaborations, with academia and through strong public-private partnerships, are key. AXA has already taken concrete commitments to help improve city resilience in addition to its support to research. By partnering with UN Habitat for example, we are contributing to disaster risk reduction and supporting vulnerable populations through the strengthening of building codes, and by helping to build back better after a disaster.

This "Resilient Cities Guide" aims at giving to a wide audience a snapshot of the state of the art of the topic and a demonstration of the relevance of cross-sector collaborations already engaged.

Alban de Mailly Nesle
AXA Group Chief Risk Officer and Responsible of the Group Insurance Office, Member of the AXA Group Management Committee and the AXA Research Fund Scientific Board

Jad Ariss
AXA Group Head of Public Affairs and Corporate Responsibility, Member of the AXA Research Fund Scientific Board

Chapter 01

Urbanization: a global issue

How can we better understand urbanization to increase resilience?

By concentrating a continuously increasing number of inhabitants, cities are facing a diverse range of multiplying risks including: socio-economic, energetic, natural (earthquakes, floods...), pollution issues and more.

For example, 944 of the 1,692 cities with more than 300,000 inhabitants are at high risk of exposure to a natural disaster; and 98% of cities of the C40 network (a leadership group representing 90 of the world's greatest cities) have stated that climate change represents a significant risk for them.

To enable the cities of tomorrow to cope with such changes, it is essential to understand the inner workings of urbanization: what will be its impact on the urban space and its environment? Where will tomorrow's neighborhoods be situated? Who will live there, and what will they be vulnerable to?

For all these issues, research and spatial planning can provide some solutions; particularly through modeling analyses that combine data from demographics, satellites and field studies.

1950   **2050**

30%   70%

By 2050, more than two-thirds of the world's population will live in cities.

Source: UN Habitat

75%

Cities consume three-quarters of global energy and emit between 50% and 60% of greenhouse gases.

Source: UNHabitat

"Rethinking population growth at the city level"

Two trends - climate change and urban population growth - are converging on the planet. Both are set to have a major impact on human lives, particularly among the world's poorest people. To prepare accordingly, we need to understand more about the possible impacts.

"To put tools and data into poor countries' hands"

Prof. Deborah Balk of the City University of New York is using new spatial demographic forecasting methods to precisely calculate the numbers of urban dwellers that will be exposed to climate-related risks, especially in emerging countries. This data will enable the development of evidence-based climate adaptation strategies.

"My results will be essential for preparing cities to adapt to climate change and other environmental disasters," Deborah explained, *"my ambition is to put these tools and data into poor countries' hands".*

Spatial is crucial

At present, urban growth forecasts focus on the global scale. *"Current methods of studying urban growth, based mainly on census information, are limited by their lack of spatial data,"* said Deborah. *"Exposure of people and infrastructure to the risks of climate change cannot be assessed if we don't even know where they are!"* she underlined.

In her view, a change of approach is long overdue. *"Forecasts of urban growth do not address where it will occur – if this growth will happen on the edges of existing, expanding cities, in new cities or in slums. We must rethink population growth at the city level, and not only at the national level".*

Data for the citizens of tomorrow

The approach proposed by Deborah and her team aims to *"predict where people will be in the future, as climate change progresses".* This involves creating a model of cumulative statistics and cross-referencing satellite data with spatialized demographic data.

These results are then compiled for different periods: *"We have opted for a cross-cutting approach that combines multiple sources of data that inform the question of where, how and how fast urbanization is happening around the world. This allows us to evaluate change in urban areas over the past few decades",* said Deborah.

Cross-checked with general climate change data, Deborah's work has identified and quantified many risk factors. Thus she determined that *"one out of every eight urban dwellers lives in a low-elevation coastal zone, the large majority of which are in Asia".* Such data is not necessarily known by local decision makers, who could consequently underestimate the risks. Eventually, thanks to Deborah's research, an ever-increasing number of them will have the data to make the best possible decisions in good conscience.

Prof. Deborah Balk

City University of New-York
AXA Outlook in 2014

"Modeling global urbanization and its environmental and social impacts"

What will be the environmental consequences of urban sprawl? How will land use management transform our cities? Prof. Dagmar Haase from the Humboldt-Universität zu Berlin is addressing these complex but crucial questions. *"My research focuses on modeling global urbanization and its environmental and social impacts at global, regional and local scales"* she said.

To evaluate changes in natural capital, Dagmar studies urban ecosystem services, which are the biological systems operating in cities that influence aesthetic and health benefits, including meeting the human demand for cool and clean air, water, food, and recreation.

Unraveling urban complexity

The metrics generated in Dagmar's research provide a new perspective on urbanization. *"Our model identifies past, present and potential future urbanization hotspots. For example, we can observe very young and rapid urban hypergrowth in China and West Africa"* she explained. By identifying the most probable sites of future urban growth, the model's results could have a huge influence on projecting climate change-induced risks for cities, such as droughts, heat waves and floods.

Encouraging more sustainable urban development

Dagmar's research has led to numerous recommendations for urban development actors. *"We need a better compromise between compact and space-intensive urban development by creating new multifunctional urban density, including more high-rise buildings with green roofs and green walls",* she said.

"We must fully explore options of greening and re-naturing our cities, implementing green infrastructure and nature-based solutions to face future challenges of heat and pollution". Other solutions include reducing car-based traffic, providing more space for bicycles and pedestrians, localizing urban food consumption, supporting community-based gardening and agriculture, reducing inequality in access to greenspace and encouraging the authorities to implement a real sustainable urban development.

Small towns, big impacts

Dagmar's research is also highlighting the importance of smaller towns. *"Large megacities tend to dominate the scientific discussion, but smaller urban areas are also critical. Small and medium towns are developing very interesting localized approaches to urbanization, which we should examine closely",* said Prof. Haase.

For example, many towns have signed up to the Cittaslow concept, a movement that aims to improve the quality of life in towns by slowing down traffic, protecting the environment, encouraging high quality local food and drink networks, and many other ideas that promote healthier and more sustainable lifestyles.
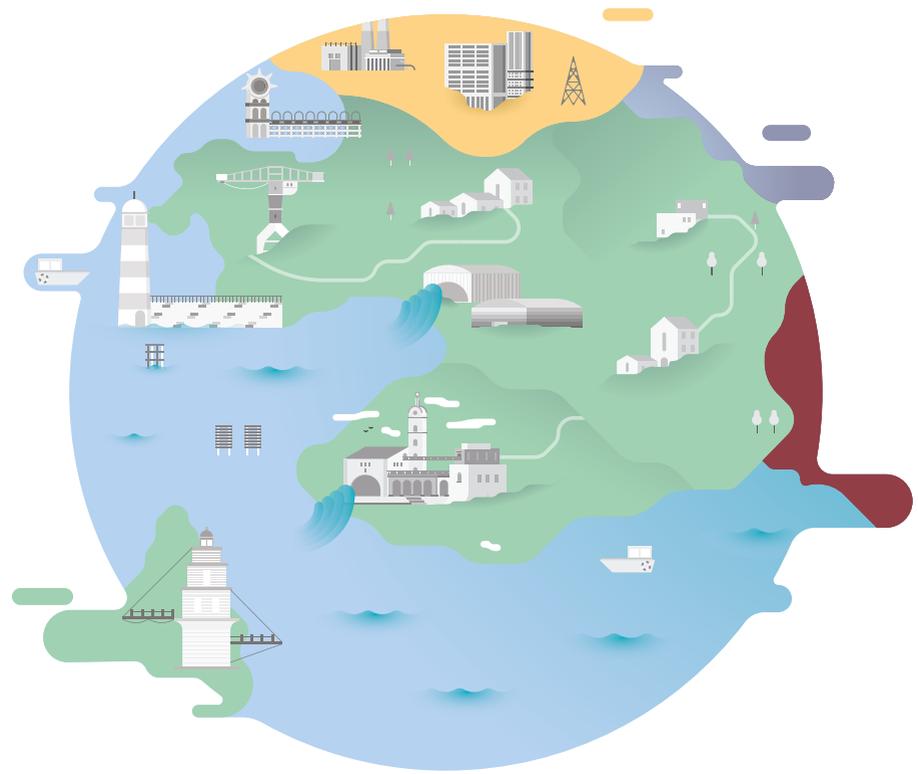
Prof. Dagmar Haase

Humboldt University
AXA Award in 2013

Chapter 02

Floods

How can we deal with flood risks?

Whether in Africa, Europe, America or Asia, no city is totally immune to flood risks. In 2016 for example, flood damage in the Paris region cost an estimated 1 billion euros. And the forecasts are far from optimistic: the number of human fatalities and the cost of material damage are set to continue growing for the years and decades ahead.

Climate change is no doubt an important factor behind this trend: it is leading to rising sea levels and an increase in the frequency and intensity of extreme weather events putting coastal and inland cities at risk. Additionally, cities are facing increasing demographic pressure in risk prone areas.

It is vital to find new and better ways to protect the property, infrastructure (personal homes and transports, schools and businesses), and lives of citizens. Taking action is possible, such as establishing water storage systems or specific reservoirs in the upstream areas of watercourses, or building flood defense programs.

Moreover, to mitigate the potential impacts of such events, researchers are modeling the evolution of flood risks, and developing early warning systems.

3.4 mm per year

This is the average rate of global mean sea level rise since 1996. A 2,000-year record.

Source: NASA

2014

5.3 billion euros a year

2050

40 billion euros a year

By 2050, the annual cost of flood damage in Europe could reach 40 billion euros. This is 7 times more than in 2014.

Source: ec.europa.eu

"Early warning systems provide the most valuable thing: time to act"

Floods are highly destructive natural disasters that affect all of the world's regions, inflicting heavy casualties and causing severe economic losses. Climate change is compounding the problem, increasing the frequency and intensity of flood damage. Innovative ways of anticipating floods and warning those at risk are therefore becoming urgently needed.

Dr. Vazken Andréassian is creating a national scale real-time flood forecasting system that integrates several types of hydrological data. *"My AXA research project is about improving the forecasting of floods and flooding. We have developed models using river gauge data that are at the core of our early warning systems",* said Vazken.

Vazken's team began their work in France by trying to understand some of the complex mechanisms at work during flooding events in the country. *"We wanted to resolve many questions, such as how can upstream floods reduce downstream floods, how can upstream flood protection measures such as dams exacerbate downstream floods, etc."* explained Vazken.

Helping cities reduce flood risks

"Many cities are situated near the coast or alongside rivers to allow goods transportation

to and from their ports" said Vazken, *"it is therefore vital that we increase our knowledge of floods to provide better information to city populations to help improve city resilience".*

A flood early warning system can be a lifeline for a city. *"Early warning systems provide that most valuable thing – time, which can enable the potential impacts to be minimized",* commented Vazken. *"For example, we can better predict where and when the emergency services will be required, and communities can be empowered to take action, such as taking their valuables upstairs, or moving parked cars away from rivers".*

Managing huge quantities of data

There are two types of flood forecasting models: one simulates the predicted flood zone, while the other translates precipitations into increased river flow. *"While it is possible to use these two models simultaneously, to do so on the scale of an entire country places an excessively high demand on computational power. So I'm looking at ways to optimally combine these two models to provide the best compromise".* In this way, Vazken's early warning system can provide real-time forecasts as well as large-scale flood mapping.

Dr. Andréassian's forecasting system will be designed to adapt to contexts in other countries. Similar tools could be deployed around the world to prepare for and limit the growing risks of river overflows. *"Our ultimate goal"* said Vazken, *"is to create a system capable of continuously monitoring nationwide watercourses to be able to issue early warnings by widely disseminating flood information to all stakeholders".*

Dr Vazken Andréassian

IRSTEA
AXA-IRSTEA Joint
Research Initiative in 2015

"Without effective waterway management, flooding can cause lasting impacts on a city"

Crossed by grand historic bridges, the Seine River in Paris is much loved by residents and tourists alike. However, recent studies have highlighted the potential severity of the flood risks associated with the river, risks that will be exacerbated by the expected increase in extreme weather events related to climate change. The ability to optimize the river's management is therefore becoming ever more critical.

Dr Luciano Raso is a water resource management researcher who has been working on the management of the Seine's upstream reservoir system that protects the citizens of Paris from flood and drought: *"My project looks at the short-term measures, such as changing the daily management of the Seine's reservoirs. At the moment each reservoir is managed independently".*

Extensive collection of hydrological data

Luciano has been developing predictive models that can be used to optimize reservoir management systems to improve control over water resources, without increasing costs. For this, his models must take into account the consequences for the entire system (rivers, groundwater, etc.) as well as all of the final uses (drinking water, electricity production). He collected information on water levels, rainfall, groundwater, humidity, and other

hydrological data from a variety of sources, on both local and global levels.

The challenge was to create a harmonized management system capable of addressing two conflicting goals: controlling the huge amounts of water that sometimes flow through our communities, while also alleviating potential drought conditions. Luciano aimed to develop a system where early action is possible, whenever floods or droughts are forecasted. The significance of this work is clear, for Paris and other communities in similar predicaments around the world.

Avoiding a repeat of history

"Without effective waterway management, flooding can cause lasting impacts on a city and its surroundings, both economic and ecological", said Luciano. *"In Paris, we have the reservoirs, but there remains much space for improvement by applying more advanced techniques to control these reservoirs".*

In 1910, Paris suffered a flood of historic proportions. If a flood on that scale happened again today, without the control provided by the reservoirs, the cost of the damage could be as high as €18 billion. *"It is estimated that the reservoirs could reduce these costs by half. My research is all about trying to work out a third number: how much more could we reduce these costs if we achieved optimal management?"* commented Luciano.

Dr. Luciano Raso

Delft University of Technology, AXA Post-Doctoral Fellowship at IRSTEA in 2013

"These new tools will make coastal communities safer"

23% of the global population lives within 100km of the coastline, and less than 100m above sea level. *"The coastal zone is the world's most heavily populated and developed land zone",* explained Prof. Roshanka Ranasinghe, who studies climate change impacts in the coastal zone at the UNESCO-IHE Institute for Water Education.

"Coastal behavior is governed by several oceanic and terrestrial phenomena, most of which will be affected by climate change, making it a key factor in coastal risks", he added. *"Such variations will undoubtedly lead to unprecedented coastal hazards".*

Advanced models carry out thousands of simulations in minutes

Roshanka and his research team are generating fundamental scientific knowledge and formulating modeling concepts to develop innovative coastal risk assessment methods. *"Coastal zone managers and planners need easy-to-use models that provide robust estimates of the physical impacts of climate change on coasts, at time scales of 50 to 100 years",* said Roshanka.

"We are developing simplified and rapid physics-based numerical models via scale-aggregation, which are capable of carrying out thousands of simulations in minutes".

Reducing risks for coastal communities with new data

Roshanka's team has produced a modeling framework for local scale climate change impact

assessments that provides reliable estimates of coastal change on a 10km spatial scale. They are also developing several other projects, including:

• a coastline recession estimation model;

• a model to provide rapid assessments of coastline change adjacent to small inlet-estuary/lagoon systems;

• and a modeling suite for rapid estimates of flooding due to climate change driven variations in river flows, rainfall, sea level rise and storm surges in coastal cities.

These tools will help coastal managers make decisions based on a better understanding of risks. *"Our models are currently being successfully applied in Australia, The Netherlands, Sri Lanka and Vietnam",* said Prof. Ranasinghe. *"I hope one day these new tools will make coastal communities safer, all around the world".*

Research enhances cities' resilience

Thousands of cities around the world are at risk of climate change impacts on the coastal zone. *"This applies to any coastal city that is not well protected and located less than 2m above sea level and/or less than 500m from the shoreline"* said Roshanka.

"Our models are specifically designed to enable quantitative risk assessment. Once economic and environmental risks at a given location are quantified using these models, informed options for risk reduction can be developed. In this way, cities will be able to improve their resilience to hazards, and do so in a cost effective way".
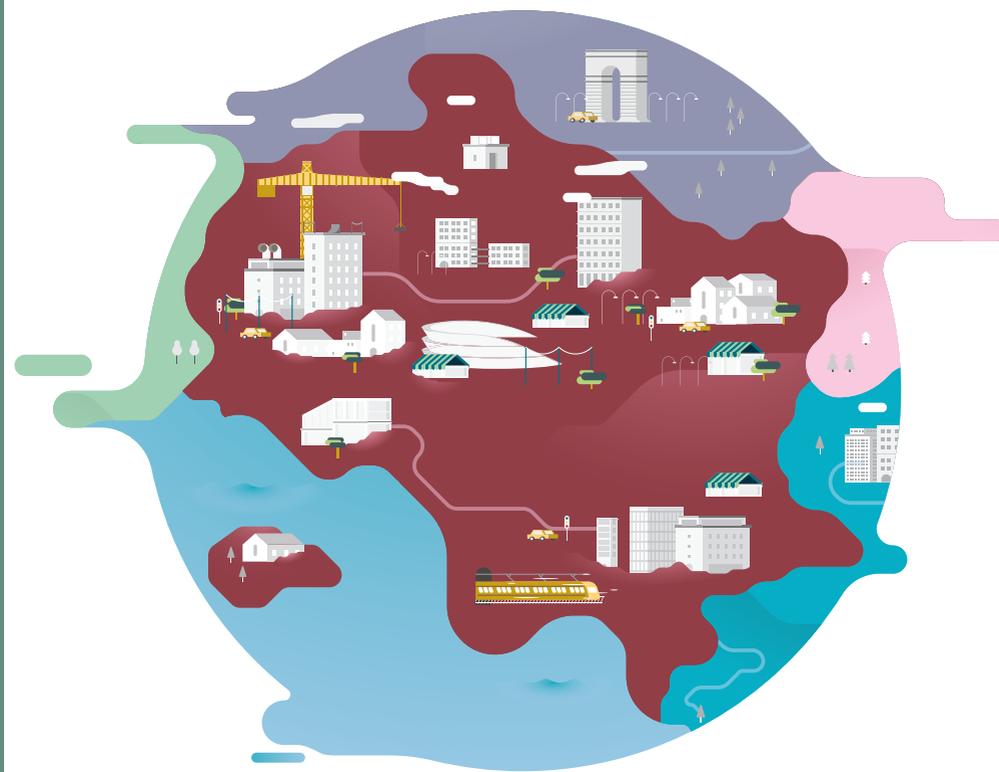
Prof. Roshanka Ranasinghe

UNESCO-IHE Institute for Water Education, Delft AXA Chair since 2014

Chapter 03

Infrastructure failures

How can we ensure continuity of infrastructure activities?

Energy, communication and transport networks, buildings: infrastructure, whether physical or not, is the backbone of our cities. For this reason, extreme care must be taken to reduce all functional risks. It is essential to be able to allow early detection not only of hidden failures and vulnerabilities, but also of critical emergent behavior. For buildings, for example, this means implementing good construction practices. To increase city resilience in the long term, it is crucial to take into account the projected impacts of climate change on the urban environment (such as rising sea levels for coastal cities or rising temperatures) and seismic activity of the region.

Transport is another essential issue, especially in cities that are experiencing rapid and continuous population growth. Indeed, how can we ensure the continuity of activities for tomorrow, if nothing is done today?

For cities, the careful analysis of current infrastructure and the modeling of risks and their potential impacts is therefore a necessity. Especially at a time when the diverse networks are becoming increasingly interdependent on each other, making cascading failures a possible, and potentially devastating, outcome.

$13 billion to $27.5 billion a year

This is the estimated average annual global cost until 2050 to adapt public infrastructure (buildings, transport networks, etc.) to climate change, based on a temperature change of 2°C.

Source: World Bank

80%

8 out of 10 cities around the world are likely to suffer significant damage from earthquakes.

Source: UNHabitat

"Our behavioral research will help design optimal future transport systems"

*"Time spent in traffic jams is wasted time…
in fact, it's miserably wasted time!"* said Dr.
Athanasia Manou, who is working on a research
project to analyze transportation systems at
the micro level. *"By obtaining a much better
understanding of traffic problems, our research
aims to aid the design of optimal future transport
systems".*

Public transport systems seek to provide
a high-quality service under very strict budget
limitations. The scarcity of resources together
with the large volume of demand typically
causes congestion in such systems. The risks
associated with congestion often result in
monetary losses, poor service quality, and
shortcomings in fulfilling societal goals such
as equality and fairness. Many of these socio-
economic risks are borne by the public as
a whole, rather than by individual users.

**Game theory to understand
passenger behavior**

Athanasia's project begins with the question:
which means of transport should a commuter
choose to take if he or she has several options?
*"The first thing to take into account is that a
commuter's decision is affected by the decisions*

of all the other commuters", explained Athanasia.
*"Imagine you have the choice between traveling
by subway train or by car. If you know that most
people are likely to use a car on a particular day,
then you'll anticipate traffic jams on the roads, so
you'll probably take the subway. These decisions
are happening on a daily basis in big cities
everywhere throughout the world. In our model
we represent this situation using game theory –
one commuter is essentially playing this game
against the others".*

The second aspect that Athanasia incorporates
into her models is uncertainty. In public
transportation systems, factors like travel
times, waiting times and available space in
a station or vehicle are random. *"For example,
on your journey to work you don't always
know for sure whether the next train will have
enough space for you. We can handle all these
uncertainties using queuing theory. This means
that by constructing a mathematical queuing
model, we can study and predict queue lengths
and waiting times".*

A third aspect that is factored into Athanasia's
model is the affect of information on passenger
behavior. *"Nowadays people have access to
more and more software applications that
provide commuters with fairly accurate delay
information",* explained Athanasia.

Tailoring public services to suit passengers

Dr. Manou's project intends to analyze
both individual and collective behavior in
these systems that involve several strategic
stakeholders, and to evaluate and suggest
policies with respect to risk-sensitive
performance measures. *"The next step will
be to address the effects of centralization and
decentralization in public service systems",*
said Athanasia.

Dr. Athanasia Manou

Koç University
AXA Post-Doctoral Fellowship
in 2014

"Our models capture the structure, physics and functionality of infrastructure"

The telecommunication blackout in Rome, the
north-eastern US electricity blackout, the Gulf of
Mexico oil spill… Alongside the ever-increasing
complexity of energy, telecommunications and
engineering systems, a number of threats can
lead to cascading failures, i.e. when a failure in an
interconnected system triggers successive failures
elsewhere in the system. Prof. Giovanni Sansavini
has developed innovative modeling techniques
to describe the failure behavior of these types of
complex systems.

**"The whole is much more
than the sum of its parts"**

What exactly is a complex system? *"They are
characterized by a large number of highly connected
components, such as the stock market or the World
Wide Web",* Giovanni explained. *"These systems have
rules of interaction between components that may
change over time. Essentially, the overall behavior
of a complex system cannot be simplified in terms of
its building blocks: the whole is much more than the
sum of its parts".*

A good example is the modern energy setup.
It behaves as a complex organization made up
of interdependent sub-systems. Such systems-
of-systems have shown the emergence of
unprecedented behaviors, such as a vulnerability
to cascading failures, which can have widespread
consequences.

Giovanni analyzes these complex systems
by creating models that faithfully represent
their specific characteristics. *"Our models
are able to capture the structure, physics and
functionality of critical infrastructure, and can
reproduce the consequences of a disruptive
event"* he said.

Towards fully renewable energy

Recently, Giovanni has applied his modeling
methods to assess the feasibility of a fully
renewable energy system. But the inherent
variability of solar and wind power raises
challenges regarding the integration of
renewable energy into existing power grids.
*"We showed the potential for a fully renewable
energy system in Switzerland, integrating
a variety of renewable energy sources and a mix
of hydro and power-to-gas chemical storage",*
said Giovanni. *"We investigated the conditions
under which the fully renewable system would
be able to guarantee a secure electricity
supply".*

Working to improve city resilience

Cities are a key example of interdependent
infrastructures where Giovanni's models
can be applied to study resilience. *"We have
carried out studies on city infrastructure to
determine the optimum trade-off between the
allocation of investment to improve resistance
to adverse effects, and investment to enhance
recovery and the restoration of functionality"*
he said. That is why Giovanni is also conducting
research into microgrids, which could ensure
the reliability of the electricity supply in the
event of power shortages.

Prof. Giovanni Sansavini

ETH Zurich
AXA Chair since 2010

"Satellite monitoring of intrastructure to prevent failure"

Many types of infrastructure are vulnerable to structural damage, which may be caused by natural or human forces. Such damage can compromise the functionality of infrastructure with potentially catastrophic consequences. These risks are aggravated in cases where infrastructure is insufficiently maintained, and in areas undergoing accelerated urbanization.

Recognizing this threat to public safety, Dr Peifeng Ma is developing an innovative satellite radar capable of continually monitoring infrastructural dynamics from space. *"I aim to provide governments with a means of obtaining data on abnormal infrastructure deformation, which will give them a window of opportunity to carry out critical maintenance work before the deformation results in structural failure",* said Peifeng.

In the same way that people should have regular medical check-ups to stay in the best of health and to detect any disorders early on, infrastructural health should also be examined regularly to avoid potential hazards. *"Before a structure like a building or railway collapses, there is often a slow deformation process taking place. Detecting these subtle deformations is very challenging because the magnitude of the changes often amounts to only a few centimeters, and the process usually takes place over a long period of time",* explained Peifeng.

A cost-effective and high-accuracy early warning system

To address this issue, Dr. Peifeng Ma is developing a modern tool with the ability to constantly monitor these small changes from space with millimeter precision, over durations ranging from a few days to several years. *"The project utilizes remote sensing radar technology, known as InSAR (Interferometric synthetic aperture radar), which can measure miniscule changes on the Earth's surface by detecting the differences in the phase of the waves returning to the satellite",* said Peifeng.

As part of this project, Peifeng also aims to design standard guidelines for infrastructural health diagnosis and the early warning of possible deformation risks, as well as enable the long-term archiving of infrastructural health data.

Immediate benefits and wider applications

The project will have an immediate impact on both local and international practices. *"By providing cost-effective and high-accuracy deformation monitoring, along with a state-of-the-art early warning system, we can help government departments in their efforts to coordinate infrastructure maintenance and avoid possible risks",* said Peifeng.

Peifeng's research will also benefit other fields in which an enhanced understanding of the dynamic mechanisms of urban infrastructure is critical, such as research into sea level change.

Dr. Peifeng Ma

Chinese University of Hong Kong
AXA Post-Doctoral Fellowship
in 2016

"Ensuring the continuity of essential services in earthquake emergencies"

With several of the world's largest cities located in high seismic hazard areas, huge concentrations of people and economic activities are exposed to seismic risks. Prof. Iunio Iervolino conducts research into building and infrastructure resilience to earthquakes, and is working on early warning systems to reduce casualties following seismic events.

Building for the future

"We have learned much on improving the safety of the built environment in earthquake zones" said Iunio, *"but resilient cities also need resilient infrastructure, such as telecommunications and transport networks, because infrastructure links up the built environment and distributes resources within it".* The ability of these networks to withstand disruptive earthquakes is crucial for urban inhabitants.

Using risk data to improve resilience

Iunio and his team are measuring the risk level of the built environment during aftershock sequences. *"Most major earthquakes are followed by a sequence of earthquakes that can last for days, weeks, months or even years.*

These events may impair the recovery of a community. So it's very important to be able to measure the seismic risk of structures and infrastructure during aftershock sequences" said Iunio. *"My colleagues and I use probability mathematics to assess these risks. We also carry out simulations in cases where analytical modeling is not sufficient. The results we obtained can help decision-makers understand how resources should be prioritized to provide the optimal mitigation of risks",* said Iunio.

One of Iunio's most important recent findings is a method to integrate aftershock seismic risk into the next generation of design codes for buildings. This has major long-term implications because it will improve the resilience of structural design, while it is also very important in the short term for emergency management.

A few seconds can save countless lives

Although it is practically impossible to stop earthquakes causing damage, especially in countries with aged built environment, much can be done to reduce the number of casualties. *"We aim to develop an early warning system capable of detecting the effective hazard of an impending earthquake and alerting populated areas before they are hit by the seismic waves",* said Iunio. Such a system would give people precious seconds to take action before an earthquake strikes. *"In under five seconds school children can take cover under their desks, factory workers can move away from dangerous machinery, or an elevator can be stopped at a certain floor",* explained Iunio. These simple but significant precautions can mean the difference between an earthquake and a disaster.

Prof. Iunio Iervolino

University of Naples Federico II
AXA Project in 2011

Sustainable housing for more resilient cities

Since 2005, economic losses due to natural disasters have exceeded $1.6 trillion. Nearly 1.7 billion people have been affected, injured or displaced. These damages will continue to rise: it's estimated that, between now and 2030, global average annual losses from disasters in the built environment will increase by 32%.

As a global insurance leader, AXA has a significant role to play to reduce disaster risk, and partnering with civil society will help deliver true impact.

Improving building practices will help save lives and reduce the economic cost of natural disasters

That is why AXA and UN-Habitat are working together to support cities facing the challenges of natural disasters.

This partnership aims at reducing fatalities and limit economic losses because of disasters by developing guidelines to help cities better enforce building codes and regulations in areas vulnerable to natural catastrophes. These guidelines will foster good practices aside housing disaster insurances by leveraging on largescale reconstruction.

Building back better, building back safer

Together, AXA and UN-Habitat promote compliance in (re)construction in order to help cities and communities to build back better and safer after disasters. This joint initiative will also involve dissemination and advocacy activities to ensure the project outputs are institutionalized and to build consensus and momentum among post disaster stakeholders.

UN@HABITAT
UNITED NATIONS HUMAN SETTLEMENTS PROGRAMME

The United Nations Human Settlements Program is working towards a better urban future. Its mission is to promote socially and environmentally sustainable human settlements development and adequate shelter for all.

UN-Habitat is applying its technical expertise, normative work and capacity development to implement the New Urban Agenda and Sustainable Development Goal 11 – to make cities inclusive, safe, resilient and sustainable.

Website: unhabitat.org

Chapter 04

Pollution

How can we stop pollution from stifling tomorrow's cities?

Our understanding of the health impacts from exposure to polluted air is improving, and cities are in the front line of the risk.

Industry, transport, housing... conurbations and their inhabitants must reduce the sources of greenhouse gas emissions, fine particulate matter and other pollutants. However, the task is complex: it is as much about changing the daily habits individually as collectively.

In order to preserve not only people's health but also business continuity during pollution peak, it is vital to put in place prevention strategies, notably in countries and cities that are most at risk.

To make public action more effective, we must study the implementation of regulatory frameworks, while working on the issue of pollution, and studying the various forms it can take. Furthermore, research provides knowledge that enables the establishment of action plans that can reduce the risks for today and for the future.

+ 60%

This is the evolution of CO_2 emissions around the world between 1990 and 2013.

Source: World Bank

92%

This is the percentage of the world's inhabitants living in areas where outdoor air quality levels do not meet World Health Organization (WHO) limits.

Source: WHO

"Adaptation is a social process when mitigation often relies on technological solutions"

There is little doubt that climate change impacts will be felt acutely in our cities. To address these impacts, local authorities must implement adaptation and mitigation strategies to support the adaptation of their communities.

Knowing that research in the field of climate change law at the local level is lacking, Dr. Magali Dreyfus set out to discover what motivates city authorities to take legal action on the climate front. In her project, she studied four urban locations: Tokyo, Paris, Phnom Penh, and Delhi. She looked at what barriers the authorities encounter when trying to implement climate action, and what solutions have helped.

Solutions to suit specific cities

Magali's research into the situation in Delhi revealed that the city has benefited from the Kyoto Protocol's Clean Development Mechanism: *"It has obtained foreign financing for the modernization of its subway, and by improving its public transport system, the Indian mega-city has been able to reduce its air pollution and greenhouse gas emissions , despite the*

recent pollution peaks", she explained. While in Tokyo, the government has taken a very different but equally inventive approach. In 2010 it launched a Cap-and-Trade Program to improve energy efficiency and reduce emissions. *"This legal innovation targets high energy-consuming buildings. If they fail to meet defined targets, they must buy credits from compliant buildings, which are allowed to sell their surplus credits. There is therefore a financial incentive: if you can reduce your own emissions, you can resell your credits. The results are very positive: 90% of participants reduced their emissions",* said Magali.

**Providing local authorities with the tools to make a difference**

Globally, cities in poor countries, which are more vulnerable to climate change impact, tend to opt for adaptation strategies. Whereas those in industrialized countries adhere to mitigation strategies, which aim to reduce greenhouse gas emissions. *"Some local governments, like Paris, may enact regulations that back up international climate commitments. On the other hand, officials in Phnom Penh are preoccupied with pressing development issues, and may not even have climate change on their agenda",* said Magali.

Although each context is unique, Magali has been able to create a framework of climate change strategies for cities. She noted that: *"Adaptation is often a social progress when mitigation relies more on technological innovation. But solutions can also be found in individual behaviors".* The conclusions that she can draw from her research will provide authorities with the tools to anticipate the effects of climate change in their decision-making processes, and make a difference in their own city.

Dr. Magali Dreyfus

CNRS (French National Center for Scientific Research), CERAPS-Lille University AXA Post-Doctoral Fellowship at United Nations University Japan in 2012
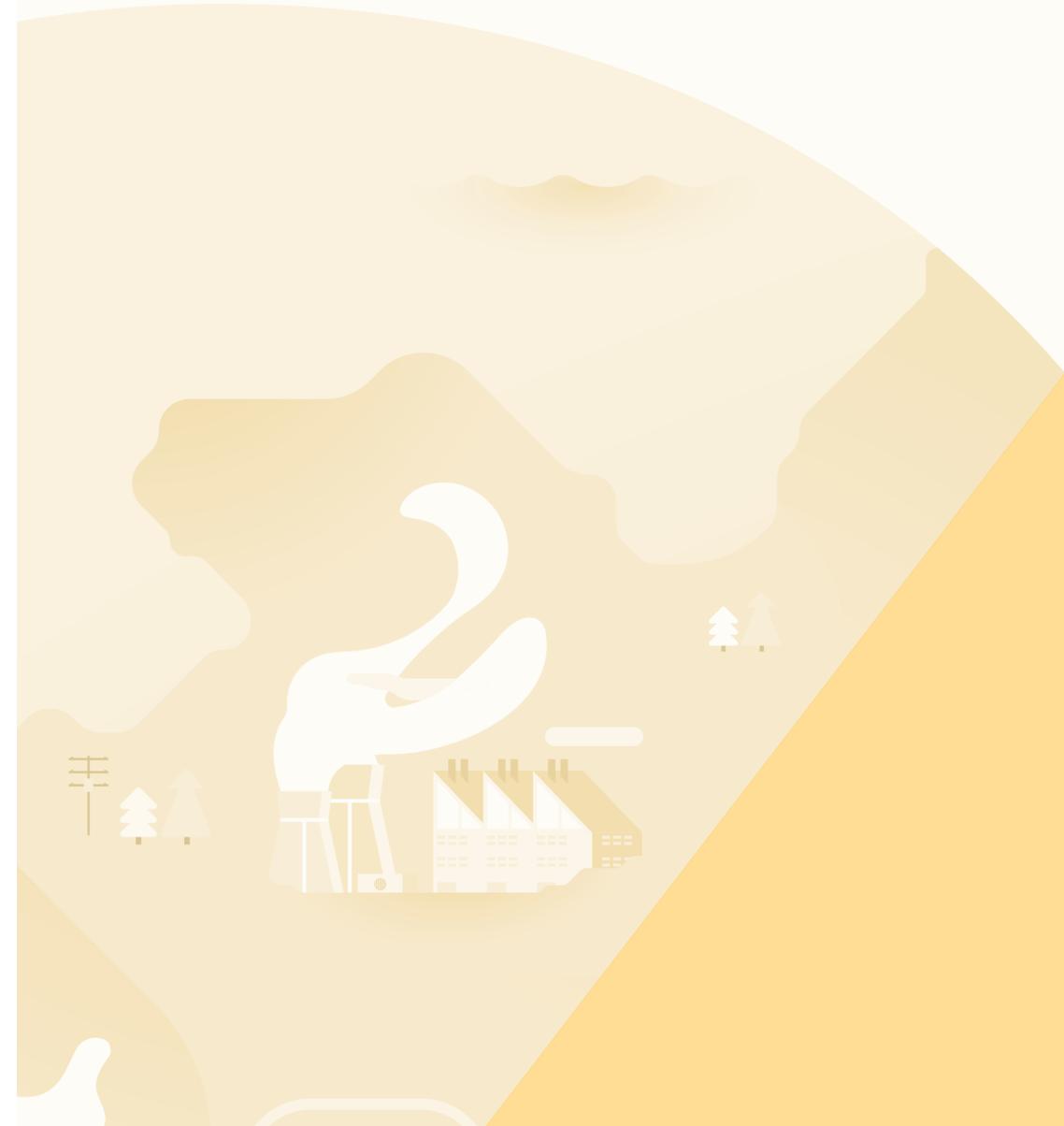
"In terms of city resilience, controlling air pollution is a win-win-win situation"

Although air pollution in China is declining, it remains a major health issue. Prof Sverre Vedal is assessing the effects of pollution exposure on human health in heavily polluted urban areas. *"The generation of robust data on health effects that are directly relevant to China can add impetus to policy implementation, and help target measures towards the most harmful pollutants and sources of pollution"* said Sverre.

Analyzing pollution via observational and experimental studies
To study the impact of air pollution on health, Sverre applies both observational studies, which look at real world air pollution exposure, and intervention studies in which there is an element of experimental control over exposures.

"We used advanced spatio-temporal models to develop a so-called 'pollution concentration surface' for six major air pollutants in Beijing, while our intervention study focused on near roadway pollution exposures", explained Sverre. The latter involved the use of respirators that block out some pollution to enable the investigation into the effects of specific pollutants on the lungs and heart.

Links to lung impacts
Some of Sverre's most important results so far are derived from the intervention studies, which identified that volatile organic compounds in traffic-related air pollution (TRAP) increase lung inflammation, which is an indication of lung injury. This finding provides strong grounds to local authorities for focusing efforts to reduce the health impacts of TRAP exposure.

From data to action
Sverre's air pollution research and his approaches to estimating population exposures in cities are not specific to China. *"Our spatio-temporal models can be applied in any large city in which there are data from air monitoring networks, from satellite imaging, or from city models of pollution dispersion that can be used separately or in combination".* The models generated from these data can be used for several purposes: 1) air pollutant concentrations and the distributions of pollutant sources can be mapped across a city; and 2), if used in conjunction with existing health study data, the models can predict air pollution exposures of individual residents.

Reducing air pollution advances several objectives
Health effects are only one aspect of air pollution, albeit a very important one. Another aspect is climate change. *"Controlling air pollution is therefore a win-win situation. Because moving from fossil fuel dependence to energy independence is also an important pillar in the overall resilience strategy, reducing air pollution is in fact a win-win-win situation. That is, cutting down on fossil fuel consumption and the use of gasoline and diesel vehicles not only reduces health risks and greenhouse gas emissions, but contributes to making cities more resilient",* said Sverre.

Prof. Sverre Vedal

Chinese Research Academy of Environmental Sciences AXA Chair since 2014

"Reducing the health impacts of polluted air for millions of subway passengers worldwide"

For Dr Fulvio Amato, the incompatibility of private vehicles with the high population densities found in cities is clear. Road traffic is a major contributor to air pollution, which is now recognized as one of the largest risk factors for premature deaths at the global level.

"We must rethink our cities, discourage conventional internal combustion engine vehicles through financial disincentives, and promote cleaner transportation modes", said Fulvio.

Understanding the impact of subway pollution

"The first step in any air quality improvement plan is the enhancement of public transport to provide a valid alternative for motorists", continued Fulvio, *"particularly subway transportation because it is an extremely energy-efficient means of reducing traffic congestion".* However, if we intend to promote subway transportation, then it is vital that we understand more about the pollution derived from this mode of transport and its health impacts.

"We are conducting intensive measurements of air pollution in subway platforms and trains with the objective of calculating exposures and dosages. We use a large number of devices including optical counters, sensors and high-volume samplers to measure suspended particulate matter (PM). We are examining particle shape, their chemical composition and their effects on the human body", said Fulvio.

Air pollution differs from one site to another

Fulvio's research is focused on Barcelona where almost one-third of the working population commutes by subway each day. He has shown there is considerable variation in subway air depending on factors such as tunnel ventilation and station design. For example, Fulvio found that passengers are exposed to half the amount of PM in stations with panels to separate the platforms from the rails as compared to open platforms.

Urban transport managers can use this information to help reduce the health impacts of polluted air for the many millions of passengers using subway systems worldwide.

Analyzing the health impacts of pollution

"The next step is to understand the health risks of such exposure, through a synergistic effort with toxicologists and epidemiologists", explained Fulvio. *"Our research shows that subway air should be included in legislation designed to clean up city air".*

Fulvio's work doesn't only concern subway air. He analyzes air pollution throughout the urban environment. A recent important finding has been the huge differences that small distances can make when it comes to breathing clean air, for example: *"moving a bike lane 10 meters away from a road can reduce pollution levels for the cyclist by as much as 50%",* said Fulvio.

Dr. Fulvio Amato

Spanish National Research Council AXA Post-Doctoral Fellowship in 2013 at CSIC-Natural Resources

Chapter 05

Epidemics

How can we prevent cities from becoming hotbeds of major epidemics?

SARS, H5N1, bird flu… as time goes by, the fear of a global epidemic remains.

Today, cities are a major concern in this regard, with populations that are growing in size and density, and an increasing number of connections with the outside world.

This epidemiological risk is most acute in many regions of the world where there is insufficiently developed infrastructure that would help cope with the problem. This is especially the case in Africa and Asia, continents where cities are growing the fastest.

While this risk can have both local and international impacts, it is essential to foster cooperation between these different levels (administrations, international bodies, etc.). As well as defining business continuity plans and management crisis actions that are ready to be applied if necessary.

Beyond coordination, the control and containment of epidemics is also based on an understanding of the dynamics of infection and its spatial and temporal evolution. Research plays an important role in this understanding, particularly through the modeling of the spread of epidemics, adapted to different territories.

44%

This is the percentage of countries around the world with less than one doctor per 1,000 people. Africa is the continent where the lack of doctors is most striking.

Source: WHO

800

Between 2002 and 2003, coronavirus (SARS) outbreak infected more than 8,000 people across 29 countries. 800 of them died.

Source: WEF

"Developing models to understand how infectious diseases spread"

To prevent the spread of diseases such as Ebola, dengue or Zika, researchers, public health workers and the relevant authorities need in-depth information about the dynamics of transmission. To address this, Dr Simon Cauchemez is designing advanced tools that are revealing the key mechanisms underlying epidemics.

"We're developing mathematical models to understand how infectious diseases spread in human populations to better anticipate the trajectory of epidemics, support epidemic planning and advise on optimal control strategies," explained Simon. His results are extremely relevant to public health practitioners, decision-makers, health care workers and residents of affected areas; and also to travelers entering current or potential outbreak zones.

Forming worldwide collaborations to tackle disease

The spread of infectious diseases in human populations raises complex scientific questions that are best solved through an interdisciplinary approach, involving experts from multiple fields. *"This is an area where there is huge room for research that can translate into definitive guidance to improve the management of epidemics,"* commented Simon. *"I'm very committed to this aspect and I work very closely with national and international health agencies to develop the translational appeal of our research".*

Centering on cities

Increased human mobility facilitates and accelerates the circulation of pathogens worldwide, and because cities are hubs for international travel, they are particularly at risk from the introduction of an emerging pathogen. This risk can be compounded in some urban environments: *"High population densities and poor health and sanitary infrastructure can also facilitate the spread of pathogens"* said Simon.

Simon's work is already proving invaluable in supporting efforts to control epidemics in cities. *"For example, recently there was a large plague epidemic in Antananarivo, the capital of Madagascar. My team was deployed there to support local authorities with a view to understand the dynamics of spread, assess the impact of control measures, and make short term predictions. We helped the authorities understand what was happening in the field and what might come next, so they could make informed decisions".*

Much of the team's work involves emergency situations, however, some projects are more long-term. For example, Simon has collaborated with partners in Bangladesh to investigate chikungunya transmission by collecting data on the mosquito vectors, and using GPS devices to track human mobility. This countrywide data is now being examined to assess the impacts on transmission.

Dr. Simon Cauchemez

Pasteur Institute
AXA Award in 2014

"With proper public health infrastructures, urban centers can mitigate epidemiological threats"

Pathogens know no borders. Infectious diseases are global in nature and their control and elimination require international cooperation. Dr. Petra Klepac carries out research that combines epidemiological dynamics with the game theory of international agreements to find ways to enhance this much needed cooperation. Her results have very important public health implications.

"For my AXA Research Fund Fellowship, I have been investigating ways to achieve the necessary levels of cooperation for successful pathogen control of immunizing infections" said Petra. *"The world is increasingly interconnected, and cities are the connection hubs of the globe. Global problems, such as infectious diseases, require global solutions. Cities cannot act in isolation, and cooperation is becoming increasingly important in addressing many of today's risks".*

Improving control of infectious diseases

Petra studies how voluntary coalitions can improve infectious disease control to enhance regional and global elimination interventions. *"In many cases, international agreements enable countries to achieve much better - and also lower cost - vaccination coverage than would be possible through only unilateral action",* said Petra.

Her work is based on metapopulation epidemiological modeling that enables the mathematical representation of discrete populations and the movement of infected individuals both within and between these populations. By studying these dynamics, Petra is able to analyze the underlying mechanisms that drive the transmission of an infectious disease, which is vital for the design of effective and successful control strategies.

"I analyze how multiple factors, ranging from seasonality, pathogen evolution, human mobility, economic and logistic constraints, influence optimal strategies for the control and elimination of infectious diseases" said Petra.

Cities can help and hinder

Big cities are prone to epidemiological risk because they bring together many people into close contact, and also have transport connections to the rest of the world. *"Human mobility is allowing pathogens to easily move across the globe. Once it reaches a densely populated area, a pathogen can spread quickly, particularly if many individuals lack immunity",* explained Petra.

"But on the other hand, urban centers mitigate these risks if they have proprer public health infrastructures, hospitals, etc. Consequently, it is in the least developed countries, where highly populated dense urban areas do not have such public health facilities, that epidemiological threats are particularly severe", added Petra.

Dr. Petra Klepac

University of Cambridge
AXA Post-Doctoral Fellowship
in 2012

Chapter 06

Protecting vulnerable populations

How can we protect the most vulnerable populations?

Every year, 26 million people around the world fall into poverty due to natural disasters, mainly in developing countries. These vulnerable populations are typically rehomed in precarious housing, which is often located in high risk areas that have been neglected by urbanization projects, and in which public services are minimal or absent.

To provide better protection for these people, research is being conducted to improve our understanding of how such communities respond to disasters, so that they can be better supported in the future.

Similarly, alerting local stakeholders and engaging them in data collection and risk assessment help improve populations' resilience to risks. In that perspective, insurance also has a vital role to play in protecting vulnerable populations against natural disasters. By fostering strong public-private partnerships, it is possible to drive disaster risk reduction and resilience at the local level.

1/3

Since 1990, 33% of the world's urban population is estimated to live in slums or precarious housing.

Source: PwC

82%

This is the proportion of cities located in areas at high risk of mortality associated with natural disasters (earthquakes, floods, cyclones, etc.). In 2014, this equated to 1.9 billion inhabitants.

Source: UN

"Data is key to understanding vulnerability in cities"

The world has experienced unprecedented urban growth in recent decades as large numbers of people are attracted by the economic opportunities and lifestyles offered by cities. However, there are also many risks associated with urban living. Dr. Cassidy Johnson collaborates with researchers and policy-makers on data collection and the measurement of environmental risks in urban areas.

"My AXA project is on metrics and measurements for urban resilience. Data is key to understanding risk in growing cities. We need to know exactly who is vulnerable, and to what, and then we can look at what infrastructure they need", commented Cassidy.

Focusing on the most vulnerable people

Cassidy's work is centered on low-income groups in cities of the Global South. The poorest among these groups often live in informal settlements, which tend to be situated in areas most exposed to natural hazards (in flood plains or on steep sloping land for example). Furthermore, these locations are often lacking in adequate infrastructure and services. The combination of these factors puts people at greater risk of illness or harm.

"I conduct research in Dar es Salaam, Tanzania's largest city and former capital. The main threats we identified here include: crime, poor solid waste management, lack of storm

water drainage infrastructure, lack of waste water and toilet infrastructure, lack of basic health services and hospitals, flooding, high living costs, and drug abuse", said Cassidy.

The most common impact of these risks was the incidence of water-borne diseases such as cholera, typhoid and malaria. Other consequences include a persistent stench and a sense of insecurity and fear, all of which underline the everyday challenges faced by residents.

Taking steps towards better resilience

The acquisition of data on these settlements allows those in charge to understand the scale of the problems, and to identify which issues should be addressed first. *"Metrics are a form of communication"* said Cassidy, *"residents are aware of the greatest everyday risks they face in their neighborhoods, and disaster experts know whether natural hazards threaten these places. Gathering all this information into a measurement helps policy-makers and local leaders take action. That's the role of metrics".*

Cassidy's research is shedding light on the risks faced by urban communities, both on a daily basis as well as those arising from large infrequent events. Action can then be taken based on this knowledge. *"While this is difficult in many low-income countries due to a lack of resources, organized communities can work together with local governments to make improvements, such as implementing community policing and community waste management",* said Cassidy.

Dr. Cassidy Johnson

University College London
AXA Outlook in 2014

"Disasters also involve the social environment"

The global community of the 21st century bears a heavy burden from flood risks of historically unprecedented frequency and intensity. Indeed, flooding is now one of the most damaging types of natural hazards in terms of economic losses and mortality.

The severity of flooding can be observed in the coastal settlements known as the Colonias, situated along the Rio Grande in southern Texas (USA), in what used to be agricultural flood plains. The Colonias, which are home to around 500,000 low-income people, lack basic services like potable water, sewers and paved roads, while housing is built from cheap, readily available materials.

An interdisciplinary approach to protect vulnerable populations

Despite their direct exposure to serious storm and hurricane risks, no research has explored the Colonia population's vulnerability to floods. Dr. William Donner is addressing this situation with an innovative, interdisciplinary approach. *"Disasters implicitly involve both the natural and social environment and are therefore well-suited to interdisciplinary study"*, said William.

Dr. Donner uses electronic cartography to map the locations of the Colonias, then interviews inhabitants to learn about their vulnerabilities and coping strategies. Several patterns have emerged from this investigation; the most notable being that Colonia residents are highly

unprepared for a disaster, few residences are insured, and even fewer have the resources to mitigate risks beyond the regular anticipated floods.

In collaboration with natural science researchers, William incorporates flood risk analyses to develop models to predict inundation patterns for the Gulf Coast hurricanes that could have a major impact on the Colonia populations. *"Through a better understanding of their social and environmental vulnerabilities we hope to inform better public policy to help protect residents of the Colonias and populations like them around the world"*, said William.

Supporting policymakers to improve flood resilience

Findings from the Colonia study will assist policymakers in developing specialized preparedness policies for Colonia neighborhoods. *"Based on our findings, we are developing a policy package that recommends the distribution of free, low-cost weather radios and education programs intended to inform Colonia residents about affordable insurance programs"*, said William.

Resilience thinking should be built into urban planning initiatives for new and urbanizing communities, as well as established cities in which infrastructure growth routinely takes place. *"Urban resilience remains elusive"* explained William, *"but the solution is to foster partnerships between academia, the public and private sectors, non-profit organizations and NGOs, as well as a host of local, community stakeholders"*.

Dr. William Donner

University of Texas
Rio Grande Valley
AXA Award in 2015

"Participatory drama opens up new spaces for resilience"

From Kenya to Southwestern UK, Professor Katrina Brown works with coastal communities to facilitate shared experiences of coping with, and building resilience to extreme weather events. *"Climate change doesn't happen in isolation; people have to juggle different risks at different timescales. That's a fact of life"* explained Katrina.

The power of participation

Katrina's project focuses on the application of performative methods to explore the concept of resilience in coastal communities. *"Participatory drama opens up new spaces, to explore lived experiences, imaginations, emotions, and possible solutions around global change required for transformative action"* said Katrina.

She has worked closely with local authorities, as for example in Porthleven (South West England): *"Some council representatives took part in our theatre performance in the town of Porthleven, and also helped us develop a game around flood risk. We hope this will be helpful for decision-makers to explore ideas about flood risks and individual and collective responses"*.

Showing the importance of emotional and subjective aspects of risk for local communities

Katrina has been able to demonstrate exciting new methods to engage with people to improve our understanding of risks. *"Our work has shown the*

importance of emotional and subjective aspects of risk and helped us gain valuable insights which moved us beyond contemporary models of climate change adaptation. For example, in Kenya we used humor as a means to bring people together to contemplate different future scenarios; while in the UK we used grief".

A problem exacerbated by poverty

Prof. Brown works mostly with people in developing countries where climate change issues are exacerbated by poverty. *"Poorer people have fewer resources to buffer them against shocks and extreme events. A single event can tip them into extreme poverty"*.

Katrina has also worked with people in Kwale, on the south coast of Kenya, where peoples' livelihoods are based on subsistence farming and fishing. *"Communities here are remote compared to coastal towns like Porthleven (UK). Fishing and farming are important in both places, but in Porthleven, there are other sources of income, so people have more assets to fall back on in times of hardship"*.

Differences and similarities in resilience

While noting that resilience is constructed very differently in Kenya and UK, Katrina observed interesting similarities. *"Coastal communities recognize that change is part of how they live. They are used to dealing with the vagaries of the sea and weather. They share a sense of place and belonging, and a pride in being coastal people. The ties that bind people to place and to each other are important sources of resilience"*.

Prof. Katrina Brown

University of Exeter
AXA Outlook in 2013

The future
of resilience
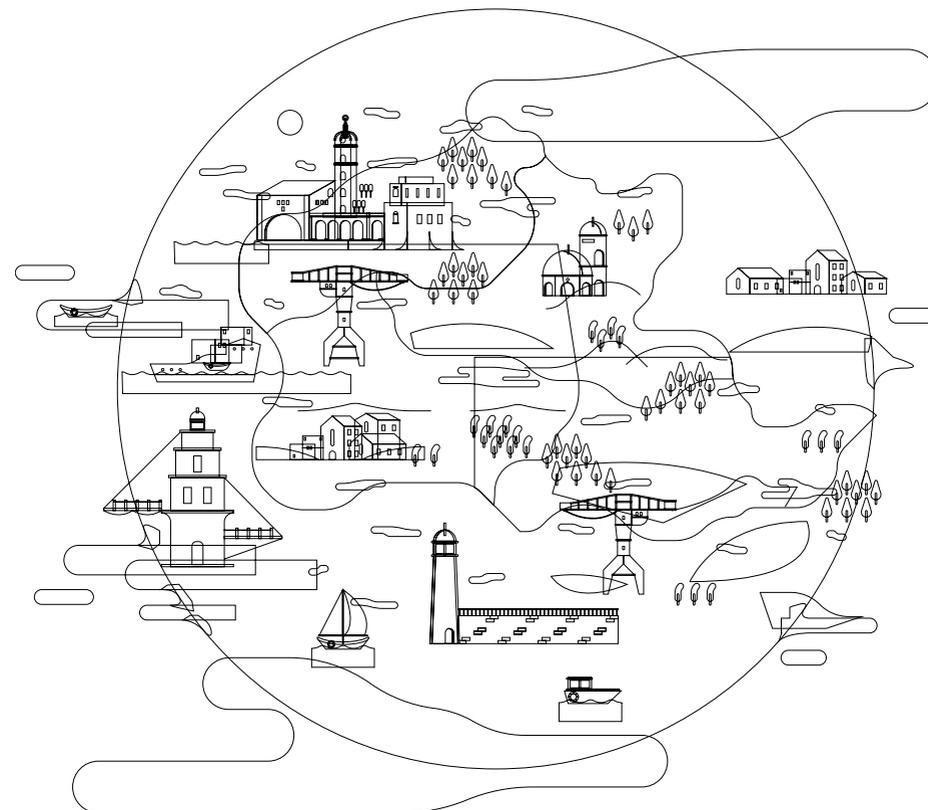
Foresight makes it possible to prepare for a diversity of potential breakdowns

While the world's population continues to grow, conurbations are developing and multiplying. So too are the risks and difficulties they face.

Thus, climate change, in addition to purely environmental problems, also raises energy, economic, health, spatial organization and transport issues. In the face of this increased interdependence and complexity of risk, improving city resilience is not only a technological matter. Indeed, while data is an essential element of tomorrow's smart cities, it cannot be the only risk analysis tool.

Foresight to make cities more resilient

In this sense, deploying a prospective approach seems essential. Indeed, to anticipate is to detect weak signals and to understand the underlying trends. Anticipating also involves equipping ourselves with the means for a systemic vision of changes that often involve technological, legal, social, economic or even political aspects.

By examining multiple scenarios, foresight makes it possible to prepare for a diversity of potential breakdowns. And it is precisely this global approach that provides decision-makers and populations today with information to make the right decisions about their future.

In this process, research of course has a fundamental role to play, through its theoretical work, its fieldwork, but also through its ability to put the present into perspective.

From sector intelligence to holistic intelligence

In this world of profound upheaval, AXA is already working on various smart city scenarios across several continents.

This is the case, for example, in Mexico City, regarding smart grids, which are electricity networks that share information between energy suppliers and consumers, and which can be very useful during occasional failures of a part of the network.

"Anticipating also involves equipping ourselves with the means for a systemic vision of changes"

This is also the case in Singapore and Bristol, where AXA's teams are working with populations, local authorities, and various industrial partners on the issues of transport, building construction, health systems and governance.

All these projects, in the long term, will make it possible to move from a smart city approach that is still overly sectoral, to one that is truly holistic. And to further increase city resilience.

Cécile Wendling
Group Head of
Foresight at AXA

Focus on
Bristol

Cities and transport systems of the Future

Recently, Bristol, in South West England, has established itself as a 'Smart City'. In that perspective, the city launched a number of initiatives to face social inequality challenges, unemployment high rates, housing issues and congestion problems.

Among them was **'Venturer'**, a Connected & Autonomous Vehicle Consortium, based in the University of West of England's Bristol Robotics Laboratory. 'Venturer' is a partnership of public, private and academic experts. It counts the Bristol City Council among its members.

A new city redesigned by autonomous vehicles

According to experts, autonomous vehicles will be an essential part of an integrated transport solution in the cities of the future. Among the various improvements expected from this new technology, when they are fully developed, we expect that there will be far less accidents on the roads, no need to take up substantial real estate with car parks, and road design will be transformed.

In addition to 'Venturer' project, AXA UK is also working with the local government to rehabilitate an old airport in the city and turn it into a brand-new neighborhood with infrastructures integrating smart solutions to communicate with driverless vehicles. Problems such as congestion, transport for certain segments of the population (such as elderly or disabled people) and some environmental issues could be solved.

A challenge for insurance

Through 'Venturer', AXA is an active participant in discussions on the future of transportation. The company also gets involved in discussions around wider infrastructure issues.

More specifically, AXA's role is to provide advice, guidance and support on legal, regulatory and insurance matters (i.e. liability schemes), and the dissemination of information from the work carried out.

Future cities will have to face a vast number of challenges, but insurers have an important role to play. A partnership such as 'Venture' allows AXA to effectively accompany the cities and transport systems of the future, and to understand and design the Products & Services its future customers will need.

*This text was written thanks to the comments of Cécile Wendling, Group Head of Foresight at AXA, and David Williams, Technical Director at AXA UK.

Focus on
Singapore

Addressing tomorrow's challenges through technological innovations

"Smart Nation". Launched in 2014 by the Government of Singapore, this program aims to address the urban challenges of the future by drawing on the potential of technological innovations, and in particular the Internet of Things and Big Data. While the city-state is digitizing its public services, its main aim is to bring about an ecosystem of partners, involving start-ups, multinational companies, university research laboratories and more.

Improving the well-being of the elderly

The SILVER project (Singapore Innovative LiVing EnviRonment), which brings together Singaporean universities, the CNRS and companies such as AXA, exemplifies this objective. Its aim: to provide a framework along with relevant and innovative tools to adapt the urban environment to suit the needs of the ageing population.

To improve the well-being, independence and mobility of the elderly, researchers first studied their behavior in the home as well as external environment, and sought to identify potential factors that might cause a deterioration in health, all of which was achieved using connected sensors. The pilot, initially deployed in 200 homes, will soon be scaled up. Data analytics should enable the creation of connected assistance services dedicated for this population.

Predicting the mobility of tomorrow

Mobility is also an important topic in Singapore. In 2017, around 100,000 shared bikes were introduced in less than 10 months. In parallel, shared electric cars have also been deployed. This shows how behaviors can change within relatively short periods of time, and how public authorities can respond promptly. An analysis of the behavioral data for these services could provide an invaluable insight into new types of mobility and the impact they might have on public transport, urban planning and enable the creation of customized usage-based insurance.

Finally, Singapore is also preparing itself for future mobility solutions, such as autonomous cars. AXA, for example, is working with partners on risk modeling for the commissioning of these vehicles in future, particularly regarding future challenges, such as liability.

*This text was written thanks to the comments of Cécile Wendling, Group Head of Foresight at AXA, and Céline Le Cotonnec, Chief Data Officer of AXA Singapore.

Focus on
Mexico

Using data and blockchain to increase road safety

Every day, between 8 and 10 million vehicles circulate on the streets of Mexico City. However, the infrastructure is by no means equipped to cope with this incessant flow of traffic. As a result, Mexico's capital is the world's most congested city. Such heavy traffic not only generates a significant amount of pollution, it also results in many accidents. With around 16,000 deaths each year, Mexico's roads are the 7th deadliest in the world.

Using data to support prevention

To address the situation, the city welcomes all proposals, whether from public authorities, civil society or companies. For example, AXA has made its road accident data publicly available. The objective: to flag up the most dangerous crossroads for motorists, in terms of both accident severity and frequency. And this has been done for all the main cities of the country including, of course, its capital. The objective: raise awareness of road safety among the population, but also among the municipal services regarding the main risk areas.

*This text was written thanks to the comments of Cécile Wendling, Group Head of Foresight at AXA, and Charlotte Serres, Head of Transformation and Innovation for Motor and Property and Casualty of AXA Mexico.

Blockchain to broaden civil liability

Another issue concerning road transport is the chronic lack of insurance policies for motorists. Despite the development of a comprehensive road safety program, only half of drivers in Mexico City are insured. Which is a major problem if an accident occurs…

As part of an innovation competition, AXA employees presented a blockchain technology project that could help certify and verify insurance policies. The benefits are twofold: for the user, this system guarantees that a policy will protect the policyholder, or a third party that he or she may cause damage to; and for the authorities, the system enables the rapid identification of genuine insurance policies and also the fake policies.

The project, which has not yet been deployed, is currently supported by AMIS, the Mexican Association of Insurance Institutions. IBM is also collaborating in the venture, through the provision of technical expertise.

While data sharing or the use of a blockchain-based proof of concept cannot on their own solve Mexico City's road transport safety problems, they do however prove that the voluntary use of new technologies is an essential element of the overall response. This approach can be applied in other risk-related areas. For example, when natural disasters such as hurricanes occur, AXA's claim experts have used drones to quickly identify the magnitude and extent of the damage; and reacts accordingly, thus speeding up the claims process.

About
AXA Research Fund

AXA
Research Fund

The AXA Research Fund: supporting Research for better lives

Because Science holds the keys for progress and better lives, AXA launched in 2007 the AXA Research Fund, a unique global science philanthropy initiative dedicated to accelerate and share knowledge and solutions for key global challenges facing our societies.

The AXA Research Fund supports academic innovation made by top-tier researchers all over the world. It provides researchers with the means and freedom to complete their work successfully, so that they feel encouraged to explore new avenues.

The awarding of grants is based on strict academic criteria following a transparent and rigorous selection process, which is overseen by our Scientific Board and presided by Prof. Tom Kirkwood (Newcastle University, UK).

"Sharing scientific knowledge, feeding the public debate, empowering people to take enlightened decision, building a better future."

Support research beyond funding

Convinced that to be useful, science needs to be shared, AXA provides communications resources and network to help selected scientists disseminate their knowledge with a broader audience and foster exchanges to enlighten decision making for a better future.

€179
millions committed

563
Research projects supported

Researchers of
58
nationalities

in
35
countries

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Please contact us at:
community.research@axa.com

Dr. Fulvio Amato

As part of the Institute of Environmental Assessment and Water Research of the Spanish National Research Council in Madrid, Fulvio Amato focuses his research on air quality and pollution modelling. In 2013, he was awarded by the AXA Research fund a Post-Doctoral Fellowship.

Dr. Vazken Andréassian

Scientific deputy director at the IRSTEA, Vazken Andréassian is the principal investigator of the AXA-IRSTEA Joint Research Initiative that started in 2015.

Prof. Deborah Balk

Associate Director of the City University of New York Institute for Demographic Research, Deborah Balk is specialized in spatial demography and the use of social science data. In 2014, she obtained an AXA Outlook grant.

Prof. Katrina Brown

Katrina Brown teaches social science and environment at the University of Exeter (UK). In 2013, she was awarded an AXA Outlook grant.

Dr. Simon Cauchemez

Simon Cauchemez is directing the Mathematical Modelling of Infectious Diseases Unit at Institut Pasteur in Paris. In 2014, he received an AXA Award grant.

Dr. William Donner

Specialized in the environmental impact on socio-economic risks, William Donner is associate professor at the University of Texas Rio Grande Valley. In 2015, he received an AXA Award.

Dr. Magali Dreyfus

CNRS Researcher at CERAPS in Lille University, Magali Dreyfus is specialized in cities and climate change through the prism of local policies and legal tools. In 2012, she completed her post-doctorate fellowship in the United Nations University (Japan). supported by the AXA Research Fund.

Prof. Dagmar Haase

Dagmar Haase, from the Humboldt University Berlin, is specialized in urbanizations trends. In 2014, she received an AXA Award.

Prof. Iunio Iervolino

Iunio Iervolino teaches earthquake engineering and structural dynamics in the Università degli Studi di Napoli Federico II. In 2011, he was granted an AXA Project focusing on Industrial seismic loss assessment and reduction.

Dr. Cassidy Johnson

Cassidy Johnson is Senior Lecturer at the Bartlett Development Planning Unit at UCL in London, where she teaches disaster risk, post-disaster recovery and climate change adaptation. In 2014, she received an AXA Outlook grant.

Dr. Petra Klepac

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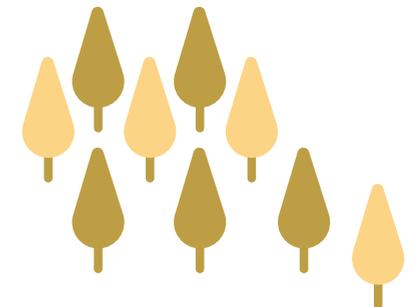
Additional information about Resilient Cities online

In partnership with National Geographic, the AXA Research Fund created a series of films. These films explore how researchers supported by AXA are using their research to help understand the impacts of natural and human-made hazards on cities and how data can help build resilient cities.

You can find these videos on YouTube:

Ep. 1 - Exploring Future City Growth & Urban Landscapes

Ep. 2 - Flooding: Exploring Early Warning Systems

Ep. 3 - Air Pollution: Exploring the Impact on Health

Ep. 4 - Earthquakes: Exploring Early Warning Systems

Ep. 5 - Insurance: enabling resilience for Cities

Also available on YouTube, "EXPLORE / PROTECT" is another serie developed in partnership with National Geographic that showcases conversations between researchers supported by the AXA Research Fund and National Geographic Explorer Jon Waterman:

Ep. 1 - Climate change & extreme weather events

Ep. 2 - Community resilience & extreme weather events

Ep. 3 - Infrastructure & Climate Change

Some articles published by The Conversation also report on the work of researchers supported by AXA Research Fund:

• Commuting by subway? What you need to know about air quality

• Earthquakes caused by industrial activities: what are the risks and how can they be reduced?

• People power: how communities and cities can help save the environment

A Guidebook, "Measures To Improve Urban Air Quality", written by Fulvio Amato, who completed an AXA Post-Doctoral Fellowship supported by the AXA Research Fund, is available online as well: www.cleanaircities.net

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