EARTH SYSTEM – ENVIRONMENTAL SCIENCES

The Innovation Biosphere

Planet and Brains in the Digital Era

Eunika Mercier-Laurent

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Foreword

Innovation Biosphere is a very interesting title for a new book intended to raise thoughts beyond the ordinary. And that is what we need – thoughts beyond the ordinary, and courage to bring disruptions into reality.

Challenges in innovation processes arise from the past, but the future is not its linear extrapolation. Solutions can only be found by considering innovation as a way of daring to seek the unexpected: daring to see beyond the surface of "obvious" solutions, daring to make a real paradigm shift.

This book presents numerous examples of new ways of thinking and their results. I hope that these examples will ignite even more ambitious goals, and target those goals by combining our knowledge across the whole spectrum. Innovation has to make things happen, and very often the real innovation happens in cross-disciplinary approaches, and in mash-up processes where (positive) collisions of ideas and knowledge ignite new solutions.

In that context, courage and curiosity are both needed. To be able to manage the path to the unknown, a good way to proceed is by experimenting, and rapid prototyping in real-world settings with real people. Only then we can see what is having a real impact and what is scalable. That very approach is also, of course, suggesting that many of those experiments and prototypes fail. However, the most important is to fail fast, as then the limited resources can be focused on the more promising approaches and their scale-up.

This book helps us to pose the right questions and to be curious about alternative approaches to the obvious short-term wins. In my view, some of those are: which are the true limitations of our biosphere? Which are the true limitations of ecosystems? How to engage all the stakeholders to a common vision? How to create the safety net in innovation ecosystems for experimenting the new in our seeking for the unexpected?

The rapidly changing technology landscape that we are living in is also very well described in the present book. That landscape, much enabled by modern ICT development, creates possibilities for new types of societal behavior and new value creation processes on both societal and individual levels.

Modern technology which creates, for example, human spare parts, augmented reality and robotization are all very important when painting the picture of our future.

Today, the unemployment problem is an issue in Europe, but, essentially, all work that can be described as well-defined processes can be robotized or automated, sooner or later. The "human work" is something where we are at our best; collaborative work requires creativity. This includes both physical and non-physical work. We are facing a major societal challenge here. For example, which are the new jobs we cannot even imagine yet, and how is the overall work–life equation developing in an inclusive way?

Hence, innovation policy needs to look beyond the obvious questions (and the obvious answers in the short-term) to respond to megatrends. In Europe, we have most of the components for proper innovation systems and their governance in place, but the systemic view should still be reinforced. The innovation pyramid has to be reversed; the users having their say in the solutions to be up-scaled. This, together with the experimentation in real world, is creating the frame for new innovations and disruptive approaches, e.g. Open Innovation 2.0.

Living Labs (or any open innovation ecosystem) interlinked with other same-minded sites can be very powerful drivers for large-scale solutions engaging all stakeholders. Let us use that opportunity better,

interlinking bottom-up approaches with the target to find pan-European solutions and concepts. We in Europe have the unique asset in our diversity and high education level.

I wish all the readers of the book an inspiring time, and hope that they will begin to look beyond the obvious, to make innovation real in their own innovation ecosystems.

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European Commission
DG Communications Networks, Contents and Technology
March 2015

Introduction

Our planet Earth is located in the ideal region of the Milky Way galaxy in the solar system. This zone contains just the right concentration of chemicals and other elements needed to support life. The planets' position in the Universe and their movements play a vital role in the Earth's ecology. Ocean tides are caused by the gravitational interaction between the Earth and the Moon. The Earth's perfect tilt and spin causes the annual cycle of seasons, moderates temperatures and allows for a wide range of climate zones. The Earth's path is almost circular, keeping us roughly the same distance from the Sun year-round. The Sun is the perfect "powerhouse" that emits just the right amount of energy. A magnetic field and an atmosphere serve as a dual shield protecting living things from potentially deadly forces emanating from the Sun. The atmosphere, which is a blanket of gases, keeps us breathing and provides additional protection. An outer layer of the atmosphere, called the stratosphere, contains ozone, which absorbs up to 99% of incoming ultraviolet (UV) radiation. The ozone layer helps to protect all forms of life from dangerous radiation. The amount of stratospheric ozone is dynamic, adapting to the intensity of UV radiation rises. The atmosphere also protects us from a daily barrage of debris from space that burn up in the atmosphere. However, the Earth's shields do not block radiation which is essential for life, such as the heat and visible light. The atmosphere even helps distribute the heat around the globe, and at night the atmosphere acts as a blanket, slowing the escape of heat. Natural water, carbon, oxygen and nitrogen cycles replenish and cleanse the planet's air and water supply.

The biosphere is also called the zone of life. According to the National Aeronautics and Space Administration (NASA), it is "the portion of Earth and its atmosphere that can support life". Like the shell of an egg, the biosphere is a very thin layer, or zone, that encompasses our planet.

The biosphere consists of living things and the environment – the atmosphere, the land and the oceans – from which they derive the energy and nutrients needed for life. For instance, plants capture solar energy and use it to convert carbon dioxide, water and minerals into oxygen and food. Humans and animals take in oxygen and food and return carbon dioxide and other matters to the environment. This cycle repeats itself and everything recycles. Thus, the biosphere can sustain life indefinitely. We will use this metaphor for innovation systems acting in harmony with the environment.

Innovation has always been a part of human activity. The main motivations for innovation are the improvement of our life, scientific satisfaction, demonstration of creativity or know-how, invention of new businesses, and becoming rich and famous. However, each new product, technology and process has an impact and consequences on the development of economy, the living and the planet. The first awakening on the state of the planet was raised during the intensive industrial revolution in the 1960s, but nothing was changed.

Within the complex economic context, innovation is considered as a potential answer to the crisis. Facing the economic, social and environmental challenges required a different approach from those that worked well in the past for the industrial era is required. Perhaps it is an effect of crisis, but people are more creative. The European programs since the 1980s have produced a lot of extraordinary projects and results. Nevertheless, their visibility should be improved to facilitate the transformation of these promising results into products and services. Many countries focus on entrepreneurship but the conditions for success are not always understood by politicians who want growth and jobs without investment into new laws facilitating development of activities, such as lower taxes and employment flexibility to help bypass the "Death Valley".

Innovation concerns all fields; however, the politicians consider information and communication technologies, biotechnologies, nanotechnologies and applications related to health as the most promising

areas. Nowadays, facing challenges requires connection and synergy with other innovations – in politics, society, education and behaviors.

Other skills apart from the traditional ones are also required to succeed in innovation. There are some schools teaching innovation with various points of view, but they mostly teach traditional 20th Century innovation. Initiatives are encouraged and experiments are conducted without measuring the impact of invested money and energy on improving the economic situation. Politicians would like the immediate results of their financial investment on selected institutions; however, they have to focus on the right persons and actions.

Science and innovation have the power to transform our lives and the world we live in – for better or worse – in ways that often transcend borders and generations: from the innovation of complex financial products that played such an important role in the recent financial crisis to current proposals to intentionally engineer our Earth's climate. The promise of science and innovation brings with it ethical dilemmas and impacts that are often uncertain and unpredictable: "it is often only once these have emerged that we feel able to control them". How do we undertake science and innovation responsibly under such conditions, toward not only socially acceptable but also socially desirable goals and in a way that is democratic, equitable and sustainable? Responsible innovation challenges us all to think about our responsibilities for the future, as scientists, innovators and citizens, and to act upon them [OWE 13].

Innovation focuses mostly on function, and takes little consideration of the impact. Researchers want to discover, while inventors (all categories) think about the services their invention may provide. Businesses and their investors expect to make money through sales. This model of traditional innovation from the previous century is followed by many. Today's context is different: the market is global, full of competitors and opportunities. This situation requires the overall innovation.

The environmental impact of innovation is not really taken into account from the beginning, except perhaps eco-innovation projects.

Current trends, such as sustainable development and corporate social responsibility (CSR), mainly focus on social and environmental aspects.

Can we really target sustainable development in a global world of greedy economics designing products to throw away? Reparation is impossible because of often changing standards and lack of spare parts. Planned obsolescence [CAS 13] and manipulation of customers lead to accumulation of waste and waste economy. Advertisement-based business models empowered by Internet make customers unhappy with what they have and push them to buy something newer and "better" right now (consumerism). The ISO 26000 standard has been provided for companies to guide them on socially responsible behavior and possible actions. However, the process is complex and is not yet adapted to start-ups or small and medium enterprises (SMEs). Too many events and actions are simply "green washing" without a real value, except perhaps the improvement of a company image. Like knowledge-based business several years ago, the eco-business is growing today. CSR principles and rules are followed by eco-design and integrated into product life management (PLM) and lifecycle assessment (LCA).

We can observe a knowledge economy paradox – many are overeducated, and this knowledge and the past knowledge are under-used. Education is not planned as a function of the market requirements. There is the risk of knowledge lost, lack of transfer in the case of retirement or turnover.

In France, after 30 glorious years, the economic and social crisis deepens. Many French have a complex with the language (they are afraid to speak English). French is recognized as an European language but, for example, the application for funding must be written in perfect English. Only a few French individuals are actively involved in the European policy and governance. The French are gifted for inventing great things but they have no talent for business. In consequence, many interesting projects do not have any economic impact. For example, the French service in artificial intelligence was the best in the world in the early 1990s.

Politicians believe that innovation must leverage the growth and stimulate job creation. The PhD students and unemployed people are encouraged to create their companies while the conditions for success are not provided. Politicians are "disconnected" from the field and lowering funds for innovation are not always given to the right persons; the return on investment (ROI) is not measured. The user-driven innovation policy may improve this situation. Only politicians are invited to Organisation for Economic Co-operation and Development (OECD) discussion groups.

Many focus on short-term business despite the planet protection. The economic trends such as globalization, capitalism and consumerism should be changed; but apart from individual innovation by necessity or awakening, nothing has been done. Globalization has amplified immigration and promoted multicultural aspects; therefore, their value must be understood and managed.

The quick development of technology also has social impacts, such as isolation in ubiquitous screens, virtual friends, and theft of time and personal data. Advertisements cultivate the attitude of "needing" and games influence behavior.

The fashion for "innovation" and "future" involves the important factor of "time" – innovation challenge is intended to not only improve our lives (not disturb) but also to let us have more time for our family and other activities.

The objective of this book is to awaken the consciousness concerning the necessity to take into account not only the economic and social impacts but also those that impact the natural ecosystems. We wish to popularize the use of artificial intelligence approaches and techniques with the aim to conceive user-friendly and useful applications that can really help humans in their work instead of replacing them and switching off their brains. Learning from nature and applying this knowledge to innovation may reduce its impacts and risks, and promote sustainable innovation dynamics.

Chapter 1 sets the scenery. It presents an overview of the current innovation fields, their interactions and their playgrounds and gives some available elements of their impact.

Chapter 2 provides the readers with the main definitions and spectrum of innovation. It describes the eco-innovation process and discusses conditions for a balance. The main barriers and paradoxes are also discussed.

Chapter 3 deals with the most important challenges both for the present and future from the global, European and French perspectives. The main elements of policies are given to explain their contributions in order to face these challenges.

Chapter 4 describes the main experiments around the world aiming to amplify innovation by involving more players. Discussion about how they take into consideration the impact follows the storytelling. It puts emphasis on the measuring of the effects of innovation and the ways of evaluating the results.

Finally, Chapter 5 discusses the major advantages of biomimicry and proposes conditions for sustainable future.

Abbreviations and Acronyms

ADEME: *Agence de l'Environnement et de la Maîtrise de l'Energie* (French national agency for environment and mastering of energy)

AKARI: Architecture Design Project – project for designing a new generation computer network architecture supported by the National Institute of Information and Communications Technology (NICT) of Japan

ANR: *Agence Nationale de la Recherche* (French National Research Agency)

AREVA: Global company for nuclear and renewable energy. Available at: http://www.areva.com/

BMW: Bayerische Motoren Werke, manufacturer of automobiles and motorcycles. Available at: http://www.bmwgroup.com

CIRAD: French research centre working with developing countries to tackle international agricultural and development issues. Available at: http://www.cirad.fr

CISCO: Cisco Systems. Available at: http://www.cisco.com/

CRM: Customer Relation Management

CSR: Corporate Social Responsibility

EC: European Community

EU: European Union

EPISIS: European Policies and Instruments to Support Service Innovation

GDP: Gross Domestic Product, the monetary value of all the finished goods and services produced within a country's borders in a specific time period. Measures total income received by a country's residents within a given period

IBM: International Business Machines

IC: Intellectual Capital

IDATE: Organization conducting studies in the field of broadcasting and telecommunications. Available at: http://www.idate.org

INRETS: *Institut National de Recherche sur les Transports et leur Sécurité (French national institute for transport and safety research)*

IP: Intellectual Property

IPR: Intellectual Property Rights

ISDN: Integrated Services Digital Network

IT: Information Technology

LCPC: Laboratoire central des ponts et chaussées

MRI: Magnetic resonance imaging

OECD: Organisation for Economic Co-operation and Development

P2P: Peer to peer (business)

PCB/PCTs: Polychlorinated biphenyls and polychlorinated terphenyls

PME: *Petites et Moyennes Entreprises* (Small and Medium Enterprises)

PSS: Product Service System

RFID: Radio Frequency Identification

RITA: *Réseau d'Innovation et de Transfert Agricole* (Network for Innovation and Agriculture Transfer (CIRAD)

SMS: Short Message Service

STI: Science, Technology and Industry

UAV: Unmanned aerial vehicle

1

Innovation Landscape and Fields

1.1. From intensive industrialization to intensive innovation: consequences of global business

The years since World War II have been dubbed by some as the Great Acceleration. In a single lifetime, people have seen remarkable advances in medicine, transport, communication and other technologies, which have brought unprecedented economic changes. Today, many people enjoy a standard of living which was once thought impossible. This progress has been made possible combining dreams (science fiction), imagination, needs and technologies. But this was not done without impacting the planet and livings things. Powerered by imagination and often by quick business, some "forgot" or were simply unaware (or did not wish to be aware) of the impact they produced. Sometimes, the effect only becomes apparent after several years of operation. Some discoveries and disruptive innovations attract entrepreneurs who look for something new to explore commercially. For example, Barbara Goldsmith describes frivolous and dangerous uses of radium, pushed by business, just after it was discovered [GOL 05]. Today, a few non-governmental organizations (NGOs) are trying to draw the attention of "consumers" on the possible harmful effects of genetically modified organisms (GMOs), cell phone antennas and nanotechnologies.

Human activities, accelerated by globalization and not governed at the biosphere-level, are pushing the Earth beyond its natural cycles so that the environmental significance of human activities is now so profound that

the current geological era was called the "Anthropocene" epoch [CRU 00, IGP 15]. Is the Earth heading for a point of no return?

Some scientists consider that the effect of changes can be difficult to predict – we might be approaching "tipping points" where sudden and unanticipated climate changes could usher in disastrous results [AMS 12]. Consider, for example, the West Antarctic Ice Sheet. Some researchers believe that with sustained global warming, there is a point where the melt of this ice sheet could be irreversible. This is because ice-cover naturally reflects the Sun's rays. But as the ice sheet thins and shrinks, the ocean below, which is less reflective, is eventually exposed. The dark ocean surface absorbs more heat, which, in turn, leads to greater melting.

Groënland is melting and the surface of the ice is becoming gray. As a result, dark areas are heated more than the bright areas. This phenomenon is known as the albedo effect [DAN 14]. A self-feeding, runaway cycle could be created. The resulting rise in sea levels from the melt water could spell disaster for hundreds of millions of people.

The statements of the American Meteorological Society, 2012, and some others note that "the dominant cause of the warming since the 1950s is human activities" [AMS 12]. Nearly 50% of the land surface has been transformed by direct human action, with significant consequences on biodiversity, nutrient cycling, soil structure, soil biology and climate. In the last 150 years, mankind has exhausted 40% of the known oil reserves that took several hundred million years to generate. More nitrogen is now fixed synthetically for fertilizers and through fossil fuel combustion than it is fixed naturally in all terrestrial ecosystems. More than half of all accessible freshwater is appropriated for human purposes, and underground water resources are being depleted rapidly in many areas. According to the Global Change IGBP[1], humans have dramatically changed the planet and are altering some of the Earth's primary cycles: the water, carbon, nitrogen and phosphorus cycles.

It is also pitting water-intensive businesses such as the Intel Corp.'s China unit and bottling plants of Coca-Cola Co. against growing urban use and the 1.6 billion people in China and India who rely on farming for a living. "Water will become the next big power, not only in China but the

1 http://www.igbp.net.

whole world. Wars may start over the scarcity of water", said Li Haifeng, the vice president at sewage treatment company Beijing Enterprises Water Group Ltd., in a telephonic interview [BLO 10].

"Around 85% of global fish stocks are overexploited, depleted, fully exploited or in recovery from exploitation" [FAO 12], while food is wasted in developed countries due to food business.

Boyan Slat, a young entrepreneur and diver, states that after the Ages of Stone, Bronze and Iron, we are in the middle of the Age of Plastic [SLA 12]. Over 300 million tons of plastic poison the food chain – it is absorbed by fish and birds because its looks like a food. This mess which we have created leads to waste economy, and although it creates jobs for now, we have an obligation to change our behavior. "Change is more important that [sic] money", he said. His crowdfunded company, the Ocean Cleanup, develops solutions to remove plastic from water without capturing the sea life. The collected plastic is then recycled.

Figure 1.1. *Plastic bags on trees closed to mini-marts (source: www.lawntea.blogspot.fr/2012/07/getting-drift.html)*

Despite some alarms having been raised in Europe since the 1960s [MER 11], the French government has only recently ordered to reduce the use of plastic bags in the supermarkets. As a consequence of Evin's law against smoking in closed spaces, French streets are "decorated" with butts simply by stupidity ("brain-off").

Since the Rio Summit in 1992, other climate change summits have been organized; various road maps have been drawn up to deal with the

"planetary emergency" which we now face. One long-standing strategy is sustainable development, which means promoting economic and social growth within the ecological limits of the planet. What have been the results? Sadly, like the global financial debt crisis, the Earth's ecological debt continues to mount unabated. Humans continue to make intensive businesses and consume our planet's resources faster than these can be replenished naturally. Many world specialists and presidents have traveled around the world to debate the planet conditions. Nobody seems to have a realistic and immediately applicable solution for reducing pollution, global warming and educating a new respectful culture. Researchers travel to various conferences and measure the ice without thinking about their contribution to the global warming.

Corporate social responsibility (CSR) and sustainable development were made mandatory with the aim to reduce the environmental impact [MCW 01]. Although many companies display their initiatives on their corporate websites, only a few are seriously practicing it. Numerous reports describe how these companies are applying the ISO 26000 norms, but none, in our knowledge, tried to adapt these norms into their real situation and innovate by proposing adapted key performance indicators (KPIs), including, for example, the impact of all these constraints on business in terms of cost and revenues. The five-dimensional (5D) return on investment (ROI) could be applied for better evaluation of impact [MER 11]. This includes the impact of sustainability actions on business.

In the meantime, the Earth's population has nearly tripled. This means there are many months to feed but also represents a huge global market facilitated by communication technology, e-business and transportation means. The Google business model based on advertisements generates intellectual and visual pollution and is an important theft of time – time to find how to close the advertisement window or 30 s if this facility is not provided. The mass media continue to promote the "to have more and to show" mentality through advertisements and various entertainment programs. "Buy more" and "throw away" are the engines of today's business.

The political landscape has been also changed. The Soviet Union collapsed and nobody, including the European Union, seems to be interested in analyzing the positive and negative sides of this experience, such as multidisciplinary research results, the innovation fields, social system, culture and motivations, long- and mid-term economic and educational

planning and motivation to work. The Soviet Union identity and Russian as a common language were mandatory. Nowadays, the European identity does not exist and English became the world communication language. It would be fairer if everyone learns a new common language instead of privileging one's mother tongue. Esperanto was created by Ludwik Lazarus Zamenhof in 1873 [ZAM 87] with the aim to provide a world communication language that everybody has to learn as a second language. Fascinated by the idea of a world without war, he believed that this could happen with the help of such a language.

The business innovation and quick development of China and other Asian and South American countries, offering the low labor cost, is one of the causes of relocation mainly the USA and Europe, in the search of quick business, with the aim to offer more for less and increase the firms' income. This way of doing increases also pollution in developing countries and the unemployment in Europe and other developed countries. Besides this, we have to recycle products, often of poor quality, made somewhere else and traveling around the world.

Innovation is considered the principal driver of growth by the European and national politics. A plethora of initiatives and experiments in Europe and around the world [MER 11] are not bringing in the expected results. Various "success stories" are available, but systematic feedback, metrics and ROI are still missing.

Innovation can be considered a major contributor to the detrimental effects of humans on the planet because the inventors and designers think about functionality, shape, look and attractiveness, but not about the overall behavior inside the environment. Business people want to sell more; nowadays, a global market is addressed without thinking about the right benefits.

The invention and industrialization of the aircraft, and later the Internet, shortened distances between places and people, created new opportunities for businesses, and was the main trigger of globalization. According to Planetoscope [PLA 14], 80,000 flights per day, or nearly 30 million flights per year, are recorded. Civil aviation generated 2.5% of global CO_2 emissions in 2010. In 2000, the airline has issued 664 million tons of CO_2, or 11.5% of the emissions of the transport sector. Information and communication technologies (ICTs), intelligent traveling and local

development may reduce the number of planes, but not without some impact on aircraft companies' business. The right balance has to be found.

Aircrafts, which are knowledge-intensive products, are still conceived for transportation of people and goods; however, in recent years, efforts have been made in using lightweight technology and optimization software with the aim to reduce fuel consumption and CO_2 emission. The new Airbus A350 is conceived to save 25% of fuel. The alternative fueling is also studied and experimented[2].

Optimization techniques, such as constraint programming, are helpful for route allocation. The choice of aircraft model is made according to the number of passengers or loads. But air transportation companies have their own hub and an intelligent optimizer of travels is still missing. The available "optimizers", such as Kayak, Skyscanner and others, work for their clients and not for travelers.

The automotive industry is focusing its efforts on a non-polluting "car of the future". Peugeot prototyped a hybrid car almost 20 years ago, but the market and governmental incitation was not yet present; however, the main barrier is the energy storage, i.e. the size and capacity of batteries. Today, Hybrid Air, an innovative full hybrid gasoline system, is available commercially. Peugeot confirmed its plans to bring an all-new hybrid car to the market place which will have a zero-emission capability in and around town and the potential to dramatically reduce tailpipe emissions on the motorway. The technology will be officially unveiled at this year's Geneva Motor Show, and is expected to be offered as an option on the B-segment Peugeot 2008 by 2016. Renault, BMW and Toyota are also working on zero-emission cars. However, the concept of car has not evolved since its invention and car designers are not ready for disruptive innovation. A Fantômas car [FAN 64], born from the imagination of André Hunebelle, was an example of what such a car could be.

The concern of energy providers and information technology (IT) application designers is on "clean" and renewable energies, such as wind turbines, solar energy and biogas. Neighbors of wind turbines raised the impact on living in terms of noise. The impact is not yet studied and the business is a priority. Plans involve installing large wind turbine plants on the sea. What is the impact of such plants on sea life?

2 http://www.thenewecologist.com/2010/09/top-10-solar-powered-planes/.

Airplanes and cars cannot exist without complex electronic computer systems. The invention of the computer and the quick development of computer science has had a very significant impact on our lives.

1.2. Computer science, the Internet and mass media

Computers which were initially conceived for calculation now support all fields and activities. "Industry after industry is being transformed by IT-enabled disruptive innovation. These include not only information-based industries, such as banking, media, real estate, and education, but also transportation, agriculture, and health care" [DUB 14].

The entertainment and image industry are a part of this list. Fluidity between Silicon Valley and Hollywood boosted the cinema industry. Using a lot of special effects allowed them to reduce the production cost and increase the attractiveness of the movies. Traditional electronic games were radically improved in terms quality, attractiveness, rapidity and "intelligence". Serious games combining immersion and training changed the traditional way of learning.

Computers in all forms are everywhere and it is often difficult to imagine life without them. Miniaturized, advanced, user-friendly and more intuitive human–machine interfaces, multimedia and the Internet have conquered all the categories of users. The smartphones have became powerful computers in our pocket/hands. The Internet has opened the highway to the world of information and knowledge, amplified commerce, offered distance learning to all, helped people to communicate and become clever in communication in order to become leaders. People share their knowledge through Wikipedia, blogs and social networks. Advertisers have understood the advantages of this tool and all the services it provides very quickly. Every click and "like" is tracked and used commercially.

The Internet and Web 2.0 services may have created a lot of opportunities, but they have also opened a "highway" for cyber-criminality. The terrorists are the intensive users of information and communications technology (ICT). Social networks may be used to build or destroy reputations. Influence on behavior – from bad to good – is one of the most important challenges of the 21st Century; serious games are experimented in facing this challenge.

> Information and Communication Technologies (ICTs) enable us to see the connections between seemingly disparate issues, like transport and energy or health and economic growth, and help us find comprehensive solutions, for example in the European Innovation Partnerships on Smart Cities and Communities and on Active and Healthy ageing. ICTs enhance our quality of life, push productivity and lead to new opportunities for EU citizens and businesses [ICT 13].

Pushed by students, on the one hand, and technology providers, on the other hand, education has become an intensive user of ICT. Politics want it to be "students-centered". However, the educational program is not adapted to changing industrial and economic environments.

To give one example the conquest of the space could not be done without technology. In space, satellites extend the communication facilities on Earth. But since the launch of the Soviet "Sputnik I" in 1957, over 4,500 spacecrafts have been hurled from the Earth's surface, nearly half of which remain in orbit. According to the new book *Orbital Debris: A Technical Assessment*, "only about 10 percent of these devices are still functional; the rest simply constitute space junk, very expensive garbage. But that's just the intentional debris. There are also many tons of 'mission-related' garbage littering the solar system" [HAY 96].

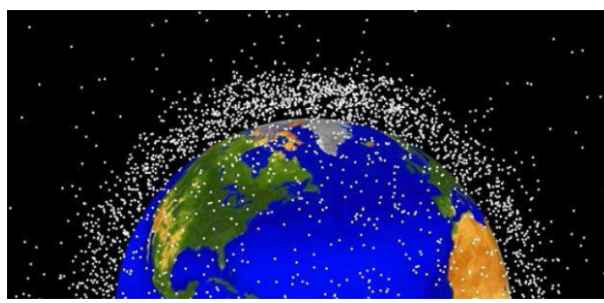

Figure 1.2. *Space garbage (source: smithsonian.com)*

The satellites and the spread of the Internet and mobile devices, smartphones and tablets have led to a veritable deluge of data, further accelerating the move toward the Internet of Things.

According to the IDATE studies, today IT companies have three main business areas: mobile, cloud and big data [DIG 12]. The topics of Digiworld 2013 were connected objects, video as a service, digital malls and digital money, smart city and digital living, future Internet and games. In 2014, they chose "mobility reloaded" as the main topic[3].

Big data offers unified access to information. It allows the large-scale dissemination, analysis and use of data for the benefit of consumers and citizens. Analytics are mainly used to find information in large amounts of data. Other techniques of knowledge discovery, such as neural networks, genetic algorithms, induction or other multistrategy machine learning hybrid tools [PIA 91], are available but underused.

Due to *sensors* and *embedded software*, objects are becoming increasingly interactive. It is possible, for example, to get them talk to each other or switch them on remotely. This radical upheaval opens up the prospect of cost and resource savings. Computer *simulation* makes a direct contribution to an economy's progress in terms of sustainability issues, particularly with regard to environmental protection, the scarcity of raw materials and the emergence of a low-carbon economy. *Smart city* ambition is offering their inhabitants increased comfort, employment and economic development.

The *Future Internet* focuses on new network architectures and more user-oriented services. Among the objectives are: increasing the speed and storage capacity, integration of connected objects, malicious programs detection, machine-to-machine (M2M) communication and Internet-enabled innovation. We could hope for a disruptive innovation, for example biometrics instead of logging and password, but all the projects around the world represent only an incremental innovation.

According to Google Product Manager, their undersea fiber optical cable system needs extra protection because of shark attacks. For that, Google cables are being wrapped in Kevlar-like material to prevent shark bites from damaging the line. Why do sharks seem drawn to the data cables that rest on the ocean floor? Do they feel attacked? Or is it simply because the cables are in their territory?

3 http://www.digiworldsummit.com.

Google has evolved from search engine to many other services related to data collected from users or captured from other organizations (geographic information system, satellites, etc.). Their vision, strategy and innovation attitude have been fruitful – in possession of a huge amount of data they have become the "master of the world" through data, the new capital. Their advertisement-based business model is copied around the world but their ethics should be reviewed – it is impossible to see a video on YouTube without losing 30 s, to search an item or topic without being tracked with the aim to show us over 90% of irrelevant advertisement. Finding in one click the information we are looking for is difficult. The paid advertisements are on the top of the list, as well as various comparators working for companies that pay for the number of clicks on their websites; the users have to spend time to find the right item. In continuous improvement and real-time innovation, they forget the users – they "offer" new services that they think we need.

Social networks, especially Facebook, are another contributor to big data. All these data are stored in data centers that must be powered and cooled. The first European data center of Facebook was established in Luleå, Sweden. Figure 1.3 presents its energetic architecture.

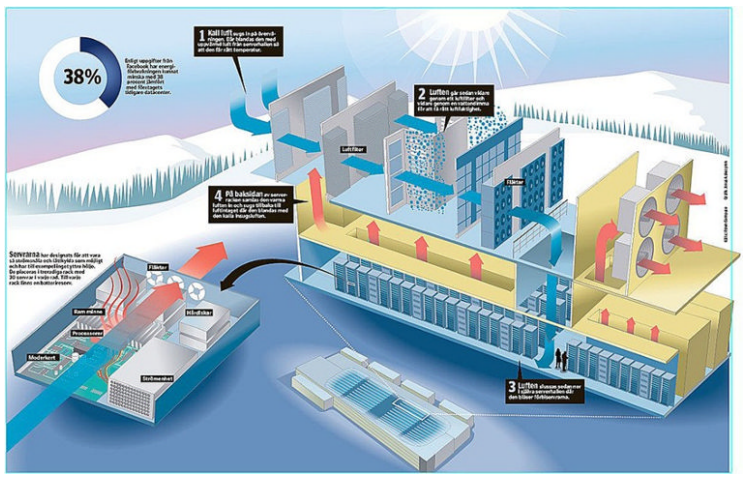

Figure 1.3. *Facebook Luleå data center, Sweden*

This provides Facebook center local job creation and impacts the regional economy. Concerning the environmental aspects, they mention the

availability of cheap, green electricity from hydropower and a cold climate that allows them to use outside air for cooling. It lets them remove 70% of the diesel units for backup power compared to the same facility in the USA. The cold climate also makes it possible to cool the thousands of servers by cold air from the environment. For cooling, Facebook has developed its own technology. This center reuses the know-how and technology of Prineville, Oregon. However, it is certainly warming outside and contributes to ice melting. Another ethic of publishing on Facebook may considerably decrease the need for big data.

Google are said to use 50% less energy than the typical data center. Designed to best use the natural environment and conditions, they use outside air and sea water in cold climates (Hamina, Finland) and reuse water from a nearby water source to stay efficient even in hot, humid summers (Douglas County). They use gray water and clean it by plants. In 2010, they started buying renewable energy from wind farms near their data centers. Google also developed a machine-learning algorithm (artificial intelligence (AI)) that learns from operational data to model plant performance and predict power usage effectiveness [GOO 14].

Energy efficiency of data centers and green IT are emerging as some of the most critical environmental challenges to be faced because of the increasing yet unprecedented trend in digitization of business processes, such as online banking, e-government, e-health and digital entertainment. The worldwide data centers CO_2 emissions achieve about half of the overall airlines' CO_2 emission [GAM 10].

What is the percentage of useful information in these data centers? How many times the same or similar data including the same pictures are registered in different databases? If only we could verify before registering and make link instead of multiple storing of the same object, it will certainly decrease the need for energy, cooling and environmental impact of data centers.

1.2.1. *Example of applying environmental principles*

Bull, a French computer company founded in 1931, applies CSR and sustainable development principles and makes efforts for innovating in computer and software design and reducing the environmental impact of data centers.

> The main challenge for IT companies is eco-efficient IT with economical use of raw materials, low energy consumption and an emphasis on recyclability. IT must also be capable of helping other industries progress more quickly with their own challenges, such as social innovation, business transformation and the quest for long-term prosperity [BUL 13].

Bull offer includes big data, the cloud, green IT and digital simulation. The latter is very useful for creating a "greener" innovation – it allows us to simulate the potential impact before transformation and to virtually try several possibilities to finally choose the most accurate one [MER 11].

Their concern is to increase eco-efficiency of data centers and of control over the environmental impacts, green IT for energy challenges and IT for change in response to sustainability issues. At Les Clayes-sous-Bois (the headquarters), data center calories are now recovered to heat offices at the site. The new modular outsourcing center opened in 2013 is targeting a high level of energy efficiency.

The Bull home eco-designed supercomputer ROMEO was ranked fifth in the world for energy performance in the Green 500 list (http://www.green500.org/).

By designing energy-efficient servers, Bull is committed toward innovation at all levels: components, power supply, cooling and load management. The most environmentally friendly product design involves progress throughout the three major stages of the lifecycle (design, use and recycling). Bull considers that the contribution of product designers and purchasing and logistics managers is key to a successful global eco-design strategy.

The ultra capacitor technology developed by Bull reduces power consumption by 15%. It makes it possible to operate the servers' power modules in the optimal part of their yield curve (40–90%) and to save on energy consumption by the inverters. Bull's various enterprise servers share many advanced energy-saving features, such as dynamic management of the energy envelope of critical applications, dynamic management of the load supply function and the extensive use of low-consumption components.

The Waste Electrical and Electronic Equipment Directive (WEEE) management system is also accompanied by a specific "on-demand service" (ODS), entailing the recovery and resale of customers' unwanted or old products. By giving them a second life as spare parts or complete systems, this service reduces annual recycling volumes and allows older equipment in need of spare parts to be kept in service control operations at its data centers and to generate energy performance indicators. Innovative solutions, such as the water-cooled "cold door" offered by Bull, are designed as an addition to an existing air-conditioning system or as an alternative to installing a new air-conditioning system. The thermal conductivity of water is much greater than the thermal conductivity of air. These doors are situated directly behind the server cabinets, dissipating heat before it is released into the room. With this technology, 600 W can extract 40 kW, compared with 2.6 kW using air alone, and consumption is reduced by half.

Replacing hardware in place for several years with new models can provide energy savings of up to 40%. The consolidation or extreme virtualization of equipment makes it possible to "do more with less", thereby taking the potential saving as high as 60%, if not higher. Their storage system based on massive array of inactive disks (MAIDs) technology enables disks to be turned off independently when not in use, reducing consumption from 40% to more than 60%. Another function automatically adjusts the fan rotation speed depending on the ambient temperature.

Having clients working in several fields, Bull also has experience of making links between seemingly disparate issues, such as transport, energy, health and weather forecast. This experience helps reuse the available software modules and designers' know-how.

In the automotive (and aviation) industry, supercomputers are used to design vehicles incorporating new forms and materials that reduce consumption. At the same time, combustion engine simulation can also be used to reduce emissions. In the energy sector, digital simulation is an essential tool for the transition from the current system using non-renewable resources toward an energy mix based mainly on renewable resources.

The involvement of Bull in health care focuses on patient management and quick diagnosis. The latest technological advances, such as high-performance computing (HPC), big data, M2M, cloud, security and mobility, dovetail neatly with the most crucial health issues: pooling and outsourcing

of resources, development of outpatient medicine and telemedicine, rapid growth in secure storage needs, secure data processing and sharing, patient modeling and virtualization, personalized and genomic medicine, and mass data simulation for medical research.

The connected objects may serve to dynamically control energy consumption and smart grids and optimize and protect urban and road traffic. It also applies to geo-localization, building, home automation, home security, industry and waste management. In the context of a smart city, they experiment digital technology, smart objects and smart solutions to promote new administrative digital services, facilitate access to transport networks and optimize energy consumption. For example, Bull has developed a smart device which, when placed at the front of the train, offers a virtual onboard presence and sends experts detailed information on system behavior, especially along high-risk sections. These telepresence, teletesting, remote diagnostics and telesupport solutions have already been successfully experimented in the next generation of trains. Such remote services are of great environmental importance because they allow acting quickly at a distance, without traveling. Thus, they reduce the carbon footprint and save time and money.

Telepresence ambition is creating a genuine environment, to let people experience an environment even when at, a distance, as if they were in a given place. Several companies now produce moving robots representing a distant person and able to establish a physical presence from a remote location (see Figure 1.4).

Figure 1.4. *Telepresence robot in the office (source: irobot.com)*

In *Cloud* technology, the server's power is shared and it may reduce the carbon footprint, but it is not evident to estimate since there are few studies on it. The UC Berkeley researchers estimated that "if all U.S. business users shifted their email, productivity software, and CRM software to the cloud, the primary energy footprint of these software applications might be reduced by as much as 87%, or 326 Petajoules. That's enough primary energy to generate the electricity used by the City of Los Angeles each year (23 billion kilowatt-hours)" [MAS 13]. NOTE.– this study was sponsored by Google, offering cloud services.

We can certainly improve these results if only we could reduce the amount of e-mails and have an intelligent antispam that learns from user and an automatic advertisment remover. In fact, CRM software contains confidential information about clients (customer capital), and companies are not keen to use cloud for processing. They are afraid to use clouds for processing of their specific activity supporting software because they do not trust the cloud security system.

The Island company GreenQloud[4] is an example of a "smart cloud". They have seized a great opportunity to use local abundant 100% renewable geothermal and hydro energy infrastructure, in a naturally cool climate, and its strategic location as a means to clean up IT and greatly reduce the industry's carbon footprint. They train their users to monitor energy metrics and carbon savings.

In France, in the past 40 years, the population has increased by 10 millions of people. Each family has several devices, but we did not build new power plants because the devices designers make an effort in using low consumption components.

The continuous improvement of electronic equipment, such as computers, mobile phones, TV, in-car electronics, cameras and game consoles, led to reduce the power consumption, but it consumes raw materials and generates a lot of products to be recycled. Too many people focus on technology only and/or on business only. As a result, we often have to change our devices because the hardware, operating system, applications, interfaces, or simply the aesthetics are no longer up-to-date (e.g. Apple).

4 https://www.greenqloud.com.

We are living in a ubiquitous electromagnetic field, both natural and artificial. According to scientific studies[5], our cell phones may cause brain tumors. Today, cell phones, tablets, consoles and other devices are in the living room; this "second" screen is said to be necessary. Many are playing for hours on these devices. Addiction to cell phones [CIS 14], games and social networks is rampant in Generations Y and Z. The workers from Generation Y use three screens. According to the Cisco study, two-thirds have taken phone calls in the car while driving. Many of Gen YZ talk with virtual friends and live in isolation. It is easy to influence them. Social networks, in particular Facebook, as well as online games, have a strong impact on the culture of communication and behaviors – teenagers become addicted and push every kind of information on it, increasing this way a need for storage of data. They have to respect a "code of conduct". Games, in particular violent, brutal, sadistic and bloody flashgames, on the Internet, may seriously influence the young and less young players. Another consequence may be obesity because of the lack of physical activity.

Our smartphones and tablets are manufactured from parts made in the Far East that are then transported thousands of kilometers into the countries buying them. This is due to the savings that companies can make in terms of cheap labor and manufacturing efficiencies. Mining the raw materials and the manufacturing process use up a great deal of energy, and most of it is produced by burning fossil fuels. The coltan (tantalum) industry is worth billions of dollars per year, but the miners, including children, work in very bad conditions. Some of the smartphones' companies, such as Nokia and Sony, are collecting obsolete devices from the users. Some try to educate the users. The European Imaging and Sound Association (EISA) launched the Green Awards (http://www.eisa.eu/green.html). Their objective is to promote a "green attitude" in their member companies.

Sims Recycling Solutions in Eindhoven recycles 60,000 tons of electronic waste annually, a third of which is in the form of monitors and televisions, and plays a leading role in reusing of components such as computers or telephone equipment that are not yet at the end of their lifecycle.

5 http://www.cancer.gov/cancertopics/factsheet/Risk/cellphones.

Figure 1.5. *Electronic devices to recycle (source: http://eco18.com/minimize-electronic-waste-to-help-protect-the-environment/)*

The most efficient process within the company is an automated machine, which is able to recover almost 100% of metal and glass from a conveyor full of TV's and monitors. The recycled glass is so clean that it is re-usable for new televisions. Also, plastic recycling is becoming more sophisticated achieving levels of almost 85% recoverability. Besides material recovery, enormous energy savings are achieved. In relation to the energy necessary to recover metals, savings of about 60% are achieved in recycled zinc and lead, 62–74% savings in steel, 85% in copper and up to 95% in aluminium. Sims[6] Recycling Solutions has collection systems for consumers, manufacturers and professional users.

All this human and electric energy can be used to eco-design and produce locally the smart and scalable devices (Lego™-like devices) with the aim to reduce the environmental impact.

1.2.2. *Artificial intelligence*

For many, AI means robots. For more than 50 years now, AI has developed methods and techniques that are now embedded into many decision support systems, diagnostic and simulation tools, educational software, innovative electronic commerce, data, text and image mining tools, creativity "amplifiers", robots and drones, etc., mostly not eco-designed [MER 11, MER 13a]. Nevertheless, the way of thinking, the methods and the techniques are still not taught and not integrated into IT, probably

6 http://www.simsrecycling.com/.

because of two different ways of thinking. IT limits to data and information processing, whereas AI is about "knowledge" thinking and problem-solving. From the very beginning, robots were conceived to copy human intelligence. It was, and still is, a challenge to build an AI device as intelligent as human, or even more so. There are some useful robots designed to help humans as industrial or surgery robots; these robots are able to diagnose and fix complex equipment in places that are difficult or dangerous to access, such as control and monitoring cabinets, nuclear power plants or high-voltage stations. Robots have been designed to take care of elderly people, to help them train their memory to take pills or simply as companions, while the number of unemployed people is high in many places. Other robots play with children because their parents have no time to play with them. Many of them move to metropolises and there is nobody to take care of their parents living in small towns and villages. Dancing or playing football robots are just a challenge for research. During the Fukushima disaster, the very famous Japanese robots were not able to manage the damaged nuclear plants.

Robots are used in the industrial plants, hospitals, at home and in the office.

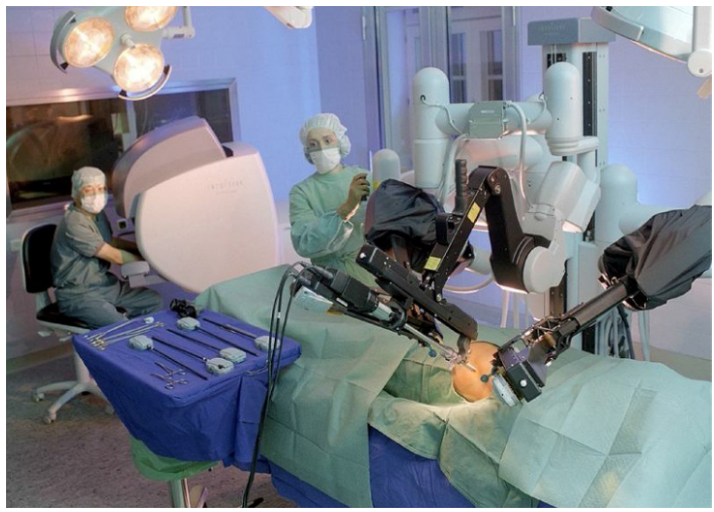

Figure 1.6. *Surgeons performing Da Vinci Robotic Surgery at Wesley Medical Center in Wichita, Kansas (photo: Wesley.ehc.com)*

A recent study has found that patients who have robot-assisted surgeries on their kidneys or prostrate have shorter hospital stays and lower risk of post-op complications but their bill is significantly higher.

In a Swedish TV series, "Real humans[7]", the hubots (human robot) can decide and replace humans in decision-taking. It is not a science fiction; it may happen. Few researchers are trying to understand the laws of the nature and deepen our knowledge of the brain. Do we really want robots to take control of our lives? Can today's research think about the future of humanity? Asimov [ASI 42] defined 3 laws for robots:

– a robot may not injure a human being, or, through inaction, allow a human being to come to harm;

– a robot must obey the orders given to it by human beings except where such orders would conflict with the first law;

– a robot must protect its own existence as long as such protection does not conflict with the first or the second law.

Are these laws considered by robots designers today? Some researches focus on the implementation of "real" agents, having unfriendly behaviors to express the real society. Is such research relevant, while there is a lot of criminality in movies, games and in real life?

Figure 1.7. *Diagnostic of Millau viaduct performed by drone (source: Eiffage CEVM/Foster + Partners/DIADES)*

7 http://realhumans.arte.tv/fr.

Drones were conceived for military purpose and they now carry out supervision and monitoring, security, tracking, picture taking and delivering (e.g. Amazon). The diagnosis of the tallest bridge in the world, Millau Viaduct, is made possible by drones. The diagnosis of buildings and other constructions, thermal diagnosis and crops fertilization are also performed by drones [BOU 12, FPD 14]. A Reaper Drone localized the Air Algeria plane that crashed in Mali in 2014.

The fact that Google bought the drones-maker Titan Aerospace is not insignificant. Drones also serve a military purpose that targets people, not always terrorists. How can a drone tell the difference between a terrorist and normal citizen? Daniel Byman (Professor in the Security Studies Program at the Edmund A. Welsh School of Foreign Services at Georgetown University) states that drones offer a comparatively low-risk way of targeting terrorists while minimizing collateral damage [BYM 13].

Despite the focus on robots and drones, all AI techniques will be used to help people in their work and activity, and not to replace them [MER 11].

Ambient intelligence represents a vision of the future where we will be surrounded by invisible technological means, sensitive and responsive to people and their behaviors, which will deliver advanced functions, services and experiences. It combines the concepts of ubiquitous technology, intelligent systems and advanced user interfaces [AMI 14].

Ambient intelligence intends to provide personalization of services according to the users' preferences, for example tracking the user of a smartphone to suggest they buy or visit objects available in their area. Multiple connected devices are embedded into the environment, adapting to, and anticipating the needs of, the users. Some claim that it is a human-centric vision of the future, while in the majority of cases it is used to make tracked people buy products or services (clothes, shoes, restaurants, hotels and travels).

This kind of application will avoid considering the user as a machine to buy. Offering the targeted services, corresponding to the user's real needs could be of great importance. The main goal of intelligent matching is to save us time and gain opportunities. Smartphones and future devices embedded with machine-learning techniques will learn from real-time

interactions with the user and not from navigation (too many errors) or a published profile only.

Ambient intelligence without invasion of privacy represents a long-term vision for the European Union Information Society Technologies Research program with the aim of bringing together researchers across multiple disciplines: computer science, social science, physics, biology, engineering, design, architecture and philosophy. A strong multidisciplinary and collaborative approach is the key requirement for large-scale technology innovation and the development of effective applications[8].

A *cyber-physical system* (CPS) is a system of collaborating computational elements controlling physical entities. Such systems can be found in aerospace, automotive, chemical processes, civil infrastructure, energy, health care, manufacturing, transportation, entertainment and consumer appliances. This generation is often referred to through embedded systems. In embedded systems, the emphasis tends to be more on the computational elements, and less on an intense link between the computational and physical elements.

1.2.2.1. *Security systems*

With growing threats such as terrorism, all kinds of attacks and thefts, the demand for global security is growing. There are two ways to fight this scourge: build sophisticated security systems or influence human behavior. The global security systems include central monitoring systems (CMS) for buildings, airports, schools, parking, city control and home automation. CMS works on an alarm-trigger principle. The alarm signal is transmitted to the central monitoring station; the controller will ascertain the nature of emergency and initiate action such as contacting the police, an ambulance service, the fire department or dispatching a response team to the emergency site. Camera records are analyzed to identify the offenders. AI techniques may help in image mining. The alternative solution is to educate society with the aim of preventing crimes.

1.2.2.2. *Innovation at home*

The early development of home automation appeared in France in the 1980s. Miniaturization and availability of high-performance communication

8 http://ec.europa.eu/programmes/horizon2020/.

services (ISDN, digitalization of networks and Minitel at home) influenced the emergence of innovative systems-oriented communication and exchange inside the housing and outwardly thereof. An effort to bring more comfort, security and usability in housing management has guided the early days of home automation. Its popularity has been increasing greatly in recent years due to much higher affordability and simplicity through smartphone and tablet connectivity. Today, it may include a centralized control of lighting, heating, ventilation and air-conditioning, appliances, security locks of gates and doors and other systems to provide an improved convenience, comfort, energy efficiency and security. The Internet of Things facilitates taking control of all connected objects from outside using a smartphone. The challenge for companies is to install this automation in every home and successfully create a viable ecosystem with standards widely disseminated to ensure an interoperability between systems, while offering simplified interfaces via solutions in line with our daily usage. What services can these technologies provide that may significantly improve our daily lives? Do we really need a fridge that is able to order milk?

Home automation for the elderly and disabled can provide an increased quality of life for individuals who might otherwise require caregivers or institutional care.

1.2.2.3. *What is still missing?*

In our knowledge, the majority of ICT companies are still not involving the final user in their innovation process; by consequence, much of the available software and products are not intuitive or really user-friendly. Service providers via the Internet, such as railways and others, change their user's interface, without asking them; sometimes a new version is radically different from the previous version and the users find that they are lost.

Search engines lack relevancy and flexibility. Ecosia is supposed to be an eco-engine, but it also adopted the advertisement-based business model. The users need an effective way of searching instead of pushing tracking-based advertisement.

The users of Microsoft, Google, Ecosia and others have to set a search language, which will limit the results of search to the chosen language. The words completer is useful, but it only works in one language; the users need to change the settings each time they change the language. The program

should recognize the user's language (he/she may speak several languages) and adapt. The SMS assistants should also evolve.

A majority of software designers implement "trees thinking". For example, the BMW navigation system includes a voice interface following tree logic, instead of allowing a direct access to a given function.

Intelligent antispam is still missing. Equipped with AI techniques, it could learn to accept or reject e-mails. We receive a huge amount of e-mails because of automatic, and unfiltered, sending.

Computer access control by log-ins and passwords will be replaced by biometric recognition system.

Three-dimensional (3D) *printers*, invented in the 1980s, are able to print a 3D object of almost any shape from a 3D model or other electronic data source primarily through an additive process in which successive layers of material are laid down under computer control. 3D printers, which may be considered as industrial robots, allow rapid prototyping in many areas. Organic and printed electronics become a reality. The Technology Partnership Vista has the ability to 3D print a wide range of both inorganic and organic matter, including plastics, metals, ceramics, enzymes and biological cells [MOL 13]. According to Design News, rocket engines, airplane components, human cartilage and carbon composite production-grade parts are 3D printed [DES 14, LIP 13]. The decreasing price of 3D printers now allows their use in areas such as design [STA 14] or in kitchens[9].

1.3. Medicine and biotechnologies

Electronics, information processing and AI have greatly influenced the extraordinary progress that has been made in the field of medicine. Internet has facilitated the exchange of medical data and experiences. Health care practices are now supported by electronic processes and communication (e-health). Many hospitals have constructed a knowledge-flow connecting patients, doctors and other stakeholders based on patients information and their treatments, health information systems offering an electronic agenda for appointments, as well as medical research survey for medical staff. Services such as telemedicine, including distance diagnosis and monitoring,

9 http://www.naturalmachines.com/.

and surgery are now available. Sensors allow to continuously monitoring a patient's vitals.

The Internet's quick access to the patients' data is useful in an emergency, but it may also be used maliciously.

Technological innovation has also changed operating theaters; robots and laser are currently being used for surgery [SAT 06]. Virtual autopsy helps students learning medicine. Technology enables the detection of serious illnesses in the initial stages (X-rays, MRI and ultrasonography). However, the art of thinking and making the right diagnosis is vital. The next step for the medical research is to find the cause of death.

Transplantology also made progress through experimentation. Organs that can currently be transplanted are the heart, kidneys, liver, lungs, pancreas, intestines and thymus. Tissues include bones, tendons (both referred to as musculoskeletal grafts), corneas, skin, heart valves, nerves and veins. Worldwide, kidneys are the most commonly transplanted organ, followed by the liver and then the heart. Cornea and musculoskeletal grafts are the most commonly transplanted tissues. Organs are also the subject of business and, at worst, part of black market trafficking traffic. Some artificial organs are now created, such as the bioprosthetic heart conceived by the French company Carmat [CAR 14], pancreas [GON 14] and lungs.

Despite these advances, we still have to cure cancers, diabetes, Alzheimer's and other serious diseases that we have generated by globalization, our activity, our way of life (working in stress, bad eating, physical inactivity and smoking), immersion in electromagnetic field, poor quality of air and water, as well as by the massive use of pesticides and fertilizers [BEL 04]. By eating chemically "improved" food, many people develop food allergies. The increase in serious infectious diseases transmitted by humans, animals and insects is alarming. The Ebola virus is one example, which killed over a thousand people in recent months. As the natural reservoir of Ebola viruses has not yet been proved, the manner in which the virus first appeared in a human at the start of an outbreak is unknown. However, we can make the assumption that the first patient became infected through contact with an infected animal. The virus can be transmitted to others by direct contact with the blood or body fluids or by exposure to objects (such as needles) that have been contaminated with

infected body fluids. An experimental treatment is currently being tested on these effected.

Older diseases such as tuberculosis, which we have eradicated in the past, can reappear. The growing population needs more doctors to fight serious diseases, but many of newly trained doctors prefer to settle in big cities, which increase the shortage of doctors in rural areas and already devitalized regions. As such, a need for first-level remote diagnostic increases, while the current educational system is not adapted to create more doctors, combined with a social security system that has less money.

Except the people who still use ancestral and holistic knowledge, for example the Chinese traditional medicine or homeopathy, we practice fixing instead of preventing. Understanding the interest in association with the alternative and allopathic medicines may reduce medical costs, which are very high in France. Deepening out knowledge of diseases and new drugs to treat them helps save or extend lives. But the knowledge of our body, the prevention, and the use of plants to cure the "easy" illnesses is not a part of school curriculum.

1.3.1. *Human spare parts and augmented human*

Repairing and enhancing humans has been the subject of many dreams and utopias. This issue, which is of both sociological and philosophical interest, is now taking a new direction in the field of health care equipped with technologies, especially those of AI. The distance between repairing and improving is disappearing. Regarding normal human enhancement, underpinned by the idea of repair/augmented human, Goffette suggests, as a part of "anthropotechnie", the idea of an "ordinary human" improved by absorbing medicines or by surgery [GOF 06, BAT 13].

Therefore, if initially new mechanisms are aimed at overcoming deficient functions of the diseased, why not also to enhance his/her capacity and expectancy of life – as suggested by transhumanists? Are we trying to reinvent human as underlined by Besnier [BES 12]? Attempts to discuss these questions have been far from consensual.

Initially, mechanical and electronic human "spare parts" were conceived to improve the life of people with disabilities after an accident or in individuals born with a disability.

We are also able to enhance human capabilities ("augmented human") through technology for increased well-being. Human enhancement is any attempt to temporarily or permanently overcome the current limitations of the human body through natural or artificial means. Some bioethicists restrict the term to the non-therapeutic application of specific technologies such as neuro-, cyber, and nanotechnologies and genetics.

Figure 1.8. *Oscar Pistorius at Beijing Olympics, 2008*

An alternative way is to discover and develop our natural possibilities, including those of the brain, as foreboding, intuition, communication and action at distance or energy feeling and transmission. Today, if someone has a capacity that science has not yet discovered and that cannot be measured, we consider him/her as a "sorcerer".

1.3.2. *Ambient assisted living*

The aim of ambient assisted living is to use ICTs to develop new products and services to offer a better life to older and dependent persons. Such services require some physical equipment to be connected using various networks and controlled by specific software. Besides these technological solutions, security, privacy and acceptance will be considered to ensure that the proposed solutions fit the requirement of older and dependent persons, as well as the needs of the people who care for them (professionals and family). This field is interdisciplinary and requires collaboration between the future users, computer science and IT as well as from the social sciences. Ambient assisted living involves technologies such as sensors, specific equipment, robotics, user interaction (multimodal interfaces) and simulation platforms. Preserving privacy and ensuring security are the basic points for its implementation.

Ambient assisted living offers intelligent environments (devices and automated services) for the elderly to allow them live independently in their own homes, and to assist people with special needs. More sophisticated environments can adapt autonomously, proactively and context-sensitively to their activity. Sometimes, these individuals just want some company and may prefer that someone simply comes to see them.

1.3.3. *Biotechnology*

The OECD defines biotechnology as "the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services" [OEC 05].

Biological processes are exploited for medical, industrial and agricultural purposes. Traditional biotechnology such as fermentation is very old – for years, we have used the biological processes of microorganisms to make useful food products, such as bread and cheese, vinegar and beer, and to preserve dairy products. Horticulturists combine pollen for more beautiful flowers; gardeners transplant trees to get better fruits. The concept of biotechnology encompasses a wide range of procedures for modifying living organisms according to human purposes, going back to domestication of animals, cultivation of plants and "improvements" to these through breeding programs that employ artificial selection and hybridization.

Modern biotechnologies appeared at the end of the 20th Century, following the scientific discovery of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). They include proteomics (large study of proteins) and genetic engineering, animal cell culture, biochemistry, cell biology, embryology, genetics, microbiology and molecular biology. Genetic engineering is the direct manipulation of an organism's genome. Biotechnologies depend on knowledge and methods from outside the sphere of biology including bioinformatics, bioprocess engineering, biorobotics and chemical engineering.

Since the mid-1990s, the field of transgenesis is the most publicized and still expanding field. Transgenesis is the process of introducing an exogenous gene, called a transgene, into a living organism so that the

organism will exhibit a new property and transmit that property to its offspring (see Figure 1.9)

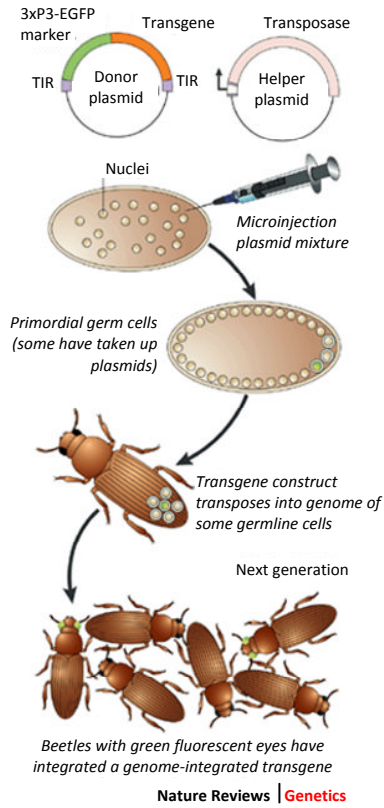

Figure 1.9. *Principle of transgenesis from [WIM 03]*

Techniques based on transgenesis became the basis of biotechnology, which is now based on the new tools for decryption of genomes, whose primary purpose is the creation of new commercial products of interest through:

– genetic modification of organisms, such as grain, to give them the characteristics they do not have, for example, resistance;

– genetic modification of other bodies to make them "useful" for man, for example the creation of goats by integrating into their genes a genome of

spiders in order to extract from their milk the fibers that can be used for textile production.

Genetic modification is not a new concept. It was probably Mendel (1866) who initiated genetic and selective breeding with the aim of improving the resistance of vegetables [MEN 66]. The profound significance of Mendel's work was only recognized over three decades later, on the turn of the 20th Century with the independent rediscovery of these laws.

There are several categories of biotechnology according to the fields of application:

– *red biotechnology: research related to medicine and medical processes* – the designing of organisms to manufacture pharmaceutical products such as antibiotics and vaccines, the engineering of genetic cures through genomic manipulation and its use in forensics through DNA profiling;

– *white biotechnology: research related to industrial processes* – it involves the use of enzymes and organisms for the processing and production of chemicals, materials and energy including biofuels;

– *green biotechnology: research related to agriculture processes* – it involves the use of environmentally friendly solutions as an alternative to traditional agriculture, horticulture and animal breeding processes;

– *blue biotechnology: research related to marine and aquatic processes* – it involves research on the application of molecular biological methods to marine and freshwater organisms for creation of new cosmetics, medicines, aquaculture, agri-food, etc.;

– *black biotechnology: research related to bioterrorism* – it involves research on all aspects of bioterrorism related to military, police, surveillance and counter terrorism;

– *gray biotechnology: research related to the environment* – it is divided into two areas: biodiversity maintenance and contaminants removal [ELS 14].

In Europe, "*yellow biotechnology*" is added to the list for the treatment and removal of pollution.

Moreover, biotechs are ranked in more explicit categories "*healthcare biotech*", "*agrifood biotech*" and "*industrial biotech*".

This progress is expected, hoped, and sometimes feared, in the fields of nanotechnology, bioinformatics and nanobiotechnology. It could, for example, allow for a scheduled production of nano- or microcompounds or biomolecules with new health risks, both environmental or geopolitical, if abuses or misuse of these new opportunities is done.

Nowadays, biotechnology plays an important role in the field of health care and in the innovative industrial processes. It has an emerging role in the areas of environment, agriculture and food.

Currently, there are more than 250 biotechnology health care products and vaccines available, many for previously untreatable diseases. More than 13.3 million farmers around the world use agricultural biotechnology to increase yields, prevent damage from insects and pests, and reduce the impact of farming on the environment. More than 50 biorefineries are being built across North America to test and refine technologies to produce biofuels and chemicals from renewable biomass, which can help reduce greenhouse gas emissions.

Cloning and "improving" human and animals raises ethical, political and economic issues. It is difficult to predict the long-term impact of genetic engineering because of complex interactions. At this stage, a simulation of the impact may help in understanding; however, it requires knowledge from related fields. As after the discovery of radium [GOL 05], some new companies are exploring commercialy the research results without considering the possible consequencies.

1.4. Nanotechnologies

The Greek word "nano" means dwarf. It is also a physical measure, 10^{-9}, used in electronics. Nanotechnology is the manipulation of matter on an atomic, molecular and supramolecular scale. It explores the special properties of matter that occur below the given size threshold. Potential industrial and military applications pushed the USA, the European Union and Japan to invest a lot in research and applications of nanotechnologies. They are now entering the phase of construction of many products for their advanced properties as more resistant concrete, self-cleaning paints and glass, and acoustic insulation. The expected benefits seem huge but their

safety remains to be demonstrated (see http://www.batiactu.com/edito/les-nanomateriaux-se-repandent-dans-le-batiment-38128.php).

Nanomaterials are also used in textiles mainly to provide stain-resistance or antibacterial properties as well as for the so-called "lotus effect": the nanocoatings, such as Teflon-like substances, form bonds with the textile so that little nano-sized molecular hooks attach to the fabric of the garment and the hair-like structures repel the liquids like the lotus leaf.

The term "nano" can be found in many cosmetic products, including moisturizers, hair care products, makeup and sunscreen (see http://www.nanowerk.com).

According to, Janez Potočnik, the European Commissioner for Science and Research:

> Nanotechnology is an area which has highly promising prospects for turning fundamental research into successful innovations. Not only to boost the competitiveness of our industry but also to create new products that will make positive changes in the lives of our citizens, be it in medicine, environment, electronics or any other field [HUL 08].

"Nano" is a technology which has unique intrinsic properties and therefore offers numerous possibilities of applications because it is unique in its properties and provides an alternative to other technologies. This natural phenomenon is not yet fully understood and must be studied further; therefore, research in this field is essential.

As for each new discovery, the standards to be met before the commercialization of products have been introduced very late as well as the controls on products potentially containing nano. Two points of control should be introduced:

1) check if products contain "nano";

2) mandatory evaluation of benefits and risks (medical, the real exposure according to the actual wear of the building material, etc.).

In research laboratories, the precautionary principle should be applied when manipulating nanoparticles. This was introduced late and the lab's staff is responsible for checking that it is implemented or not.

According to Gaelle Offranc Piret, a researcher at INSERM/CEA Leti: "the danger may come from what we do not know yet. It is vital to move faster in understanding the phenomena such as interaction between energy and matter in the universe, reactions of biochemistry/biophysics in/between living systems, etc.) for better protection. For now nanos (often materials or molecules that we assemble) are not active. We control them and we activate them just for a very specific function."

Nanomedicine, the European Technology Platform[10], is an initiative led by industries and set up together with the European Commission. Their members wish to accelerate the development of medical nanoproducts and foster connections between laboratories, companies and investors. They address serious diseases such as cancer, atherosclerosis, diabetes and arthritis. Nanomedicine for the eye aims at developing effective drug therapies and reducing health cost related to aging, such as macular degeneration, diabetic retinopathy, glaucoma and dry eye syndrome. Other groups work on nanomedicine for combating infections from antimicrobial-resistant bacteria and on tissue engineering.

1.4.1. *Biological risks of nanoparticles*

Biological risks of nanoparticles, which were raised by Michael Crichton in his book *The Prey* [CRI 03], are studied by *Échange et Coordination Recherche-Industrie* (ECRIN) in France, as well as by Sara Linse [LIN 14], Christophe Brechot and others.

When nanoparticles enter a biological fluid (blood, lung fluid, etc.), their surface is rapidly covered by a corona of proteins. This corona defined the biological safety or risk of the nanoparticle because it is the particle with its corona that the biological system responds to. The research of Sara Linse's team in the Center for Molecular Protein Science has shown that the corona around many nanoparticles is remarkably specific and contains a small number of proteins, and their relative surface concentration is very far from a random representation of their relative occurrence in the body fluid. They studied how the corona composition changes over time, or when the nanoparticle travels from one body compartment to another. They have developed a methodology to identify the nanoparticle-associated proteins, to measure their interaction parameters and to study nanoparticle-induced effects on protein aggregation and function. Their findings at the molecular

10 http://www.etp-nanomedicine.eu.

level are related to testable assumption involving function that may be perturbed at physiological level.

Christophe Bressot, a researcher at *Institut National de l'Environnement Industriel et des Risques* (Ineris), works on the impact of nanomaterials: "the risk evaluation formula is simple: exposure multiplied by toxicity. In the absence of exposure there is no risk, as if the toxicity were nonexistent. In the case of nanomaterials, the toxicity is unknown. The challenge is to reduce exposure, in particular by inhalation because it is a main entry point to the body".

All the particles smaller than 4 μm affect the pulmonary alveoli. The entire population would thus be exposed: the industrials involved in production, consumers of a finished product and the environment during the end of life of products. Researchers point out the absence of data related to the risk of the skin contact or the ingestion of nanoparticles [BAT 14].

Nanotechnologies are used and experienced in all kinds of fields: automotive, electronics, construction, pharmaceutics, biomedicine, cosmetics, textile and food [MON 08].

A growing, enhanced and longer living population represents many mouths to feed and many individuals do not have any time to play chef due to a multitude of various promptings in addition to their usual work. ICT adapts, anticipates or creates new needs. Supermarkets were created to let us find everything in the same shop, as well as to buy more. The latest trend is a digital mall. What more can we buy and eat?

1.5. Agriculture and food industry

According to Pyarelal, secretary of Mohandas Gandhi, the late spiritual leader of India, "the Earth provides enough to satisfy every man's needs, but not every man's greed".

Quick business and human avidity have been a very strong engine in the industrial production and transformation of traditional food. On the pretext that it is necessary to feed more people, many initiatives aiming at producing more were launched. For example, extremely modern giant farm Gemeente

Westland[11] in the Netherlands intensively produces fruits, vegetables and flowers using renewable energy and fully automated gathering and logistics, as well as artificial fertilizers, lighting and trucks for delivery. They are proud of being such an innovative center, generating jobs and growth for local people.

As food is not managed at the level, planetary specialists believe that we need to produce more food. Global competition imposes low prices to meet the criteria of purchasing power. As a result, the central purchasing for supermarkets requires the low prices, the farmers are poorly paid for their work and they grow farms to produce more despite the quality. As they have to produce more big and good-looking products, they use chemically treated seeds, fertilizers and pesticides to fight against more resistant and self-adapting harmful insects and diseases. The more sophisticated farming equipment is also polluting. The animals in the large farms have little space and they are fed growth hormones and antibiotics.

The practice of monocropping, such as cereals, on only one large surface, leads to land degradation and proliferation of pests. Artificial fertilizers and strong pesticides pushed by chemical giants increase pollution and cause serious diseases. This is definitely not a sustainable solution. Researchers work on how to improve the effectiveness of crops and eradicate various pests using genetic engineering, and others study natural methods. Our ancestors practiced crop rotation, used natural fertilizers and mastered the art of vegetables association to avoid harmful effects, such as planting the carrots alongside the leeks to avoid carrot fly and worm leek. These old rules, created from our ancestors' observation, are known and practiced by producers of organic food.

We observe that food waste is highest in countries with "sell and buy more" attitudes. After fast food, the fashion of processed dishes and drives was introduced under the pretext that people work more and have no time to prepare food. The "modern human" feeds himself/herself with fast food, processed food and drinks sodas while working, watching TV or playing games, and becomes fat because of their sedentary lifestyle. Drugs and a lot of services are readily available to make you slim. Many practice self-medication – drugs are available and often cheaper online.

11 https://www.gemeentewestland.nl.

The quality of the water we drink is increasingly polluted and must be cleaned (another business). It contains many chemicals such as pharmaceutical, nanoparticles, pesticides, insecticides, processed food "improvers", flavor enhancers, and artificial fertilizers which are difficult or impossible to clean. Fish and other living beings in ecosystems absorb these chemicals and are poisoned. Research and innovation can provide new methods to clean water, such as laser or membranes, and sometimes rediscover natural cleaners, such as plants.

Genetically modified seeds (GMSs) are pushed by business giants. The paradox is that farmers are not allowed to grow their own seeds; they have to buy GMS seeds from giants such as Monsanto. As a result, the GMS space is growing (see Figure 1.10).

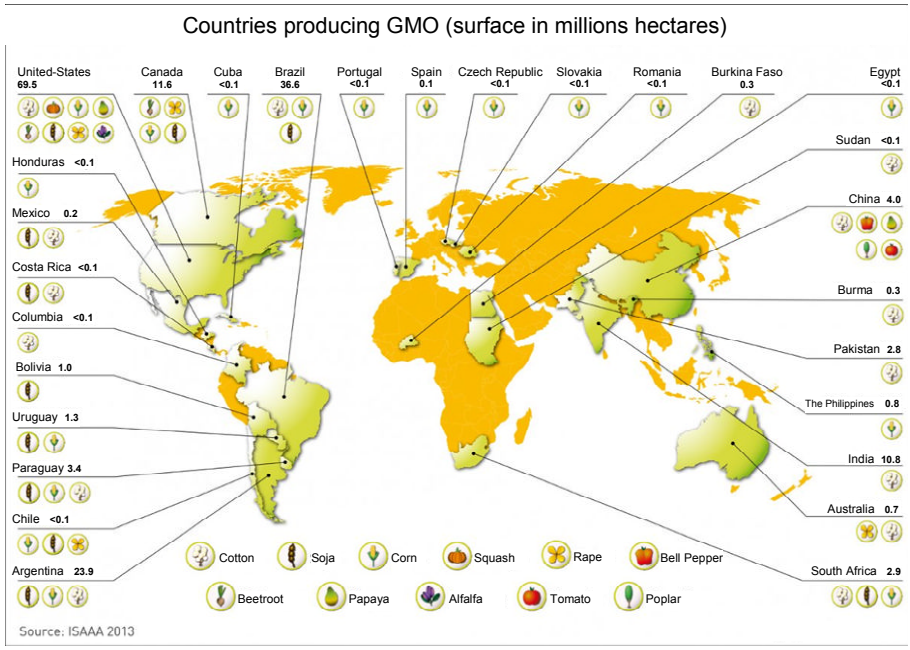

Figure 1.10. *GMO in the world (source: http://www.europabio.org/news/map-global-status-commercialized-gm-crops)*

Industrial food contains a lot of chemicals and technological innovations are improving the efficiency of the extraction of oil; the taste, smell and color are chemically improved.

According to Seignalet [SEI 12], the "pollution" of food was developed in the 20th Century due to the industrialization of food production, motivated by quick revenues. For example, the industrial mode of preparation of oils has three main disadvantages: persistence of harmful substances, such as hexane, which is impossible to eliminate totally, saturation of a part of unsaturated fatty acids and transformation of unsaturated fatty acids *cis* to *trans*. The overall process is described in detail by Chapell [CHA 98].

Ingestion of trans fatty acids can cause hypercholesterolemia, atherosclerosis, obesity, resistance to insulin in diabetes and coronary acute. The deficit in polyunsaturated fatty acids (*cis*) affects the functioning of cell membranes and unbalances the metabolism of prostaglandins (substances that act as cell regulators), which influences inflammatory and immune reactions.

Professor Henri Joyeux, a French oncologist, confirms the existence of a direct link between the quality of food and health [JOY 14].

We can observe that the nature is becoming more "aggressive" – insects such as wasps, ants and mosquitoes are proliferating due to lack of predators. Plant growth is suffering and disease is flourishing – only weeds survive. Large number of insects are eating our fruits and vegetables. As trees and plants are "traveling" due to globalization, insects and plant diseases are also moving around the world. For example, the Asian hornet kills honey bees already decimated by pesticides and *Paysandisia archon* kills palms in the south of France.

Some French researchers at the French CIRAD are working on sustainable agriculture. RITA, the recent initiative for the Antilles Islands, is building a network for sharing knowledge and practices in sustainable agriculture ecosystems, including ancestral knowledge [RIT 14].

Initiatives such as the National Sustainable Agriculture Coalition[12] publish the guidelines for the whole agriculture ecosystem [KRO 14]. Their mission, among others, is to encourage new and existing farmers to transition to sustainable and organic production practices enable producer access to local and regional food systems and increase consumer accessibility to sustainably produced foods. The knowledge from our past may be extremely useful.

The aim of European Initiative for Sustainable Development in Agriculture (EISA) is "to develop and promote Integrated Farming throughout Europe. Integrated Farming is a sustainable system, which helps farmers improve the way they farm for the benefit of the environment, the profitability of their business and social responsibility, including all important aspects of sustainable development".

> In modern times, they (farmers) have been greatly helped by scientific research and innovation, sound professional education and high quality advisory services. They are well informed about the best crop management methods, how to manage livestock efficiently with high welfare standards, and effective ways to manage their land and natural resources. However, sustainable agriculture as practiced through Integrated Farming means much more than just applying the right amount of fertilizers, feeding animals properly or keeping crops healthy. Integrated Farming is based on a holistic (whole farm) approach, on science-based management and on the optimal blend of experience and innovation in a continuous pattern of "planning, evaluation, and improved management" [EIS 12].

Even naturally grown food may be contaminated by surrounding pollution. Fish and seafood absorb industrial toxic chemicals circulating in the seas and rivers. These include mercury, dioxins and other man-made chemicals that are known as Persistent Organic Pollutants, such as polychlorinated biphenyls and polychlorinated terphenyls (PCBs/PCTs). Some are recognized as carcinogenic, for example endocrine disruptors.

12 http://sustainableagriculture.net.

Once again, we need to find a balance between research satisfaction, business from innovation, growth and impact on living and the environment. It would be beneficial to have a sensor able to detect chemical components in food and the freshness of the products to eat.

1.6. Knowledge city, smart city, green city and wise city

The idea of a "knowledge city" likely appeared from the 2003 Helsinki meeting of Entovation network. En2polis[13] was defined as a physical and virtual space where world citizens worked together sharing knowledge, experience and innovation. The following year, the event "Knowledge Cities, Knowledge Regions, Knowledge World" was held in Monterrey, Mexico. Since then, many initiatives around the world have flourished. IBM launched its "Smarter planet" offer in 2010, re-packaging their products to eco-applications such as energy optimization or water management.

A european program on Smart Cities begun in 2010 [EUR 10b]. The initial idea was use "digital technologies for better public services for citizens, better use of resources and less impact on the environment"[14]. The main objective is to bring more ICTs to budding metropolises. The European program focuses on zero-energy buildings, optimized heating, cooling and energy as well as sustainable mobility. Other Smart City programs are devoted to intelligent or green buildings, providing useful information to citizens and to their well-being and environment. In this "game", the winners are still the same – large companies such as IBM (Smarter Planet), CISCO (Smart Connected Communities) and General Electric, while in Europe we have many smart companies.

The very new initiative ‚Wise City, also involves large companies, while there are many start-ups having a "lego" solution; such a project just needs an architect able to explore the best of each player and influence the local development. The Wise City Hong Kong project[15] was initiated by the French Chamber of Commerce, Dragages – the affiliate of Bouygues Construction, a global leader in the building, Alstom – a global leader in the world of power generation, power transmission and rail infrastructure – BYME

13 http://www.entovation.com/group-alliance/en2polis.htm.
14 http://ec.europa.eu/digital-agenda/en/about-smart-cities.
15 http://www.wisecity.hk/partner.

Engineering (HK) Ltd and, a specialist contractor in all mechanical and electrical services and an expert in energy performance.

A city can be considered as "smart" when it wisely manages its tangible and intangible capitals, such as intellectual and social, traditional and digital communication, natural resources and quality of life, and innovates continuously for the sustainable success of all participants. They learn from the past (e.g. accumulated knowledge) and from each other, solve day-to-day problems and improve their capacity. This implies a new kind of governance, involvement of citizens in public policy and the smart use of ICT.

Smart city ranking has become a new "smart" business. Governance, economy, mobility, environment, living and people are among the indicators to define which city is the smartest.

For example, in Japan, companies such as IBM, Panasonic, Tokyo Gas and Accenture are focusing on making solar energy a more crucial element in suburban planning. Is it enough to be a smart city? Giffinger *et al*. [GIF 07] state that a smart city can be ranked using six axes: regional competitiveness, transport and digital economics, natural resources, human and social capital, quality of life and participation of citizens in the governance of cities. The main objective is urban growth and development.

To face the economic crisis, cities and territories have to optimize their functioning and reduce their costs. Smart city is an intensive user of ICT, intelligent technology, big data, connected objects and others. The majority of big cities are equipped with video cameras with the aim of reducing the criminality. Intelligent image mining systems can help to monitor what is happening.

The exodus of people looking for jobs from village to town, from a "poor" country to a "rich" country and the human desire to govern more territory impulsed agglomeration in France and megalopolis in the other countries. In fast developing countries, such as China, this phenomenon is spectacular. But this exodus of populations to the big cities causes a decay of villages, small towns and regions. Their revitalization is a big challenge for the 21st Century.

To preserve our planet, biodiversity and quality of life, do we really need to have more and to become bigger? What alternative is there to more technology, more companies, more business and bigger cities?

Some citizens and architects act on the concept of green city – the buildings are conceived or transformed to include a part of a garden. This idea is not new – small gardens on balcony or on the roof have already been installed by habitants. Green building is not only about energy efficiency [LEG 14], or using "green" materials, but also about producing food by citizens transformed into farmers. In France, we had *jardins ouvriers*, or workers' gardens, where small surfaces are offered for rent. *Feng shui*, the ancestral method to achieve physical, moral and intellectual fulfillment, was applied among others to plan the town of Suzhou [XUY 00], but it is still practiced for the quick development of megapoles. The Japanese also have a long tradition of zen and gardens, which they try to preserve.

Figure 1.11. *Qatar green building (source: http://arabbrains.com)*

Citizens' initiatives, such as "vegetables to take for free", contribute to greening and feeding at the condition that those who take also plant for the others benefit. A list of other French initiatives can be found at http://creativite-et-territoires.org/.

The 2020 objective of Hong Kong is to become a Wise City[16]. Theoretically it means they the city intends to use collective knowledge in an intelligent way, although this is not clearly mentioned in their website.

16 http://www.wisecity.hk/project.

1.7. Tourism and business travel

While the invention of the airplane amplified tourism, the present availability of low-cost flights has boosted this mass tourism. Many tourists are not respectful to nature; they just go to the beach, dive and prefer to use cars for short distance, instead of bikes or walking. These activities, added to those of the islanders, wanting to have more, increase pollution and destroy natural ecosystems and biodiversity [BER 09]. The awakening comes from wise local people, wanting to preserve their beautiful environment [KOH 14a], but often business wins. Some technological applications, such as e- and m-tourism, are tried to spread knowledge about a local ecosystem, influence the behaviors and disseminate the responsible and eco-tourism [CON 12].

European programs encourage mobility through various opportunities such as Erasmus, students, PhD and scientific exchange (Marie Curie Actions[17]). The student and professor exchanges have a positive impact on their social life, which lets them learn about new culture and a new language, gain knowledge and network to find partners for applying to EC programs or jobs.

The ICT offers a very good quality of videoconferencing and other distance communication tools, but paradoxically, it has not decreased the business travels. Numerous scientific conferences and other professional summits and forums make people travel around the world, more than before. European prescriptions on mobility for job also push to travel. A compromise needs to be found. A solution is certainly in the right managing of skills on European level (knowledge base of talents). Smart mobility projects are devoted to optimize travels and invent new, clean transportation. But we also have to use our intelligence to decide what is the best solution. Intelligent travel optimizers may help; they are still to be designed.

1.8. Fashion victims

The fashion industry is one of the most creative and innovative industries. Textile and textile techniques are beyond their usual playground, and new

17 http://cordis.europa.eu/fp7/people/home_en.html.

textiles are also inspired by ancestral raw material and are also integrating nanomaterials and sensors. Nettle, hemp, linen and wood are back. One of the last natural textiles is Tencel® produced from wood. The textile techniques are now widely applied in the airline industry to make fuselage for aircraft. Smart carpets control cleaning robots via radio frequency identification (RFID) (Vorwerk), transform harmful substances into harmless steam and carbon dioxide (duraAir). Two-layer textiles such as Transtex, that wicks away sweat and evaporates moisture, was initially used by athletes. Geotextiles made from steamless woven tubes are ground stabilizers in construction. Intelligent-wear (I-wear) textile integrates a solar power heating, flexible keyboard (ski gloves) and sensors [TEX 09]. Technological progress has lightened and improved the performance of firemen clothes and those of astronauts. Sport clothes are also light efficient.

Textile properties are improved with nanotechnology. They control odors, provide ultraviolet (UV) protection and are water and dirt repellent or self-cleaning. Nanoparticles of cyclodextrin, aluminum oxide, silver, silicon and vanadium dioxide provide the desired effect.

The *Centre Européen de Textiles Innovants*[18] was founded in 2012 "to enable businesses to fully benefit from the prospects offered by textile materials and by technologies of new fibres and nonwovens; to provide them with the best in textile innovation so as to rethink or to create products".

Sensors and other devices are now embedded in textiles to measure our vitals or protect us. A tailor-made bulletproof suit uses carbon nanotube material to create a lightweight and flexible body armor, capable of stopping small arms ballistics. Microsoft diversifies to lingerie – they develop a "smart bra" to monitor stress and discourage emotional eating[19].

Technology has also changed the profession of textile. However, technology must be associated with design and fashion to make new products attractive.

Paris was always a capital of fashion, but today the French and Italian models are copied and counterfeited, bringing a prejudice to coveted brands.

18 ceti.com.
19 http://www.wearabledevices.com.

Figure 1.12. *Wearable devices (source: http://www.wearabledevices.com)*

The quick business and avidity changed the human values and ethics. At the global level, there are too many products to sell – the marketing strategy is to offer "new" product instead of reusing, repairing and remanufacturing.

As a result, in France alone 600,000 products/year are not sold, including 22 million of clothes. Paradoxically, we design products needing long transportation which we then throw away or recycle. It is true that recycling creates jobs, but it is also energy- and water-consuming and polluting. The design, production and distribution of clothes involve many professionals and ensure jobs, mainly in China. However, many clothes and bags are produced in Italy by Chinese workers in aim to label them "Made in Italy". Chinese are the owners of a large number of shops in Europe. Intelligent wearing also includes "remanufacturing", i.e. creating new from the old [GRZ 57].

The gathering of clothes is among the latest trends of social innovation. Collected clothes are given or sold at a very low price to the homeless and the poor. We give them what we do not want, instead of helping them to find a job, develop useful skills and start a company.

1.9. Responsible innovation?

The described innovations not only produce an impact on ecosystems and human health, but also influence the change of moral principles, ethics and behaviors.

> If innovation is essential for the survival of any organization in a global and competitive market it can not be separated from the notion of responsibility. This is the challenge of innovation-manager who ensures reconcile at the same time the need to stimulate innovation while incorporating the necessary measures to ensure that the effects of our actions are compatible with the permanence of a lifetime authentically human on earth [JON 85].

The incredible paces of technological and scientific innovations that directly or indirectly affect humans raise questions of responsibility. Whether applications, accessories connected to our bodies, or even entirely artificial organ transplants, companies offer us so many ways to improve esthetically, physically, intellectually and even genetically. The growing impact of these developments on our consumption, our needs, as well as our health and human nature, leads us to pose new questions. It is no longer whether we can do but what we do. When the range of possibilities expands, and the exact impact on our lives is unknown, who returns it to decide whether a project should be developed or not? What are the responsibilities of organizations in the development of these offers? In France, the precautionary principle is applied, but it is also a considerable barrier for research.

Sustainable development focuses on recycling; it allows not only reusing the raw materials, but it also has an economic and environmental impact. Recycling influences the design process. How to influence intelligent buying, remanufacturing and reusing at all levels?

In developed countries, we observe a large number of critical diseases and species extinction [BER 09]. The impact on humans and other living beings health is growing, but it remains difficult to demonstrate the cause of effect in a short time because of the time scale. For example, French scientists have studied the influence of the smartphone on the human brain over a period of 5 years and they concluded that in 5 years there is no impact, while other researchers say otherwise [SAR 13].

Compared to nature, where everything recycles, everything we do has an impact, but the majority of us are not concerned with the consequences.

1.9.1. *What alternative?*

a) b)

Figure 1.13. *a) Leaf blower and b) sweeper in Ueno Garden Tokyo*

There are still some commercialized “innovations” , for example a leaf blowers that are less effective than old methods, energy consuming and polluting (air and noise), making people lazy physically or “thinking” instead of the user (switching off the brain).

What is the impact of the activity presented in Figure 1.13? The impact of activity in Figure 1.13(a) is not efficient and polluting. In Figure 1.13(b), cleaning the park with a broom will certainly be less polluting and more efficient. The physical work is beneficial for health. The individual doing this work is an older Japanese man and this activity allows him to be useful, get a salary, move and have contact with nature and other people. Such a solution is certainly better than a nursing home.

This search for the simplest solution is a basic principle of innovation intelligence. In the 1960s, the Fisher Pen Company invested $1 million to create the space pen. They patented a pen that could write upside-down, in freezing an boiling conditions, and even underwater or in other liquids, and offered the AG-7 “Anti-Gravity” Space Pen to NASA in 1967 and the agency decided to use it on spaceflights. The total expenditure on the Space pen research was very expensive, while the Russian astronauts continued using a simple pencil.

Motivation can be both an engine of innovation and a barrier. Researchers are motivated by recognition and awards, while companies are motivated by revenues. The principle of scientific publications and evaluation of researchers is among the most difficult to change because it involves the change of existing systems that became inadequate with the reality [MER 11]. Researchers are pairwise evaluated only for publications in a given field. Technology transfer, entrepreneurship or influence of their research on the progress of other fields are not taken into account. Such a system is contradictory with the challenges and expectations of innovation. In this context, the evaluation of impact is not easy because it involves distant fields from the original area. In our recent project dealing with eco-design, the convergence of the fields such as design, sustainability, knowledge management and innovation was difficult. Actually, each field has a specific vocabulary and way of thinking. It takes energy and time to build common references, and sometimes it does not work.

Related barrier is the thinking limited to a given field, resulting from specialization. The last European Commission Program Horizon 2020 put

emphasis on multidisciplinary projects. To address the set of challenges, a combination of knowledge from several areas is vital. However, the majority of proposal reviewers are mono-field specialists. As a result, the innovative projects combining several fields are rejected.

Considering the social position rather than the value of the brain may prevent innovation. The knowledge economy is supposed to generate values from our individual and collective knowledge. The main barrier in developing this economy is the psychological barrier – it is a strong culture of context instead of the value of the brain. Very often, people ask about a company instead of asking about the given person's knowledge and experience.

Certainly, we need technological progress, but it should help us in our work and make life easier without deteriorating our conditions and the environment. Searching for the simplest solutions and taking into account the consequences from the beginning are vital. Open Systems Science [TOK 10] considers the "neighbors" of a given science that may have an impact on balanced solution. The challenge is also to use and combine the past and today's multidisciplinary knowledge and "intelligent technology" to invent sustainable products, services and methods taking into account the 5D impact. Do we really need to grow to be happy?

2

Innovation Ecosystems

2.1. The innovation biosphere

> Earth is a complex, dynamic system we do not yet fully understand. The Earth system, like the human body, comprises diverse components that interact in complex ways. We need to understand the Earth's atmosphere, lithosphere, hydrosphere, cryosphere, and biosphere as a single connected system. Our planet is changing on all spatial and temporal scales – NASA Earth Science

By analogy, innovation is a complex and dynamic system composed of diverse components that interact with each other and it needs a biosphere to live, grow and reproduce without destroying this environment. Innovation is expanding and evolving with time.

This chapter presents innovation as a reflexive process and a component of ecosystems including research, enterprises, technology (digital ecosystems), users, policy, education and environment. Apart from helping humans, innovation also has a potential to influence our culture and society. While innovators are expected to supply an economic value, they also have a duty to evaluate and reduce the impact of their activity on natural ecosystems and learn from them.

When talking about innovation, many researchers quote Schumpeter [SCH 12]. He specified that innovation meets five main criteria: the manufacture of a *new good*, introduction of a *new production method* or of *new means of transportation*, implementation of a *new organization*, opening a *new market* and the conquest of a *new source of raw materials*.

The latter is one of the most complete definitions since 1911. However, for over a century now, the innovation landscape has radically changed. We switched from manufacturing to new industries of services; from a local market to the global one; from sustainable products to planned obsolescence and we thereby created new problems to solve. There has been a substantial shift from the primary and secondary sectors to the tertiary sector in developed countries. Producing various services, it is now the largest and fastest growing sector of the economy in the Western world. A plethora of services were born due to the Internet and smartphone. Technology-empowered communication, television (TV), cinema, video games, writing and creation of other cultural assets changed the need for skills. Culture is one of the biggest employers in Europe. We moved from factories to offices. E-learning, m-learning (mobile) and e-commerce work is becoming e-work and m-work.

The first and second industrial revolution paradigm is no longer valid, but mentalities have not changed. Intensive globalization resulting from the second industrial revolution and hypercompetition influence the strong "quick business" culture amplified by innovation in marketing- and advertisement-based business model.

Many consider the disruptive innovation as a "magic wand" to overcome the crisis. The trouble with disruptive innovation is that it cannot be programmed and its economic impact is difficult to predict. Sometimes, it takes decades to have a significant impact. The design of the Eiffel Tower was conceived by Maurice Koechlin and Emile Nouguier as an idea for a centerpiece at the 1889 Exposition Universelle. Stephen Sauvestre added the decorative arches to the base, a glass pavilion to the first level and the cupola at the top. The enhanced idea gained Gustave Eiffel's support for the project. He applied to the open competition for the centerpiece of the exposition that he won. A contract was signed in 1887; he got half million francs toward the construction costs (less than a quarter of the estimated cost). Eiffel was to receive all the income from the commercial exploitation during the exhibition and for the following 20 years. To manage the tower, he established a company. When Gustave Eiffel presented his project, nobody wanted to sponsor him and the critics were severe. Fortunately, it was the only project that met the requirements of the commission. He did not imagine that it will have a long-term economic, cultural and social impact. The Eiffel Tower became the symbol of Paris, attracting tourists and generating important revenues. In 1957, the radio

antenna was installed on the top of the Eiffel Tower, which is still working. The Eiffel Tower has featured in at least two James Bond movies, although there have been many appearances in a variety of movies throughout the years. Having attracted more than 200 million visitors since its construction, the Eiffel Tower is by far the most popular paid tourist attraction in the world. According to the 2012 study of Italian Chamber of Commerce of Monza and Brianza [BUS 12, EST 10], evaluating the most famous monuments in Europe, the Eiffel Tower is estimated at €434 billion. It is ranked before the Colosseum of Rome (€91 billion) and the Sagrada Família in Barcelona (€90 billion).

Antoni Gaudi's work has a similar effect and it can serve as an example of innovation ecosystem. He was influenced by his passions in life: architecture, nature and religion. He aimed to place his artworks in the most appropriate natural and architectural surroundings by studying the location of his constructions thoroughly and trying to naturally integrate them into those surroundings. For this purpose, he often used the material that was most common in the nearby environment. Another aspect is the intelligent distribution of space, always with the aim of creating a comfortable, intimate, interior atmosphere. Apart from taking care of every detail of all structural and ornamental elements, he ensured that his constructions had good lighting and ventilation. For the Sagrada Família, for example, he carried out thorough studies on acoustics and illumination in order to optimize them.

The viaduct of Millau[1] was designed to shorten the crossing of the valley and to reduce environmental impact, but the second effect is increasing number of tourists wanting to see this artwork. The side effect of the viaduct is an economic impact and visibility of this full of history and wonderful place, leveraging the excellent local products, such as leather, Roquefort and other gourmet food, and offering paragliding and other sports activities[2].

If Douglas Engelbart, the inventor of the computer mouse, could be paid per clicks, he would have been immensely rich[3]. Xerox invented the foundations of modern information systems, but they were never commercially successful with what they invented. What are the conditions

1 http://www.fosterandpartners.com/projects/millau-viaduct/.
2 http://www.millau-viaduc-tourisme.co.uk/.
3 http://en.wikipedia.org/wiki/Pay_per_click.

for success? Can we manage it? How can we demonstrate the impact and, in particular, when can we ask for funds?

This chapter recalls some definitions of innovation and related extensions. After describing the main components of innovation ecosystems, it points out the conditions for balance and sustainable success of all participants of the e-co-innovation process [MER 11]. The focus is also on the role that knowledge and computers may play in the whole process, and especially in evaluation of five-dimensional (5D) impacts and preservation of innovation biosphere. The way of managing the environmental impact and other intangible benefits and capitals will be given. Few barriers and paradoxes are also pointed out.

2.2. Some definitions

According to Ron Dvir, who, inspired by George Por's *Knowledge Ecology* and *Innovation Garden* [POR 00], named his company *Innovation Ecology*, this expression represents multiple facets of innovation with many complementary dimensions such as physical, virtual, human, financial, cultural, strategic and educational. Addressed simultaneously, they create an environment in which innovation has better chances to flourish and have an economic impact [DVI 08]. However, he does not pay attention to the environmental impact of innovation activities.

In the United States, the new Innovation Forum sponsored jointly by the National Academy and Innovation Ecologies Inc. attempts to understand and analyze the complex relationships that drive innovation in the emerging global economy [GRI 09]. They examine the governmental, economic and technological factors contributing to country's innovation ecology that have an impact on sustainable economic growth. Quality of life is one of their 230 indicators[4]. However, it is impossible to know whether environmental impact is taken into account and how. It is stated that the national innovation strategy should align the various pieces of the innovation ecosystem, and needs to provide coordinated support for all of them. Innovation is considered from various perspectives such as firms, regions and nations that need to be innovative.

4 http://www.innovationecologies.com.

To understand the deep meaning of innovation ecology, the component words and neighbor expressions will be considered:

– *Ecology*, from Greek: οἶκος, "house"; -λογία, "study of", is the scientific study of the relationships that living organisms have with each other and with their natural environment;

– *Biosphere*, according to National Aeronautics and Space Administration (NASA), is "the portion of Earth and its atmosphere that can support life". The biosphere consists of living things and the environment – the atmosphere, the land and the oceans – from which they derive the energy and nutrients needed for life. For instance, plants capture solar energy and use it to convert carbon dioxide, water and minerals into oxygen and food. Humans and animals take in oxygen and food and return carbon dioxide and other matters to the environment. This cycle repeats itself and everything recycles. Thus, the biosphere can sustain life indefinitely. Innovation, as a part of human activity, must act in harmony with this systems, even participate in the protection of this zone of life.

Ischwaran [ISH 12] presents various scientific perspectives and extends the previous definition to the global ecological system integrating all living beings, computers and robots and their relationships, including their interaction with the elements of the lithosphere, hydrosphere, atmosphere, ecosphere and sociosphere;

– *Ecosystem ecology*[5] field studies living and non-living components within their environment – how these factors interact with each other, and how both natural and human-induced changes affect the way they function. The biosphere is the ultimate determinant of where organisms can live, grow and reproduce. The biosphere includes climate, which consists of long-term trends in temperature and precipitation and soils.

The above definitions demonstrated that there are as many points of view as fields, but the main thought is that biosphere is a zone of life providing the necessary conditions for sustainable existence of its interactive organisms and their well-being.

5 http://www.nature.com/scitable/knowledge/ecology-102.

The term *sustainability* is derived from the Latin *sustinere* (tenere, to hold; sub, up). Sustain can mean "maintain" or "support". We do not know exactly who first said the phrase: "we do not inherit the Earth from our ancestors; we borrow it from our children", but it has become a slogan of sustainable development. Since the 1980s, the word *sustainability* has been used more in the sense of human sustainability on the Earth. In June 1992, the first United Nations Conference on Environment and Development, held in Rio de Janeiro, adopted Agenda 21: a Programme of Action for Sustainable Development. Finally, the most popular definition is the following: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Can we talk about sustainable development in the world with limited resources and increasing pollution? How do we define needs in the context of a greedy economy?

According to Por [POR 00], by analogy to natural ecosystems, "*knowledge ecology* is an interdisciplinary field of management theory and practice, focused on the relational and cultural aspects of knowledge creation and utilization. Knowledge exists in ecosystems, in which information, ideas, and inspiration cross-fertilize and feed one another through productive conversations".

Innovation "is one of the most bandied about terms in global business today, but exactly what it means can be nebulous" [GRE 14]. Innovation may be defined in various ways depending on the field, involved persons and "product" of innovation. The most popular is technological innovation. The majority define innovation as the process from invention to commercialization. The OECD Oslo Manual [OEC 97] takes Schumpeter's definition and focuses on technological product innovation: "a technological product innovation is the implementation/commercialization of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer. A technological process innovation is the implementation/adoption of new or significantly improved production or delivery methods. It may involve changes in equipment, human resources, working methods or a combination of these". Many other definitions can be found on the Internet[6], but in our knowledge, none has taken into account all dimensions and the impact of innovation. Since the Lisbon Treaty, technological innovation has not fulfilled the expectations of

6 As, for example, http://entovation.com/innovation/10definitions.htm.

growth and we have to face new challenges, so the European Union has now extended the focus to social and service innovation.

Social innovation aims to improve social conditions. Its value for society may be strong, but economic impact is not easy to estimate because of complex business models. Some examples of social innovation: help in transfer capacity to project and small businesses in Africa, inclusion of prisoners via online business management, free services for students, social gardens with free vegetables, innovation for social change, for inclusion and many others. Social innovation is one of the focuses of H2020 European program; projects will attract more people from social and human science disciplines.

Service innovation has always existed but nowadays its influence is extending with the fast development of technology. Service is usually related to the use of products and a base of open-source business model. Designers of products have all the necessary knowledge to be used for related services, for example, software training. This "knowledge economy" is, in general, linked to industry; however, the sectors of "tertiary", such as entertainment, telecommunication services, cinema, creative and cultural industry, health, tourism, restaurants, banking and insurance, are also concerned with innovation involving knowledge about clients [BEY 13]. The employment capacity of the tertiary sector is growing in Europe. Regional authorities in France focus on developing personal services, such as meal delivering, home services, senior sitting, etc.

Product service system (PSS), or servicizing, is a part of service innovation and a new business model. The concept is based on the idea that what customers want from products is not necessarily the ownership, but rather the function that the product provides or the service the product can deliver [STA 94]. For example, Michelin offers fleet management solutions whereby truck tires are sold per kilometer driven instead of selling tires. This service includes maintenance and replacement when needed.

Eco-innovation, according to European Union: "core purpose of eco-innovation is to protect, conserve and enhance the Union's natural capital; to turn the Union into a resource-efficient, green and competitive low-carbon economy; and to safeguard the Union's citizens from environment-related pressures and risks to health and well-being" [ECO 14a]. Clean energy and transportation, water management, recycling, green buildings and

construction are a part of this program. All these activities generate revenues and create jobs.

Knowledge innovation was introduced by Debra Amidon in 1997 [AMI 97]. From her holistic perspective, the knowledge innovation is:

– the creation, evolution, exchange and application of new ideas into marketable goods and services for:

– the success of an enterprise;

– the vitality of a nation's economy;

– the advancement of society.

This definition focuses on the economic impact of innovation and highlights the importance of knowledge at all levels.

Responsible innovation was probably first introduced by Hans Jonas [JON 85]. He states that the environmental impact of innovation should be estimated and managed. His focus is on technological innovation. Another definition: "responsible innovation is an approach that consists in taking into account various environmental, societal, social and economic concerns throughout the innovation process with a view to creating value for society while respecting the environment[7]", demonstrates clearly the application of corporate social responsibility (CSR) principles to innovation. The three pillars of CSR are environment, society and economy. Technological and cultural aspects are still missing here. It may include economic innovation such as circular economy and PSS.

CSR refers to companies taking responsibility for their impact on society. "As evidence suggests, CSR is increasingly important to the competitiveness of enterprises. It can bring benefits in terms of risk management, cost savings, access to capital, customer relationships, human resource management, and innovation capacity" [EUR 11]. It is also a constraint for them – they need to be certified ISO 26000.

In their report, Beylat and Tambourin [BEY 13] present another perspective of CSR: "In order to strengthen the participation of major groups

7 http://www.karimnetwork.com/responsible-innovation-definitions/.

in the development of innovative SMEs[8], we propose the addition to disclosure requirements of Corporate Social Responsibility of any company of more than 2,000 employees a criteria or indicator on behaviour towards innovative SMEs, to allow a strong internal incentives to managers and executives". This recommendation puts emphasis on social responsibility of large companies that have a role to play in the development of small ones.

E-co-innovation concept introduced in my previous book includes all the above definitions and the evaluation of 5D impact as well.

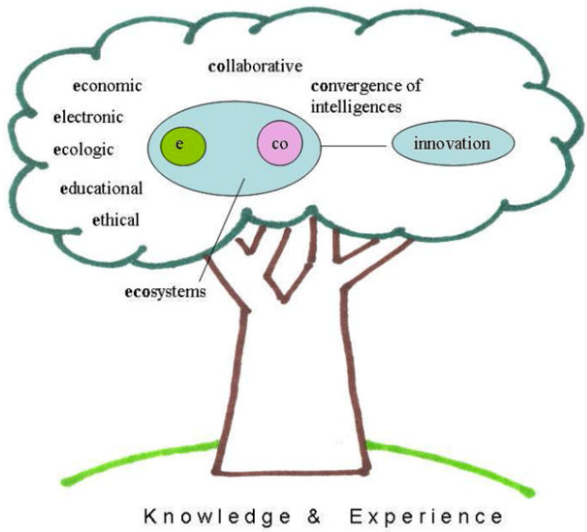

Figure 2.1. *E-co-innovation [MER 11]*

As shown in Figure 2.1, knowledge is fundamental for the success of innovation and all participants: knowledge and experiences of our ancestors, knowledge of needs, knowledge of acceptability of disruptive innovation and multidisciplinary knowledge for complex problem-solving, including those of natural ecosystems and skills for its realization. E-co-innovation is a reflexive and collaborative process involving all correlated ecosystems, natural and digital ones. Technology may play various roles in this process: it can be the object of innovation itself, helping in finding relevant

8 Small- and medium-sized enterprises.

knowledge, serving for evaluation of impact and for problem-solving, collecting and processing collective experience and supporting the whole process.

The *innovation spectrum* is composed of four main families and more than 15 kinds of innovation, as defined in [MER 11] (see Figure 2.2).

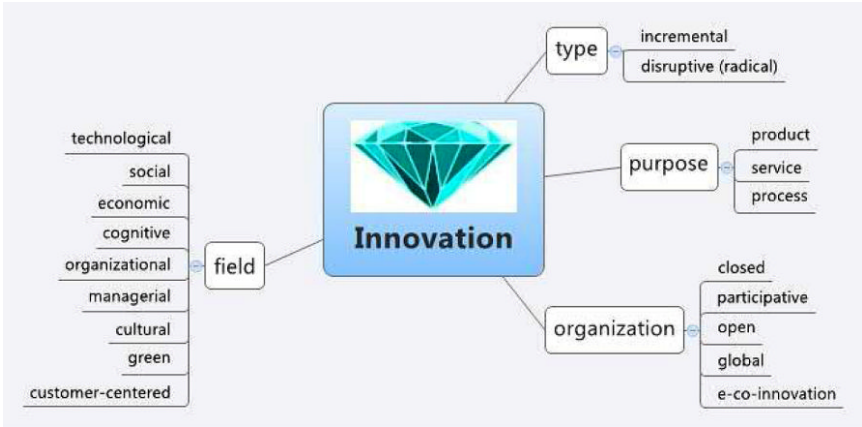

Figure 2.2. *Ontology of innovation*

2.3. Innovation life

As in the biosphere, the innovation ecosystems form a suitable environment to the good progress and to the sustainable success of the e-co-innovation process. All living beings practice the innovation culture.

2.3.1. *Continuous innovation and its context*

The e-co-innovation process, as shown in Figure 2.3, can be defined as a never-ending activity, beginning by an idea and leading to sustainable success of all participants. The environment is considered a participant, because we take benefits from its resources and we have to minimize the impact of our activity with the aim to preserve the initial balance. The innovation roots and resources are in knowledge, which has to be maintained for future use, shared and applied through information and communication technology (ICT) and intelligent and creative technology (another meaning of ICT).

Creativity and transformation are two main interrelated stages of the e-co-innovation process. An idea can come from expressed, observed or co-discovered needs with users or can create new needs in the case of disruptive innovation. ICT-powered generator of ideas may assist the creativity. Ideas are evaluated by a committee composed of several professionals with the aim to check the alignment with a company's vision and strategy (market positioning), realistic technology and availability of appropriated skills for its realization. We put emphasis on the need to verify and simulate the various impacts before transformation and monitoring them along the way to reduce the risk and impact. Evaluation of the target market, technological feasibility, availability of the raw materials, expected benefits, economic and environmental impact, as well as social and cultural impact, if any, are the items, among others, to be verified. Simulation tools may be useful for optimizing the whole process or simply for minimizing the environmental impact, the related risk and the choice of raw materials and the recyclability facility at the end of life.

The continuous feedback allows us not only to improve the existing products, services or methods but also to capture new opportunities and new ideas.

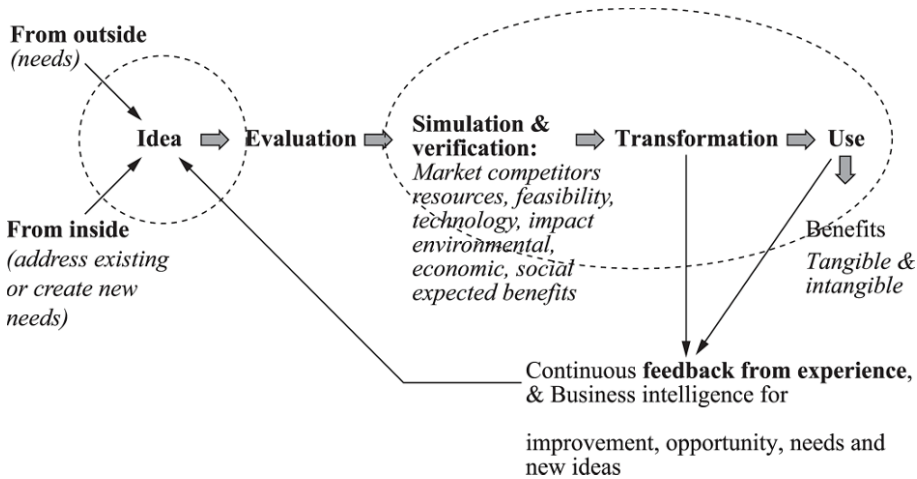

Figure 2.3. *e-co-innovation process*

Innovation is seen here as a *perpetuum mobile*, a never-ending activity, because it is an attitude of knowledge cultivators, used to capture opportunities and work in collaboration based on complementarity. Today, companies must innovate not only to survive but also to become and remain leaders. That is why the expected outcome will be a sustainable success of all stakeholders, including those of our planet. The benefits from such a process are both tangible and intangible. Besides the economic success, it will make clients happy, enhance the image, leadership and expertise, facilitate acquiring new skills and smartly managing them, take advantage of intelligent use of technology, increase the ability to make successful alliances and minimize the environmental impact. Benefits and progress have to be measured on a regular basis using the above indicators and more if necessary [MER 11]. This model may be easily adapted to governmental or non-governmental organization (NGO) innovation.

2.3.2. *Innovation dynamics*

The key components of innovation ecosystems are education, research, companies, funding organizations, politicians, supporting technology and environment, as shown in Figure 2.4. It is not easy to present such a system in two dimensions because of multiple interrelations and influence of each other.

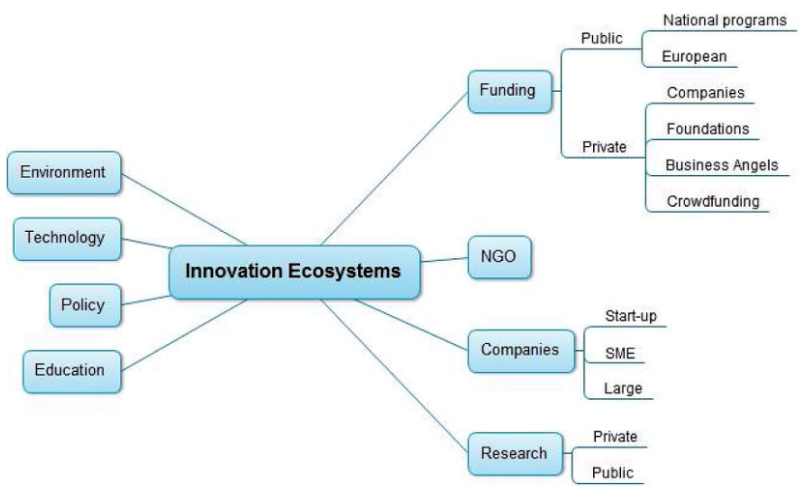

Figure 2.4. *Main components of innovation ecosystems*

For clarity, users are not represented in the figure. In fact, all players can be users of innovation in their respective contexts such as company, organization, city or region. All kinds of companies and organizations are concerned with innovation, including government and NGOs that get involved in social and eco-innovation.

Funds for powering the system may be public and/or private. Only the European system is represented here as the most common. The economic crisis is affecting national and European funding; the applicants are encouraged to supplement two-thirds of the overall budget by private ones; some are trying crowdfunding. The evaluation and management of "return on investment" and benefits, in particular for research, will be improved.

Figure 2.5 shows the interrelationships between main components of the innovation ecosystems. Current systems are mostly driven by "user-must-have" vision from the business point of view and by ambitions of researchers – they present their achievements to companies, expecting to get funds for further research. They believe that the companies need these "solutions". Companies are dealing with complex problems that may be interesting and ambitious challenges for research. This path is explored a little.

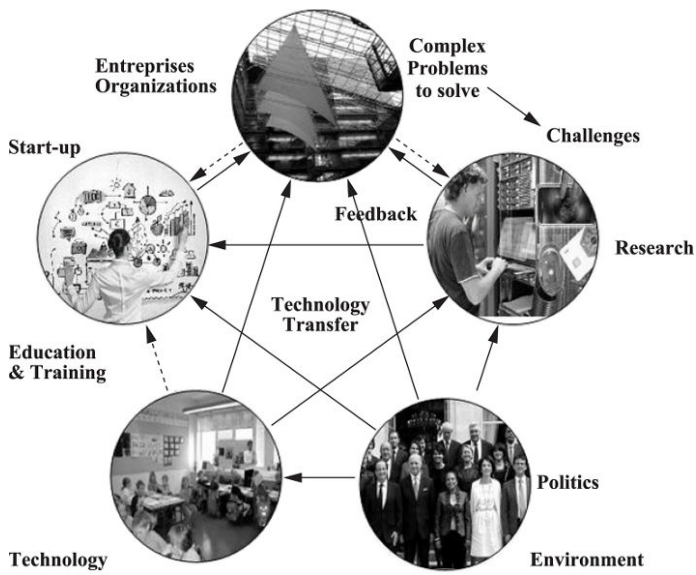

Figure 2.5. *Interrelations in the innovation ecosystems*

Most start-ups, and, in particular, those issued from research (technology transfer), imagine that customers absolutely need their products and they are rather pushing their solution instead of listening, adapting and anticipating the customers' needs [MER 11]. When they address large companies, sometimes they do not focus on the right person, for example an Information Chief Officer instead of users. A few of them, however, run the users' clubs and take advantage of the exchanges to improve their products and services, even to transform the clients' wishes into new offers.

We can observe a strong technological "push and see", as in the case of Internet of Things or connected objects. The acceptation by the user [PUB 14] and "time-to-market" are vital. Another way is to address the real needs, not the supposed needs as many businesses are doing – "we have the solution to your problem". It imposes a close relation of companies with their customers and their involvement in the collaborative innovation process.

The current education system focuses on fields to learn and on supporting technology. The teaching methods do not facilitate obtaining the skills required by the current economic environment. Each subject of "core curricula" is taught by specialized professors (geography, history, mathematics, etc.) and there is not enough time allocated to collaborative projects (problem-solving), involving several fields and allowing learning by acting together. A lot of technology is pushed but the learning methods have changed a little and the content remains the same. The entrepreneurial spirit is not a part of the curriculum in Europe, but we progress. Traditional Masters' of Business Administration (MBA) courses are introduced late in some engineering schools. The impact of education on employment/ entrepreneurship is not evaluated. A little feedback from companies is possible via internship at the condition of willing to take this point into account.

The government elaborates the innovation policy without involving companies, research centers and citizens. They decide the rules, the amount of taxes, laws for employment, public research system and educational program. Some incentives for innovation are offered but the selection methods do not accept any breakthrough idea from "outside the system". Researchers are pushed for entrepreneurship without any preparation by educational system.

The task of technology is to provide an intelligent support to the whole system. An organized flow of knowledge with feedback and selected practice will support continuous learning.

All activities benefit from the environment and all participants have a duty to minimize their impact with the aim of respecting the initial balance.

In current systems, connections are missing, impacting the balance of the whole innovation dynamics.

2.3.3. *Balance: conditions for sustainable success*

According to specialists in the biological and human ecosystems (sociologists), the balance is maintained by exchanges "giving and receiving". It is a part of innovation culture practiced by all participants. Maintaining the balance in innovation ecosystems depends on multiple factors; one of them is the innovation culture practiced by all participants.

2.3.3.1. *Educating the innovation culture*

The *innovation culture* includes the attitudes of "knowledge cultivators" as shown in Figure 2.6. The ability of smart communication, audaciousness and other capacities shown in Table 2.1 are essential to establish and maintain the overall balance.

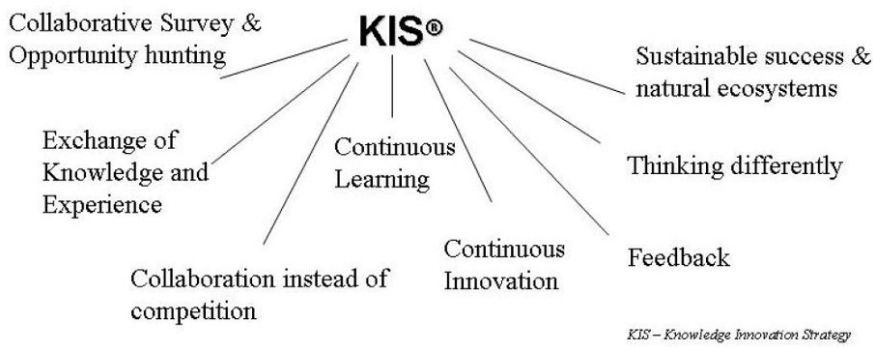

Figure 2.6. *Main elements of innovation culture [MER 11]*

Such attitudes facilitate the *collaboration between research, small and large companies and policy makers.* This synergy is vital for maintaining the balance of the innovation ecosystems. All groups represent a set of wishes and needs that must be fulfilled with innovation. Collaboration of small and large companies enhances the sustainability of the first and the flexibility and innovation capacity of the second.

The role of politicians is enhanced by a two-way communication with others participants; it helps them to define an appropriate policy leveraging the efforts of all.

Educational and training system contribution is essential to educate, maintain and evolve the skills of knowledge cultivators and entrepreneurs, able to think differently, to solve problems using individual and collective knowledge and to stimulate collaborative intelligence.

Organized flow of knowledge nourishing innovation and exploring the best of technology empowers all participants.

Ecosystems of industry and research are similar, but their motivation and objectives are different, restricted by the existing systems. Industry focuses on business, while research, and in particular public research, puts emphasis on the evaluation and ranking. Academic research has to produce scientific papers in their respective fields; industrial transfer of results and entrepreneurship is not taken into account by the current evaluation system. This fact represents a significant barrier for collaboration of these two populations, particularly in France. The scale of time is also different, because researchers have no constraints, except for PhD and national and European sponsored projects (3 years). Despite the trend for multidisciplinary research at national and European levels, the opening between neighbor fields is a practice only in Open Systems Science [TOK 10]. The recent European program Horizon 2020 encourages multidisciplinary projects, which is just a beginning.

For over 15 years, many efforts, human energy and money have been spent in France on trying to build a balanced ecosystem between research and companies. A huge amount of public money, national and European as well, was invested through initiatives and programs such as *Pôles de Compétitivité* (Competitiveness Clusters) in France, Investment for

the Future, and other national programs, Living Labs, Future Centers, Open Innovation, Innovation Union and others at the European level. Despite successful efforts, none have been able to create favorable conditions to influence a sustainable convergence of these two populations for better synergy and results.

The change of the research evaluation system involves the change of whole education and research system in France and probably in Europe. What evaluation may improve this situation? U-multirank, European project, defined the right evaluation criteria, but it will be introduced to the educational and research system, will be practiced and only then will it become a standard. A convergence criterion may be added to this evaluation system. Thinking within the limits of a given area makes this convergence process difficult. Only the projects having a common goal, involving open thinking people, may succeed.

Large companies, members of *Pôles de Compétitivité* or other initiatives aiming at making work together large and small enterprises, can easily take money for collaborative national and European research because they allocate resource and have the necessary know-how on proposals writing to win. The financing institutions trust them more than small innovative companies. They include researchers into the national funded projects because it is required. In reality, very few prototype an innovative solution together [DEG 13].

Another attempt of connecting research and companies is *Rendez-vous Carnot*[9] initiated by *Instituts Carnot*[10] grouping 34 French research centers. *Rendez-vous Carnot* aims at facilitating a synergy between research and industry through exposition of the research results and successful collaborations between two populations. However, their Website does not publish how many successful matches and long-term collaborations were initiated through this event.

Despite considerable efforts, the current innovation policies do not facilitate the development of small companies. France offers too much "financial dusting" instead of less but more effective funding. Often, it is

9 http://rdv-carnot.com/.
10 http://www.instituts-carnot.eu/.

necessary to spend a month writing a proposal, which is an impossible task for small companies that need to focus on their business. The evaluation of proposals and selection of projects for financing is rarely done by persons able to evaluate the innovative capacity of a small company and the real economic, technological and environmental impact of a given innovation, in addition to realistic business plan.

Public and private actors are offering speed dating hoping to match demand of large companies and aiming to offer of start-ups. In fact, these actions reinforce the competition between small companies instead of encourage them to elaborate a common offer to win. Start-ups have to be very smart in elaborating of pitches.

Another condition for fruitful innovation is taking into account the *impact on living and planet* and learning from the environment. Knowledge of natural ecosystems influences the respectful and is even inspired by nature innovation. Considering the economic impact is a great progress, because usually research teams in France and "old Europe" are not willing to "work for money".

2.3.3.2. *Checking 5D impact*

While many organizations focus on creativity, few consider the whole process (from idea to sustainable success), including the impact of innovation. Google recently announced their diagnostic system using nanotechnology inside the human body for early detection of diseases. Taken as a pill, the tiny magnetic nanoparticles (more than 2,000 can fit inside a red blood cell) have antibodies and proteins attached to them. As they circulate in the bloodstream, they can seek out and attach themselves to other particular types of cells, such as cancer cells. Via a wearable technology device on the outside of the body, the nanoparticles can deliver information to medical physicians about the potentially harmful cells inside a human [ALP 14].

Did they hear about prevention? Or about non-invasive enzyme screen for cancer detecting the presence of a matrix metalloproteinase in urine samples obtained from a patient [MOS 04]? Probably, but it is not the same business and not the same impact. What are the consequences of swallowing nanoparticles on our body and its context?

Evaluation of the innovation impact includes technological, economic, environmental, cultural and social aspects (5D). These are interrelated and will be balanced as shown in Figure 2.7.

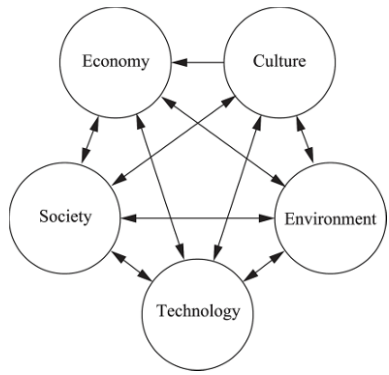

Figure 2.7. *Conditions for balance [MER 11]*

Companies wanting to fit CSR requirements focus on environmental and a little bit on social impact, "forgetting" economic, technological and cultural impacts. The actions are conducted by the Sustainability Chief Officer and the results strongly depend on their way of considering things and their openness. While all efforts focus on environmental and social impact (less), the economic aspects as well as power of technology are underestimated, as shown in Figure 2.8. In the majority of cases, the technology is used at its basic level, limited to professional software, organizational Website, Intranet, social network and office tools. Often, the management of cultural aspects is limited to diversity management (mandatory), a human resources strategy that is intended to foster and maintain a positive workplace environment and to encourage cooperation among workers with differing backgrounds. Related norms (ISO 26000) are complex and require verifying a very long list of conditions.

The aim of *Convergence*, a French national sponsored applied research project, was to help SMEs in integrating the environmental aspects into design. The consortium prototyped a toolbox for guiding design-related professionals [ZHA 13, MER 13]. The pilot company is very active in sustainable development; however, their actions are mainly concentrated on image and not enough on economic issues, on better use of technology and on knowledge management (KM) aiming at improving the effectiveness of

their innovation process. Their innovation is spontaneous – the employees' ideas are discussed in small groups and decisions on what is relevant to produce are taken collectively one by one, without a real vision and related strategy. Their innovation system balance is shown in Figure 2.8.

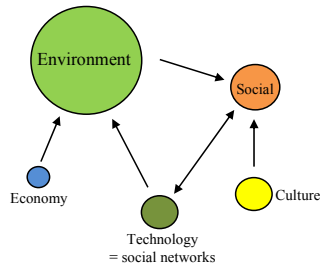

Figure 2.8. *Five dimensions of initial impact in Convergence project [MER 13]*

A detailed diagnosis of this situation demonstrated that the innovation process is not managed on a regular basis; knowledge flow is embryonic and is not supported by technology. Focus mainly on environmental and social impact, they use some CSR indicators (KPI), which is insufficient to evaluate tangible and intangible benefits for the firm and stakeholders.

Technological innovation focuses mainly on technology and omits the four other aspects, as shown in Figure 2.9.

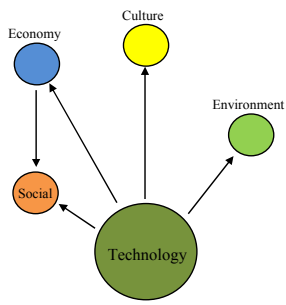

Figure 2.9. *5D of traditional technological innovation*

This situation is specific for France, but also for Europe and certainly for some other countries. While the economic impact is only taken into account by private research, it is not at all considered by public research, because this

element is not evaluated for ranking and the majority of researchers are not focused on money (mentality). The majority of start-ups consider that the "best" technology is enough to be successful. The same attitude can be found in the industry; for example, designers of cars think that the best engine and nice look are enough for commercial success. Chemical and food industries focus on packaging, smell and taste, rather than on efficiency of components, obtaining promised effect, nutritional quality or long-term effect on health.

Traditional eco-innovation, such as clean energy and transportation concern, is on greening industrial activities and using more ICT for it, such as machine-to-machine communication, visualization, optimization and decision support. This trend increases activity and generates economic impact; however, the overall environmental effect is rarely estimated. For example, electric cars are silent and may not be accepted by people liking engine noise. Silent cars may be a threat for pedestrians and bikers using headphones.

For all the above-mentioned reasons, the estimation of 5D impact may lead to more efficient and respectful products or services and the sustainable success of companies.

2.3.3.3. *Way of thinking*

The way of thinking has consequences on the innovation capacity, efficiency of innovation and its impact. Innovation requires a continuous "gymnastics of the brain". Mankind has a tendency to perpetuate the same mental diagrams and to cling onto known reference marks. This is one of the main barriers of disruptive innovation. The famous metaphor "thinking outside the box" is about the ability to choose an appropriate mental model that best fits a given situation. In our knowledge, such brain gymnastics is not preformed in the majority of schools.

Most computer science training teaches how to think about "data" (classifying things), whereas artificial intelligence enables us to learn how to think about "knowledge" (problem-solving). In this frame of mind, Allen Newell [NEW 82] has proposed a new way of modeling knowledge to make it "comprehensible" by computers: conceptual modeling independent of the implementation. Thinking about a "concept" is not easy; it requires a capacity of abstraction.

Edward de Bono developed the concept of lateral thinking [DEB 67]. The main objective of his method is to obtain new, unexpected ideas. For this,

the "lateral thinker" must be able to modify his/her perception of the world. This way of thinking is not natural – we need to make an effort to find alternative points of view. His six hats method [DEB 99] is used to solve problems in creativity sessions. Each hat represents a different way of thinking and participants can play several hats during one session.

An abstraction of the problem-solving field is implemented in the TRIZ method. It integrates the universal mechanism of thinking, independent of the application field – solutions used in one field can be applied to another field. This way of thinking, conditioned by the capacity of abstraction, is infrequently, or not at all, taught in schools.

The conditions minimizing the impact of innovation on ecosystems require the knowledge of the latter and the ability to choose the suitable mental schema. Although mental flexibility can be acquired, a single person cannot possess the entire knowledge of the ecosystems. Capacity for visualizing links and detecting complementarities is imperative. The ability to think in global, system and holistic [MER 11] ways is also important to succeed in the knowledge economy. Global thinking allows us to know the context, system thinking allows us to know interinfluences and holistic thinking enables us to work in an incremental way.

2.3.4. *Role of knowledge and skills*

In the beginning, there is an individual or collective vision. It can be the result of a creativity session, of the technological and economical watch, of the analysis of the market and of its evolution on short-, mid- and long-term. It can also be the result of the observation of trends and gaps, or simply of the imagination of an inventor.

The know-how related to innovation includes the mobilization of knowledge necessary to initialize and manage for success of the innovation process, including the environmental aspects.

The main knowledge components of the innovation process are:

– knowledge of a company's vision and strategy;

– knowledge of management and creativity methods, of psychology;

– professional knowledge and ability of problem solving;

– real-time knowledge of challenges and opportunities;

– knowledge of the market, of competitors, of possible alliances;

– ability to combine the innovative business models;

– knowledge of customers, their needs and motivations;

– knowledge of context (policy, taxes, legislation, prices and trends);

– ability to evaluate the 5D impact and potential risk;

– knowledge of ICT possibilities;

– knowledge of intellectual property;

– ability to organize and manage the maintenance, experiences and feedback.

All these types of knowledge are possessed by the different actors of the company and by the stakeholders. Elements of knowledge are found in electronic and paper documents, on the Web, in different computers and other mobile devices, in Clouds, in design, decision and diagnostics support systems as well. To ensure the instantaneous and relevant access for all participants, it is better to build an organized knowledge flow, intelligently assisted by computers in all its forms [MER 11]. Suitable organization and management of knowledge flow generated by innovation activities remains a *sine qua non* condition of the success.

The efficiency of the innovation process depends on how all this knowledge and experience is captured, and stored for immediate or future use, on the facility of finding the relevant information/knowledge and on the smart management of all these components. All knowledge related to the innovation process will be organized and managed through appropriate knowledge dynamics.

For over two decades now, knowledge management (KM) has been introduced and practiced in companies and organizations. This experience shows that the user-oriented KM gives the best results, compared to technology-oriented or pure top-down approaches. The user-oriented approach allows us to incrementally build an optimized knowledge flow corresponding to the real needs. Supervised by top-down (vision and strategy), this method enables doing “small” but thinking “big”. The initial flow may start with a generator of ideas and grow by progressively integrating new needs of company and stakeholders. Depending on the firm

activity, a knowledge flow may start with the most important problem to solve, such as collective experience worldwide, diagnosis, customer satisfaction, security, design, e-commerce, documents or human resources management and others.

Endowed with the right technology, such a flow has the potential to create collaborative human–computer alliances using the best capacity of both. Computers, which are programmed to use the "knowledge approach", can play various roles in the innovation process: the roles of a facilitator of the collective intelligence; a generator of ideas, able to check whether a new idea has already been carried out somewhere in the world; a business intelligence specialist; a consistency and constraint controller; a simulator "to see before doing"; a design assistant; an adviser and a box of ideas.

Equipped with artificial intelligence techniques, computers can "think", solve problems, become experts and accumulate a collective experience, under the condition that we transfer to them the relative knowledge and the necessary reasoning and learning techniques.

The triggering factors favoring this vision are imagination, intelligence, intuition, knowledge of the mankind, of human activities in individual contexts, in company/organization and social contexts, of behaviors and motivations. The ability to foresee the future allows us to anticipate the technologies to come, the needs and the market trends. Difficulties, shortages and limited resources amplify imagination and creativity.

Nowadays, most of the companies are looking for short-term revenues and success. However, to remain successful, they need a long-term vision. We highlight the importance of envisioning and being visionary when taking decisions (go, no-go). Such decisions may influence a leadership position. While decision-making is often the matter of one person (e.g. a CEO), it involves a collaboration of knowledgeable and intuitive people having a global view of what is on, able to envision the next trends and needs, even to introduce new ones. Intuition is among the capacities to develop; it has a power to boost innovation. The insight may come from external stakeholders such as partners, subcontractors and clients. That is why companies who innovate with clients are more successful than others that don't.

What are the essential skills to innovate and turn innovation into a sustainable success? These skills are numerous – from the management of

ideas and people to the implementation and commercialization. The Chief Innovation Officer is not necessarily a person in charge of research and development (R&D), but someone who is able to mobilize imagination, collective intelligence and technology.

Two interrelated steps of the innovation process require curiosity, imagination and risk taking, making links between people who know and fields. Creativity requires stimulation and permanent questioning.

Traditional skills related to industrial economy and still taught in school are not aligned with those required by the new economy. Table 2.1 presents the evolution of skills from industrial to knowledge economy.

Industrial Economy		Knowledge Economy
Functional title	Focus on	New role
Enterprise Manager	Planning, organizing, staffing, leading or directing, and controlling an organization (a group of people or entities) or effort for the purpose of accomplishing a goal.	Leader, visionary and strategist, focus on dynamic governance , sustainable success manager, stakeholders, strategic alliances
R&D	Managing research and development projects	Manager of the e-co-innovation dynamics
Human Ressources Manager	Managing human resources, training and lay-off	Talent miner and optimizer, manager of the Intellectual Capital
Marketing Manager	Market study and customer relation	Opportunity hunter Risk taker
Communication Manager	image	Image and links maker
Corporate Social Responsibility Manager	Image, environmental impact, recycling, CO2 emission	e-co-innovation, minimizing the impact and packaging, nature inspired design
Project Manager	Managing tasks and people, reporting	Facilitator of the collective intelligence and creativity able to motivate and valuate
Practitioner of the *faster-cheaper-better*	Manager of delocalization, cheaper workers finder	Practitioner of the e-co-innovation culture
Financial	Estimation of ROI (return on investment)	Measuring the capacity to innovate and the of tangible and intangible benefits and values
Computer user	Planning, reporting, scoring	Master of ICT (intelligent and creative technology), able to take the best of technology

Table 2.1. *Contrast in managerial roles [MER 11]*

Briefly, the Chief Innovation Officer must know how to mobilize imagination, collective intelligence, knowledge and right technology to the useful and respectful innovation, generating values for all participants.

2.4. Barriers, constraints and paradoxes

We are living in a global world, practicing global economy without global governance. Groups such as G8, G20, and other global meetings, made some statements and issued good wishes, and resolutions, but we still have wars, unemployed people, climate change and increasing pollution because of the almighty "business first" logic.

During the recent events in French politics for innovation, the precaution principle and law was pointed out as a main barrier for development of mainly disruptive innovation such as genetically modified seeds, nanotechnology, use of stem cells, deoxyribonucleic acid (DNA) modification or extraction of shale gas. Such innovation intimidates populations that sometimes lack information of the impact. This lack of trust pushes them to destroy sometimes over 10 years of research results by grubbing of transgenic corn or bananas. The citizens must be informed to be more confident in research. Mobile phone transmitters are also pointed out as a potential cause of cancer. Cell phones emit radio frequency energy, a form of non-ionizing electromagnetic radiation, which can be absorbed by tissues closest to where the phone is held. The amount of radio frequency energy that a cell phone user is exposed to depends on the technology of the phone, the distance between the phone's antenna and the user, the extent and type of use, and the user's distance from cell phone towers. According to the National Cancer Institute, "studies thus far have not shown a consistent link between cell phone use and cancers of the brain, nerves, or other tissues of the head or neck. More research is needed because cell phone technology and how people use cell phones have been changing rapidly"[11].

In some cases, a sophisticated simulation system based on the collection of multidisciplinary knowledge may help understand the impact and consequences. A distinction between an useful innovation and one that simply allows one to make money could help us better.

11 http://www.cancer.gov/cancertopics/factsheet/Risk/cellphones.

Sometimes, the innovation policy may not work, in particular when the same system is imposed to a population of a different culture. For example, the residents of La Reunion island, which is a French ex-colony, do not have the same assets and values as Parisians. The local authorities having a deep knowledge on inhabitants' behaviors, capacities, past knowledge and ambitions should have given a possibility to adapt the general innovation politics to their conditions and let them to manage it the best they can.

Jean-Paul Delevoye, a politician, considers that the French culture and administration system, adapted to govern an empire, is an innovation barrier *per se* [DEL 12].

According to Lauvergeon [LAU 12], France has to make an effort modifying a cultural ecosystem and organization with the aim to make innovation successful in terms of economic impact. Tax system, regulatory requirements, gloomy situation and lack of confidence in the future do not make life easy for innovators. France dares to act and take risks.

Beylat and Tambourin [BEY 13] state that the innovation policy should strongly encourage entrepreneurship and value creation. It should allow the integration of a wide variety of cultures and knowledge by attracting the best students, young researchers and entrepreneurs. It should also help to increase the efficiency of technology transfer. It must be focused on graduates and must assert an overall view of its actions according to the results and position the public investment where it contributes best to the growth and revitalization of the economy. Finally, an innovation policy must support the growth of innovative companies relying on private funding or by public order, facilitate and reward the creation of economic value and jobs. What example can be given by politics that never lead a company?

All society levels can innovate, but facilities are only offered to researchers and start-ups. Large companies take advantage of European and national programs because they have people dedicated to this task.

Acting "in the box" is a serious barrier for innovation. Specialization of researchers and other professionals makes it difficult to consider things unconventionally from a new perspective. The duty of educational systems is to integrate a creative way of thinking into educational programs, from kids to university. This involves the radical revision of educational system and those of research publication and evaluation. Eco-design is an example of

convergence of traditional design methods (lifecycle analysis) with intelligent technology and environmental norms that could be adapted to each case.

The ways to consider the innovation may lead to limited vision; for example, French automotive manufacturer Peugeot, as many others, focuses on technology. They build the best and nicest hybrid cars but their vision and strategy must consider the user's needs and wishes to be commercially successful.

The history of innovation shows that the majority of inventions focus on the function, rarely on the design and even less on the impact.

Another potential barrier is the lack of social appropriation by potential users and the fear of novelty. iPhone, offering an intuitive interface, is still a great commercial success. If a new product is complex, it will not be accepted by users, especially if they have a choice. Innovation is accepted if it improves life when such an improvement is needed. Washing machines, refrigerators, vacuum cleaners, computers, smartphones and many others were immediately accepted. While three-dimensional (3D) printer is extremely useful for prototyping, quickly providing spare parts, even organs when appropriate, do we really want to have a 3D printed pizza?

Time-to-market is a traditional barrier for innovation. If a product is available on the market too early or if it is too expensive, then there is the risk that only a few advanced clients will buy it. It was a case of Apple Lisa.

Communication plays an important role in amplifying innovation effect. Most people act in "push" mode – they talk about themselves instead of listening more to others. This communication is mostly practiced in professional social networks used to evaluate the person who talks instead of creating synergies and projects together.

2.5. Some paradoxes

The deep understanding of the innovation context and impact requires multidisciplinary knowledge [MOO 01] and a combination of global, system and holistic thinking, while the criteria for evaluation and ranking separate fields.

Ecological disaster has been caused by intensive industrialization, domination of "quick business" attitude and globalization, considering human as a "machine to buy" and money as the only asset. Media are promoting the attitudes of "to have and to show". The technological push without taking into account the real needs and evaluation of the impact, using a system approach, lead to many paradoxes. Many technological products focus on the elderly market, while they need to feel loved and want someone to talk with. A robot reminding about taking pills, asking questions for brain stimulation or telling stories may also give a hug, hold a hand and understand hidden wishes.

While robots are useful in the situations and places we cannot access for any reason, in the office, they have certainly strong psychological and social impact. A French proverb says "it is better to be alone than in bad company".

Figure 2.10. *Do we really need robots in our office? Source: http://www.irobot.com*

Surely, we will need skilled people to maintain or reprogram robots as they become increasingly sophisticated.

A large part of technological innovation is switching off the brains, replacing people and making life automatic providing little effective virtual help. It is a strong reason for considering real customers' needs and prototyping with them the products/applications able to provide an intelligent help and based on the best of both human and "machine" capacity.

The eco-business is flourishing, creating jobs and revenues for the Chinese. In the sunny Montpellier area in France, several start-ups initiated solar energy business, adapted to the local needs. Initially produced in France, now the solar panels are produced in China and are transported thousand kilometers to the south of France, just for the lower price, generating pollution. This situation is similar in many fields.

The Member States and the European Union order the reports in major international consulting firms, which do not necessarily have the knowledge of the real situation in a given field, but they have the reputation. Why do not ask the local experts to write such reports?

2.6. Measuring benefits

Despite all the mentioned barriers and paradoxes, innovation is an essential engine of humanity. All the hopes of politicians are in generating jobs and growth. As it is complex to measure, they trust statistics. The evaluation of benefits requires the appropriate method and metrics to measure tangible and intangible benefits. Figure 2.11 presents the main types of capital comprising human, relationship and structural elements. All these elements influence each other.

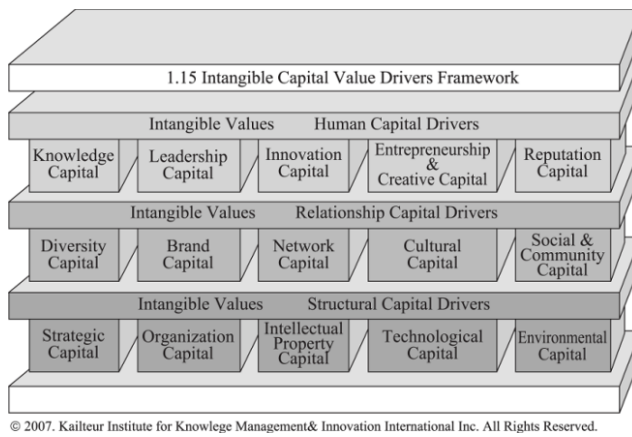

Figure 2.11. *Intangible capital*

While the evaluation of tangible benefits is rather easy, that of intangible benefits is not evident.

Among the most important elements to measure are leadership positions, image, creation of joint ventures to extend the initial market, rate of new products and services per year, environmental impact, participation of stakeholders, real-time learning, collaborative watch and opportunity hunting, financial and other benefits, and the right use of technology supporting a knowledge flow related to the e-co-innovation activities [MER 11]. These metrics are generic and will be adapted to each case.

2.7. Trends and future innovation

In search of economic growth and job creation, several approaches have been experimented at the European and country levels, such as technological innovation, eco-innovation, social innovation and, recently, service innovation. Technological innovation still makes up a large part of national and European programs, while social innovation aims at larger involvement of social and human sciences professionals and enhances the use of technology for facing social challenges. Some examples of such innovations are given in the European brochure [EUR 10a]. Solutions to health and social care problems for excluded people, training for children from lower income families, bike renting, home-based health care, post-carceral inclusion, activities for the youth in the rural areas, animal breeding and small businesses in devitalized areas are a few among these innovations. As many of these actions are on a voluntary basis, the most difficult task is to find the right business model and to evaluate the economic impact of such activities.

Service innovation was pushed by the economists in the 1990s [GAL 96] as another means to generate growth and jobs for people not necessarily involved in technology. In relation to products, service innovation seems evident, but it also enters the traditional service areas such as banking, food, travel, insurance, health and others. The recent European report presents service innovation as the next new trend [KUU 12]. Among economic trends, a PSS is of interest. The awareness that services in combination with products could provide higher profits than products alone was probably a trigger for this move. The concept is based on the idea that customers may want the function that the product provides or the service the product can deliver and not necessarily the ownership. Some researchers have redefined the PSS as including environmental improvement because it reduces the use of materials [ZHA 13].

Economy of sharing that has already been practiced in the Eastern Europe after the World War II makes its entry to developed countries becoming poor. Sharing of cars, tools and houses is a practice by individuals in parallel to the sick economic systems.

Today, the economic future of the developed countries depends on their capacity of facing together the various components and the way they manage the local resources including talents to leverage. The future of developing countries depends on their capacity to integrate the feedback from experience from developed countries and a capacity to balance the business and impact.

"Responsible" eco-innovation should be correctly managed taking into consideration all possible impacts.

What is the impact of storing information about world citizens' life, activity, houses, health, "buying behaviors" in the Google or Facebook servers without any possibility to control them by tracked persons?

What are the current challenges that can be faced by innovation?

3

Challenges and Innovation Policies

3.1. Challenges for the next decades

Despite the extraordinary advancement of technology and apparent improvement of human's condition, the world is still facing many serious challenges, such as unemployment and exclusion, depletion of natural resources, pollution and its subsequent serious diseases, organized crime and cyber criminality, terrorism, devitalization of regions and overpopulation in megacities, a need to improve the quality of life and planet conditions, an aging population, diversity and societal challenges, eco-efficient technology, impact of sensitive technology to manage, business transformation, economic growth, knowledge preservation, food and water for all, housing, well-being, access to education for all, etc.

All these challenges are interdependent. How can we handle them simultaneously? Can innovation culture and intelligent technology help in this task?

There are many initiatives around the world trying to face some of these challenges separately.

> A fast-growing human population and the consequent growing demand for food, energy and water are the most serious. In addition, anthropogenic climatic change is a severe threat to mankind and requires that we significantly reduce our current greenhouse gas emissions to avoid detrimental consequences for the globe. Only the use of new technologies will allow us to bridge the gap between economic growth and environmental sustainability in the long run [KIN 10].

This report put emphasis on biofuel production as an alternative for fossil-based products. The authors promise that the development of the biofuel industry will be done in a manner compatible with the highest environmental and social standards. Among contributors to this report, we find the major companies involved in the business of energy. Their motivation is rather in increasing the use of energy than in education of energy-saving attitudes. What is the impact of biofuel produced from waste and of exploring dedicated to energy parcels? How can technology influence the intelligent use of energy? By the way, technology needs energy to run.

> Feeding people is a real challenge for the twenty-first century; we will be 9 billion people in 2050 and already in 2009 one billion people are hungry while another two billion suffer from malnutrition. Considering increasing number of families, how can we increase the mass of food available and to better distribute it? What are the economic, social and environmental challenges of the green revolution, GMOs, the extensions of crops and intensification of production? [BAZ 09].

How can we balance the food waste and food business, as well as unemployment and lack of workforce in the services areas such as tourism, hotels and restaurants, agriculture and others? Through control of birth and lack of immigration management? How can we balance growth and exclusion? What innovative methods can help us to eradicate terrorism? What are the priorities of politics and what should be done? How can we create a synergy between spontaneous citizens' actions and policies?

Numerous think tanks at different levels are discussing with the aim to fix this situation, but a global consensus in terms of vision, strategy and tactics is still missing.

Politicians debate during the various summits such as the Earth Summit, G20, G8, UN Climate Summit, World Summit of Regions on Climate and Davos. The OECD leads politics brainstorming on the current challenges and elaborate reports. The European Parliament and the European Commission have defined the major policy lines for the member countries including innovation policies. All these policies are supposed to solve the today's problems. The statistics and scoreboards are published, but the improvement is not evident. Are they using the right methods to evaluate the situation and

measure the progress or their methods are inappropriate to manage dynamic changes?

This chapter presents some challenges for the 21st Century and analyzes the alignment of politics with them. The gap is discussed to provide some perspectives that may help building a better future.

3.2. Main challenges: global, European and French perspectives

The Millennium Project is a global participatory think tank created in 1996 under the American Council for the United Nations University that is now an independent organization with 46 nodes around the world. It groups world leaders and scholars participating in research, connecting global and local perspectives. Their last report [GLE 14] states that we are living in a seemingly perfect world:

> People around the world are becoming healthier, wealthier, better educated, more peaceful, and increasingly connected, and they are living longer. However, water tables are falling on all continents, intrastate conflicts and refugee numbers are increasing, glaciers are melting, income gaps are increasing, coral reefs are dying, ocean acidity is increasing, ocean dead zones have doubled every decade since the 1960s, half the world's topsoil has been destroyed, youth unemployment has reached dangerous proportions, traffic jams and air pollution are strangling cities, $1–1.6 trillion is paid in bribes, organized crime takes in twice the money per year as all military budgets combined, civil liberties are increasingly threatened, and half of the world is potentially unstable.

We have identified 15 global challenges:

– How can sustainable development be achieved for all while addressing global climate change?

– How can everyone have sufficient clean water without conflict?

– How can population growth and resources be brought into balance?

– How can genuine democracy emerge from authoritarian regimes?

– How can policymaking be made more sensitive to global long-term perspectives?

– How can the global convergence of ICT work for everyone?

– How can ethical market economies be encouraged to help reduce the gap between the rich and the poor?

– How can the threat of new and re-emerging diseases and immune micro-organisms be reduced?

– How can the capacity to decide be improved as the nature of work and institutions changes?

– How can shared values and new security strategies reduce ethnic conflicts, terrorism and the use of weapons of mass destruction?

– How can the changing status of women help improve the human condition?

– How can transnational organized crime networks be stopped from becoming more powerful and sophisticated global enterprises?

– How can growing energy demands be met safely and efficiently?

– How can scientific and technological breakthroughs be accelerated to improve the human condition?

– How can ethical considerations become more routinely incorporated into global decisions?

These challenges are not prioritized. They are interdependent, transnational in nature and transinstitutional in solution. They cannot be addressed by any government or institution acting alone and they require collaborative action among governments, international organizations, corporations, universities, non-governmental organizations (NGOs) and creative individuals. [GLE 14] mentions some cause-to-effect relations: "because the world is better educated and increasingly connected, people are becoming less tolerant of the abuse of elite power than in the past. Because youth unemployment is growing, more people have more time to do something about this abuse. Unless these elites open the conversation about the future with the rest of their populations, unrest and revolutions are likely to continue and increase".

The Millennium Project provides the State of the Future Index as an alternative to gross domestic product (GDP) as a measure of progress for the world and nations. Their method uses "data thinking" and a model with 30 variables; the progress is presented only by comparing the values variable by variable.

The "knowledge thinking" approach will certainly bring better results, but it requires a combination of global, holistic and system consideration.

The expressed challenges concern research, companies and politics.

The main challenges for China are environmental pollution, corruption and aging population. Environmental pollution results from quick economic development focused on the revenue. China's growth-rate is slowing. China's growth is driven entirely by exports and state-investment. The internal Chinese economy needs to be reformed and opened up to make it more productive. This is politically difficult. China is getting old due to the one-child rule. There are more than a hundred protests in China every day, mainly against the country's environmental pollution and increasingly corrupt ruling class.

The main challenges of India are environmental pollution and growing population. In general, the developing countries focused on economic development rather than on the living conditions.

3.2.1. *Challenges for Europe*

The European Economic Community was created by the Treaty of Rome in 1957; it became the European Union (EU) in 2009. The euro (€) was introduced to world of financial markets as an accounting currency on January 1st 1999, but we still do not have a European identity but cultural diversity amplified by immigration, and no common language. The main challenges for Europe were defined in the Treaty of Lisbon: making the EU the most competitive economy in the world and reaching full employment before 2010. This objective has not been reached and therefore, a new view by 2020 has been developed and put into practice in a strategy for an *intelligent, sustainable and inclusive growth*. The above challenges are expressed in the European Work programs. The innovative solutions are expected from funded researchers and companies.

The priority themes of European 7FP Work program 2013 "Socio-economic Sciences and Humanity" were: employment and competitiveness in Knowledge Society, combining social, economic and environmental objectives. "Research and innovation are key drivers of competitiveness, jobs, sustainable growth and social progress" [EUR 12]. Overcoming the crisis remains one of the most important challenges. The ongoing projects

are expected to provide the answers to questions related to growth, employment and competitiveness; discovering the major trends in the European society and their implications, face social, cultural and educational challenges in an enlarged EU and environmental challenges as well. The quality of life, socioeconomic and scientific indicators, foresight activities, such as the future implications of global knowledge, migration and aging were also among the criteria of selection for funding.

The EU is awakening about a capacity of SMEs to create jobs and growth. Another theme in the same Work program was "Research for the benefit of SMEs". Both SMEs performing research and SMEs acquiring research are considered.

The new program, Horizon 2020, continues the previous objective [EUR 13] and goes beyond in preparing the building blocks for Europe after the crisis. The Societal Challenge section of this program includes the themes such as political challenges, the role of young generation in social changes, preservation of cultural heritage and new forms of innovation as the innovation in public sector, open government, business model innovation, and innovative scheme open innovation and science 2.0, to assist universities in order to become open innovation centers for their region in cooperation with companies, and to enable public administrations to drive innovation in and through the public sector. The last challenge may influence the regional development if only the universities succeed with connecting their research objectives and motivation with regional ones and express their interest in entrepreneurship and collaborative work with local companies and organizations. Smart Region may provide an enabling environment for such a synergy.

The Horizon 2020 program also contains sections regarding Excellence Science and Industrial Leadership. Excellence Science comprises Future and Emerging Technologies (FETs). FET actions are expected to radically initiate new lines of technology through unexplored collaborations between advanced multidisciplinary science and cutting-edge engineering. It is expected that it will help Europe in grasping leadership early on in those promising future technology areas which are able to renew the basis for future European competitiveness and growth.

The Industrial Leadership program aims at renewing industry through information technologies (ITs), nanotechnologies, advanced materials,

advanced manufacturing and processing, and biotechnology as well as space exploration for societal needs, among others.

3.2.2. *Unemployment paradoxes and quick fixes*

Growth, employment and exclusion are related to each other. In reality, many European companies collapse for because of inadequate policies, high taxes, lack of flexibility in the rules for hiring and the lack of orders from large companies and public organizations. Even the French government as well as the EU would rather choose Big Four than local, small and often networked companies having the required knowledge skills to elaborate various studies and reports. The relocation out of production in search for cheaper workforce is still on and mobility for work is strengthening. The relocation to Europe creates jobs in various services for expats.

According to Confrontation Europe [CEU 14], there are 26 million unemployed people in Europe. However, the firms in charge of the unemployment survey are playing with numbers – persons on training are removed from the list of jobseekers.

The classic solutions to face this problem as summits and debates, "*Pole emploi*[1]", or "*maisons d'emploi*" (house for employment), are of high cost and remain ineffective. Their information systems are not programmed for effective and relevant matching of offer and demand. They need to be revisited, modernized and managed by the motivated staff, paid based on the result.

The Europatriates initiative deals with young employment in Europe [HAR 12]. "The unemployed young people are given opportunities for personal and professional development in a partner country. A 2–3 year apprenticeship, direct placement in one of the partner companies or coaching to establish a company of their own in their respective home countries to further create opportunities for employment in their country of origin". The Europatriates kick-start was on the first European Congress "Solutions for Youth Unemployment in Europe" which was held at the end of June 2014 in Saarbruecken, Germany. The best models to help tackle youth unemployment in Europe were supposed to be brought together. "The Congress and its accompanying fare will provide: concrete solutions against

1 National Agency for employment http://www.pole-emploi.fr.

youth unemployment in Europe" [EUR 14]. Once again, they focus on the training while there are a large number of various schools and training centers across the Europe. They are not managed at the European level. While such opportunities are mainly offered to 18–25 years old, the other age brackets are also concerned (25–40) – those in between the young and the seniors. There is no program offered to this population.

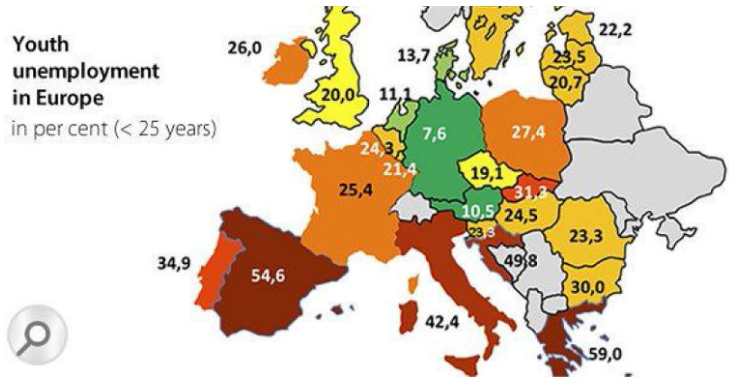

Figure 3.1. *Youth unemployment in Europe (source: http://www.europatriates.eu/index.php/en/)*

Jobs creation remains just a desire without providing the appropriate ecosystem and necessary conditions for the development of existing companies and creation of new companies. There is a need for systematic management of human capital by companies, cities, regions and countries, exploration of local talents and balance between health of companies, union's claims and educational program adapted to the current challenge.

As there are many unemployed not only in France, but also in other countries, we have to face exclusion, and find an antidote for ever-strengthening criminality to educate/influence better and respectful behaviors. Young people, mostly immigrants' children, confined in suburban ghettos, educated by television and local bands of thugs, want to have an "easy life" and become… dealers. The others, in the search of a life goal and impressionable, may become terrorists.

There are two main kinds of immigration: for better livelihood and for training. Many of the immigrants in search for training do not want to go back to their of country origin. Immigration produces social diversity in

terms of religion, respect, living conditions and impact on language and behaviors. The cultural capital and related knowledge is not considered, while it has potential to bring another perspective and enhance the local capacities and language skills. Globalization enhanced mobility that also contributes to the diversity which should be correctly managed.

3.2.2.1. *Technological progress and employment*

The appearance of the first industrial automats and robots in factories and production units has begun the polemical replacement of workers by machines. Initially, industrial automation was introduced for two reasons: to help humans and avoid them from working hard in difficult conditions, and to increase productivity. In the industrial era, they contributed to more products and economic growth. According to Brynjolfsson and McAfee [BRY 11], increases in jobs corresponds to increases in productivity, but technological progress are eliminating the need for many types of jobs. "The pattern is clear: as businesses generated more value from their workers, the country as a whole became richer, which fueled more economic activity and created even more jobs. Then, beginning in 2000, the lines diverge; productivity continues to rise robustly, but employment suddenly wilts. By 2011, a significant gap appears between the two lines, showing economic growth with no parallel increase in job creation. Brynjolfsson and McAfee call it the "great decoupling". Finally, Brynjolfsson says that he is confident that technology is behind both the healthy growth in productivity and the weak growth in jobs.

Do we still need to produce more? They seem to ignore that the industrial landscape has changed and we are no longer in industrial era. We need different skills and educational, and training system is not anticipating this change. Rotman [ROT 13] states that "economic theory and government policy will have to be rethought if technology is indeed destroying jobs faster than it is creating new ones".

Artificial intelligence (AI) is also pointed out for destroying jobs – robots are replacing humans [FOR 13]. According to Ford, "advances in AI and robotics will have significant implications for evolving economic systems". The majority of the workforce has to adapt to this to remain relevant. "Technology has often disrupted and even destroyed whole industries and employment sectors. In the United States, the mechanization of agriculture vaporized millions of jobs and led workers to eventually move from farms to

factories. Later, manufacturing automation and globalization caused the transition to a service economy. Workers repeatedly adapted by acquiring new skills and migrating to jobs in new industries". Are workers able to adapt?

According to Ford, computers and machines are increasingly taking on intellectual tasks and, in the long run, all high-end, low-end and part-time jobs will be impacted. "Machine learning, one of the primary techniques used in the development of IBM's Watson, is in essence a way to use statistical analysis of historical data to transform seemingly non-routine tasks into routine operations that can be computerized. As progress continues, it seems certain that more and more jobs and tasks will move from the 'non-routine' column to the 'routine' column, and, as a result, an ever-increasing share of work will become susceptible to automation". Big data will be used to give organizations a competitive advantage in terms of marketing and customer relationships; lawyers will be displaced by e-discovery software that can rapidly determine which electronic documents are relevant to court cases; sports and business writing have already been automated. Increased automation is taking hold in the fast food and beverage industry which is in reality a form of just-in-time manufacturing. Mobile applications offer in-store access to product information and customer service. Supermarkets are offering services of mobile phone payement. To avoid the long lines, shoppers can just scan barcodes of the items they are picking out and then check out by entering their pass code at a devoted machine. "Technology will continue to accelerate, and it is certain to be tightly integrated into any new industries that arise in the future. This fact should be considered both in the education of future IT specialists and economic planning". This reasoning leads to two essential challenges: finding ways for people to occupy their time and the income distribution.

Certainly, this vision could be applied for an IT professor. Such a professor could be replaced by a robot in the nearest future. The role of IT (including AI) is to teach the synergy between human, computers and other intelligent machines and how to combine the best of both capabilities to help humans in their activities and increase their well-being. From this perspective, the education of future IT specialists and economic planning is a short-term goal and only a part of the overall current system renewal.

3.2.3. *Challenge for France*

In the report "One principle and seven ambitions for France" [LAU 13], the commission headed by Anne Lauvergeon, the former CEO of AREVA, listed seven ambitions (and challenges) for France. They are as follows:

– the storage of renewable energies;

– recycling of materials: rare metals;

– exploration of sea resources: metals and desalinization of sea water;

– vegetable proteins for tomorrow food and plant chemistry (development of new materials);

– personalized medicine (genomics, proteomics, etc.);

– the silver economy, innovation for longevity;

– the valuation of big data.

These challenges "can be seen as seven critical pillars to initiate in France the process of long-term prosperity and employment". The aim of this report was to provide foundations for innovation policy up to 2025.

To implement the recommendations of this report, the French government launched the World Contest of Innovation in December 2013 with the aim to support young innovative companies in meeting these challenges [DGE 13]. Among 58 projects selected for funding, 15 are concerned with exploring big data, 13 others address the personalized medicine and 10 are concerned with energy storing. One participant plans matching public employment data with those from companies to create a decision support system dedicated to both recruiters and jobseekers. Another participant aims at improving the autonomy of the elderly through the connected objects. The third selected project ambitions in transforming the waste from food industries into chemical molecules designed to create new materials and products.

For instance, the seven ambitions are not covered in the first contest and we do not know how governmental agenda plans to involve companies in the missing topics. Is the contest enough to achieve all seven ambitions? We did not find any information about how the progress is measured.

The program for research, elaborated by the French National Research Agency [ANR 14], identified nine major societal challenges:

– efficient resource management and adaptation to climate change;

– clean, secure and efficient energy;

– industrial renewal;

– life, health and well-being;

– food security and demographic challenges;

– sustainable mobility and urban systems;

– information and communication society;

– innovative, inclusive and adaptive societies;

– freedom and security of Europe, its citizens and its residents.

These challenges should be addressed by applicants to various calls published on the website of the Agency. Some of the above challenges can also be found in the European program.

However, other important challenges are not considered in the Lauvergeon report nor in the Agency for Research programs. One of them is revitalization of regional ecosystems and inclusion of people who have lost their jobs. In a small town, a plant closure or bankruptcy has a strong negative impact on the related activities.

Desertification of regions situated far from big cities raises social and economic issues as well. Lack of businesses and convenience stores impacts the local budget for development of activities and services. Inhabitants are deprived of basic services, such as post offices bakeries, groceries and medical services considered to be unprofitable. Many are elderly and cannot get around for the nearest services. Yet the majority of these lost villages are beautiful and have the potential to be explored. Some positive examples of such an evaluation should be shared and copied. For example, the region of Clermont-Ferrand decided to attract the young entrepreneurs. The regional funds are allocated to ensure them the first year of salary and they are exempted from taxes for the first year. Small villages try to attract young medical doctors on the same basis to replace retired doctors.

The aging population, combined with the rise in chronic diseases (cancer, diabetes, Alzheimer's disease, etc.), also represents an important challenge for the society in the coming years. The quality and speed of diagnosis and the efficiency of health care must be improved, regional disparities and shortage of staff must be adressed, and the increasingly stringent regulatory framework complied, all within the tight budget allocated for healthcare spending. Maintaining the quality of life at home is the best solution for both the involved person and for the social security. Connected objects may help, but an opportunity for offering new, or bringing back old, services, such as a social link through a postman, should be considered using a holistic approach. Many elderly people are victims of scams of any kinds and should be protected. While statistics predict the longevity on a linear basis, pollution, stress and an increase in serious diseases may shorten the average lifetime in the near future.

IT supports many activities; as a result, the challenges are numerous. Those related to IT Energy efficiency of Data Centers, and Green IT in general, are emerging as some of the most critical environmental challenges to be faced. IT is supposed to have the biggest potential for job creation. The majority of users are not IT engineers, therefore, there is a strong need for ergonomic, intuitive and multimodal interface. The artificial intelligence techniques may provide an efficient help without however "switching-off" the users' brain. Applications should be user-friendly. There is a need for interface designers more than for programmers and for useful applications such as intelligent anti-spam and intelligent and accurate search from image or talent finding. Preservation of knowledge and experiences in Collective World based on knowledge models and knowledge navigation will be useful for more accurate and immediate finding. It raises another challenge for educational system: to extend teaching of intelligent systems.

One of the most difficult challenges remains the evolution of mentality and the way of thinking. The switch from poverty to abundance is easy, but the reverse is tough. Most of the humans perpetuate the same mental patterns for years. For example, politicians apply the industrial era thinking to today's innovation. The context of capitalism and socialism has changed and new concepts and rules are emerging, such as model of "free" or "commonism" coexisting with old "to have and to show" mentality. The China "world factory" ambition is to become the master of the world. How many years will it take to understand that this way is dead end? How many

investments, time and energy, are wasted just to keep people believing that politicians are motivated in creating a prosperous future? Disruptive economic models are just beginning to bloom – an alternative to more production and to "faster, cheaper" with less margin costs, stress and taking care about the well-being of citizens.

3.2.4. *Best practices in matching offer and demand*

The Innocentive website[2] publishes challenges proposed by various organizations with the aim to find solvers, while Pact PME organizes physical meetings only. Both are effective, but they do not have the same impact on finding.

Innocentive crowdsources innovative solutions from the world's smartest people with the aim to provide ideas and solutions to important businesses and address social, political, scientific and technical challenges. Their global network of problem solvers and cloud-based innovation management platform help their clients in quick matching of offer and demand. Their knowledge base covers many fields. Some examples of demands are given below:

– NASA is seeking applications that utilize the Climate and Earth Science data recently made available on the Open NASA Earth Exchange (OpenNEX) platform on Amazon Web Services (AWS) in new and creative ways;

– Defense Advanced Research Projects Agency (DARPA) seeks methods to accurately forecast the spread of chikungunya virus in the Caribbean, and North, Central and South America;

– segmentation, the process of partitioning an image into different regions, is a key step in the analysis of medical images and is used to delineate areas that correspond to different tissue types, organs and pathologies. Segmentation is typically done by a physician examining each image and drawing the contours by hand. For example, the seeker can design an image processing algorithm to automatically/semi-automatically perform segmentation on stacks of images of the esophagus.

2 https://www.innocentive.com/ar/challenge.

Such an initiative will be copied at national and European levels.

The challenges addressed both by national programs and Horizon 2020 correspondent partially to real needs in overcoming the economic, social, environmental and cultural crisis.

How do politicians at different levels address these challenges? At the national level, they speak about reforms, but each new president resets the previous reforms and introduces new reforms that are impossible to realize within the short-term (5 years) they have. The strong legal constraints at the regional level prevent citizens bringing in their opinion on the real needs and on current policies. They are barely involved in regional innovation and not at all in country innovation. While many cities and regions are excited about being smart or innovative, as in most companies, the "clients" are not involved in the innovation process. How to reduce the distance between policies and on-field experimentations?

3.3. Innovation policy

Amidon [AMI 14] states about National Innovation strategies:

> Most nations – industrialized, developing and emerging – have developed some form of National Innovation Strategy (NIS), tracking indicators with available information. Many have elevated an Executive Secretariat/Ministry of Innovation reporting to the President or Prime Minister, coupled with Education, Economic Affairs an/or Community Development. Larger countries have State or regional approaches with sub-communities – "zones of innovation". Many countries have launched strategies across nations beyond the formal regional structures (e.g., EU, ASEAN, African Union *et al*.) and beyond the known international trade missions. New performance measures are under development in societal organizations (e.g., the UN, World Bank, and OECD) as well as most technology firms and consultancies.
>
> Competitive innovation reports abound for geographic, regional and even cross-border virtual communities (e.g. Sister Cities, Transdisciplinary Innovation Consortium, Investing Across Borders).

> Major rethinking University IP policies – including Chief Academic Innovation Officers – with a focus on building the "flow of knowledge" across stakeholders. New field of Knowledge/Innovation Economics has emerged – learning to measure the intangible value.

The recent OECD publication [OEC 14a] reviews the key trends in science, technology and innovation policies, and performance in more than 45 economies, including OECD countries and major emerging economies. Eighty pages of this report (see Appendix 2.A in the report) present comparative tables of national STI strategies or plans, OECD countries and some major non-OECD economies. This policy analysis and measurement use a "data approach" and are based on statistic methods, and not on real knowledge about the current situation. Like most of publications, it is published for sale; however, reading online and sharing is allowed.

Another OECD publication [OEC 14b][3] presents assessments of the innovation system of OECD member and partner countries, focusing on the role of government. They give some recommendations on how to improve policies that impact innovation performance. Each review contains some exemplary practices from which other countries can learn. The contributors of [DUT 14] find that the current innovation and industrial policies characterized by top-down government interventions are not the right approach for development. "The reasons for the failures of such a policy are well known and include the risks of capture by vested interests, lack of information on the economy and strong asymmetry with private actors, and the lack of capability in the public sector for effective policy making". The authors point out the need for more open innovation policy with the room for experimentation that helps to improve the innovation policy. This experimentation should follow a method including diagnostic, experimentation, monitoring, evaluating, learning and improving. Such an approach rests on close cooperation with private and non-governmental actors which have better knowledge about the innovation barriers and who know the areas for productive investment. This way may allow the policy makers to learn from the experience and the mistakes that are made; it encourages more entrepreneurial experimentation and risk-taking by all involved, including policy makers. The knowledge about complex systems and their behaviors will be improved and will serve to achieve more

3 www.oecd.org/innovation/reviews.

sustainable growth and shared prosperity. The authors point out the role of platforms and networks in learning, experience sharing, integrating feedback for improvement and improving the innovation policy (knowledge flow). A portfolio of experiments illustrates the theoretical evidences. However, the described examples concern only new technologies, while the other fields are also playgrounds for successful innovation. The emphasis is made on involving the venture capital (VC) industry at the early stage of start-ups lifecycle. The main innovation here is considering VC as an initiator of search network for identifying and combining finance, technical expertise, marketing know-how, business models, standard-setting capacity and others. The above elements describe an innovation ecosystem [MER 11], but VC is considered as a starting point, an "opportunity finder" and business developer. Such an approach is applied for spreading the American technology in Europe; the reverse path needs to be tried.

The green innovation policy is discussed in Chapter 7 of [DUT 14] that explores the role that innovation can play in achieving a greener economy. It focuses on "well-designed performance measures" of existing policies, continuous feedback and learning for improvement. Global consortia may emerge from existing bilateral ones, for example, Canada–India. Briefly, the right measures should be proposed for evaluation and the progress must be monitored. These aspects were already pointed out in [AMI 97] which proposes metrics and associated methods for measuring the impact of innovation.

The described approach fits very well to the current situation, but it did not take into consideration the simple fact that the politicians are "never wrong".

Although there are a large number of reports available, the knowledge base of practices does not exist. Such a base could help to quickly find a case that applies into a given situation and could be enhanced, in real time, by registering new cases. Surprisingly, technology is considered as one of the most important vehicles for innovation and potential generator of values, but its power is a little used to manage the eco-innovation systems.

With a political emphasis on innovation as the only way to overcome the current situation, many are considering technological innovation only. They are convinced that technology has a great potential to create jobs and the wealth will depend on our ability to innovate. How can we estimate this

ability and measure the influence on sustainable success of innovation? Nothing is measured. The small US-based company Innovation Ecology[4] headed by Robin Gaster says to be focused on measuring, evaluating and assessing innovation and developing policy for companies, non-profits, regions and national governments. His regional innovation index, as summarized in their Regional Innovation Index as summarized in Figure 3.2, which represents comparisons between Maryland and six other states across 230 indicators in 13 categories. It will be interesting to know how this index influences the US innovation policy, what are the results in terms of economic growth and how the whole process is monitored.

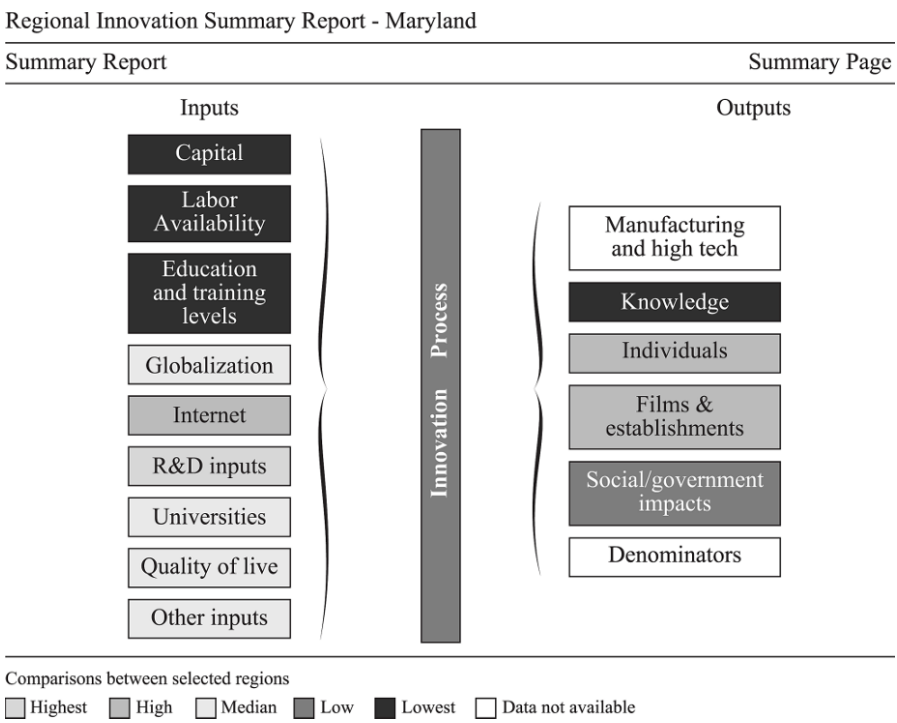

Figure 3.2. *Comparison between Maryland and other six states (Innovation Ecologies)*

4 http://www.innovationecologies.com/innovation_ecology.htm.

The EPISIS Task Force 6 [KUU 12] studied *service innovation policy* developments in 15 countries, including 11 Member States of the EU: Austria, Denmark, Finland, France, Germany, Ireland, Netherlands, Poland, Slovenia, Sweden and the UK. In addition, service innovation policy surveys were conducted in China, Korea, Norway and the United States. Curiously, the Appendix on French Policy was elaborated by the UK consultant who gathered available information on the web without checking the real situation in service innovation policy. The consortium identified the following service innovation policy approaches:

– policies supporting service innovation in specific industry or in a sectoral context (Norway, Netherlands, UK, USA and the EU Commission). For instance, knowledge-based services and creative industries are frequently targeted by service innovation policy, while the retail sector is not targeted by service innovation policy in any of the surveyed countries;

– service innovation support in technology context (Germany, Korea and USA);

– neutral and horizontal innovation policies are targeting businesses across the sectors without a defined focus on any technology or service development (Norway);

– thematic policies, such as grand challenges approach (EU);

– demand- and user-driven innovation policy approach was indicated by majority of surveyed countries as a new emerging approach to service innovation support.

Figure 3.3 presents the identified fields concerned with service innovation.

The services related to smart cities and other public services are not mentioned. The authors state that “at present the value of service innovation across the industries is not fully recognized. It is important to further develop statistics and measures to be able to highlight the real value of service innovation”. Perhaps instead of benchmarking policies, the EU should invest in Task Force on measurement of results and impact. How can we evaluate the service innovation and make it “fashionable”?

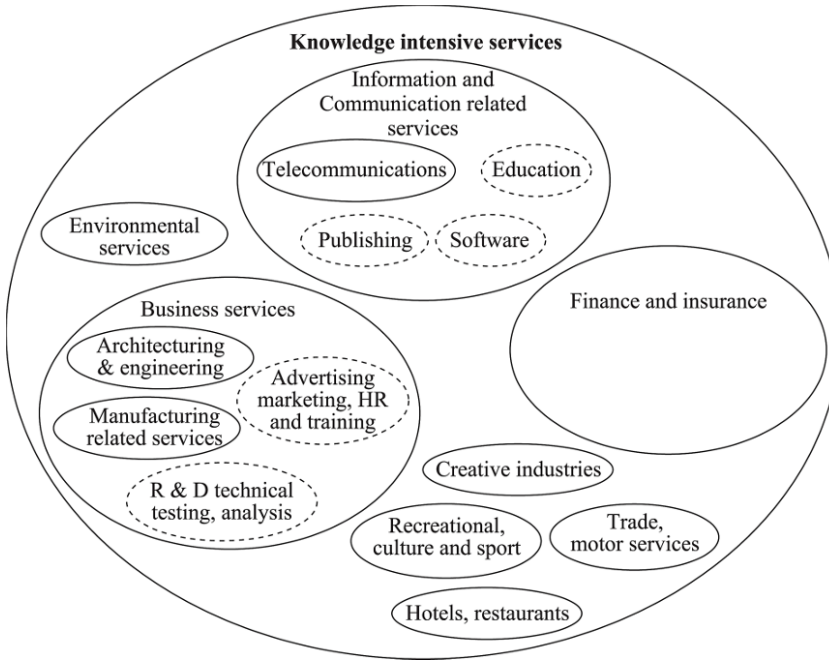

Figure 3.3. *Key services identified on the basis of their innovation activity [KUU 12]*

3.3.1. *Innovation policies in Europe*

Innovation is at the heart of European, national, regional and metropolitan politics. It has a very tough task – impulse growth and jobs creation, trigger the renewal of the industry, planet protection and solve various social problems, including European identity. The afore-mentioned OECD report [OEC 14] presents a global overview and an analysis country-by-country, but the analysis of Europe as a whole, using knowledge approach, is missing (in our knowledge).

Since the Lisbon Treaty, a huge amount of reports have been published, presenting innovation from different angles, but there are no significant changes in policy. Each state is responsible for the adaptation of main lines and results. The Maastricht ranking continues to publish the results by nation, creating competition between countries instead of considering Europe as a whole. Politicians are not connected with the reality; they are not entrepreneurs. If they were to make money as an entrepreneur using their skills, without involving their contacts, it would be a real disaster.

A large amount of documents on innovation policy are available on the website of the EU; it is not easy to find an overall view. The innovation policy for industrial innovation [EC 14] groups several items, such as social innovation, regional innovation, public sector innovation and others. The objective is "to develop policy initiatives aiming at the modernization of the EU industrial base through accelerating the uptake of innovation. An industrial modernisation in Europe requires the successful commercialization of product and service innovations, the industrial exploitation of innovative manufacturing technologies and processes as well as innovative business models". The EU's Industrial Policy focuses on:

– the *monitoring of innovation performance and of the uptake of innovation* in order to identify developments that require a policy intervention;

– the development of policies to *foster the broad commercialization of innovation* by EU industry (e.g. public procurement of innovation or design);

– the development and coordination of policies to *accelerate the uptake of advanced manufacturing technologies* and other cross-cutting innovations with a view to modernizing the EU's industrial base.

What is the innovation performance and how it is monitored?

The policy states that: innovation policies are about value creation and require fresh thinking. We follow closely the latest trends in businesses and remain attentive to challenges faced by innovators". This feedback is collected and integrated into new programs. This document does not mention whether the feedback from funded projects consortia and others is also collected or not.

The Innovation Union is one of the seven flagship initiatives of the Europe 2020 strategy for smart, sustainable and inclusive growth (see Figure 3.4). Spreading the policy lessons within the Commission and to Member States and regions is a core dimension of our work. We also coordinate the implementation of the Innovation Union actions under the responsibility of General Directory for Enterprise & Industry. The aim of Innovation Union is to speed up and improve the way of conceiving, developing, producing and accessing new products, industrial processes and services which they consider vital for creating more jobs, building a greener

society, improving the quality of life and maintaining European competitiveness in the global market.

Figure 3.4. *Seven flagship initiatives of the European Strategy*

The three pilars of European Horizon 2020 program are: Smart, Sustainable and Inclusive Growth. The challenge of the Growth is considered as the most important. These pillars and their characteristics are presented in Table 3.1.

Smart growth	Sustainable growth	Inclusive growth
Innovation: "Innovation Union"	Climate, energy and mobility: "Resource efficient Europe"	Employment and skills: "An agenda for new skills and jobs"
Education: "Youth on the move"	Competitiveness: "An industrial policy for the globalization era"	Fighting poverty: "European platform against poverty"
Digital society: a digital agenda for Europe		

Table 3.1. *The three pillars of Europe 2020 Strategy*

The Innovation Union and Digital Agenda play the most important role in regaining a leadership position of Europe.

Inclusive growth aims at raising Europe's employment rate for women, young people and older workers and in helping people of all ages anticipate and manage change through investment in skills and training. A platform

against poverty will support and help people to integrate in the communities where they live, get training and help to find a job and have an access to social benefits.

3.3.1.1. *Innovation Union*

Innovation Union integrates the European, national and regional innovation instruments into its approach in a new way, also highlighting the transformation from linear to open innovation systems.

The Innovation Union action plan contains over 30 points aiming to:

– make Europe into a world-class science performer;

– remove obstacles to innovation, such as expensive patenting, market fragmentation, slow standard-setting and skills shortages, which currently prevent ideas from getting to market quickly;

– revolutionize the way public and private sectors work together, notably through Innovation Partnerships between the European institutions, national and regional authorities and business.

These three points represent very ambitious tasks – regain the leadership position in science, remove obstacles to innovation and make the various stakeholders work together. We do not know what actions make it possible to remove obstacles from innovation. The listed obstacles demonstrate the lack of knowledge about the current situation on the job market. For example, rather than the shortage of skills, we can notice a lot of highly skilled people looking for a job. Visionary and modern marketing specialists and smart commercial are needed. Working together is a nice theory; various experiences from knowledge management may help.

3.3.1.2. *Implementing the strategy*

Implementing this strategy is complex. [EC 14] contains many hypertext links that make it difficult to follow: “the Innovation Union Information and Intelligence system (I3S) has more detailed information on the implementation of these action points. After each point in the detailed list, you will find a link to the corresponding section of I3S. To print the complete list, simply use your browser’s print function. You can also view the whole list on this page”.

The following actions are listed:

– promoting excellence in education and skills development. This action focuses on higher education and research, research evaluation criteria, university ranking, knowledge alliances and e-skills;

– delivering the European Research Area (ERA) (focuses on infrastructures and mobility);

– focusing EU funding instruments on Innovation Union priorities;

– promoting the European Institute of Innovation and Technology (EIT) as a model of innovation governance in Europe;

– enhancing access to finance for innovative companies, put in place financial instruments to attract a major increase in private finance, investment in knowledge transfer and start-ups;.

– creating a single innovation market. Standardization, public procurement and eco-innovation action plan;

– promoting openness and capitalizing on Europe's creative potential, creative industries – European design leadership board, open access to research results;

– spreading the benefits of innovation across the Union, helping people to acquire the necessary skills, improving the performance of national systems and implementing smart specialization strategies and trans-national projects, maximizing social and territorial cohesion;

– increasing social benefits (focus on social and sector innovation);

– pooling forces to achieve breakthroughs: European Innovation Partnerships – partnerships promoting active and healthy aging;

– leveraging our policies externally to attract international talents;

– reforming research and innovation systems;

– measuring progress.

> The Commission proposes to launch the necessary work for the development of a new indicator measuring the share of fast-growing innovative companies in the economy. This will require the full cooperation of Member States and international partners. Subject to these commitments, the Commission will submit the necessary proposals and take urgent action to

> develop this indicator within the next two years, working with the OECD, as appropriate, so that it can become, over time, a new headline indicator allowing as part of the EU 2020 strategy to benchmark the EU's performance against its main trading partners.
>
> Starting immediately, the Commission will monitor overall progress on innovation performance using the Research and Innovation Union scoreboard [EC 14].

While participation is encouraged, it is impossible to find how to participate, since the provided link is empty.

The above list raises many questions: what does excellence mean and what are the criteria? Do we know what we have and what skills are needed for the future? Why only one more institute (EIT)? What are the financial instruments to attract a major increase in private finance? Who is in charge of finding private finance (a very hard task)? Who has to invest in knowledge transfer? What knowledge? Creating a single innovation market is extremely difficult. How will it be done and when? How can we control the institutions giving a contract to "friends" instead to an innovative SME? How is it possible to capitalize on something we do not know? How can we reform the research system without strikes? Measuring progress is still only a goal and the right indicators need to be invented.

I3S[5] provides an agenda of events, but the 6th European Innovation Summit[6] is not mentioned. NOTE.– there is no country balance in K4I political members.

In the meantime, the new indicators elaborated for Maastricht ranking are still in use [MAA 09]. They are not adapted to evaluate the progress in facing the main challenges, such as job creation, employment and economic growth. Such a ranking encourages competition between the European countries instead of challenging them to act as a whole.

3.3.1.3. *Digital Agenda*

Digital Agenda aims "to reboot Europe's economy and help Europe's citizens and businesses to get the most out of digital technologies". Including

5 http://i3s.ec.europa.eu/commitment/39.html.
6 http://www.knowledge4innovation.eu/.

the Internet, these technologies should deliver sustainable economic growth. To accomplish this ambitious challenge, 101 actions grouped around seven key areas were elaborated. These include:

1) creating a new and stable broadband regulatory environment. Providing fast and ultrafast Internet to match world leaders such as South Korea and Japan, Europe needs download rates of 30 Mbps for all of its citizens and at least 50% of European households subscribing to the Internet connections above 100 Mbps by 2020;

2) providing new public digital service infrastructures through Connecting Europe Facility financial instruments;

3) launching Grand Coalition on Digital Skills and Jobs (in IT) in the face of a critical shortfall of talented ICT experts. This contradictory picture reveals a mismatch between the skills on offer and those in demand in today's fast developing technology market. As a result, Europe might face a shortage of up to 900,000 ICT professionals by 2020. The EU vision of IT skills for the future is shown in Figure 3.5.

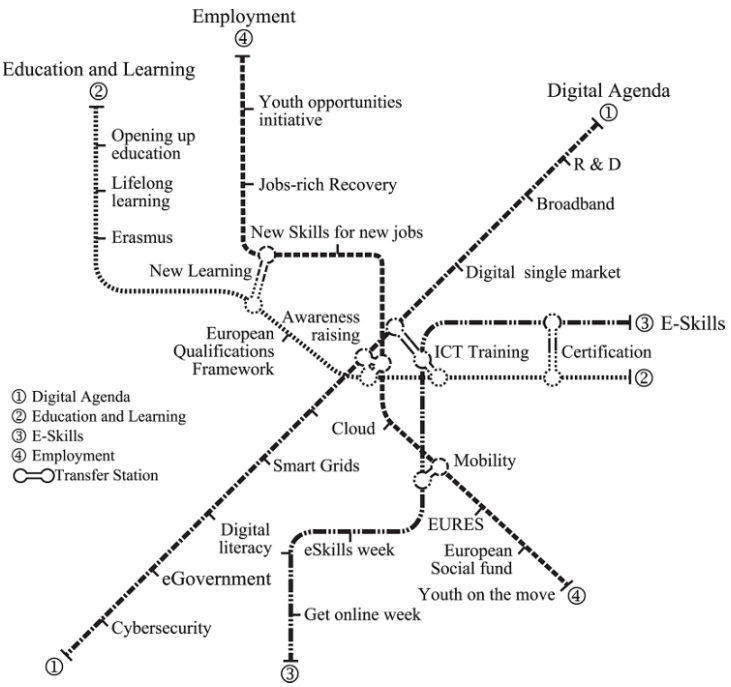

Figure 3.5. *Skills required for an ICT*

4) proposing EU cyber-security strategy and Directive;

5) updating EU's Copyright Framework;

6) accelerating cloud computing through public sector buying power;

7) launching new electronics industrial strategy – an "Airbus of Chips". A strategy for growth of the micro- and nanoelectronics components and systems industry in Europe.

In parallel with the US Global Environment for Network Innovations and Japanese project AKARI, Future Internet Research and Experimentation Development research programs have been funded by the EU to foster research on the future developments of the Internet architecture, technology and services. It is also considered vital to the continued economic growth in Europe [BLE 08].

The EU aims at fostering favorable conditions through coordinated action including joint development of related skills. The other tasks include:

– services and networking architecture;

– location independent, interoperable, coherent, consistent, scalable, pervasive, reliable, secure and efficient access to a coordinated set of services;

– tools supporting collaborative business models and social network applications;

– technologies ensuring the robustness and security of the networks, managing identities, protecting privacy and creating trust in the online world;

– approaches and tools to leverage the full potential of the Internet of Things;

– skills for supporting the creation, sharing, locating and delivery of new-media content.

The Future Internet Initiatives and activities are grouped in the EC portal http://www.future-internet.eu.

3.3.1.4. *European Open Innovation Strategy and Policy Group*

The European Open Innovation Strategy and Policy Group (OISPG) activity is aligned with the Innovation Union strategy. This group is very active, attracting researchers and enterprises of all sizes around various experimentations. Their *Yearbook 2013* [PUB 13] presents the policy from an open innovation perspective and highlights some of the new thinking to support the objectives of Europe 2020 and those of Innovation Union for European competitiveness, jobs and growth: "the focus is on a holistic view for innovation which integrates the various European Commission instruments and the national and regional actions, and reinforces the whole process on modern innovation. A strong systematic innovation approach is suggested to ensure the full impact of the merge and integration of societal and technological innovations".

Successful innovation combines several disciplines, all stakeholders and societal and technological drivers. While the linear innovation model may still be valid for some industries… but the more we shift to knowledge society-related innovation, the clearer we see the parallelism of the different innovation elements. They both increase the speed of innovation as well as the success rate of the deployment. Bror Salmelin, the leader of OISPG, refers to the bridge analogy, shown in Figure 3.6. Each component of this bridge plays its specific role in the process, leading to strong cross-fertilization of ideas, technologies and societal drivers. All the stakeholders (industry, research, public sector and the user community) need to be involved, and crowdfunding may accelerate the process. This open system of user-centric and sharing-based innovation approach requires new types of IPR to foster sharing and value creation. Such a bridge links knowledge to market, but this dynamics does not ensure the sustainable growth of start-ups to large companies.

In the original version of the bridge crossing the valley of death, the objective is to grow from a small company to a big one. The White House's *Startup America*[7] initiatives' bridge is composed of four elements: access to capital, removing regulatory barriers, mentoring by business experts and lowering taxes. Access to market is important but not sufficient for sustainable success of innovation.

7 http://www.fastcompany.com/1740238/tell-white-house-how-power-startups.

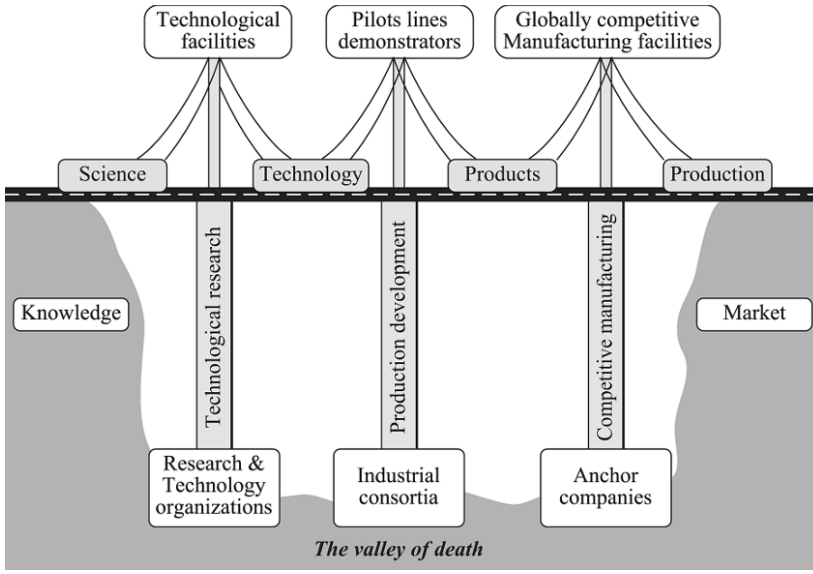

Figure 3.6. *The bridge analogy [PUB 13]*

The Horizon 2020 program structure supports demand orientation that links interdisciplinary thinking to problem-solving. In previous programs (6FP and 7FP), pilots were driven by public sector organizations in eHealth, eGovernment and eProcurement. In H2020, piloting is extended beyond the downstreaming to prototyping, testing and demonstrations in real-world settings: "pre-commercial procurement and public procurement of innovation will be reshaped and extended to provide the necessary bridge from prototypes and experiments to scale-up. Public sector procurers have tremendous purchasing power, meaning that their impact on take-up of modern solutions can be of crucial importance".

To provide support for disruptive innovation, a cross-sectorial approach is proposed. It leads to high rewards and high impacts. "The risk level of this initiative is rather high, but by dividing the process into phases, the risk is managed". One of the targets of this scheme is to create new markets through the disruptive approach. According to this *Yearbook*, the conditions for sustainable innovation are:

– it is full of disruptions;

– it is about (value) choices;

– it is beyond (political) buzzwords;

– it is holistic.

This method was elaborated to be included in the new Horizon 2020 program. The first call shows that it is moderately included. Evaluating experts were expected, but, for instance, the European Commission practices incremental innovation and the disruptive one is not yet understood by the current evaluation experts.

> The science-driven innovation part of the programme supports the growth of new science and technology-based results to be harvested in the other parts of the programme. One of the targets of this scheme is to create new markets through the disruptive approach, which very often also involves the strong presence of the problem owner (clientele, citizens) in the project execution. At its best, it enables co-creativity in innovative solutions [SAL 13].

The novelty is that the European Commission recognizes that "SMEs are often very dynamic and knowledgeable players in business ecosystems and bring agility and focused solutions to specific problems". A specific program for SME is now proposed.

The recent *2014 Open Innovation Yearbook* [PUB 14] is devoted to Innovation 2.0. What is new compared to 2013 edition? "Open Innovation 2.0 (OI2) is a new paradigm based on principles of integrated collaboration, co-created shared value, cultivated innovation ecosystems, unleashed exponential technologies, and extraordinarily rapid adoption. We believe that innovation can be a discipline practiced by many, rather than an art mastered by few". The parallel innovation processes are replaced by innovation ecosystems. They progress with understanding of the whole process, but the implementation should follow.

> Only with this focus will it be possible to tear down the walls that form separate silos of civil, academic, business, and government innovation. Silos will be replaced with creative commons, shared societal capital, and the systematic harvesting of experimental results. Information technology will play a special role because IT can supply the necessary connectivity and enable social networking among innovators and the communities they serve [OPE 14].

This statement does not take into account the necessary conditions to influence such collaborations, as changing the existing research system and finding the other motivations and common goals for researchers. While a "common language" is vital for succeeding the multidisciplinary projects, it is an extremely difficult task because various populations are used to use a field-limited vocabulary and references. Few are able listening to the others and trying to understand the added value of each. Such projects require more time for convergence in the first stage.

Later, in the academic perspective, this *Yearbook* presents the same classic references, while we have also wise people in Europe; they are not all in academia or other public institutions and are not considered as "world-class speakers".

> For OISPG, the OI2 paradigm is an innovation model based on extensive networking and co-creative collaboration between all actors in society, spanning organizational boundaries well beyond normal licensing and collaboration schemes.
>
> A second core characteristic of the OI2 paradigm is the use of the quadruple helix model where government, industry, academia and civil participants work together to co-create the future and drive structural changes far beyond the scope of what any one organization or person could do alone. This quadruple helix innovation approach is most successful when there is a shared vision and a shared value is created. User-driven innovation is a crucial part of the OI2 paradigm and is also a key lever for adoption because users co-create solutions that meet their needs [OPE 14].

This model allows us to take advantage of ideas' cross-fertilization leading to experimentation and prototyping in real-world setting.

The principles of integrated collaboration, co-created shared value, cultivated innovation ecosystems, unleashed exponential technologies and extraordinarily rapid adoption are the good wishes and they require mental efforts to work. They believe that innovation can be practiced by many.

There is still much left that needs to be done to establish the appropriate innovation ecosystems in Europe. This is why policy makers must make serious efforts to understand what people are prototyping and strengthen the framework supporting the innovation approaches.

According to *Yearbook 2014*, the new Open Innovation process is composed of five elements:

– networking;

– collaboration: involving partners, competitors, universities and users;

– corporate entrepreneurship: enhancing corporate venturing, start-ups and spin-offs;

– proactive intellectual property management: creating new markets for technology;

– research and development (R&D): achieving competitive advantages in the market.

Twenty innovation drivers are presented in Figure 3.7.

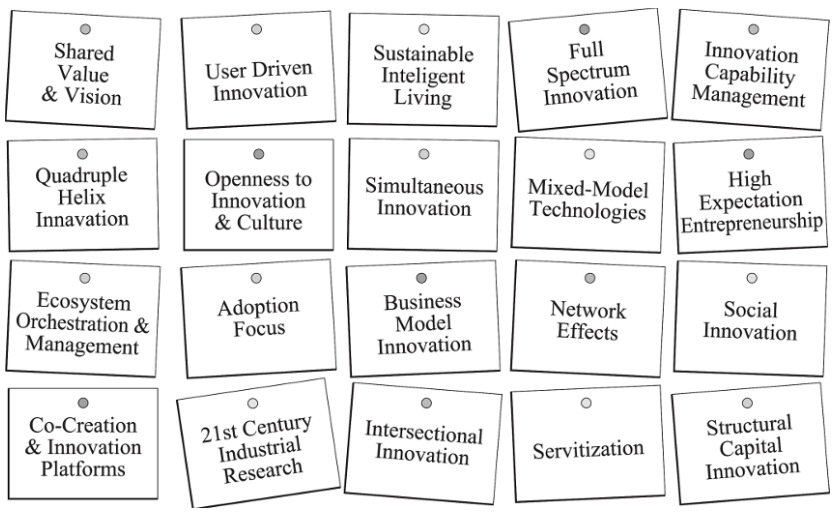

Figure 3.7. *Twenty drivers of Innovation 2.0 [OPE 14]*

A "flat" presentation of these drivers requires a decoding system for the persons who had not participated in their elaboration. The color code groups

some drivers but no explanation is provided. The source document on 20 drivers just describes them one-by-one [CUR 13].

Among the good wishes: Quadruple Helix innovation where the private, public and research institutions collaborate seamlessly for cross-disciplinary innovation. In reality, such collaboration and cross-disciplinary innovation should face more barriers and require more efforts than traditional innovation. In the 20 drivers, the environment, as well as the evaluation of the innovation impact, is missing. We observe the lack of indicators and measures to achieve the goals.

In the conclusion section of the *Yearbook 2014*, we can read "using the collective and collaborative potential of people in Europe and beyond, we can create a brighter more sustainable future". Yes, we can, but it requires considerable efforts of all at all levels and real collaboration of the EU, governments of member countries, evolution of education and research system, involvement of citizens and clients, and ability to mobilize the collaborative potential and intelligence. The connection between politics and on-field experiments still needs to be activated. Many excellent ideas are lost in the bureaucracy of the "system". The H2020 made progress but they need a better understanding of real barriers and must push forward from the final project report. Considering Europe as a whole and not as separate countries may impulse the progress and bring a contribution to prosperous future.

Both *Yearbooks* (2013 and 2014) describe some experimentations to illustrate how these principles can be implemented in real life. The most promising principles are presented in Chapter 4.

3.3.2. *French innovation policy*

In France, there are many initiatives, such as Ministry contest for innovative enterprise creation by researchers that was initiated in 1999, Retis[8] network, Technopoles and others. Seventy-two *Pôles de Compétitivité* (clusters) were founded for more synergy between research centers, large companies and SMSs of a given region [MER 11]. All these actions claim the synergy between actors, but in reality we can observe the dispersions of energy and means. The previous government (2007–2012) introduced the autonomy of public universities and launched the reforms "innovation for

8 http://www.retis-innovation.fr.

industry, agriculture and jobs". In addition to Competitivity Clusters, research tax credit *Crédit Impôt Recherche* (CIR), to support the R&D effort of businesses, has tripled. With the aim of creating jobs for tomorrow, the Plan of Future Investments of €35 billion was launched in 2010 and centered on higher education, research and industries of tomorrow. It has allocated €16 billion for education and research and €19 billion for the industries of tomorrow, including the support of SMEs, technologies for sustainable development and digital economy.

To boost the creation of companies by researchers, universities with research departments each have a special service devoted to technology transfer, instead of grouping them at the city or regional level.

In 2012, on demand of new government, Anne Lauvergeon, the former president of AREVA, led a group of experts studying the main ambitions for France to stimulate innovation in companies and ensure prosperity and employment in the long run. One innovation principle and seven ambitions, mentioned previously (section 3.2.3), were described in the final report [LAU 12]. The seven ambitions are: energy storage, recycling of rare metals, exploration of sea resources, vegetable proteins and plant chemistry, personalized medicine, silver economy and longevity and valorization of Big Data.

The authors of this report state that:

> To be successful, France has to influence the cultural ecosystems and organizations which currently do not encourage innovation. Tax, regulatory, gloomy conditions or cautiousness are among main barriers that we have to remove. Main motivations are economic potential of emerging markets, extending the duration of life, increasing urbanization, access to water, energy and raw materials, increasing effects of climate change. The progress is combined with the utility, simplicity and right use. The need for security of people, goods or information is growing as those for health and well-being at any age. Innovation must address these challenges. Each Ambition has a potential to create jobs and revenue in 2025 [LAU 12].

The storage of renewable energy is a global deal [TOK 15], but the education of an intelligent use of energy as well as the eco-design of powered objects may reduce the consumption and then the needs for energy and recycling. Combining the traditional and locally available renewable

energies is a new profession that should be recognized, taught and evaluated. Recycling may create jobs; however, a systematic optimization of total recycling cost, income and impact should be considered.

Exploration of sea resources has certainly had an impact on biodiversity and water ecosystems. The ocean is one of the Earth's most valuable natural resources. It provides food in the form of fish and shellfish. It is used for travel and shipping. It is mined for minerals such as salt, sand, gravel, and some manganese, copper, nickel, iron and cobalt and drilled for crude oil [MAR 14]. What is the total impact of these activities? The ocean plays a critical role in removing carbon from the atmosphere and providing oxygen. It regulates the Earth's climate. The ocean is an increasingly important source of biomedical organisms with enormous potential for fighting disease. Exploring these in greater detail is helping us to understand why we must keep the ocean healthy for future generations. But who manages it at the global level?

As in many others, this report sees the "silver brains" as clients only, not as valuable resource (knowledge and experience) to explore. It states that France (as well as Europe, according to politics) has to attract the best talents, but it does not suggest identifying and managing the available skills and making plans for education of future talents that we will need in the nearest future.

Suggested tactics include innovation contests, public procurement, stake, normalization actions, simplification of specific regulatory, related training and experimentation. Lauvergeon [LAU 13] recommends organizing discussions bringing together entrepreneurs, representatives of civil society, scientists, social partners, elected officials and administrations with the aim to elaborate together laws, regulations and administrations with the aim to elaborate together laws, regulations and administrative measures necessary to deploy the seven ambitions.

This report focuses on the economic potential of innovation only. The interaction between these ambitions is not considered. The Commission assumes that the current development and transportation of goods and people will continue and increase, following the unchanged principles of global economy.

The change of mentalities and the creation of a political ecosystem enabling innovation and sustainable entrepreneurship remain the greatest

challenge. It is much more difficult than the achievement of the seven ambitions separately. The contest is an easy way to show the short-term results.

3.3.2.1. *Research and innovation*

Created in February 2005, the French National Research Agency (ANR) provides funding for project-based research in all fields of science – for both basic and applied research – to public research organizations and universities, as well as to private companies. Employing a method based on competitive peer reviews, ANR attaches great importance to providing the scientific community with instruments and conditions that promote creativity and openness, and stimulate new ideas and partnerships, particularly between the public and private sectors. Its activity also contributes to enhancing the competitiveness and the influence of French research in Europe and across the world. Since 2010, ANR has also been the principal operator of the Investments for the Future program in the field of higher education and research. In this role, it ensures the selection, funding and monitoring of projects related to the centers of excellence, health, biotechnologies, and the transfer of technology and the creation of value from research.

The ANR Work Program comprises four interlinked components, each with a specific budget and governance:

– major societal challenges;

– at the frontiers of research;

– building the ERA and France's international attractiveness;

– economic impact of research and competitiveness.

They are aligned on European strategy – the "major societal challenges" component of the ANR Work Program takes up the nine challenges, mentioned before, identified in the "France Europe 2020" national strategic agenda, itself consistent with the structure of the "Horizon 2020" European framework program.

The French ANR supports the development of public–private partnerships that have a direct impact on the economy and competitiveness. The generic call for proposals was defined to support collaborative research

projects involving enterprises. In addition, the following specific programs were defined:

– *Industrial chairs:* for the purpose of establishing chairs at public research facilities, in partnership with enterprises, and financed jointly by the latter and the ANR;

– *Instituts Carnot:* the 34 Carnot Institutes are committed to promote the development of contractual research between public research institutions and private companies. They have their own governance and they receive financial aid from ANR as a function of the amount of revenues created by the partnership research contracts;

– *LabCom*: the objective of Labcom is to establish joint research between public research institutions and SMEs.

Moreover, the French ANR works with competitiveness clusters with the aim of making research outcomes more compatible with the activities of business enterprises. Hence, the ANR calls for proposals that can be supported by such clusters [ANR 13].

Programs dealing with environmental and energy transitions are managed in partnership with ADEME, the governmental agency for sustainable development. ADEME is a public industrial and commercial entity working under the joint supervision of the Ministry of Ecology, Sustainable Development and Energy and the Ministry of National Education, Higher Education and Research. The role of the ADEME is to provide businesses, local governments, public authorities and the general public with their expertise and advisory capabilities. It also helps to finance projects, from research to implementation in the following areas: waste management, soil conservation, energy efficiency and renewable energy, the quality of the air and the fight against noise. According to the public policy goals for energy, environment and energy transition, ADEME supports the innovation, development and research activity. They are in charge of the direction, programming and facilitation of research in their areas of expertise: energy and climate; consumption, materials and waste; development and environment (soil and air).

The OECD *Reviews of Innovation Policy: France* 2014 provides an OECD view of innovation policy in France [OEC 14b]. This review compares the performance of the French innovation systems with that of other countries and presents the conclusions of interviews with 30 key actors

in the French research and innovation system. The report recommends pursuing structural changes to improve financing, better evaluation of public research and closer coordination between industry and the public sector. Universities with powerful public research should be better involved in the process. Public sector research funds could also be spent more effectively. The review finds that heavy taxation of businesses and investments is holding back private-sector R&D spending. It suggests that easing overall corporate taxes and introducing more modest R&D tax credits would be a better way to drive innovation than the current system of overgenerous but unevenly distributed tax credits. According to OECD Secretary-General Angel Gurría, "France can do to better support private-sector innovation and improve how public funding is allocated. It is essential to implement the needed reforms of research and innovation policy to completion".

3.4. Matching policy and challenges

Increasing pollution and global warming are among the critical challenges we face. Despite various summits and other conferences, debates and studies, there is no visible improvement. Europe and other developed countries are declining in this respect. It is urgent to find realistic solutions for unemployment and exclusion.

All challenges mentioned in this chapter form a complex system and need to be addressed simultaneously, while the majority of players are used to act in their respective domains and face them separately. The European and national programs strive to encourage a synergy through multidisciplinary programs. Politicians try to solve these problems elaborating new laws, while the engineer's approach to problem-solving could give better results. Such a situation requires asking the right questions, collecting related knowledge and bringing together people who are able to elaborate satisfactory solutions for the challenges at hand. While local authorities often look for famous experts, they may ignore that they have local people who know the context and capable of dealing with a given challenge.

The EU has elaborated a vision and strategy for 2020. The plan for implementation includes organization and H2020 program, launched in 2014. However, nothing is done to track the progress.

Since the beginning of the European research programs such as Esprit 1 and Esprit 2, 6FP and 7FP, Eurostar and now Horizon 2020, an extraordinary amount of creativity and knowledge has been deployed; new approaches and techniques were invented, new tools were prototyped. These results still remain the "raw material" to be explored. This "Big Data" generated over the past 30 years is the innovation treasure of Europe, but should be empowered by an intelligent engine allowing the efficient finding of the relevant information and knowledge to facilitate transformation of results into innovative products and services and open to those who wish to improve these "diamonds" in the rough.

Politicians are dreaming about growth, but their strategy conceived using top-down method and industrial era thinking has not created the favorable conditions to accomplish this goal. The lack of continuity in the reforms due to the change of government is an important barrier to achieve the goals. Observatories and conferences in France debate why SMEs are not successful instead of understanding the real causes, launching concrete actions and collecting the feedback from them.

Strong political constraints, too many barriers produced by laws and precaution principle for research slow down the achievement of innovative projects. For example, persons in charge of smart city projects have difficulties to directly collect the ideas or needs for services from inhabitants. Many smart city projects including network, water and energy management are led by IBM and CISCO, leaving no room for innovative SMEs. They need more promotion to let them grow. Contrary to popular beliefs that large companies are sure, the small companies are agile and have a potential to create jobs if they are not killed by the lack of businesses, taxes and rigid legislation system. They just need to collaborate.

Initiated in Europe, probably by Piero Formica in 1999, Masters' of Entrepreneurship and schools are now booming, but only a few teach modern entrepreneurship. In Europe, the United States and other countries, efforts are made to encourage students and PhD scholars to start their companies. Almost every university in France has the transfer service. Evaluation of projects is made once a year to offer €5,000 to the best project. But who estimates these projects? Evaluators are often theoretical specialists who have never managed a company. The bridge between start-ups and markets letting them grow is still being built. Many promising start-ups offering really useful digital applications, for example global security, have

no access to high-level decision makers of large companies and thus collapse due to lack of orders.

Media, such as TV, has the power to influence new behaviors and spread the entrepreneurship spirit promote professionals such as football players, top models and other "stars". Recently, "*chefs de cuisine*" competitions have become a point of interest. Just one channel in France devotes 30 s daily for the presentation of a selected profession with the aim to inspire those who have to take a decision or change a professional life. The tremendous gap between the revenues of "stars", really useful professions and entrepreneurs influences the life choice of many young people.

Exploring better the collective and collaborative potential of people in Europe and other parts of the world, we can create a brighter sustainable future. This objective also requires education of attitudes, intelligence of mobilizing resources, smart eco-design and packaging, smart eating, smart living, smart buying and intelligence of mobility as well.

All kinds of innovations have potential to create jobs, and not only digital society, service and social innovation. Conditions for sustainable success include intuition, imagination, intelligence, audaciousness, flexible thinking and evaluation of impact.

Reverse approaches to development may give better results. After transforming fast food into slow food and maybe slowing down, we need to switch from megapoles to territorial development, from immigration to local development and from recycling to reusing. Do we really need to produce more or smarter? While immigrants are looking for better life conditions, why not to help them in developing their countries by funding jointly managed schools educating country and elite alike?

The EU website offers a "who is who" facility[9]. The search engine facilitates consulting in three ways: by person, by organizational entity (directorate or department) and by hierarchical order. This base content is limited to those who are with the EU. It will be nice to add to political leadership the EC practical leadership and a "who knows what in Europe" knowledge base. What they do not offer is an online service matching

9 http://europa.eu/whoiswho/public/index.cfm?lang=en.

problems to solve and existing solutions or projects results. Solutions for raised problems could be elaborated through new programs.

After promoting social innovation, more chance for service innovation is now given. This change should be followed by people evaluating projects, used to rate products.

Many private initiatives focus on greening, matching demand for jobs and offer, or try to help unemployed people to become entrepreneurs. Such initiatives and its results should be known to politicians with the aim to impulse the changes needed in policy making. This bidirectional communication is vital to successfully face the current challenges. Removing administrative barriers by involving citizens and clients will certainly improve the countries', as well as Europe's, conditions and leadership. To progress, Europe needs a clear vision elaborated with all stakeholders and measures tangible and intangible, the result of actions and their impact on a regular basis.

The next chapter (Chapter 4) describes some experiments in the world, in Europe and in France, with a common focus, i.e. the improvement of life conditions through innovation.

4

Experimentations and Results

4.1. Ubiquitous or sustainable innovation

Tremendous excitement and interest in innovation organizations can be seen around the world. Many events are devoted to pushing people, particularly students and researchers, to become entrepreneurs. Innovation contests are blooming. Regional authorities or private investors provide locations devoted to innovation, such as incubators and clusters, hoping to attract companies and influence economic growth. Traditional policy is applied and there is still a misunderstanding of the difference between innovation and research, and between the industrial era and the global knowledge economy. A huge amount of money is being spent on public and private initiatives. However, it is difficult to find information on the impact of all these actions in the face of the challenges and the progress made, probably due to the absence of measures and diversity of stakeholders and institutions involved.

A plethora of various projects, meetings and initiatives in Europe, led by the European Union (EU), be they arising from the European programs or not, should influence growth and job creation from innovation. Among them are the Open Innovation Strategy and Policy Group (OISPG) which offers frameworks for experimenting in many fields. It offers frameworks for experimenting in many fields. Initiated by Living Labs, and now connected through the Enoll network, their experimentations are extending into various fields and countries. Their experiments cover the various aspects of smart cities and the applications of information and communication technology (ICT) for lighting and water management, as well as the contribution of open data to the smartness of growing cities.

Numerous initiatives supported by the EU programs are described in *Research*eu Results Magazine*[1]. One of them is devoted to green innovation and covers the fields such as food security and sustainable agriculture, the ocean and the blue economy, keeping water clean and fresh, sustainable cities, biodiversity and ecosystems, sustainable energy, sustainable lifestyles, green skills, green and smart industries and prevention of natural disasters due to climatic change [RES 12]. The mentioned topics are considered on the global scale and involve non-member countries as well.

Technological innovation has a lead but social innovation and services are also developing. This trend is global – all continents are innovating. Nevertheless few of them consider the 5D impact.

The comprehension of all aspects of innovation ecosystems progresses. However the involvement of customers, evaluation of impact and of progress, on regular basis, is not yet general. If we want to succeed in facing the current challenges, the impact should be raised, taken into account and measured. It is easy to say "it is difficult" and do nothing rather than find and bring together intelligent people, able to envision a sustainable future, and to define metrics and appropriate actions. A lot of human energy and money is wasted on various initiatives aiming at leveraging innovation, but, in fact, it leverages the European, country, regional or city authorities and the organizations they support. Many claim to be running networks, while the majority of networking actions are too short and are not managing to bring significant results in the long run.

This chapter presents some selected initiatives from around the world at the European and national levels and points to a way of considering impact and measuring the success. The available results of private and public initiatives are also highlighted.

4.2. Selected actions around the world

The National Aeronautics and Space Administration (NASA) addresses a very ambitious new challenge – to build on their collective scientific foundation an international program of Earth System Science [NAS 14]. They consider that the Earth functions as a system, with properties and

1 http://cordis.europa.eu/research-eu/home_en.html.

behaviors that are characteristic of the system as a whole. These include critical thresholds, "switch" or "control" points, strong nonlinearities, teleconnections and unresolvable uncertainties. Understanding components of the Earth System is critically important, but it is insufficient on its own to understand the functioning of the Earth System as a whole. Humans are a significant force in the Earth System, altering key process rates and absorbing the impacts of their activity and global environmental changes. We expect that this ambitious program will help us to better understand these interactions with the aim of dealing with the most prioritized ones.

The Silicon Valley model is still an inspiration in so far as many organizations try to reproduce it in their respective countries without considering the local conditions and the all necessary ingredients for success. The innovation culture, entrepreneurial spirit, private and public partnership, business angels, trail and errors facilities are among these ingredients. The Silicon Valley Global Network[2] group was founded by Sheridan Tatsuno with the aim to share entrepreneurship experience all around the world. Companies in Silicon Valley are still based on competition and a few consider the impact on livings and the environment. They are pushing technology and only economic success is considered.

The Innovation Forum, jointly sponsored by the National Academy and Innovation Ecologies Inc., attempts to open a new conversation about policies that can address the need for a national innovation strategy – not one that can only be designed and implemented by the federal government, but one that aligns the various pieces of the innovation ecosystem, and provides coordinated support for all of them. The first part of this conversation focuses on ways to think about innovation. Historically, innovation has been conceptualized in varied ways, at the levels of firms with the focus on factors that allow innovating successfully, at the level of regions (Silicon Valley, Route 128), or at the level of nations' focus on competitiveness. Additional analysis can be found on "factors of production" approaches, grounded in classical economics. Some of this is bound to federal funding for research and development (R&D). Other aspects include immigration, training and education. The infrastructure of innovation considers the role of universities, incubators and other possible supports for innovation-related activities. Regulation, technology or sector approaches are also considered.

2 http://www.siliconvalleyglobalnetwork.com/.

Any strategy needs a process of constant reassessment. The most important question is: how can progress be measured? What tracking, metrics and measurement are needed?

The Regional Innovation Index[3] was developed. It contains 230 indicators in 13 categories and provides a tool for policymakers to benchmark regions.

The interest of this attempt to develop a National Innovation Strategy is in its overall approach, considering all the influential factors, however, whilst also considering their interactions is vital to the balance of the whole system. How can the results of this benchmarking be turned into collaborative innovation systems?

Innovation4jobs[4] founded through the Center for Innovation and Communication at Stanford University, has the ambition of disrupting unemployment. They try to find a solution for the intersectoral problem of unemployement. Their motivation is expressed in the following statement: "The current economic crisis has brought the interplay between innovation and jobs. Countries badly need innovation-driven productivity gains to grow out of debt, while it remains unclear whether such growth will also significantly reduce unemployment ... Persistent mismatches between employee skills and job requirements can seriously impede innovative activity". The United States alone spends ~$100 billion a year on unemployment benefits. The value of underused people is much bigger. All people can create value to each other, but how do we connect offer and demand? This statement points out main "truths", difficulties and challenges: innovation knows how to create products and services but not jobs; economy is task-centered instead of being people-centered; students must learn real-world problem-solving; we have to connect science *and* business. There is also the need for a common language facilitating communication between innovation and social/labor experts.

Among the topics for the next summit are: how do we accredit marketable skills, design and finance public services, and how does the Internet of Things increase personal heath and job creation?

3 http://www.innovationecologies.com/the-regional-innovation-index/.
4 http://iiij.org/i4j.

What is not clear is the result of these discussions and experience sharing on fighting unemployment.

Another Stanford initiative is the Triple Helix Association[5] which connects the same populations and focuses on academic conferences.

The OnStar service is a very good example of a collaborative innovation system. It is a result of collaboration between General Motors (GM), Electronic Data Systems (EDS) and Hughes Electronics Corporation. Each of the founding companies brought a specific area of expertise to the enterprise: GM brought vehicle design and integration and a distribution system, EDS brought much of the system development and information management and customer service technologies, while Hughes contributed communications and satellite technology and automotive electronics. Their offer relies on CDMA[6] mobile phone voice and data communication, primarily via Verizon Wireless in the United States and Bell Mobility in Canada, as well as location information using Global Positioning System (GPS) technology. Drivers and passengers can use its audio interface to contact OnStar representatives for emergency services, vehicle diagnostics and directions.

OnStar can be seen as a platform of engagements embedded in a network of individuated co-creation experiences, enabled by technological capabilities entailing wireless telephony, satellite communication, vehicle integration systems and internal sensors, as well as the technologies needed to integrate the vehicle diagnostics into public networks, call center operations and external services such as 911 emergency networks. We did not find any information on whether clients participated in the development of this offer that began with stolen vehicle tracking systems (real need). The above platform has been developed incrementally by adding other useful services that help not only clients but also other stakeholders such as police, insurance companies and others. Such collaboration has multiple positive impacts – competitive advantage for GM and their partners, more services for clients, contribution to fighting criminality and reduction of C02 emission due to guiding. We have not yet been able to try the voice interface, we hope that it is smart.

5 https://www.triplehelixassociation.org/.
6 Code division multiple access.

The Hewlett Packard (HP) Living Progress Report is excellent for the image of the firm. It addresses human, economic and environmental impacts. HP claims to practice sustainable supply chain, protecting personal data and providing their technology for medical care to remote villages in India. Their foundation invests on social and educational programs and supports disasters. HP Life e-Learning offers free information technology (IT) training. Nevertheless, they can do better in reducing environmental impact by smarter managing of printing tools and supplies. Involving customers may improve their real impact; the possibility to send feedback is only given using their multiple choice survey which is a little inefficient.

IBM began the *Smarter Planet* program in 2010. Their main objective was to reposition their offer in the field of energy and water management. Currently, they are involved in the majority of Smart City projects. The impact of this vision and strategy is at least threefold: business, reducing environmental impact and image.

The *Kohala Center Hawaii* initiative is an excellent example of overall innovation [KOH 14]. The considered "modern" style of life has influenced local nutritional habits and massive tourism has damaged natural ecosystems of the island. According to Matthews M. Hamabata, president and chief executive officer (CEO), the results of the 1999 health survey pointed out chronic health disparities such as diabetes, obesity, heart disease, and drug and alcohol abuse. It made it clear that this problem should be addressed using an overall approach – communities needed to be provided with greater educational opportunities for the island's youth to ensure that young adults were qualified for the new jobs that ought to be there (rather than training young people for the existing job market), and diversify the economy. With this realization, The Kohala Center was founded in 2000 as an independent, community-based center for research, conservation and education. This center connects researchers and traditional knowledge into action so that communities in Hawai'i and all over the world can thrive ecologically, economically, culturally and socially. Their focus is also on energy self-reliance, food self-reliance and ecosystem health. They tend to reconstruct the initial mindset of the island "where individuals realize their potential, contributing their very best to one another, to the community and to the 'āina (land) itself, in exchange for a meaningful and happy life". The (re)education of values of productive and responsible interdependence is necessary to achieve this goal. The initiatives such as the lending program put emphasis on non-financial values, giving weight to applicants' commitments to

culture, community and nature. One of the program's loan recipients is a family that has produced food and farmed *lo'i kalo* (wetland taro ponds) for generations in Waipi'o Valley. While the production of poi is where the greatest financial return is, the family wanted to press forward with expanding the number of lo'i they had under their care: not to make more money, but because of a core desire to *aloha 'āina* – to show love for and connect intimately with the environment in the valley – and to work in partnership with neighbors to maintain and improve the *'auwai* (irrigation ditches) and carry forward their cultural heritage.

Among the other initiatives are the protection of the fragile coral reefs of Kahalu'u, a vital nursery of their coastal fisheries [KOH 14b]. School gardens flourish across the island and the state because of committed teachers whose work is supported and organized by the Hawai'i Island and School Garden Network and the statewide Hawai'i Farm to School and School Garden Hui. Small family farms are being empowered to promote and improve biodiversity through seed-saving training and resources offered by the Hawai'i Public Seed Initiative. Local businesses are growing and prospering with assistance from the Kohala Rural and Cooperative Business Development Services team. They are making efforts to reduce their economically crippling dependence on imported fossil fuels, and its damage to the environment spawned an implementable plan to increase ridership and efficiency in Hawai'i Island's mass transit system.

4.2.1. *Open Systems Science: Tokyo and Paris*

Open Systems Science was initiated in 2008 by Professors Mario Tokoro and Luc Steels at Sony CSL Tokyo and Paris. It is probably the best research approach taking into account both the environmental impact and well-being of researchers. They experiment with a system approach for addressing today's challenges such as open energy systems including renewable energy storing, environmental and social sustainability, health and medicine, and human augmentation. The conventional scientific method consists of isolation of a domain of study, analysis of its constituents and working out how the various constituents fit together to make the whole is not effective for this kind of problem where each domain influences the other. Examples include the environment, sustainability, economic phenomena and life itself. These are open and dynamic systems with the potential to change each larger system, which are all in constant flux.

> Open systems may be manmade, such as the vast digital systems and man–machine interactions that are made possible by the Internet. Huge systems of this kind have constantly shifting boundaries and service requirements. As a result, it is virtually impossible to know enough about any specific component of the system. Moreover, for such a system to be truly user friendly, a great deal needs to be known about the people who interact with it – but human beings, too, are extremely multifaceted, and their behavior is strongly influenced by the context in which they operate. In short, it is impossible to learn anything of significant value about any open system by attempting to reduce it to its constituent parts. A conventional scientific approach simply does not work. Open Systems Science, on the other hand, offers a way to solve a problem in its real-world context, including how it influences and is influenced by different but related problems. This is precisely why we need an "Act Beyond Borders" approach. Lab studies may deepen a researcher's understanding of an isolated phenomenon, but you cannot understand that phenomenon in relation to others unless you study it in its living, changing, real-world context. In fact it is no exaggeration to say that without such a mindset, Open Systems Science would be impossible. [TOK 10]

The way of thinking, methodology and working environment established at Sony CSL optimizes the efficient and effective use of computers by scientists in their efforts to understand the past, predict the future and address today's challenges. To succeed with such an initiative, the multidisciplinary teams work together in the same space, exchanging and inspiring each other to keep exploring new domains, new concepts and new technologies. They expose their research on a regular basis to the wider public to increase awareness and to get feedback.

The researchers are evaluated based on their contribution to humanity and society, new science and technology, industrial progress and product development.

One of their projects is to explore open energy systems able to dynamically transmit power in ultradispersive environments, maximize the potential of naturally occurring energy and provide a stable electric system

that uses natural energy as its primary source. It may be very useful for many towns and villages in developing countries with either no electricity or a very unstable supply. Recreating the kind of power grid used in developed countries would take a vast amount of money and time. If small-scale open energy systems can be built in these areas, electricity can be provided for several hours a day. This would help improve education and medical services, and contribute in some way to economic independence.

To deal with information overload, new representations allow people to assimilate data in a simpler way not only through the use of existing visual channels, but also auditive and tactile ones.

Computer vision, medical imaging and machine learning deal with high-dimensional, noisy and heterogeneous datasets that are inherently non-Euclidean. To better understand and explore those datasets and extract both qualitative and quantitative information, a new paradigm and toolbox of computational information geometry with path-breaking applications in imaging is in development.

Econophysics, a new field of science, tackles the analysis of economic data based on a methodology developed in physics.

Comic computing uses a graphic art form and interaction technique that combines text and images to represent a story and provides the user with non-conventional communication systems which are more interesting and visual.

Human–computer integration teams explore the technology able to expand the capacities of mankind that leads to "human augmentation". The scope of "augmentation" is considered in terms of intellectual, cognitive and physical capacities. This research group develops and experiments wearable computers that can recognize the user's line of sight, the realization of out of body experience viewpoints and capacity-expanded telepresence.

Environmental disruption, resource exhaustion and food crisis contribute to the loss of balance in ecosystems. Tracing the history of the Earth back to the beginning of life, it is possible to learn how early organisms, such as photosynthetic bacteria, made the planet livable for the ones that followed. No organisms are either complete by themselves or unchanging throughout their lives. They need to complement each other and continuously evolve so that the entire system stays in balance. The molecular mechanism of life is

studied as part of this parasitic/symbiotic complex from the viewpoint of the global cycle of nature with a special interest in the microbes and other organisms that sustain the food chain at the bottom. A multidisciplinary approach ranging from computer science to molecular biology, integrating knowledge from the East and the West, is applied in this research.

Another project studies our perception and organization of information about biological phenomena. They share a new concept of cellular memory which surrogates the hysteretic properties of an organism and attempts to actualize predictive and preemptive health care and medicine.

Eradication of physical disability with technology raises social problems that need to be solved. Differences among intact, disabled and elderly people would almost disappear if we could not only compensate for a lost function, but augment it. In order to tackle the technological problem, we need to figure out whole system of neuro, reflex, brain and muscular systems and design technology that fits with human body motion. On the other hand, in order to disseminate the technology to disabled people living in developing countries, constraints such as poverty and environmental issues also need to be addressed. In this case, the open science system and cross-disciplinarity may also make a huge impact on the world.

The brain and creativity are also studied with the aim to understand how the mind arises from the physical activities in the brain.

An innovative agriculture system, called “synecoculture”, is based on symbiotic associations of edible species whose practice itself strongly recovers and reconstructs a natural environment under any arable climatic condition. It plans to establish a new relationalistic life science of an “in natura” state, beyond conventional reductionism, and realize a “symbiotic earth”, where all living species can manifest their function to its full potential through primary industries under human direction.

Natural language processing, autonomous robots that develop and evolve aspects of human language such as spatial language, action language and tense-aspect systems are used to build artificial assistants, and improve human–computer interaction and gaming. Such systems are resilient to noise, perceptual deviation, ambiguity and unorthodox language use.

Uncovering molecular mechanisms of reproduction dysfunction, it is aging-related failure, accumulated through time-dependent epigenetic (genetically intact) modifications of deoxyribonucleic acid (DNA), establishing novel patterns of gene behavior (network). Stress-related adaptive response of neuroendocrine-immune system (NEI) largely contributes to the reversibility and controllability of gene network through the hormonal regulation; thus, these two systems should be seen together.

One group is working on the development of interactive systems, transmission of real-time first-person experience, storage and sharing of total experiences, humans augmenting humans and other related topics. Their purpose is to trace the contours of the relationships between humanity and technology, and between human beings themselves, as they are redefined by the "human as medium" phenomenon. They believe that by guiding the development of technology under an appropriate path based on this vision, they can contribute to the expansion of the totality of society's experience and knowledge.

The common difficulties in solving problems which we are now faced with, such as climate change, loss of biodiversity, food/energy shortage, economic/social instability, and so on, lie in that these problems are "open systems", where the solvers, i.e. we humans ourselves, reside inside the problems as internal observers. This means that we can neither have full control over the systems nor reset them. Science has had difficulties in handling these kinds of problems because its methods rely on validation or falsification of hypotheses by observing reproducible instances. However, if simulation virtually reproduces a one-time-only-problem, the boundary of applicable range of science can be pushed far beyond. This group develops an integrated simulation of infectious disease that includes not only the pathogenetic properties but also their evolution, including its coevolution with the human side and other environmental factors. Their objective is a holistic understanding of open systems leading to their essential long-term solutions.

It is important to think about the "essence" of research – it should be passionate for researchers and it has to serve to the open future bringing a contribution to the society and humanity.

"Synthetic Space" is a neologism for the architectural space of the future, whose invariability has been instead replaced by the capricious plasticity of digital bits. For occupants of Synthetic Space, transforming the makeup of the surrounding built environment will be as easy as changing the wallpaper image on a present-day personal computer (PC). The goal of this research is to make this future a reality through an eclectic approach of engineering and design.

Health, which empowers us to contribute to our society, should be the target under a new health care system and the value in 21st Century. However, our current medical system has long focused on "disease cure", rather than health care. Technological advance is allowing us to protect and save health in advance of disease onset, which opens the door to the health capitalism era. Japan has a universal insurance system and standardized information infrastructure. Using these assets as an advantage, this team gathers and analyzes health data of administrative (billing) and lab results to detect care gaps and neglected patients. Solutions for such missing areas also need to be developed. Finally, the goal is the implementation of such solutions in ordinary lives of an appropriate target population, delivering a new solution to the health care industry and changing the paradigm.

As a survival strategy, organisms adapt to fluctuations they receive from the inheritance of genetic characteristics and from environmental factors. This feature is known as robustness. In the Earth's environment, various disturbances (environmental factors, gene transformation, chemical substances, etc.) are integrally entangled, leading to unpredictable reactive properties. To become predictable, we need to control robustness. This team endeavors to understand and control biological organisms' environmental responses and survival strategies from an experimental biological approach. This is extremely important in drug development and tailor-made medical care, and it is their hope that it will also lead toward an understanding of cancer, autoimmune diseases and other illness, and to the creation of preventive medicine and wide range of therapeutic strategies.

Much of their research have been transferred to industry (i.e. Sony Corporation, Sony Computer Entertainment and other Sony group companies, as well as some external companies) and commercialized.

The Sony CSL Paris center focuses on personal music experience, developmental cognitive robots, self-organizing communication systems and sustainable environment simulation. They have launched a number of projects to raise awareness about the issues through volunteer computing for climate modeling and participatory sensing of pollution.

4.2.2. *Qatar Foundation*

The Qatar Foundation (QF) is an example of intelligent investment of money other than in buying cars and malls. From a temporal perspective, it is nothing new, just reproducing and adapting the Lorenzo de Medici vision to the current context. However, it is an example of quite a general strategy of innovation.

A starting point of the Qatar Foundation for Education, Science and Community Development was a vision of Sheikh Hamad Bin Khalifa Al Thani and Sheikha Moza bint Nasser and a resulting plan for the future development of their country. The main objective is to provide Qatari citizens with a large choice in education, health and social progress. They had chosen the Sidra tree as a logo (*Prosopis cineraria)*, namely the "tree of life", because growing in harsh environment, it is a symbol of perseverance and nourishment across the borders of the Arab world and of solidarity and determination. QF attracted more than 80 centers and joint ventures and "the branches of the Sidra tree represent the diversity of QF today. The leaves, flowers and fruits represent the individual lives that the tree nourishes, with the fruits going on to produce seeds that guarantee sustainability and a healthy future. The Sidra tree's deep roots are seen as a strong anchor, connecting contemporary learning and growth with the country's culture and heritage. Poets, scholars and travelers would traditionally gather in the shade of the Sidra's spreading branches to meet and talk. This aspect of the Sidra tree's role is reflected in QF's commitment to education and community development. The tree's fruits, flowers and leaves provide the ingredients for many traditional medicines, which reflects QF's science and research objectives"[7].

The QF published their Vision 2030 in July 2008. It outlines how Qatar will use the vast revenues from its hydrocarbon resources to transform itself

7 http://www.qf.org.qa.

into a modern knowledge-based economy. They put emphasis on "Unlocking Human Potential", their main priority for the next 15 years. Through education and research, QF leads human, social and economic development of their country. They wish to become a vanguard for productive change in the region and a role model for the broader international community. Though supporting and operating programs in three core mission, the foundation strives to nurture the future leaders of Qatar. By giving example and sharing its experience, the foundation also contributes to human development nationally, regionally and internationally. Through these activities, the foundation supports an innovative and open society that aspires to develop sustainable human capacity, social and economic prosperity for a knowledge-based economy.

The environmental concern is not yet integrated into all activities, but limited to traditional such as green building and housing, transportation and solar energy. The Qatar Green Building Council aims at changing modern architecture to a green one by changing the way buildings are conceived and used. Biotecture's aim is to develop environmentally sustainable and esthetically pleasing cities with plants and vegetation that can operate as insulation on outer cladding to keep cool air in and heat out in summer. This is not a question of cost, but of a different way of thinking. How far will this architecture change the desert and delicate ecosystem of this country and biodiversity in the city? How does it influence an evolution of outdoor living without air-conditioning? The Passive House is also a part of the environmental program.

Other "green" projects include the campus at Education City and Mobility Innovations Center. The intention is to gather information about air quality. The pilot program involved multigas monitoring stations being placed at two locations on the campus. Information is sent to an intelligent sensing and services delivery platform that provides real-time air quality information. The e-survey aims to gather information from Qatari citizens and expats living in Qatar about how they use electricity, gas and water, in addition to their behaviors in using regular household appliances such as air conditioners, washing machines and televisions. With the aim to protect and learn more about the dugong population of Qatar, a recent tri-party agreement was signed between ExxonMobil Research Qatar (EMRQ), a tenant of Qatar Science & Technology Park, Qatar University (QU) and Texas A&M University at Galveston (http://www.tamug.edu/). The Petroleum Engineering program at Texas A&M University, Qatar, has

ambitions in leading to safer, more environmentally friendly wells for the oil and gas industry. Solar energy is also in the spot. The road map outlines 10 conditions and related policy recommendations as a framework to discuss a range of interlinked policies and actions to transform into a green economy. These conditions include social, environmental and economic innovation; collaboration between all sectors; integrated governance; balancing short- and long-term strategies and multilateralism. The road map also exists to share existing best practice and initiate new collaborative activities. The education of "green" attitude is in the way, and the next step may be the education of "knowledge cultivators".

4.3. Europe

There are many initiatives at all levels trying to address the today's challenges. They are led by citizens, companies and institutions. We selected those addressing the challenges, having potential to do more and considering the associated impact.

Since 2008, the EU publication *Research*eu* has been highlighting the most promising EU-funded research and development projects. In 2010, its name changed to *Research*eu Results Magazine*. It is published 10 times per year and covers biology and medicine, social sciences and humanities, energy and transport, environment and society, IT and telecommunications, industrial technologies and space areas.

4.3.1. *From Living Labs and Enoll to Innovation 2.0*

The Living Labs was initiated in 2006 by the European Commission (EC) and the Finnish EU Presidency. Since being founded as a modest start-up, the Living Labs has developed into a network of regional innovation ecosystems on all continents. They follow the quadruple helix innovation model (see Figure 4.1), where the innovation trials and scale-up can happen more successfully due to engagement of the citizens in the regions.

Living Labs can be considered as an example of needs-driven innovation. However, a needs-engineering process [MER 11] is not applied. This program explores how technology may improve citizen life. The "Push and see" method is preferred rather than collaborative elaboration of adapted solution addressing the given needs.

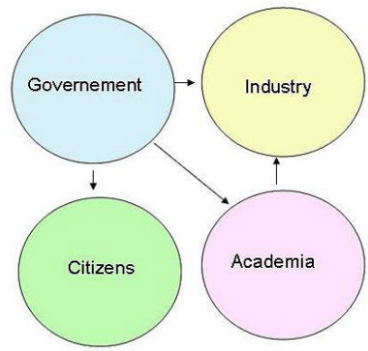

Figure 4.1. *Quadruple helix model of Living Labs*

Enoll[8], a network of Living Labs, now connects 50 countries experimenting with innovation. Among the topics of strategic projects, there are four on smart cities, two on the Future Internet, two involving cross-border and cross-sector collaboration, two on user-centered design, one on big data, one dealing with game design and serious gaming and one involving education and creative industry. Only one of these projects (ECIM) includes the environmental concern – optimized green transport, while this challenge concerns all Living Labs.

One of the initial Living Labs projects PERIPHÈRIA[9] applied creativity and Future Internet Technologies to address the sustainability issues of a city and blends technological and social innovation. Its objective was to deploy convergent Future Internet platforms and services for the promotion of sustainable lifestyles in and across emergent networks of "smart" peripheral cities in Europe, with a specific vocation for green creativity. Its Open Service Convergence Platform, an "Internet by and for the People", extends and enhances the Save Energy project's Social Information Architecture, integrating key new components – sensor networks, real-time 3D and mobile location-based services – with the Future Internet (FI) paradigms of Internet of Things, Internet of Services and Internet of People. It defines five "Arenas" – specific urban spaces:

– Smart Neighborhood: where media-based social interaction occurs;

8 http://www.openlivinglabs.eu/.
9 http://www.peripheria.eu.

– Smart Street: where new transportation behaviors develop;

– Smart Square: where civic decisions are taken;

– Smart Museum and Park: where natural and cultural heritage feed learning;

– Smart City Hall: where mobile e-government services are delivered.

Pilot projects have been initiated in Malmö Sweden (SE), Bremen Germany (DE), Athens Greece (GR), Genoa Italy (IT) and Palmela Portugal (PT) and used the Serious Games to stimulate social interaction of "people in places", cross-city linking of Arenas and discovery-driven platform convergence. Transfer scenarios have been developed with the six sponsoring partner cities. This project's results also influenced the creativity, for example, Malmö participates in other EU-sponsored projects such as Green Digital City, Climate Smart City, Sustainable City and practice Sustainable Urbanism. It will be nice to know how these projects influence economic development, improvement of environmental attitude and social progress.

La Reunion Island Living Lab focuses on teaching and learning by playing. Reunion Island is located between Madagascar and Mauritius in the South West of Indian Ocean. The University of Reunion Island Living Lab likes to foster open and sustainable territorial innovation involving researchers, teachers, students and entrepreneurs through teaching and learning. This Living Lab activity covers both domains of nature diversity (insular tropical environment) and culture (creative industries). The aim is to educate new attitudes of sharing, enhancing and disseminating the island heritage know-how through serious games as tools for knowledge acquisition in physical and virtual environments.

Teaching biodiversity, performing an art (music, dance, painting, sport, cooking, handicraft, etc.), science (medicine), communication and tourism can be empowered by ICT in a sustainable manner by following some innovative methods for developing e-service. Their method of knowledge transfer using gestures produces a base containing interpretations of know-how-to-do things and succeeds in doing them. Knowledge management creates knowledge bases containing textual descriptions for knowing what-these-things-are. Knowledge management using ICT cannot manage the knowledge that is between the ears of individuals or in books. We can only manage know-how and interpretations that subjects (experts, amateurs) communicate by speaking,

showing and practicing an activity. For example, there is a big difference between knowing the recipe of a dish and making it.

The education process is more attractive and effective if it facilitates communication between teachers and learners. The University of Reunion Island Living Lab for Teaching and Learning (UR.LL.TL) developed a platform to share live interpretations, i.e. performances from various types of subjects. It facilitates the transfer of knowledge that is found in books or in specialists' heads. To achieve this result, the play between teaching and learning is a fundamental part of the process, because this enjoyable activity has always driven human understanding between the child and adult development process: draw me a sheep, said the little prince! Moreover, young people are playing a lot with video games instead of reading books. Finally, gaming or playing must be taken seriously between activities of teaching and learning at school and also in the universities. New gaming research actions have been developed managing know-how rather than knowledge. Learning by playing is often based on gesture reproduction by imitating the professor.

The teaching methods have to show how to do the right movement in order to be able to decompose it into instructions and thus understand the produced result in consequence. In this explanation context, which is similar to electronic fraternity, sign bases are more efficient than knowledge bases because they show examples furthermore than they describe them. Sign bases are made with multimedia technologies (3D, High-definition television (HDTV)), which are the best means for showing examples from teachers and answering the questions of learners for a better education service.

Multimedia annotations help to build the meaning of objects interpreted by subjects, for example, the right motion that produces the beautiful sound. This process is called sensation (physical sense acquisition) or signification (intellectual sign construction) from the human side of learning. On the machine learning side, it is called formalization (intension concept acquisition) or classification (extension class construction). Their living labs (LL) method makes both human and computer sides converge for codesigning e-services with ICT on a Creativity Platform and therefore enhance the sharing of live subjective interpretations with Semiotic Web, which is the Web of signs rather than the Web of objective things, i.e. the Semantic Web.

Figure 4.2. *Instrumental e-learning service codesigned on a Creativity Platform [CON 12]*

This project reuses the experience from previous ViBRANT FP7 program (http://vbrant.eu) supporting the development of virtual research communities involved in biodiversity science for managing biodiversity data on the Web using biologists and computer scientists.

The Open Living Lab Knowledge Centre has been opened to share knowledge and experiences among developers, researchers and other stakeholders of the living labs. Enoll members meet on a regular basis and continue to collaborate, applying together for the EU funding. There are no reports on how far this investment improved economic growth, job creation and young employment and has addressed other strategic European challenges.

OISPG, which mainly focused on technology, is now considering the impact on society. The just-released *Yearbook 2014* states: "We moved from the traditional approaches to the Open Innovation 2.0 paradigm – the innovation dynamics, processes, and the environments have all fundamentally changed. It is important to see how these changes in the drivers for success have led to different policy approaches by all stakeholders. Also the roles and collaboration of stakeholders is very different from the past" [PUB 14].

To illustrate this purpose, the above *Yearbook* presents some experiments following the OISPG method presented in Figure 4.3.

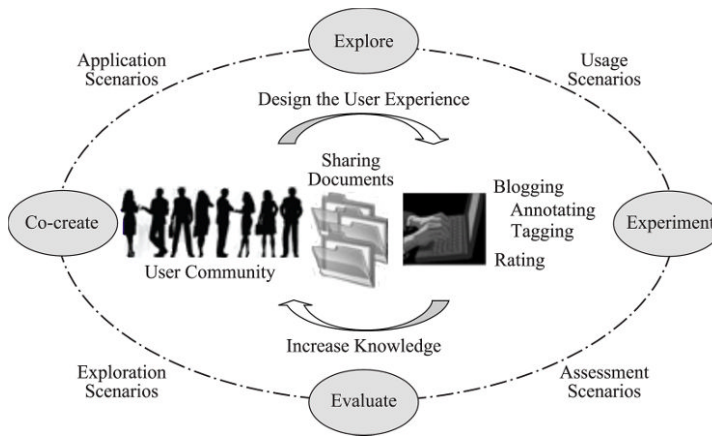

Figure 4.3. *Innovation 2.0 method [PUB 14]*

This method is not new; it has been applied by a few software companies practicing innovation with clients through the initiatives such as User's Clubs [MER 11]. Innovation with the client goes further, because it starts with need discovery and not addressing supposed needs with existing technology, as many are doing. However, applying the same method to research may be considered as disruptive innovation in research methods. The OISPG ambition is to influence the evolution of values and to consider tangible as well as intangible ones. It is the biggest and most difficult challenge of this century.

The 2014 edition of the *Open Innovation Yearbook* [PUB 14] presents some cases classified as Innovation 2.0. Compared to the previous edition, presented cases focus more on the value creation. The notion of the value extends to include another www – wealth, welfare and well-being. According to Ramaswamy, the ubiquitous connectivity has changed the social interactions and methods of engaging and cocreating value. It may lead to cocreative and more inclusive economy. The principle is shown in Figure 4.4.

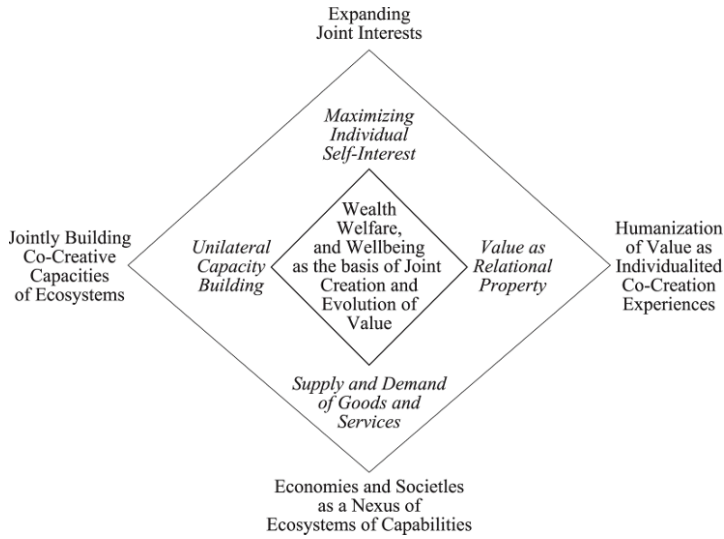

Figure 4.4. *Principle of wealth–welfare–well-being cocreation [PUB 14]*

Stakeholders are considered here as cocreators. The author believes that cocreation thinking expands the current approach (wealth generation) to create wealth–welfare–well-being in economy and society. To illustrate his theory, he gives example of OnStar telematics – providing information to passengers for their safety and emergency service to customers. Telematic is solely about providing paid service to customers. While customers may feel more secure, the author does not explain if and how the customers participate in the innovation process of provider.

Another more convincing case for the above approach is those of Unique Identification Authority of India (UIDAI) public–private organization. A crucial factor that determines an individual's well-being in a country is whether their identity is recognized by the government. Weak identity limits the power of the country's residents when it comes to claiming basic political and economic rights. In many countries, several different identification systems had been created for various purposes with cards including voter identification cards, ration cards, driver's licenses and income tax cards. To solve this problem, they introduced the UID number which contains person's demographic and biometric information registered in a database. UID branded as Aadhaar guarantees only a person's identity, not rights, benefits or entitlements. Enrolling for Aadhaar is optional; the

central government of India budgeted approximately $380 million to fund UIDAI, and enrolment commenced in August 2010, with a goal of enrolling 600 million people by 2014. Registration is going on; more than 180 million Aadhaar numbers have already been issued. When completed, it will probably be the world's largest single-entity biometric database. This initiative is both technological and social. It provides a universal identity infrastructure over which private, social and other public sector enterprises can build services and applications that benefit residents across India. Such an ecosystem provides multiple benefits to citizens, to government and to service providers. As it can be used as a centralized number of identification for each resident of India, policies can easily be implemented with one unique identification number, and airport check-in can also be done in a single go with all details already mentioned within the number. UID can be used from shopping reward points to government policies implementation.

It is not said if the possibility was given to citizens to participate in improving this system or asking for specific services. We do not know how their identity is protected, because it is only digital one.

Another case dealing with young unemployment is the European Young Innovators Forum (EYIF), a leading foundation dedicated to promoting youth innovation. It involves the institutional, academic, financial, industrial and market actors who can support them in building and transforming their ideas and early-stage projects into innovative products and services in areas of socioeconomic importance for the future. The best ideas and early-stage projects will be awarded seed grants (below EUR100 000) and supported by an incubation program hosted by one of a European network of business incubators.

The other cases described in the *Open Innovation Yearbook 2014* are about innovation networks such as Oulu Innovation Alliance, Big Data exploration, smart urban lighting and innovative services for lawyers. The latter is a very promising case of service innovation being copied and adapted in many countries.

4.3.2. *Future Centers*

The first Future Center (FC) was probably that initiated by Leif Edvinsson in Vaxholm, Sweden, for Skandia. The idea was to replace

traditional training center by a special innovation enabling organizational environment using all senses, to boost creativity and innovation in an inspiring place. The participants coming here are invited to a total innovation experience – one that blends creative space, wide range of creativity methods, inspiring facilitators and a set of innovation triggering values. The users take part in a short-time engagement which is usually focused on a particular question or mission – for example, finding a solution to challenges, the organization has to face. It is expected that after experiencing the total innovation and conducting some productive work there with their colleagues, they will reuse the learned methods and values in their today's work.

This model was reproduced in Scandinavia due to its deep participatory culture and was exported to the United Kingdom and the Netherlands. More recently, there has been a growing interest in FCs in the Far East, and several centers were founded in Japan, following a growing pressure to move from "Excellence in Quality" to "Excellence in Innovation" and the need to try more open and less hierarchical forms of work. Currently, there are 30 FCs all over the world.

During the first annual meeting of the international FCs community dedicated to exchange knowledge, inspirations and experiences between its members, it was decided to apply for an EC-funded R&D program with the aim to explore collectively the art and practice of FCs. OpenFutures[10], a 2-year long international research project funded by the 7FP of the EC provided an opportunity to a group of 13 organizations (FCs, academics and consultants) with the aim to improve the concept of FC through design, observation, exploration of its effectiveness and ways of managing it. Future Center Alliance[11] (FCA) was founded in 2011 to exchange insights and build together the collective bank of knowledge on the related topic. The communication between the Alliance members includes annual or biannual meetings of the community, usually hosted by one or several FCs, collaboration between FCs on joint projects and informal communication between the community members.

Finally, Futur Centers can be defined as special working environments helping participants to break out patterns and routines, see issues from

10 http://cordis.europa.eu/project/rcn/80168_en.html.
11 http://www.fc-alliance.net.

multiple perspectives and choose effective courses of action. They enable people to create, develop, prototype and communicate ideas, strategies, plans, solutions and actions that help them to deal effectively with today's and tomorrow's challenges and deliver sustainable solutions and results.

During the OpenFutures project, participants defined a set of 13 principles and five building blocks. The principles include:

– long-term and sustainable focus: the center supports its users in addressing long-term issues and significant challenges, in order to arrive at sustainable solutions that can be realized in the short and middle term;

– results and impact focus: the center's mission is to make a difference. It actively helps its users work toward translating results and desired futures into reality;

– organizational and personal growth: the center addresses, triggers and catalyzes both organizational renewal and its users' personal growth. It empowers people to take responsibility for their future;

– futurizing: consider present challenges, visit the past to explore past solutions, go into the future to experience possibilities and return to the present to apply what has been learned;

– cocreation and collaboration: ideas, visions, solutions and action plans are developed through a collaborative process that involves diverse stakeholders;

– systematic and facilitated: the working process is facilitated and well designed. At the same time, the systematic innovation process enables, recognizes and takes advantage of serendipity;

– continuity and discontinuity: the center supports continuous innovation, rather than one-time events and one-off campaigns. It supports the creation of an innovation culture in the organizations/sectors/individuals using it. It also triggers discontinuity: disruptive innovation and questioning of the *status quo*;

– contactivity: the center is not an ivory tower; it actively works with a wide range of internal and external collaborators, in multiple networking settings. Diversity is the key;

– multiple perspectives and multidisciplinary work: a center invites people coming from diverse backgrounds and disciplines to participate in the

work process, in order to create richer and more robust visions, strategies and solutions. It encourages and supports users to adopt multiple perspectives and many points of view;

– meeting people on equal terms: each participant has an equal voice, which is independent of his/her hierarchical, political or professional position;

– thinking-dreaming-playing-doing work environment: integration of physical, virtual, emotional and mental spaces in order to create rich environments that contribute to effective group and individual processes;

– time-out: the center invites people to take a time-out from their daily workload and routine stress, to focus on the long term, to engage in deeper conversations, to ask questions and to reflect on priorities and consequences;

– concrete results: the focus of all sessions is on producing concrete results. Prototyping is a work tool actively used to make ideas and intentions tangible.

The metaphor of a well-constructed house, where each building block represents one of the constructs of the FC. This model is used for its simplicity and clarity, but in real-world centers, the building blocks blend with each other and are never planned and operated as stand-alone aspects of the place. These blocks are represented in Figure 4.5.

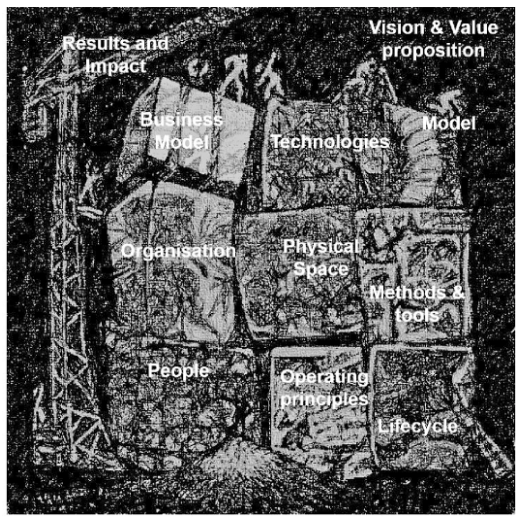

Figure 4.5. *Building blocks of Future Centers [DVI 08]*

The first critical success factor for an FC is a clear *vision* that relates to the overall vision of the organization, to its current challenges and its desired future and course of action. The vision should be updated when needed, in order to ensure that the FC remains relevant to the changing environment in which the organization operates. The 13 *operating principles*, described previously, are the values that guide the concrete operation of the FC. The *operating model* is the core-facilitated process (or set of processes) that translate the operating principles into concrete action and tangible results. Each center has developed a Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals. Each center has developed a rich set of concrete *methods and tools* applied in the different phases of a project. The list of methods includes tools developed by the FCs themselves as well as well-proven methods which became almost standard in the toolbox of innovation facilitators, such as Open Space Technology, Knowledge Café, rapid prototyping and even most basic brainstorming using post-it. There are various methods of positioning FC in an *organization*. It should be visible for all departments and even from outside of a company, connected with the organization's core issues and the daily work practice of its personnel (relevancy), and have an impact on a company's success. It may be internal or independent. The physical and virtual building blocks are selected as a function of needs and objectives. The *people* building block includes the staff of the FC which is one of its critical success factors. In some FCs, the team is composed of full-time employees of the center. Typically, this in-house team includes five to six team members (director, facilitator, host, content expert, etc.). In other centers, the team is much leaner, and most of the facilitation work is done by experienced external facilitators. The staff attempts to use the best of participant's capacities. The diversity of positions and age, internal/external, gives the better results. The business model bloc deals with finding the right funding and/or sales the results. Based on the specific opportunities that the center identifies, other business models can be applied. Each FC has a unique lifecycle – from the initial idea of launching an FC to its ongoing operation/transformation (and in some cases, closing down). It is influenced by the specific circumstances of the initiative – the organizational culture of the parent organization, the available resources, the objectives of the center and even the personalities of the people involved.

Some benefits from Future Centers

Each FC develops its own business model depending on its mission. Moreover, frequently, the business model changes over time and is modified to new circumstances and needs (or constraints) of the mother organization.

Some of the direct results:

– helping to solve complex challenges of the mother organization as well as the community it serves;

– assisting stakeholders in building consensus in complicated circumstances;

– helping the organization to invent new products, services and ways of working. Some of them are real breakthroughs;

– supporting organizations in conceiving, designing and launching large-scale projects;

– helping define better policies.

Some of the indirect results:

– spreading a culture of participatory innovation. People come to the FC and work there for a few days – and once they go back to their regular working environment, they carry the "virus" of such culture with them;

– promoting optimistic, collaborative, more democratic and proactive culture in the organization. We can design the future;

– contributing to the image and sometimes even branding of the organization as a future-oriented one;

– making the organization a more positive workplace. Employees that come to the FC are recharged with new energy;

– greatly helping to remove internal organizational barriers – as this is a "neutral" zone in which people form various functions to interact very closely;

– strengthening the network of the organization and triggering all types of collaborations.

The concept of FCs is interesting from an environmental point of view and stimulation of creativity. While the impact for the organization having

an FC may be evaluated in terms of new products and services, it is not clear if and how the various impacts are measured. The environment and equipment of an external FC may have an impact on creativity.

4.3.3. *Green and eco-innovation*

DG Environment[12] (The Environment Directorate General of the EC) was set up in 1973 to protect, preserve and improve the Europe's environment for present and future generations. The Commission proposes policies and legislation that protect natural habitats, keep air and water clean, ensure proper waste disposal, improve knowledge about toxic chemicals and help businesses move toward a sustainable economy. They also make sure that member states apply EU environmental law correctly by helping them comply with the legislation they have agreed, and following up on complaints from citizens and non-governmental organizations. The REACH entered into force on 1st June 2007. Its main aims are to ensure a high level of protection of human health and the environment from the risks from chemicals, the promotion of alternative test methods, the free circulation of substances on the internal market and enhancing competitiveness and innovation. The 7th Environmental Action Program will guide the EU environmental policy until 2020.

The DG Environment website offers access to the base of "Good Practice". As usual, the access to this base follows the traditional IT logic – access by area, while cross-inspiration could be enhanced with the "problem-solution" approach. This base contains the cases as usual classified by areas: Agriculture (9), Air quality (4), Biodiversity (1), Cities (1), Construction (11), Energy efficiency (30), Industry (15), New services/business models (3), Recycling (23), Resource Efficiency (24), Sustainable Consumption and Production (14), Technology (27), Transport (17), Urban (4),Waste (10) and Water (16). Technology supports most of the mentioned cases. One of them is washing without water.

Head polymer cleaning technology developed at Leeds University may be used in washing machines instead of water. The beads agitate, attract and transport away stain and soil from textile surfaces and absorb dirt into their molecular structure. The beads spin in the washing machine along with the

12 http://ec.europa.eu/environment/.

dirty garments, and reduce the water requirement by up to 90%. They are reusable and recyclable, capable of hundreds of washes before reaching lifespan. They have also proven as effective as standard washing with water, especially for removing grease and oil. Laundry detergent is still needed, but at reduced quantities – washing consumes only about half of the chemicals of standard washing processes. Xeros, the company commercializing the results claims that bead cleaning is the "first *real* innovation" in laundry for 60 years. However, cleaning beads cannot be used in machines that are designed for washing with water. For the future use of the technology, a switch to bead cleaning washing machines will be required; the CEO of Xeros said that these will not be more expensive than current washing machines. This example demonstrated that association of several fields may produce interesting results; this technology has potential to create an economic and environmental impact, to create jobs and to disrupt washing. However, the washing machines have to be redesigned.

The ancestral method of washing uses ashes and lavender. It remains to be demonstrated which one is more effective, less polluting and cheaper for the users.

Several projects developed solutions for recycling, but none for remanufacturing. Curiously, none offer 3D printers for printing spare parts instead of recycling.

"The Wellmet 2050 project is exploring five options for steel and aluminium: designing products with less metal, reducing waste, reusing components, diverting waste to other uses and extending product life. The consortium finds that most products, such as food cans, could be designed with 30% less metal and they still perform the same function. The amount of steel wasted could be reduced, as around a quarter of cast iron ends up as scrap. There are no technical barriers to reusing steel sections in construction and the economic case is not bad either. To extend product life, buildings could be made with a solid steel core and renovations only of add-on components such as windows". Promising renewal in the steel industry, this project, like many others, aims at reducing material of packaging and finding the lighter structures.

The *Research*eu Results Magazine* No. 13 is devoted to "Green Innovation for Sustainable Solutions". The Sustainable Urban Metabolism for Europe (SUME) project focused on how to design future

urban systems to be less damaging to the environment. They used the concept of "urban metabolism" to explain the way urban societies use environmental resources such as energy and land for maintaining and reproducing themselves. Based on urban metabolism models and spatial development scenarios, the project team explored the flows of resources, energy and waste that maintain the urban system. The spatial qualities of urban systems have an impact on the qualities and quantities of resources needed to maintain them. They analyzed the impacts of some cities and urban environments on resource use in order to significantly reduce resource and energy consumption and transform urban building and spatial structures for the future. The project developed four case studies on Vienna, Stockholm, Oporto and Newcastle, as well as spatial development scenarios for Athens, Marseille and Munich. The metabolic impact analysis method was developed to assess the impact of large-scale urban development projects on resource use and on the overall resource performance of a city. The SUME principles for metabolically efficient cities are the following:

– spatially focused densification;

– high-density development only with high-quality public transport;

– functional mix in urban quarters (i.e. residential, jobs and services);

– combine urban and building (object) reconstruction.

The interest of such a project is the integration of urbanism, architecture, energy, water, transportation and existing technological solutions.

4.3.4. *Social and service innovation*

All 10 selected projects on social innovation [EUR 10a] focus on the social impact, providing access to health care, education, services to older people and those with disabilities, connecting activities for better impact or connecting generations. However, the economic impact is not easy to estimate – the various business models are experimented. Some of these projects help to create jobs; one is about reducing environmental impact. While all are useful for society, the aspects of job generation and business models should be improved. The H2020 opened the opportunity for more social and service innovation and introduced a social innovation as crowdfunding – the applicants are encouraged to find complementary private funds to succeed with their projects.

Among other social innovation initiatives, there are networks of people that need or provide service or experience, collaborative using of bicycles, cars, flats and other goods.

In many cases, the social innovation is connected to service innovation. However, the service innovation playground is very large and technology may help to enhance services not only in traditional fields such as health, banking, insurance, tourism and other, but also help in "industry renewal", by offering services related to products.

Several reports on service innovation are available. Among them, the *OISPG Yearbook* [OIS 11] presents cases mainly focused on the use of technology for innovating in traditional service areas. Technology empowers creative industries, allows mobile banking and mobile services, e-invoicing, e-identity, e-procurement and crowdfunding. Smart City represents an innovation in city management and it provides innovative services to citizens, organizations and companies. e-Health and telemedicine are also examples of service innovation.

4.4. Experiments in France

For several years, the various initiatives are booming. Some companies such as Bouygues Telecom organize Open Days to show their innovations and get feedback from visitors.

Sentier is a quarter of Paris devoted to textile and fashion. Traditionally, they design and produce textile and clothes. As many others, this industry suffered the globalization effect. Companies in this area have set a Website http://www.le-sentier-paris.com/ to be stronger together and to connect with their customers (resellers), providers and other related partners. Faced with competition from China some companies went bankrupt leaving a precious space in the center of Paris. The association Silicon Sentier was born in 2000 with the aim to offer digital services in this area. They have initiated several key projects such as La Cantine, primarily intended for digital players, offering collaborative workspace, common resources and producing events. The association is also at origin of Digital District project, a laboratory for

experimentation of innovative services. In April 2014, they renamed themselves NUMA[13]. Their main activities are:

– coworking space;

– promotion and support of innovation;

– accelerator camping which hosts 12 start-ups per 6-month season. Some of the supported companies have been bought by Twitter or IntraLinks;

– experimenting new forms of collaboration, such as DataShaker SNCF program or an internal innovation program with Airbus.

More than 800 events have been organized since 2008. Among them, MobileMonday™ is one. Originating in Helsinki in 2000, with activities organized by more than 300 volunteers around the world, MoMo has become an industry leading mobile platform network. Chapters have run thousands of events to date, 500 in 2013 alone, spanning more than 100 cities on all continents, and we continue to launch new locations monthly in an open community of mobile industry visionaries, developers and influential individuals fostering brand neutral cooperation and cross-border peer to peer (P2P) business opportunities through live networking events to demo products, share ideas and discuss trends from both local and global markets. Run in France since 2005 by Silicon Sentier and FING, joined in 2010 by the Mobile Marketing Association France, and in partnership with Orange, Blackberry and Figaro, Mobile Monday Paris celebrated its 35th year at the Mobile World Congress 2010 at the French Pavilion. The Parisian version of this event consists of monthly meetings organized on current topics of interest to the community of professional mobility (mobile applications, games, geolocation, fixed mobile convergence, IT security, machine2machine, etc.). The opportunity is given to start-ups and small companies to present their offers, mainly products, expecting to find clients, funding or alliance. With 150–300 participants per month, the community of Mobile Monday Paris counts approximately 8,500 players.

Orange FabLab[14] initiated in San Francisco and in Paris is three-month accelerator program offered to selected start-ups.

13 http://en.numa.paris/Numa-About.
14 http://orangefab.com/.

Another collaborative innovation space in Paris is 104[15]. It offers a virtual and augmented reality space for artist and citizens, and a place for prototyping innovative projects in the area of urbanism.

Some other big towns run their own initiatives, such as, for example, Digital Lyon.

Since 2009, Greater Lyon has been leading a "digital mission" that includes an approach dedicated to innovative services and uses, placing users at the centre of its strategy for the city of tomorrow. This involves identifying – in conjunction with partners – the extent to which digital technologies can improve our lives through new services. As a result, this approach has brought together domains as diverse as mobility, culture, tourism and the postcarbon city. As Living Labs, they develop and test various applications, such as new forms of mobility, energy transfer and smart grids or remote and contactless service.

The initiatives and projects are similar. Many of them focus on standard digital service, smart transportation and energy, improvement of housing and greening, recycling, eco-design, but to the best of our knowledge, none concern overall impact and the way to measure the progress. They just measure the number of events and participants, number of start-ups, but not their sustainability and influence on the vitality and long-term economic development of the regions.

The origin and motivation of presented initiatives are to develop activities and create jobs.

French Embassy Scientific Service in Washington offers a discovery week for selected start-ups wishing to extend their activity in the United States through the NETVA program (http://www.netvafrance.com/).

A serious game developed by *Du flocon à la vague*[16] sport association attempts to educate citizen's attitudes towards water protection and intelligent use of water through playing. Their game associates sport and knowledge of water. To win, it is necessary to know all about water. They introduced a concept of Negawater – another game which teaches the minimization of water footprints.

15 http://www.104.fr/.
16 http://dufloconalavague.org/.

4.4.1. *Merging for multidisciplinary (and cost saving)*

IFSTTAR, the French Institute of Science and Technology for Transport, Development and Networks, was founded on 1st January 2011, from the merger of *Institut National de REcherche sur les Transports et leur Sécurité* (INRETS) and *Laboratoire Central des Ponts et Chaussées (LCPC)* under the joint supervision of the ministry of ecology, sustainable development and energy and the ministry of higher education and research. Their objective is to conduct applied research in the fields of transport, infrastructure, natural hazards and urban issues with the aim of improving the living conditions of citizens and promoting the sustainable development of societies.

The institute is said to play a key role in the debate on the accessibility, equitable distribution and safe use of public space in a context of increasing urbanization, limited resources of raw materials and with regard to sustainable development. It has thus been given the important political and social role of improving the living conditions of all members of society, while helping to protect fundamental rights such as mobility, safety and access to an environmentally-friendly living space that takes account of the individual.

It groups together the existing expertise in the areas of civil engineering, transport and road safety and intends to meet new challenges, such as climate change, sustainable development and aging populations. A systems approach and coworking of multidisciplinary teams are reflected in the structure of its research programs.

Their scientific strategy for the next 10 years is based on four major scientific challenges:

– inventing sustainable transport and mobility;

– efficient and sustainable construction, deconstruction, preservation and modification of infrastructure;

– taking better account for climate change, natural hazards and environmental and health impacts in man-made environments;

– designing and planning sustainable cities and regions: systemic and multiscale approaches.

Such an approach and strategy is a step forward for sustainable innovation taking into consideration the environmental impact of human activity and trying to influence behaviors. The realization of these ambitious goals is tough and initially implies the education of convergence between merged populations for better synergy. What capacity is needed for successful management of such a center? How do we succeed with this approach while the evaluation system is still evaluating excellence in one specific area [DIS 14] defined by Centre National de Recherche Scientifique (CNRS)?. The other countries have to face the same problem. What measures are needed to evaluate the progress? How are the principal stakeholders – citizens – involved, instead of involving only researchers, providers and sponsors? These questions are still awaiting answers.

4.5. Results and perspectives

All presented initiatives and experiments demonstrated that the comprehension of the innovation facets, of influence factors, connections between actors and domains and conditions for success is progressing. However, verifying impact before taking action is still embryonic. The consciousness that everything we are doing influences is the natural ecosystems needs to develop.

The challenges to face are complex and cannot be solved without change in the way of thinking, taking into consideration that we are no longer in an industrial era and related principles are no longer valid. The right metrics are yet to be defined, but are vital to progress.

Many actions focus on reducing environmental impact by applying technology to control the use of resources *a posteriori*. There are only a few actions trying to influence behaviors of smart energy and water consumption.

Technology seems to be essential for all kinds of innovation and for all problem solving, while past knowledge is frequently ignored or lost. The search for alternative solutions is never asked in the European programs. Most projects delivered complex and costly solutions, while those which are simple and cheap may exist.

Web 2.0 services are modifying the whole landscape – everything becomes virtual, “e-” and connected. What is the backup in the case we lack energy? Social networks connect people that decide common useful actions,

but also influence them. More initiatives come from connected citizens themselves: to develop social and military economies, to buy directly from producers, to plant vegetables to take for free and to share cars and flats. They take inspiration from the experience of others.

While many people dream about disruptive innovation, only a few put emphasis on creating the favorable conditions for fruitful innovation in terms of environment, places, surrounding objects, lighting and bringing together the right people who have complementary skills and experiences. It already happens in some projects concerning the environment and they are successful.

Some understood that the education is the base of progress. Various training materials are available online, but not always easy to learn without the help of a teacher.

The massive use of technology demonstrates that we are living in the Digital Era, but what is the role of humans? The right use of technology is to help humans provide a complementary capacity and not to replace them. This fact is extremely important for our future. The inventors and researchers have to keep in mind the activities in which humans are better than machines and create a symbiosis between the both.

Unfortunately, there is still a huge amount of money wasted on events, actions and projects whose effects are not useful and not measured, because of politicians' ambitions, sometimes sponsoring the wrong people. The Return on Investment (ROI) is not applied to research projects. The most promising projects need evaluation and visibility for a quick transfer.

Some proposals for Future Positive [DEB 79] were made by Edward de Bono in 1979, but how many politicians and researchers know this book?

5

Environment and Sustainable Success

5.1. Know, appreciate and protect what we have

Many examples from the real world show that the intensive industrialization and quick business-based system are destroying the ecosystems of our planet and deteriorating our health. In this scenario, pursuing wealth, welfare and well-being would be unrealistic, because we can not secure it. The only improvement we can influence requires a different way of thinking, acting, considering things, innovating, and exploring accumulated knowledge. We may call it responsible innovation and focus on CSR, biomimetics and living machines, but this is not sufficient because of the long history of the mechanical Industrial Model of the distrustful/devaluing and competitive enterprises and veins that work in exactly the opposite direction, of collaboration spirit, valuing, appreciating and envisioning each other.

Nature has endowed us with wonderful things living and working in harmony. Human activity destroyed the initial balance. The variety of forms and the beauty of "packaging" of seeds, fruits, vegetables, animals, birds, trees and flowers attest the multidisciplinarity – artistry, engineering, mathematics and physics are working together and not separately. All this represents an extraordinary source of inspiration.

Everything in nature recycles and reuses itself (carbon, water and nitrogen cycles). Looking for better performance? We invent things without, in general, taking into consideration the environmental impact produced along the whole lifecycle. Planned obsolescence generates more waste. A greedy economic system empowered with ubiquitous advertisements and continuous innovation

in marketing requires us to transform into buying machines. Packaging must attract, regardless of whether it is difficult to recycle. A large number of electronic devices are frequently replaced by more "up-to-date" electronic devices. All these activities influence natural cycles.

We have an obligation to understand things as whole ecosystems before creating "improvements" or new things dissociated from their natural context (harmony of the universe). This challenge is not easy because of human nature. Humans still destroy the "previous" to build "new", without taking into account the knowledge learnt, experience and wisdom. Inventors think that they are the first in the world having invented a revolutionary product or process, without checking if something similar was already known in the past or exists in the present. The Internet facilitates finding, but it does not contain all knowledge from the past, lost, because of the lack of transfer. Many solutions from the past are still valid and simple, for example, the simple pencil instead of expensive zero gravity space pen.

The recent discoveries with high potential of business, such as nanotechnology, biotechnology and transhumanism, have created a temptation for business hungry people to make quick money without taking into consideration the impact of such technologies on human beings and their natural ecosystems. The discovery by IFREMER[1] of the deep sea treasure of copper, graphite and other materials attracts money-hungry companies to explore these resources, who care little the impact on surrounding ecosystems. Instead of asking "do we really need these materials?" they ask, "how quickly can I make money exploring it?"

The power of creative thinking and technology can transform lives, energize businesses and empower communities. However, the creativity should be guided by a human–computers–planet balance. By focusing on tangible values, people "forgot" to respect each other. The "business first" attitude replaced the respect for our natural environment. Amplified by cultural diversity, the impact on planet and behaviors must be re-educated.

Environmental impact is among the five dimensions of innovation [MER 11] that we have to consider preferably before "doing". Some call it "responsible innovation" but it only focuses on environment without considering the other system impacts.

1 http://wwz.ifremer.fr/institut_eng.

HP Living Progress, the HP framework "for thinking about how we do business", aims in creating a better future for everyone through their actions and innovations. But what is the distance between the wishes and reality? In fact, the HP cartridges are conceived to print limited number of pages, users must print a page for alignment and their devices are made in low labor-cost countries.

In France, the government assigns the labels; the last is French Tech and Metropole. The next could be Green French Tech, but curiously there are some companies already called "green tech". Among them are Greentech [GRE 15a] that since 1992 has been developing and producing active ingredients from plants, algae, microalgae and biotechnology in cosmetic, pharmaceutical and nutraceutical fields, and Green tech industries which sells electric scooters or solar panels. Another company called GreenTech [GRE 15b] offers products and services such as modular natural turf, green roofs, roof gardens and urban agriculture. Greentechmedia and many others, having added "green" to their name, focus on energy in general [GRE 15c, CNE 15].

The sustainable success (not sustainable development) is a condition of survival and an expectation of those who invest in the innovation. Everybody can be creative, but few agree on the components of the innovation ecosystems and few know how to manage the innovation process in the 21st Century. This chapter describes the main elements to consider for lifelong creativity and sustainable success and gives some tips.

5.2. Problem solving

Challenges and problem solving are the principal innovation engines. The present century created a need for new kinds of innovation:

– to fix the damages made by human (with five-dimensional (5D) spirit);

– to innovate in doing things;

– to innovate in education;

– to innovate for improving our life (what does improvement mean?);

– new professions – fixing, cleaning, greening and three-dimensional (3D) printing.

In general, innovation produces a solution for a given problem or challenge, or creates new needs. The capacity of problem solving is one of

the most useful. Many various approaches were proposed and are currently used. We focus on the knowledge-based problem-solving approach. This "philosophy" is represented in Figure 5.1.

Figure 5.1. *Knowledge-based problem-solving method*

The deep understanding of a problem in its context is 80% of a solution. A vision of something great that may change the human condition can be the innovation trigger. Through the interaction with involved persons, this vision defines objectives to achieve. The related strategy will decide priorities and how the knowledge will be used to achieve goals (actions). However, a deep knowledge of context and motivation may influence the way to solve a given problem or even modify the problem to solve. Context may contain knowledge of policies, financial and tax systems, laws, funds available and environmental requirements. The results of actions strongly depend on the motivation of a person or team concerned. The impact of the decided actions should be evaluated to improve the actions if needed.

5.2.1. *Motivation*

What are our motivations? The main motivation for innovation may be personal satisfaction, making money, become famous, helping people in their work or improving their life conditions. A few may focus on planet protection, living in peace, be satisfied with little and be happy, privileging knowledge over money. This topic has been studied by numerous philosophers, psychologists and other specialists. Many different organizations and utopia were attempted, leading sometimes to disastrous results.

The decline of developed countries has multiple causes; one of them is the motivation to have more. Industrial commercialization of numerous devices or various applications of nanotechnologies are clearly motivated by generating more business and do not care about the accumulation of waste,

or are not concerned with the long-term impact that may have on living organisms absorbing the nanoparticles in various forms.

Persons who work too much and are stressed dream about well-being. Researchers dream about the Nobel Prize and companies dream about sustainable success. Their problem solving will be strongly influenced by their motivations.

5.2.2. *Understanding the problem to solve*

The essence of innovation is the understanding of a given problem, taking into consideration its context and applying knowledge with the aim to find a solution or invent something radically new (disruptive innovation) and useful for society. The disruptive innovation involves the knowledge of future users' motivations. The art of asking the right questions may help, but it is not taught at school. Why future customers need it, what the connections with existing environment are, what the best solution is, how this solution will interact with the environment, what impact it will have and how far it will change the natural context are only few examples of questions to ask.

Problem solving requires humility and questioning: has something similar already been invented? What are the connections with past knowledge and the existing environment? Is it possible to find a solution by observing nature? What impact could this solution produce? This is opposite to current attitudes. The best solutions are simple, but not easy to find.

5.2.3. *Solutions from the past and alternative solutions*

Humans have always produced tools for everything. The recent exposition at the Smithsonian[2] attests the ingenuity of the human spirit across time and culture. "Materials may vary, but they're using the skills and materials of their time, whether it's using the gut skin from beluga whales to create an absolutely windproof and waterproof parka, or technology of our contemporary time to look at the Sun, millions of miles away, to understand how what happens on the surface of the Sun reflects what is happening to us here on Earth. It's about how we push ourselves, as humans, regardless of where we are and what period we're from." (Matilda McQuaid, the

2 http://www.smithsonianmag.com/smithsonian-institution/nearly-two-million-years-innovation-told-through-tools-180953578/.

museum's deputy curatorial director [MCC 15]). A total of 175 tools were selected to represent human design. Unfortunately, this exposition is not available in virtual visit. Many of them do not need electric energy to work.

The *Saudia Aramco World*[3] magazine provides information on Arab Science. However, it is not always evident who invented things first.

The Internet facilitates access to information only if someone registered it. There are many books and patents that nobody has read for different reasons, such as publication language or simply lack of interest in the past. This is why curiosity and humility are so important, as well as knowledge transfer. Considering this, we will be able to switch from arrogance to humility.

Finding alternative solutions requires the art of thinking "without borders" between domains.

5.3. Innovating in harmony with environmental intelligence

The intelligence of nature – that of plants, insects, animals, ocean cleaning and other cycles – has inspired many. All these wonders enhance mankind's creative intelligence and are an inexhaustible source of inspiration and knowledge.

From the beginning of humanity, the surrounding world has been studied, but most of this knowledge has been lost for several reasons. Knowledge was considered as a privilege of few and not shared. My father who was knowledge "hungry" said, "the only wealth we can give you is the curiosity and the love of knowledge". Today, we can observe the knowledge retention and the lack of transfer. Knowledge is still considered as power, but having just a small amount of it in a specific field is not sufficient to understand the interactions and impact. Sometimes, a discovery is made by searching the real causes of an event. For example, unexpected mortality of kudus led to the discovery of some proprieties of leaves they absorbed [MIN 13]. This experience like many others demonstrated that every effect may be a result of complex chain of causes.

3 http://saudiaramcoworld.com/.

5.3.1. *Minds of plants*

Plants have been always used to take care of health or to kill. The deep knowledge of their properties is explored by phytotherapy to produce drinks and cosmetics. *Encyclopaedia Britannica for Kids*[4] provides an excellent explanation on plant usages, on plants for food, shelters, medicine, fuel, clothing and paper production, and puts emphasis on the contribution of plants to the balance of nature. "Humans are dependent upon plants. Directly or indirectly, plants provide food, clothing, fuel, shelter, and many other necessities of life. Humankind's dependence on crops such as wheat and corn (maize) is obvious, but without grass and grain the livestock that provide people with food and other animal products could not survive either".

The fact that plants are able to adapt is also known. Flowers follow the Sun, fold their leaves if they lack water and feel the geological disturbances such as faults and underground rivers. Globalization has made it possible to buy trees and plants from all over world. While some are dying, many adapt to new conditions.

Plants are equipped with memory and a nervous system. They are able to feel and protect themselves. In late 1998, during the severe drought in South Africa, the food for wild animals became scare, only acacias resisted. The sudden death of kudus were observed. The scientists investigated the reasons behind this death of healthy animals. After analyzing their stomach content, they discovered the reason for the kudus' death – the low rate of fermentation caused by a high level of tannins. In fact, the acacia leaves protected them from eating leaves by emitting gas and generating tannins – the combination of the two killed the kudus [MIN 13]. Numerous experiences demonstrated that plants are endowed with sensors, have the seductive power to attract pollinators or "food" in the case of carnivorous plants, by colors and smell.

They are also able to adapt and work in collaboration with other species. Sergiy Shemet, a researcher at Dnipropetrovsk National University, Ukraine, states "I've been interested for some period in plant electrophysiology and investigated literature on the topic and then realized that formal "intelligence" should not be directly applied to plants. They are brilliant, "inside-out" creatures, breathing by their surface, not only consuming O_2,

4 http://kids.britannica.com/comptons/article-206598/plant.

but also producing it, never hurrying – so plants don't need to move fast and make decisions in real time" [SHE 14].

All these are controversial to animals. However, plants express their "intelligence" in the course of evolution. If we see how they developed very smart environmental features, we will be surprised that they are no less intelligent than animals [PAT 76]. Also, electrophysiology and signal transduction in plants are very promising fields for investigation – spike potential on the membranes in plants develops in dozens of seconds [GRO 76], while in animals – in milliseconds. He studied abiotic plant stress. Research on allelopathic interaction between plants was largely founded by Andriy Grodzinsky [GRO 92]. The allelopathic interaction is well known by organic cultivators. It is the main reason for crop rotation. Rotation allows decreasing the use of herbicides. It also supports the development of microflora in the soil and assists the survival of useful insects. However, the intense farmers continue to grow monoculture and use artificial fertilizers, which lead to the depletion of the soil.

Color is a base of interaction between plants, insects and humans. Shemet's research and that of his teacher Volodimir Fedenko focuses on one unusual aspect of interaction. Among three types of metabolism – material substances, energy and information – the last metabolism gains increased interest in studies. Plants had to interact with pollinators during mutual evolution; therefore, they developed lots of features to optimize this interaction. Briefly, there are common bases for communication between plants and insects (and humans, in part) – the range of plants' colors corresponds to the range of insects' visual ability. By taking into account insects' ability to see ultraviolet (UV), they obtained a very interesting "color gamut" [CHI 94]. Humans can see other colors, overlapping in some regions (whilst lacking UV, human vision extends into the red end of the spectrum). Certain types of plant coloration reduce informational dimension and facilitate interaction [FED 02]. Plants color themselves for bees, not for humans; so we cannot see such features as nectar guides and other patterns of coloration. Shemet relishes studying these aspects since flowers are always beautiful! Of course, when flowering plants (angiosperms) evolved from gymnosperms, and developed huge variety of anthocyanins, they could not "predict" that these beautifully colored compounds would be exceptionally useful years later, allowing plants to cope with the excess of heavy metals in the environment, caused by humans. However, while Nature was playing with anthocyanin pigments to tune the coloration of flowers, it

turned out that one "side-effect" of these compounds allows anthocyanins to chelate heavy metal ions, eliminating them from cell metabolism [FED 05], thus allowing plants to tolerate the most toxic metals, such as cadmium [SHE 05].

Also being studied is a small microenvironment of a plant's root – the rhizosphere – and its interaction with heavy metals, herbicides and multicomponent pollution, as well as a plant's strategy for surviving during combined abiotic stresses.

Medical properties of plants have been studied and explored in medicine for years. Plant phenolics and carotenoid compounds have medicinal and biofortifying properties, such as Echinaceae. Secondary metabolism in plants remains largely unexplored.

Plants have an ability to perceive the environment and to feel the world around itself. They explore opportunities (twisting around a branch) [BAL 05]. Plants have the ability to protect themselves from dangers (their leaves being eaten) by generating gas which is able to kill predators. Plants are also used to clean water and purify air, remove pollutants or radioactivity. The last property has been studied in Chernobyl and Fukushima as well by other researchers [HEN 14, EVR 14].

Stefano Mancuso, a plant neurobiologist, explores signaling and communication at all levels of biological organization, from genetics to molecules, cells and ecological communities [MAN 13].

We have mentioned here only a few pieces of research on plant intelligence that use multidisciplinary and system approach. There are many other pieces of research exploring this large domain, but most of them focus on specific areas. For example, the architecture of carnivorous plants includes all the ways in which to attract insects by colors and various and beautiful forms and how they are presented from escaping [LAB 12]. Why can they not be used instead of insecticides?

5.3.2. *Copying nature: biomimicry*

"Biomimicry is an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and

strategies."[5] Careful observation of nature may bring sustainable solutions for design. Nevertheless, the deep knowledge about the given organisms (insect, plant or animal) and their interrelations is vital to achieve the desired effect with a minimal impact on natural ecosystems.

Janine Benyus states that "in a biomimetic world, we would manufacture the way animals and plants do, using sun and simple compounds to produce totally biodegradable fibers, ceramics, plastics, and chemicals. Our farms, modeled on prairies, would be self-fertilizing and pest-resistant. To find new drugs or crops, we would consult animals and insects that have used plants for millions of years to keep themselves healthy and nourished. Even computing would take its cue from nature, with software that 'evolves' solutions, and hardware that uses the lock-and-key paradigm to compute by touch" [BEN 97]. But such way of considering things requires curiosity and motivations other than money.

To face today's challenges, we can learn from our environment – from dolphins: how to communicate in water; from prairies: how to grow food in resilient ways; from kingfishers: how to break through boundaries; from termites: how to build a sustainable building without air-conditioning; from bees how to optimize useful surfaces in buildings; and from humpback whales; how to create efficient wind power.

a) b)

Figure 5.2. *a) Honeycomb and b) Honeycomb tower (source: http://www.buro247.com/me/lifestyle/design-and-architecture/paris-eco-towers-by-vincent-callebaut.html)*

Honeybees (*Apis mellifera*) construct their honeycombs with wax secreted from their abdominal glands. The honeycomb is regarded as an engineering marvel. For centuries, mathematicians suspected that partitions in the shape of hexagons were better than equilateral triangles or squares – or

5 Definition of Biomimicry Institute, biomimicry.org.

any other shape – for maximizing space with the least amount of building material. But they could not fully explain why. In 1999, Professor Thomas C. Hales [HAL 01] provided mathematical proof for the advantage of what he called "honeycomb conjecture". He demonstrated that regular hexagons are the best way to divide a space into equal parts with minimal structural support. By using hexagonal cells, bees can make the best use of all the space available to them, produce a light but sturdy honeycomb with a minimum amount of wax and store the maximum amount of honey in a given space. Honeycomb inspired architecture in creating resilient and space-efficient buildings. The aeronautic industry uses honeycomb panels to build planes that are stronger and lighter and thus use less fuel [CRO 09].

Locusts migrate in large swarms without colliding with each other. The largest swarms have covered hundreds of square miles and consisted of many billions of locusts. Behind each locust's two compound eyes is a motion-sensitive neuron called the lobula giant movement detector (LGMD). When a collision appears imminent, these neurons send messages to the wings and legs, prompting the locust to act. Its reaction speed is five times faster than the blink of an eye. Inspired by the locusts' eyes and neurons, scientists have developed a computerized system that allows a mobile robot to detect and avoid approaching objects, without the need for complicated radar or infrared detectors. This technology is also applied to vehicles, providing them with a fast and accurate warning system that could reduce collisions.

Animals are especially good at collision avoidance even in a dense swarm. In the future, every kind of man-made moving machine, such as ground vehicles, robots, unmanned aerial vehicles (UAVs), aeroplanes, boats and even moving toys, should have the same ability to avoid collisions with other things, if a robust collision detection sensor is available.

Scientists in Switzerland, Germany and France working on the CURVACE[6] (CURVed Artificial Compound Eyes), the EU project, explored how the insect eye works in order to develop miniature eyes. It is hoped that an artificial compound eye could be used in areas where panoramic motion detection is primordial. Possible future uses include being attached around automobiles for efficient obstacle detection, e.g. during parking maneuvers, for automated vehicle guidance, or for the detection of vehicles or pedestrians that are getting too close. Another possible use is being implemented in micro-

6 www.curvace.org.

air vehicles for vision-based, collision-free navigation, e.g. during landing or for obstacle avoidance, such as in rescue operations. The compound eye features characteristics and functionality similar to the eye of the Drosophila fruit fly and other arthropods. The eye, a small (12.8 mm diameter) cylindrical object, is made up of 630 "basic eyes", called ommatidia, arranged in 42 columns of 15 sensors each. Each ommatidium is composed of a lens (172 microns), combined with an electronic pixel (30 microns). These sensors have advanced optical properties, such as an undistorted panoramic field of view of 180° × 60° and a large depth of field; they can also adapt to a wide variety of lighting conditions.

In order to reduce our dependence on fossil fuels, scientists have drawn inspiration from the butterfly wing system to improve the light-harvesting efficiency of solar collectors [ZHA 09].

In fact, butterflies are equipped with a natural solar system to heat their body. Their wings contain tiny scales that serve as solar collectors. When butterflies spread their wings and bask in the sun, these solar collectors are soaking up sunlight to warm the butterfly's body. The wings of some species of swallowtail are remarkably efficient at trapping and absorbing sunlight. The association of their dark pigment and the structure of overlapping scales coating their wings make them very efficient. The scales contain rows of honeycomb-like holes separated by inverse V-shaped ridges that funnel light into the holes. This structure traps the incoming sunlight, making the wings extremely black and warming the butterfly. It is still unknown how these black wings absorb so much sunlight and reflect so little [UNI 15].

The multifunctional wings of Morpho butterflies are composed of nano/microstructures that are presently beyond the capabilities of any current technology to reproduce them artificially [MIY 13]. That carbon nanotube-containing composite adopts honeycomb-shaped networks when simply self-assembled on Morpho butterfly wings used as a template. The unique nano/microstructure of the composites exhibits multifunctionalities such as laser-triggered remote-heating, high electrical conductivity, and repetitive DNA amplification. The Miyako *et al.* [MIY 13] study highlights the important progress that has been made toward the development of smart nanobiomaterials for various applications such as digital diagnosis, soft wearable electronic devices, photosensors, and photovoltaic cells.

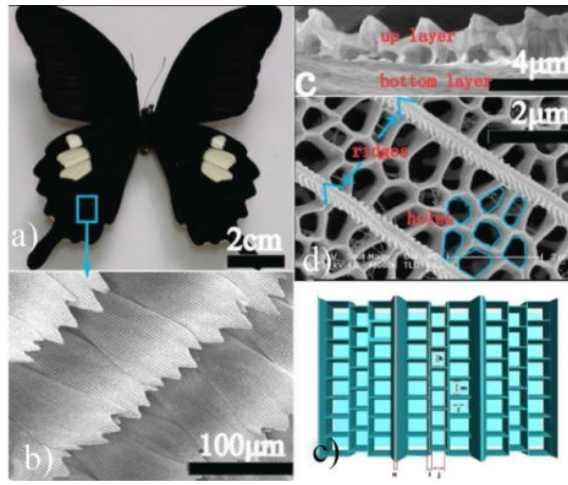

Figure 5.3. *Nature picture and low-magnification optical microscopy, low-magnification FESEM (Field Emission Scanning Electron Microscopy) images and high-resolution FESEM images showing the wing of the blue male (a-c) and black male (d-f). The insets in the lower left-hand (c, f) corner show the two-dimensional, logarithmic Fourier power spectra of square areas selected from the images [ZHA 09]*

Reducing the energy required for heating may be also inspired by penguins' thermoregulatory system. They are warm-blooded and equipped for surviving in the coldest places on Earth. Their feather structure makes them almost impenetrable to wind or water and provides 80% to 84% of the thermal insulation. The dark feathers on their back absorb heat from the sun to helping them to warm up. To reduce the heat loss, penguins keep their flippers close to their body and shiver to generate additional heat. King and emperor penguins are able to rest their weight on their heels and tail, reducing contact with the icy surface and the heat loss. Thanks to a complex heat exchange system in emperor penguins' nasal passages they can recapture up to 80% of the heat escaping through their breath. Penguins' circulatory system, based on counter current heat exchange, helps in conserving or releasing heat to keep the temperature constant. The blood flowing to the flippers and legs transfers its heat to blood that is leaving the flippers and legs [WAR 01]. This technique may be used to optimize the use of energy in building systems.

The horse leg system has inspired researchers and designers of quadruped robots for field missions in a natural environment[7]. The current legged-locomotion devices are complex and of low speed particularly if high payloads have to be transported. They are far from reaching the performance of biological quadrupeds in natural environments. The horse capacities are superior to any other animal of equal size; its leg system is able to provide speed, endurance, agility and strength with little energy spent thanks to elastic energy storage.

The horse rear legs are relatively lightweight, yet strong enough to deliver very large thrusts and to sustain tremendously heavy loads. The horse hip joint is mainly a hinge to turn the thigh forward and backward. The muscles and tendons focus their effort in simple joint motions. And all this with enough economy of effort to provide endurance, which is achieved by means of elastic energy storage in tendons during certain phases of the locomotion cycle and the later return of this energy to the more exigent phases [HIL 87]. The muscles in the legs act also as dampers to avoid injuring its tendons when horse gallops.

A kinematic model of a robot leg inspired by those of a horse is proposed by Garcia *et al.* [GAR 11].

The lotus leaves are known to be superhydrophobic and self-cleaning due to the waxy low surface energy material and hierarchical roughness of their leaf surfaces. This quality, created by tiny structures on the leaf surface, means that water is repelled and any dirt that may have collected on its surface is removed. As a result, lotus leaves always stay clean and photosynthesis is never affected. The self-cleaning effect of a lotus leaf is caused by contamination being attracted to a rolling drop of water on the leaf's surface. Due to an extremely low surface energy of a lotus leaf, any contaminants are attracted to a water drop and are removed from the leaf surface upon drop movement across the leaf. In order for this effect to happen, water should roll freely on the leaf surface driven only by gravity forces. This property is exploited for self-cleaning surfaces. Applied to photovoltaics (nanocoating), it reduces the degradation of their output due to self-cleaning effect [XCO 15b].

7 http://biomimetics.mit.edu/

The American house spider (*Parasteatoda tepidariorum*) produces a web with adhesion that can be strong enough to stick to a wall or weak enough to detach from the ground and thus acts as a spring-loaded trap for walking prey. The spider anchors its web to a wall, a ceiling or a similar surface by weaving highly adhesive patches of silk called scaffolding disks, which are strong enough to withstand the impact of flying prey. Researchers at the University of Akron, Ohio, USA, have discovered that, on the other hand, the patches of silk that are attached to the ground – called gumfoot disks – have an entirely different architecture or construction. With far fewer attachment points than scaffolding disks, gumfoot disks allow the web to detach with ease and yank off the ground any prey that has walked into it. They are working toward developing a synthetic adhesive that mimics this intelligent design strategy employed by the house spider[8]. Scientists hope to create an adhesive that can be used both for common bandages and for treating bone fractures.

The same spider silk inspired Jalila Essaidi, the Dutch artist who, along with the Forensic Genomics Consortium Netherlands, created a piece of "bulletproof" skin from spider silk and human skin cells and found that it indeed can repel bullets – as long as they are not traveling too fast. The bulletproof skin showed its superiority over normal human skin by stopping a bullet fired at a reduced speed. But it fell short of surviving a shot at normal speed from a .22 caliber rifle, the benchmark for protection for a type 1 bulletproof vest. The result did not discourage her. She just wanted an art project demonstrating the relative concept of safety [TEC 11]. Do we need the protection against bullets or to educate our society?

Many other examples of exploring the nature design in industry are available and the interest in biomimicry is growing. However, the connection with natural ecosystems is not taken into consideration in most cases.

5.4. Conditions for sustainable success

Innovation should be considered as a component of the Earth's biosphere and bring a contribution to enhancing life. Thus, it impacts directly or indirectly living things and the environment – the atmosphere, the land and

8 http://www.uakron.edu/im/online-newsroom/news_details.dot?newsId=9c0b4b18-3e91-4750-8426-00928d5b89b7.

the oceans – from which they derive the energy and nutrients needed for life. Human activity, including innovation, should fit to natural cycles. Observation, discovery and the association of related knowledge provide the favorable conditions for successful innovation providing tangible and intangible benefits for all participants. It is a never-ending activity.

Many efforts have been made and a huge amount of money has been spent to produce the innovations we know and those that will be available in the near future. The spectacular progress is observed in technology, medicine and other domains but the impact on solving the current challenges such as employment, social inclusion or pollution is weak. Much hope is still in technological innovation as well as in social and service innovation. Responsible Research and Innovation is entering to the H2020 programs; we hope that the appropriate methods of evaluation allow the estimation of impact beyond the CSR requirements.

We are living in a strong technological-push era. Eyes on the screens full of various applications and advertisements, headphones in the ears, wearing fitness and health devices, guided by connected objects, having virtual friends, constantly watched by street cameras and, overhead, by drones, do we really enjoy life? Industry and medicine are powered by robots; personal robots enter into our home and office. Is the technology helpful in discovering our brain capacity or switching it off? Is there any room for the human element? Does innovation have to continue this way?

We are on the crossroads of the industrial, digital and knowledge eras. What does sustainable success mean in this context? The most important challenge is to change values – from “buy and have more” to “have a better life”, including the quality of the air we breathe, water we drink and food we eat, time we spend with family and real friends, and enjoying nature.

With the aim to preserve a balance of the ecosystem, the sustainable innovation should consider the 5D impact: technological, economic, environmental, social and cultural. The “green” innovation is a step toward a sustainable future, but it considers the current behaviors; however, we have to change the way we use resources.

Before designing and producing something new, we should consider the reuse of existing products or repairing it if this is possible. The greedy economic system which produces things to throw out should be replaced by

a more sustainable one. The eco-design approaches include recycling, but repairing is more sustainable and creates local jobs. The nature-inspired design is promising through its premise to take into consideration not only technical solutions but also the integration and interactions with natural ecosystems. Poor nations know how to recycle and reuse everything, we can learn from them.

Knowledge and the art of problem solving facilitate finding simple solutions. Sometimes, past knowledge is valuable in that it is available and can be applied into the current context. A solution for a given problem may have been fluttering right in front of our eyes if only we had looked for it by observing nature. Observing nature may lead to smart ecosystems, for example, aquaponics [BER 15]. Fish produce ammonia (among other things) as a waste product of respiration and their general metabolic processes. While ultimately deadly to fish, this chemical is a potential boon for plants. All they require is a little help from naturally occurring and largely omnipresent nitrifying (meaning they convert the ammonia into nitrates) bacteria, which reside in a porous, inert growing medium, inside a plant-growing bed. Water from the fish reservoir is pumped into the bed, where the bacteria process the ammonia into a form available to plants, which then take it up and flourish. The water, now "biologically filtered", is returned to the fish tank, gaining oxygen along the way. The net result is healthy, "happy" fish and strong, productive plants with reduced water consumption.

The ability of making multidisciplinary connections helps to find solutions to complex problems, for example, dismantling of nuclear power plants. Connecting people from several related areas fosters cross-pollination. Today, clusters provide common services but cross-fertilization is rather weak. Our life is too short to know everything; there is a reason to connect with those having complementary knowledge and experience to be more intelligent together. Such a way requires humility, curiosity and the ability to listen to others.

Global, systematic and holistic thinking facilitate the understanding of a given problem and its context that may influence a solution.

3G (generation) organization of innovation may be more successful than 1G only. Experienced people are the source of knowledge; UK and Japan have recognized the power of the older generation. Connecting the active

(second generation) with the first (geeks) and third may give surprising results.

Better knowledge and the use of local resources avoid the transportation and create local jobs. Nevertheless, it involves an intelligent management of the intellectual capital – knowing and planning it in relation to the regional projects and vision.

Although diversity today is mainly considered as a challenge, it can be considered as an asset too. The knowledge of cultural strengths and the right exploration of them allow composing the more successful project teams than monocultural ones. For example, the French are creative, while the Americans are gifted for business; together they can achieve more rather than separately.

The innovation ethics will avoid the invasive solutions affecting privacy and will guide designing of useful products and services that will make life easier. For example, a virtual assistant should be intelligent and able to provide directly the right answer to a customer's or visitor's questions.

Well-being is an important goal in the world where everything goes too quickly and where we are overloaded with information or tasks to perform "for yesterday". For Sony CSL, dreaming, thinking, organizing and managing are important for fostering innovation.

The intensity of working to produce more and sell more deteriorates our living conditions. Should we work less? The French reform on reducing working hours to 35 per week was introduced in 2000 with the aim to share work and reduce unemployment. Unemployment is still high and 35 h/week is exceeded in many companies. Carlos Slim's suggestion in 2014 was to reduce the working week to 3 days.

Well-being is not about being young, taking enhancing pills, undergoing surgery or other means. According to Irena Gumowska, the Polish journalist and promoter of healthy eating and well-being under difficult conditions, the most important thing is to have an organized and comfortable life, to respect the environment and manage one's own time, to take care of one's physical and mental health, of oneself and the surrounding environment [GUM 68]. She puts emphasis on eating wisely. She wrote several books to explain what and how to eat to keep in good health [GUM 96, GUM 02].

The only way to know whether progress is being made to measure it using the right indicators – key progress indicators – another KPI – including the right use of technology, training, stakeholders' networks, environmental impact, leadership, image, alliances, tangible and intangible benefits and others that apply in a given situation. Key planet indicators, key success indicators, key value indicators and key happiness indicators may be a part of new metrics as a function of the motivations. However, the question to ask is: what does progress, success or happiness mean for participants?

We also need room for serendipity.

5.4.1. *Removing the barriers*

Most barriers are related to industrial systems and a separation between research and business. Besides fundamental research, the research programs should be closer to the needs and businesses. In France, it sounds like a utopia, but it is the only way to invent useful things, even if it is extremely challenging. Evaluation systems must evolve and must be beyond publishing, patents and the Nobel Prize, with the aim of being closer to economic reality and to motivate researchers to participate in improving society. Contest criteria should reward teams as well as individuals, with the aim of encouraging collaboration. The role of education is to teach problem solving methods using appropriate knowledge, rather than assessing individual knowledge in separate domains.

As in the United States, entrepreneurship has to be a part of educational programs in Europe too. There are still too many barriers, such as high taxes, inflexible labor laws and a strong lobby of unions defending social benefits. The goal of the unions has changed, but the understanding of a new goal, such as jobs for all, is not evident. There is a need for balanced policy and entrepreneurs' claims for sustainable development.

Today, the access to funding is difficult; there is strong competition and the amount of allocation in France and Europe is decreasing to encourage crowdfunding. The funds are not always allocated to the right projects and teams because of traditional evaluation system. Applying to the European or national program requires a lot of work and time; the selection system should be simplified to open access to funds for innovative SMEs and research projects with a high potential of impact. The awareness about the

impact (5D, on health and living) should be among the acceptance criteria, as well as the integration to natural ecosystems.

Paradoxically, technological progress and large possibilities offered are not fully explored to support the whole innovation process and eco-activities. As usual, people refer to what they know; new technologies with embedded intelligence and those for knowledge processing should be taught, better known, used and managed. Software designed with the users helps instead of perturbing them. Customers and pilot users may provide considerable help all along the innovation lifecycle.

Science was split into various areas and evaluation is made in the given area. By splitting everything into fields, we lost the links necessary for deep understanding. The existing research system in France and probably in many countries should evolve; politicians are aware of this fact, but nobody dares to start the process of renewing based on more efficient models than those from the last century.

Most of the French government members are lawyers. To be closer to reality, they should have experience as entrepreneurs. The numerous crises demonstrate that the political system also needs to be renewed with the aim to find an effective solution to today's difficult challenges.

As mentioned before, a precautionary principle is a strong barrier for innovation. However, politicians are convinced that it is necessary to keep this principle because the population is afraid of the unknown and to avoid the consequences if any. The discussions are ongoing. In awaiting decisions, the simulation and evaluation of impact may provide some proof and confirm assumptions. Sometimes, the effect may be visible after several years of exploration; this is why the continuous feedback from experimentation and exploitation is necessary.

Many stakeholders are used to perpetuate the same mental schema – to reuse that which they already know, while innovation requires the art of combination of the various approaches. The challenge for new education is to learn such "brain gymnastics" and to combine multidisciplinary knowledge for solving challenging problems. Working on problem solving is much more useful in life than absorbing knowledge that we will never use and often forget after passing the exams. We need passionate teachers who are able to inspire interest, vocations and future leaders.

The diversity is not an excuse for lowering the educational level; schools should teach the right exploration of cultural assets.

Another challenge is to discover and develop our brain capacity beyond 10%. Observing gifted persons, having special capabilities as discovering water sources, natural or human-made disturbances of our energy, we can acquire capacities that we could never learn in school. There is certainly a lot to discover.

5.4.2. *New professions: perspective for jobs*

Table 2.1 presented the necessary evolution of current jobs. In today's challenging and exciting context, we need new professions such as thinkers, visionaries and facilitators of connections. These are not taught at school and there is no competition for thinkers and visionaries, nor a Nobel Prize.

A new mindset is required connecting intuition, imagination and innovation [AMI 14]. The knowledge cultivators [MER 11] are already practicing the new capacities such as the art of using knowledge from the past, building collective knowledge, facilitating collaboration and collective intelligence, mastering "intelligent" technology and thinking differently. The verification of impact before doing has to become a new attitude.

We need all kind of optimizers: for the correct use of resources, for designing smart travel systems, able to combine the different approaches and cultural optimizers as well to take the best from diversity with the aim of being smarter.

To reduce health costs, it may be useful to know how to use and combine the various approaches, such as traditional Chinese medicine, Indian yoga, those of Native Americans and others teaching the knowledge of our body and their connections with the universe as well as simple methods keeping us in good health.

All the above mentioned are not yet recognized by the system in use.

We need people who are able to imagine a better future, to think differently, to combine the past and today's knowledge, facilitating multidisciplinary connections, and ready to take risks to succeed. The

capacity of managing growing risks is also required to manage both generated by human and growing natural risks due to climatic changes.

While many efforts are focused on educating and training managers of sustainable development, it is not enough on the new capacity of double connection between environment and innovation: innovation for environment and from environment.

We need geeks who are fascinated by new technology and who are able to evaluate what is really useful and to promote it in their professional/school environments.

To reduce waste generated by bad quality and planned destruction, we need more people in order to be able to fix them and repair services such as with 3D printed spare parts.

To increase the quality and reduce waste, more energy should be invested in eco-design. These professions are just emerging.

The existing job search system, using the coded classification of known professions and lacking in effective association of supply and demand, should evolve or be replaced by effective and evolving IC management systems empowered by analogy-based search engines and natural language processing. Such an effective job finder is also a new profession. Such a search system will be able to offer the right job at all levels to qualified people. Educational systems have a difficult task in anticipating these needs.

Politicians have a great role to play in renewing the current systems; they need to be advised by visionaries and thinkers and be motivated in building a better future.

De Bono in his book *Future Positive* [DE 79] gives some tips and ideas to try, for example, new motivating systems rather than prison for criminals. Why not use technology and in particular peaceful and knowledgeable games to influence them? It opens a great opportunity for game designers, but who will sponsor such games?

Living in permanent stress and searching for well-being and happiness, we need to reconsider our professional and living conditions. New professions related to well-being are emerging and opening new possibilities.

Conditions for a Sustainable Future

Jeremy Rifkin [RIF 14] claims that “zero margin cost” is a trigger for a new economic system based on two things: collaborative commons and connected objects. He envisages a long-term application for society: “zero margin cost” will replace the old economy which is looking for an increase in productivity and a reduction in margin cost. This paradigm, which has been successful for years, is now leading to an end game. With the technology revolution, consumers have become prosumers; they produce and share for free. He considers that the freemium model is naïve because it does not stimulate premium on a large scale. Prosumers would rather share physical goods and services instead of buying them, which is happening already, but not on a large scale. Connected objects are everywhere: sensors on the roads full of driverless automatic vehicles, on factory floors, in back offices, retail shops, connecting all of us with everything. Big data is collected from devices; we will be able to create our own apps and smart analytics to use them and increase our productivity (to do what?).

Publishing on the Internet is free but Rifkin’s book is not on https://creativecommons.org/ and it is not free. Rifkin is a very good example of using the Internet for his own promotion but in reality, there are people who talk and people who know, and they are not always the same. Low-cost business and the free business model generate a disastrous and slave society, managed by the almighty Google, a world full of devices and “brainless” people driven by technology.

To face the crisis, individuals are freeing their imagination: they share houses, tools and cars today because we have to share scarcity.

According to specialists, it is too late to protect the planet; however, if each of us makes an effort, we will be able to improve this situation and cultivate new more respectful attitudes. Is it possible to dream about a sustainable future?

The basic question to ask is this: what do we need to be happy? The answers depend on motivations and refer in most cases to short-term vision.

Perhaps the solution is in becoming greener and innovating innovation, but it is certainly in turning the tide.

After some tries with switching from fast food to slow food and from faster, cheaper, better to slowing down, we can continue to build a collaborative Translator for the Future containing, among other things, the following:

– arrogance versus humility;

– greed versus happiness with little;

– relocation-out *versus* relocation in;

– cheaper workforce versus local talents;

– big versus small and smart;

– more and bigger to less, smaller and local;

– wealth versus quality of life;

– megacity versus mega pleasure;

– work versus pleasure (interesting work);

– big data versus world knowledge base.

It is time to switch from “quick business, having more and to show what we have” to an awareness about the beauty and resources that our planet may offer if only we take care of it.

A sustainable future requires a change in the way of thinking, changing values, models, attitudes through new teaching and learning – learning how to learn and ask the right questions, how to reuse and improve the existing knowledge and problem-solving methods, and how to make complex systems simple.

We need to reconsider the value of the brain without context (company), of work, manage our talents better and share experiences, taking more time for inspiring conversations.

A positive scenario for the future includes new ideals, new ways of being and new skills.

Take time to observe and read; sometimes interesting books are not on the Web.

Anticipate your contribution to the above translator.

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The objective of this book is to heighten awareness about the necessity to take into account the impact of innovation, not only its economic and social repercussions but also those on natural ecosystems. We wish to popularize the use of artificial intelligence approaches and techniques in order to conceive friendly and useful applications that aid humans in their work instead of replacing them and rendering their minds obsolete. Learning from nature and applying this knowledge to innovation may reduce its impact and risks, as well as encouraging sustainable innovation dynamics.

After the opening chapter sets the scene and provides an overview of current innovation fields, Chapter 2 provides the reader with important definitions and the different ranges of innovation. E-co-innovation processes, balance conditions, obstacles and paradoxes are also discussed.

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