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Innovation for sustainability: toward a sustainable urban future in industrialized cities

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Abstract Achieving a sustainable urban future has become an important focus globally. In this paper, three major themes of a sustainable urban future are presented: a low carbon society, cities in the context of an ageing population and revitalization of the urban–rural fringe. Visions of these themes, in the context of highly industrialized regions, are discussed. To achieve a low carbon society, the importance of technological innovations such as new technologies and systems applied in buildings (homes and businesses), industries, and transportation are emphasized. To adapt to an ageing society, a compact city is seen with responsive transport, infrastructure and services that cater to the needs of the elderly. To enhance the urban–rural fringe, the introduction of eco-industries, which can create opportunities for both sides, is proposed.

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Introduction

The world is becoming steadily more urban as people continue moving to cities and towns. According to the World Urbanization Prospects report, by the middle of 2009, the number of people living in urban areas (3.42 billion) had surpassed the number living in rural areas (3.41 billion) (United Nations 2009). As of 2009, already about 82% of North American populations live in urban areas, as do almost 80% of people in Latin America and the Caribbean as well as more than 70% of people in Europe and Oceania (Fig. 1a). In both Africa and Asia, urban dwellers represent about 40% of the total population. By 2050, the world urban population is expected to increase by 84%, from 3.4 billion in 2009 to 6.3 billion by mid-century. There are, however, significant variations between individual countries, and some major disparities in the level of urbanization remain among developing ones. Figure 1b shows the top 30 most populous countries, where more than three-quarters of urban dwellers lived in 2009. By 2050, 29 of the 30 most populous countries in 2009 will have more than 50% of people living in urban areas.

In addition, there is a continuing trend towards ever-larger urban agglomerations. In 2009, there were 21 megacities in the world, each with at least 10 million inhabitants, accounting for 9.4% of the world urban population. Megacities come about because of the fusion of several cities or urban localities that are linked functionally and form an urban agglomeration. It is projected that the number of megacities will increase to 29 in 2025, and they will be habited by 10.3% of the world urban population.

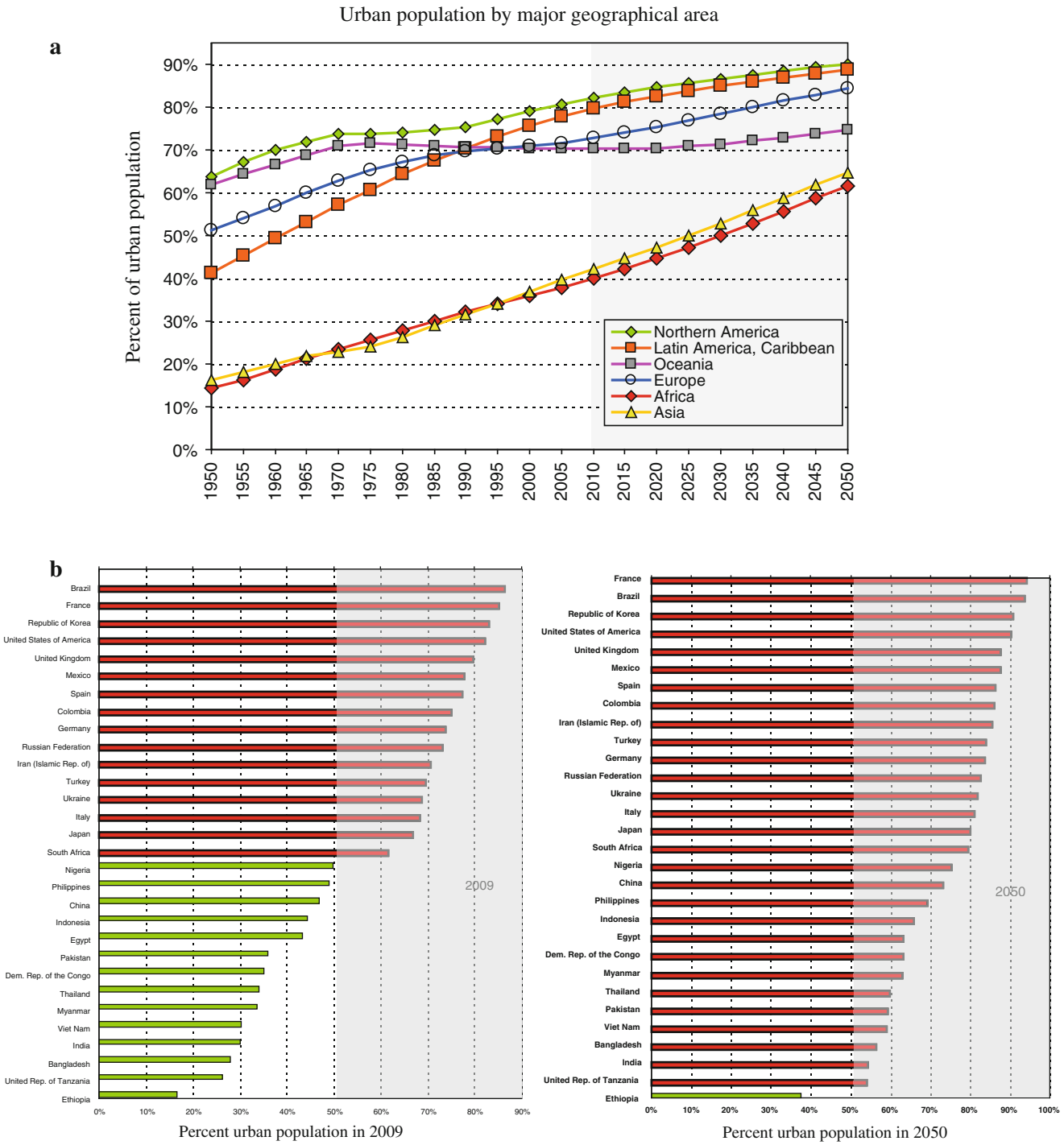

Fig. 1 Urban population data by **a** geographical area, **b** top 30 most populous countries in 2009 and 2050. Modified from United Nations (2009)

Presently, Asia has 11 megacities, Latin America has 4, and Africa, Europe and North America have 2 each. By 2025, when the number of megacities is expected to reach 29, Asia would have gained an additional 5, Latin America 2, and Africa 1 (United Nations 2009). On the other hand, these megacities represent only <10% of the global urban population. It is important to note that most cities have a population of <500,000, accounting for over 50% of the global urban population. These smaller cities are also considered to be more vulnerable because they lack the political and economic resources of megacities.

Urbanization usually accompanies social and economic development, but rapid urban growth on today's scale will lead to an unprecedented demand for resources to meet the

needs of people for food, shelter, transportation, energy, etc. (Tolley 1987; Parikh and Vibhooti 1995; Satterthwaite et al. 2010). It will put strains on the capacity of local and national governments to provide even the most basic of services such as water, electricity and sewerage (UNFPA 2007). In addition to these inherent problems of urbanization, additional challenges face urban centers, including ageing society and the impacts of climate change.

Demographic changes whereby the proportion of ageing population increases will also pose an additional burden to cities as they grapple with how to address the rising challenges from this group. Economic progress has been linked to declining fertility rates and improved hygiene related to clean water access and sanitation and advanced medical technology, etc. have accompanied an extension of life span, resulting in slower population growth and continuous ageing. Ageing is a global phenomenon and the ageing process is already underway in developed countries like Japan. Until the early 1980s, the pace of ageing in Japan was slower than in the United States and Europe, and only <10% of the population was elderly at 65 or older. But since then, the percentage started to surge, and in 2005 Japan became the fastest-ageing society, exceeding Italy as seen in Fig. 2 (Fuyuno 2007). In the developing countries in Eastern and Southeastern Asia, as well as Central and Eastern Europe, the aging process is expected to begin around 2020.

According to the World Health Organization (2010), from 2000 until 2050, the world's population aged 60 and over will more than triple, from 600 million to 2 billion. The proportion of older persons was 8% in 1950 and 10% in 2000, and is projected to reach 21% in 2050. This is the fastest growing age group. A high proportion of the increase is occurring in developing countries, where the number of older people will rise from 400 million in 2000 to 1.7 billion by 2050. In 2005, life expectancy in Japan and France was already more than 80 years. In developing countries, life expectancy is also rising: a child born in Chile, Costa Rica, Jamaica, Lebanon, Sri Lanka or Thailand can expect to live for more than 70 years. However, there are still several countries in Africa where the life expectancy is 40 years or below. There are also high inequalities within countries, in the United States of America, higher socioeconomic groups can expect to live up to 20 years longer than those in lower groups.

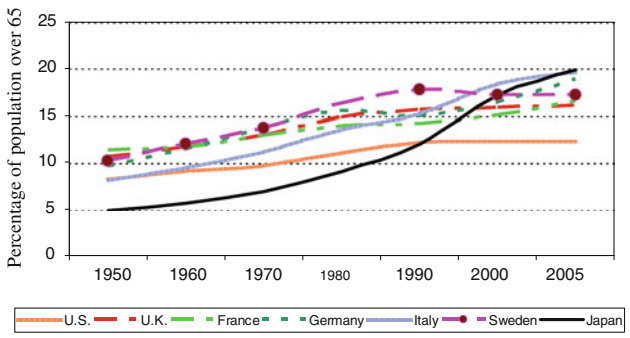

Fig. 2 Percentage of population aged 65 years and over across nations

The shift in age structure as a consequence of an ageing population has a significant impact on a diverse range of economic, political and social conditions. As more people live longer, retirement, pensions and other social benefits tend to extend over longer periods of time. This would necessitate changing the social security systems considerably for them to remain effective (Busse et al. 2003). Additionally, longer lives can also result in increasing medical costs and more demands for health services and facilities, as older people are more susceptible to diseases. Transportation and housing schemes have to be modified also to cater to a growing number of older people (Dickerson et al. 2007; Evans 2009; Bartley and O'Neill 2010; Webber et al. 2010).

Additionally, the impacts of climate change are also being felt in cities. Many large cities are located in low-lying areas as well as near coastlines and rivers. Their location makes them vulnerable to potential risks due to climate change such as intense typhoons and cyclones, increased sea level rise, extreme waves and storm surges (IPCC 2007a). Whenever rainfall occurs in urban areas, there is a risk of flooding as buildings, roads and infrastructure prevent the natural infiltration of water into the soil. Intense typhoons and cyclones bring heavy and prolonged rainfall, which produces large volumes of surface runoff that can overwhelm drainage systems. In many developing cities, there is inadequate provision for storm and surface drainage, resulting in floods that cause loss of lives, displacement from homes, extensive damage to buildings, infrastructure, agriculture; disruption of utilities, communication and transport services; disruption of tourism activities; spread of land contamination, among others (World Bank 2010). For instance, there are heavy impacts on water supplies and treatment plants, which often are located near rivers and coastal areas. This infrastructure, especially electrical and mechanical equipment as well as pipelines, can be affected severely by floods. Sanitation can also be affected as pit latrines and septic tanks become damaged, releasing fecal material into urban floodwaters.

Cities located in low level, coastal areas are also at risk from sea-level rise, waves and storm surges and other seaward hazards induced by climate change. Estimates for sea-level rise vary from 18 to 59 cm up to the end of the twenty-first century. Rising sea levels will increase the risk of floods. According to McGranahan et al. (2007), this area along the coast that is <10 m above sea level represents 2% of the world's land area but contains 10% of its total

population (i.e., over 600 million people) and 13% of its urban population (around 360 million people).

Increased migration to cities, ageing population and climate change impacts are some of the challenges facing the development of cities worldwide. In the face of these challenges, how then is it possible to attain a sustainable urban future? In this paper, a vision of sustainable urban future for highly industrialized nations in 2050 is conceptualized through the achievement of a low carbon society, in the context of extended life of the population and enhancement of vitality of the urban–rural fringe.

Concept of a sustainable urban future in industrialized cities

Cities are complex and diverse socio-technical systems and the creation of sustainable urban futures will need breakthroughs in technology, planning and management and the engagement of international cooperation with involvement of citizens, industries, researchers and policy makers, etc. Sustainability issues such as long-term patterns of material and energy consumption, water availability, infrastructure maintenance, inequities and conflicts, accessibility of public services (health care, education), and so forth are magnified in cities, and often display more complex features (Wiek and Smith in press). In the twenty-first century, achieving a sustainable urban future has become one of the most important focuses in the worldwide scope, especially against the background of ageing population and climate change. Since 1987, when the World Commission on Environment and Development issued its report, *Our Common Future*, the terms "sustainability" and "sustainable development" have been widely, if sometimes cynically, embraced by public and private sector bodies. The concept is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (Gibson 2006) "The development requires taking long-term perspectives, integrating local and regional effects of global change into the development process, and using the best scientific and traditional knowledge available." (Agenda 21, 1992) "The protection of the environment is essential for human well-being and the enjoyment of fundamental rights, and as such requires the exercise of corresponding fundamental duties." (Earth Chapter 1995)

Innovations for sustainability imply some process of creative thinking: the capacity to see a problem in a new way, perhaps even reformulating it as a quite different problem with a quite different range of possible solutions (Jerneck et al. 2011). Sometimes this can be quite fundamental, as when it was suggested that mental illness could be better treated outside mental hospitals, or that traffic planning consisted not in changing the city for the car, but in restraining the car in order to maintain the environment of the city. Sometimes it is of a second order, not involving a fundamental paradigm shift, but nevertheless redefining the problem and thus opening up a different range of solutions.

Regarding potential topics where the innovativeness of initiatives can be assessed, there are a number of important issues including green or environmentally friendly transportation systems, communications, for example wiring cities, economic regeneration like shifting a city from manufacturing to services or developments within specific industries, encouragement of social cohesion, new forms of more sustainable infrastructure, urban governance, as new forms of participation and democracy, indicators, monitoring, evaluation and benchmarking (EFILWC 2005). These could play important roles in contributing to the realization of sustainability from the aspects of technological innovation, government role, social concerns, economic incentives, etc.

As illustrated in Fig. 3, cities in developed nations are facing tremendous challenges that need to be tackled urgently, such as how to mitigate greenhouse gas emissions by 50% by 2050, problems of population decline and extended life of population, maintenance of the vitality of urban–rural fringe, issues of energy sources, restoring of bio-diversity, coexistence with nature, recycling of waste, and disaster adaption. They also must consider dangers of increasing violence, economic disparities, injustices, and public health issues. In this section, we focus on three major issues in industrialized countries: achievement of a low carbon society, cities in the context of extended population life and enhancement of urban–rural fringe vitality (Australian Government 2010).

Low carbon society

The world's urban areas account for around 80% of all carbon dioxide emissions (Satterthwaite 2008). In order to

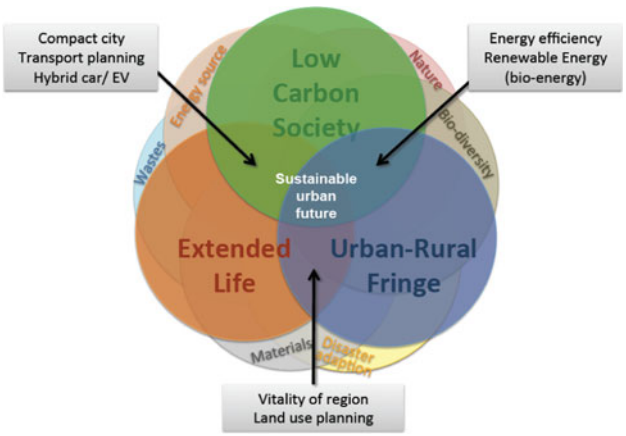

Fig. 3 Three major focuses among multiple themes concerning a sustainable urban future

reduce current global emissions by half by 2050, all countries need to unite and make efforts to establish a low-carbon society. According to a report by the Ministry of Environment of Japan in 2007, if per capita carbon dioxide emissions were the same worldwide when the 50% reduction is realized, the developed countries would need to reduce their per capita emissions by 70–80% comparing to the current level, and the developing countries would need to keep approximately the current level while sustaining their economies and improving quality of life. At the current trends, this cannot be realized. It is therefore important that all countries commit to take action toward attaining a low carbon society. Climate change is now recognized as an economic as well as an environmental problem. The costs of strong and urgent action both in mitigation of and adaptation to climate change are vastly outweighed by the future costs of inaction. According to the Intergovernmental Panel on Climate Change (IPCC), the expected macro-economic costs of moving to low-carbon societies are a <0.12 percentage point reduction in annual global GDP growth. Any delay in mitigation causes significant cost increases (IPCC 2007b).

In the ultimate sense, a low carbon society is a society that emits greenhouse gases only in amounts that can be absorbed by the environment. Achieving this would entail a system where all sectors, such as government, industry and households, carefully consider options that minimize carbon dioxide emissions. A change in lifestyle will be required where people forgo mass consumption and recognize the close coexistence between humans and the environment.

In Tokyo (Japan), the Tokyo Half Project (THP) was carried out to discover ecologically effective and economically rational technologies that can be implemented in order to reduce CO_2 emissions in the city by 50% (Hanaki 2002). Using the distributed object-based modeling environment (DOME) shown in Fig. 4, simulations could be carried out for solving large scale problems and improving urban sustainability. This model was able to compute total CO_2 emissions within Tokyo from various sources. It was also able to determine the effect of reductions from individual sources on total CO_2 emissions from the city. Measures could then be identified to aid consumers, businesses and industries in their efforts to reduce CO_2 emissions by half.

In transportation, the efficiency of cars can be enhanced by using lighter bodies, and the widespread use of motor-driven cars such as hybrid cars, electric vehicles, fuel-cell cars will decrease CO_2 emissions and overcome the related air pollution problem. If environmentally friendly transportation are advocated and consumers guided with relevant information such as the CO_2 emissions of each transport option, intelligent transportation systems will not only collect and provide traffic information, but will also enable advanced billing methods, thereby forming the basis of a low-carbon transportation system. Depending on the scale of the city, public transportation services including railways and buses can be implemented, and sophisticated management of these systems can be carried out using information and communication technologies.

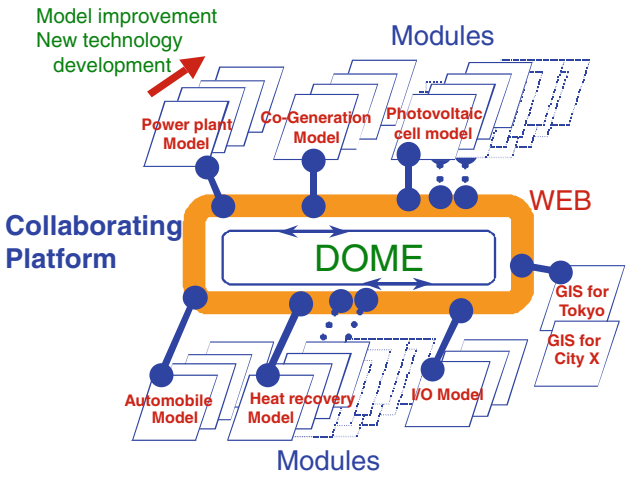

Fig. 4 The Tokyo Half Project (THP), demonstrating the potential to reduce carbon dioxide emissions from Tokyo

Living and working spaces can also be modified to reflect a low carbon output. This is how the image of spaces would look in a low carbon society. More energy-efficient and natural energy-based devices would be developed for common use. Control technologies using ICT would be utilized. Equipment such as lighting and air conditioning can be operated by the movement of people. Natural materials adapted to local weather conditions can be promoted for building houses. Efficient design for creating comfortable living spaces that require less heating and cooling can be developed. Construction methods and designs and renovation techniques to lengthen the life of housing (200-year houses) will be improved.

In Switzerland, although the whole nation's electricity consumption rose in 2010 by 4.0% to 59.8 billion kWh, the notion of the 2000-W society, where per capita consumption of primary energy is be below 2000 W and no more than 1 ton of greenhouse gases are emitted, has grown in popularity. Zurich has declared the 2000-W society as a political target for 2050 and has adopted this in its planning and development schemes. Heeren (2010) investigated how building parks can contribute in these reduction goals by means of a bottom-up building park model. In his study, assumptions regarding the most important physical drivers, as well as energy efficiency parameters of new buildings, building retrofits, building technologies and other energy applications were made and their respective leverage effect examined. On the basis of several assumptions, the model

showed that it is possible for Zurich to meet its goal of becoming a 2000-W society. Greenhouse gas emissions can be reduced by approximately 85% in 2050 compared to 2005 values. This would correspond to an annual per capita greenhouse gas emission of 0.3 tonnes CO_2-equivalent for residential buildings.

In the industrial sector, changes can also be made to reduce carbon emissions. Innovative manufacturing techniques will be adopted and low carbon power generation can be advanced through use of thermal power, renewable energy, and efficient transmission grids. The development of renewable energy is necessary. Even if the total amount of energy consumption can be reduced through changing people's lifestyles, and the efficiency or recycling of energy can be enhanced, there is still a need for large amounts of energy resources as reliance on fossil fuels cannot continue indefinitely. Efforts must be made to develop alternative energy resources such as hydropower, solar energy, wind power, biomass energy and geothermal so as to make a soft landing to a sustainable energy system.

According to Naso (2010), sustainable energy is the basis of sustainable development. Sustainable energy can be defined following the Brundtland declaration on sustainable development, that is, "the provision of energy such that it meets the needs of the present without compromising the ability of future generations to meet their needs". A number of authoritative studies have presented forecasts for energy supply in the twenty-first century. Conclusions drawn from those analyses have become a driving force for the development of the plan for the sustainable energy system. The common issues are concluded by Afgan et al. (1998) as follows: (1) prevention of energy resource depletion with scarcity index control, (2) energy efficiency assessment, (3) clean air technology development, (4) development of intelligent energy systems, (5) new and renewable energy sources, (6) environment capacity for combustion products, and (7) mitigation of nuclear power threat to the environment.

By adapting a closed product cycle (from raw materials, manufacturing, usage and disposal), it is possible to attain an ecologically neutral and sustainable framework for energy. Closed cycles of energy resources aim to achieve no consumption of non-renewable resources and also produce no impact on the environment. This will in theory be done using renewable resources, namely water, solar, wind, biomass and geothermal.

The reduction of GHG emissions by achieving a low carbon society will aid in mitigating climate change impacts and reduce its associated risks. However, even though reduction efforts are underway, measures must still be undertaken to deal with climate change impacts such as flooding. The best option is to take an adaptive approach that builds climate resilience in the development strategies. Hanoi, the capital of Vietnam, lies below the water level of the Red River, which makes it susceptible to constant flooding due to overflowing waters. One measure that is being implemented is the creation of spillways along the river dykes in order to reduce the possibility of embankment failure. Villagers around the spillways help with this endeavour. In Tokyo, to protect areas near rivers, embankments are extended. This would also allow for new development to take place on top of the embankment, providing an excellent urban development space. In the Netherlands, floating houses are constructed that adjust depending on the water level. The houses can accommodate a change in water level of up to 5.5 m (Herath 2010).

Moreover, technological innovations such as new technologies and systems applied in buildings, manufacturing factories, and transportation will play positive roles in contributing to a low carbon society. In detail, the important aspects for concrete actions may include the following aspects. One is to adjust measures to local conditions, closely combining local reality, and vigorously promoting science and technology innovation. The second is to strengthen scientific research and the generalization and application of technical achievement to improve the level of technological innovation and advancement. The third is the drive to improve the application level of information integration, making great efforts to enhance service and support capacity. Information construction will combine actual, clear direction; strive for top design, and integrate existing resources. The fourth is to promote energy conservation, special operations and demonstration projects to raise the willingness of stakeholders. The role of government is to promote, guide, and fully mobilize the enthusiasm of enterprises, through effective technology and management measures in social infrastructure, focusing on the aspects of construction and operation management, promoting energy conservation and emission reduction (Chen 2010).

Extended life of the population

A second concern is to tackle the problems caused by the extended life of the population. The demographic structure of the world is changing, with more people ageing. This will have an impact on sustainability, as future efforts must be made in the context of an ageing society. There is a need to move towards a demographic balance. Innovation is needed in many areas to address the challenges of ageing society (Edwards 2010).

Although population ageing can be seen as a triumph of modern society as it reflects improving global health, it also brings many challenges in both developing and developed countries. These include pressures on pension and social security systems, more demand for health care

services, and changing infrastructures and services to cater to elderly needs. As more people live longer, pensions and other social benefits are extended over longer periods of time, which considerably strains the current system. Longer lives can also result in increasing medical costs and more demands for health services and facilities, as older people become ill more readily. Disasters and emergencies impact older people severely. During the Indian Ocean tsunami in 2004 and the Great East Japan earthquake and tsunami in 2011, the highest percentage of fatalities were people 60 years of age and older (Takeuchi and Chavoshian 2011), and during the heat wave in Europe in 2003, the majority of the victims were people 70 years of age and older (World Health Organization 2008). Policies to protect older persons during emergencies and disasters are necessary. In planning urban infrastructures, the changing demographic structure should be taken into account.

Figure 5 illustrates a future vision of the compact city in an ageing society. The compaction of the city, promotion of modal share of public transport, bicycling and pedestrian walkways, assistance of new technology (e.g., LEDs), use of renewable energy (e.g., solar power), and improvement of energy efficiency would help to adapt the transformation to an ageing society and maintenance of elderly people's quality of life. This kind of integration of several planning targets and countermeasures will be a dominant trend in future development. Compact cities provide several benefits, including lower car dependency, reduced energy consumption, the reuse of infrastructure and previously developed land, a regeneration of existing urban areas and urban vitality, a higher quality of life, and the preservation of green spaces.

Concerning the ageing society, empowerment is the key feature. There are a substantial number of initiatives, especially in more deprived areas, that involve people more directly in decision making but not in a tokenistic way. A further theme is bringing in groups such as children, women or the elderly more intentionally into the planning process.

Urban–rural fringe

The third focus of this paper is to enrich the development of the urban–rural fringe. Known as the outskirts or the urban hinterland, the urban–rural fringe can be described as the area where the city meets the countryside. In most large cities in developing countries, there is increasing demand for land by industrial, commercial and residential use. Migration of people from rural areas accelerates the increase of population density in urban areas. In fact, many industrialized cities in developing countries, including Bangkok, Hanoi, Jakarta and Ho Chi Minh City, have expanded in area in the last 20 years (CICRED 2007; Nitayaporn and Parida 2004; Pham and Yaushi 2006; Han and Kim Trang 2008; Tran 2008; Abidin et al. 2009; Arellano and Roca 2010; Douglass 2010). Competition has increased because land is cheaper compared to the city center, there is good accessibility and more room for expansion of new roads, there is less traffic congestion, little pollution, and there is a more pleasant environment with more open spaces. Developers put up housing, science and business parks, power, water and sewerage plants, recycling facilities, factories, recreational facilities such as golf courses and shopping centers. These can cause some problems as large areas of the countryside is lost leading to lost habitats for wildlife, buildings may be out of character with existing rural buildings, small villages become absorbed and urbanized, traffic builds up and noise and other pollution increases. In many cases, the infiltration of the urban-industrial economy into the countryside increases the exploitation of natural resources in the rural society for the benefit of the urban economy (Cecchi 2010). It is often overlooked that urban and rural areas are one system and so the decisions taken for one area will have an impact on the other, though this might be unintended and unanticipated. It is the responsibility of governing bodies to promote urban growth while at the same time safeguarding public interest and protecting the environment in rural

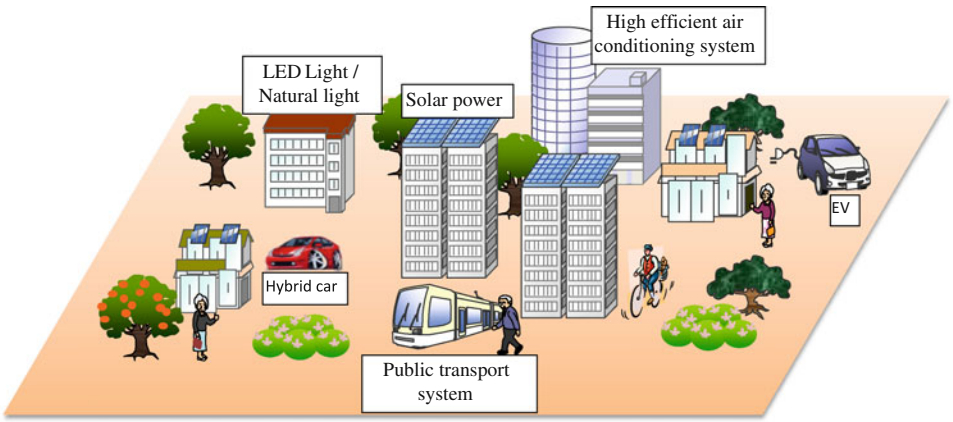

Fig. 5 Future compact city image in an aging society (example)

areas. Hara et al. (2010) proposed strategic urban planning considering resource circulation and environment to make the urban-fringe sustainable by controlling density. In many developing countries, the urban poor accumulate in peri-urban areas, and creating a vital urban–rural fringe may therefore create conflicts that require solving social issues (Marshall et al. 2009).

Developments in the urban–rural fringes must be managed. A strategy is to create green belts, which are zones of country side around a city where development is controlled. These would prevent urban sprawl, prevent towns from merging, preserve the character of towns and protect agricultural lands. Usually, the urban–rural fringe serves as a purchaser of energy and organic materials that are generated in rural areas and processes those raw agricultural resources into edible and marketable products and supplies to urban area. Adversely, this area always suffers from considerable environmental damages in the form of waste disposal and resource constraints (Fig. 6). To avoid the environmental problems and ensure the enrichment of urban–rural fringe, introduction of those eco-industries, for example, the bio-fuel production industry will be a sustainable solution, through which a large amount of biomass waste from urban areas could be transformed into renewable energy and, at the same time, employment opportunities would be created and new business could be expanded. Thus the vitality of this area could be enhanced. Furthermore, the living conditions of local residents would be improved as a result of better use of waste material and reduction of pollution.

Urban–rural sustainability thus provides the capacity for a city to be self-supporting, flexible and responsive according to changing circumstances. As for the economic incentives, common themes are concerned with providing access to capital for marginalized communities, improving training for the hard to employ, promoting racial integration within stakeholders, establishing environmentally friendly business initiatives, finding innovative means of avoiding redundancies and creating new jobs, etc. The popularity of these schemes depends on the nature of debate of corporate responsibility in any given country and the incentives structures within cities, regions or countries.

Conclusions

This paper looked at a sustainable urban future through the specific analysis of three major issues: achievement of a low carbon society, extended population age, and enhancement of vitality of urban–rural fringe. Through investigation of the characteristic interaction of these issues and possible countermeasures, we propose a conceptual vision of a sustainable urban future in 2050 for industrialized nations. For the achievement of a low carbon society, various technological advances in transportation (intelligent systems, hybrid cars, EVs), buildings (energy efficient devices, efficient design and use of natural materials), and industries (innovative manufacturing techniques) are among those that can contribute towards this end. A compact city adapted to an ageing society has also been proposed. In this environment there is less dependency on cars, reduced consumption of energy, greater preservation of green spaces, more responsive services catering to elderly needs. For enhancement of the urban–rural fringe, the creation of eco-industries that can result in job and business opportunities for both urban and rural areas has been presented. However, the vision of a sustainable urban future proposed in this study also acknowledges several limitations, such as its exclusive suitability only for highly industrialized regions like Japan or central Europe, and that its implementation might come with some unintended negative consequences. In addition, among the various challenges of urban sustainability, only the three aforementioned aspects are discussed in detail while other daunting urban sustainability challenges, including violence, economic disparity, injustice, public health issues, etc. have not been investigated.

We discussed the importance of integrating all the objectives with the support of new technology, policy control and planning, change in people's lifestyle, etc.

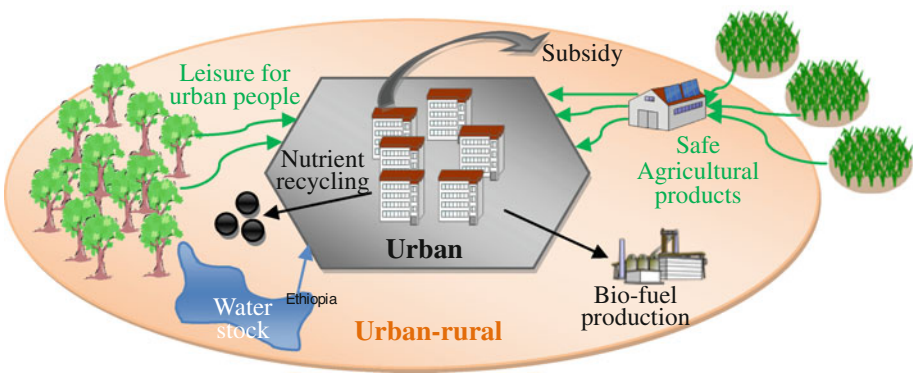

Fig. 6 Image of a sustainable urban–rural fringe for a large city in Asian monsoon region

It was found that a combination of planning targets and countermeasures that interact with each objective are necessary, and should be the dominant trend in future developments.

Many developing countries are undergoing economic growth with increasing population and accelerated urbanization accompanied by urban sprawl. Problems such as the extended lifespan of the population, mitigation and adaption to global warming, and management and enrichment of the urban–rural fringe have not yet been paid much attention compared to other problems like economic growth, water and food security, health, etc. However, with people's increasing desire for future sustainability, it is necessary to start taking action now, through local endeavor and international cooperation so as to achieve a sustainable urban future.

Innovation in systems of society and technology is vital in order to tackle problems that society has never faced before on this scale, including climate change, rapid urbanization, demographic change, energy and resource shortages, etc. Various projects have been launched in order to address these problems. A fund to support developing countries for climate change adaptation has been established in COP 16/CMP 6 at Cancun, Mexico in 2010 (Mwendandu et al. 2010). Approximately USD 36 billion has been allocated to restore damaged areas in east Japan. Vast amounts of money will be invested to explore alternative energy sources due to global anti-nuclear power movements. As discussed in this paper, these problems are not necessarily solved individually. The same action may solve different problems simultaneously and eventually lower the amount of investment.

These investments are also an excellent opportunity for businesses. There are several chances to develop new fields that are not based on conventional business models, and sustainability science programs at higher education institutions can be geared to train tomorrow's leaders in the need and methods of reforming society through innovation of social systems.

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