Bernhard Müller
Hiroyuki Shimizu
Editors

Towards the Implementation of the New Urban Agenda

Contributions from Japan and Germany to Make Cities More Environmentally Sustainable

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Contents

1 The Transition Towards Sustainable and Resilient Cities—Urban Challenges and Solutions in Germany and Japan 1
Bernhard Müller, Hiroyuki Shimizu and Andreas Otto

Part I Landscape Change and Management

2 Dialectic Developments of 'City' and 'Country' in Japan's Metropolitan Regions 23
Atsushi Katagi

3 Urban Ecosystem Services and Biodiversity Offsets 39
Wolfgang Wende and Marianne Darbi

4 Sustainable Landscape Management and Landscape Management Labor Accounts 49
Hiroyuki Shimizu, Chika Takatori and Nobuko Kawaguchi

Part II Climate Change and Urban Green

5 Modeling the Current and Future Urban Climate Using Downscaling Techniques 65
Satoru Iizuka and Yingli Xuan

6 Urban and Green Planning Based on an Evaluation of Urban Climate 75
Chika Takatori

7 Demands, Opportunities and Constraints of Green Space Development for Future Urban Development under Demographic and Climate Change 87
Stefanie Rößler

Part III Environmental Risks in Urban Areas

8 Environmental Risks in Urban and Regional Development—Assessing the Effects of Flood Resilient Technologies 101
Thomas Naumann and Sebastian Golz

9 Flood Risks and Their Management in Urban Japan—Modeling Inner Flooding in Tsushima City, Tokai Region 117
Takashi Tashiro and Aung Khaing Min

10 Pre-reconstruction Plans for Urban Areas in Japan 127
U Hiroi

Part IV Built Environment and Material Flow

11 The Efficiency of Settlement Structures 137
Clemens Deilmann

12 Weight of Cities—Material Stock and Flow Analysis Based on Spatial Database over Time 147
Hiroki Tanikawa

13 Preservation and Utilization of the Urban Heritage of East Asia and Japan 157
Yasuhiko Nishizawa

Part V Urban Energy Concepts

14 Revolution of Urban Energy System 173
Masaya Okumiya

15 Building Energy Management: Performance Verification and System Simulation 183
Hideki Tanaka

16 A New Concept for Air-Conditioning in Japan: An All-Air Supplied Induction Radiant Air-Conditioning System and Cool Room 193
Teruyuki Saito

Part VI Future Challenges of Planning

17 Operationalizing Urban Resilience—Learning from the Past while Preparing for the Future. The Case of Dresden, Germany 207
Paulina Schiappacasse

18 Reconsidering Urban Planning through Community-based Initiatives 223
Akito Murayama

19 Planning of Public Facilities in Japanese Communities Facing Demographic Decline and Super-Aging 235
Hisashi Komatsu

20 Developments in Urban Planning by Public Facilities Management Based on Regional Characteristics 247
Kazuhisa Tsunekawa and Koji Saito

21 Identifying Gaps and Opportunities for Research on Urban and Regional Resilience—Highlighting the Advantages of Research Cooperation 259
Paulina Schiappacasse and Bernhard Müller

Chapter 1
The Transition Towards Sustainable and Resilient Cities—Urban Challenges and Solutions in Germany and Japan

Bernhard Müller, Hiroyuki Shimizu and Andreas Otto

Abstract In 2015 the United Nations General Assembly adopted a set of Sustainable Development Goals (United Nations 2017a). For the first time in history, sustainable urban development was unanimously acknowledged as a central objective of the global community. The New Urban Agenda adopted in Quito in October 2016 can be understood as a basic document to translate the Sustainable Development Goals into the urban and regional context (United Nations 2017b). It will serve as a point of reference for urban planners and managers, strongly influencing urban development worldwide over the coming 20 years. Therefore, the demonstration of good examples in different contexts and under distinct development conditions will be of utmost importance. As two nations with mature economies and aging societies, Japan and Germany face a number of common challenges to environmentally sustainable and resilient urban development. Both have given special consideration to such issues in the past, and have established related policies at all levels of government such as the "FutureCity Initiative" in Japan and the "Strategic Research and Innovation Agenda on the City of the Future" in Germany. Furthermore, both countries have vast experience in actively promoting urban transformation. In this way they are rather unique from a global perspective while simultaneously serving as forerunners in finding solutions to challenges which other countries will have to face in the near future. In this sense, Japan and Germany can be highly instructional cases to help the international community realize the Quito Implementation Plan of the New Urban Agenda.

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1 Sustainable Development Goals and the New Urban Agenda

In 2015 the United Nations General Assembly adopted the Sustainable Development Goals (SDGs). These will form the basis for new initiatives, programs and actions over the coming years until 2030. They build on the previous Millennium Development Goals (MDGs): On the one hand, they are supposed to complete the tasks which the MDGs did not achieve. On the other hand, the 17 goals with their 169 targets are much broader than the MDGs, incorporating new aspects and perspectives ranging (a) from poverty eradication to inclusive and equitable quality education and ensuring healthy lives for all age groups; (b) from ensuring the availability and sustainable management of water and sanitation to promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; (c) from building resilient infrastructure to ensuring access to affordable, reliable, sustainable and modern energy; (d) from taking urgent action to combat climate change and its impacts to protecting, restoring and promoting the sustainable use of terrestrial ecosystems and halting and reversing land degradation and halting biodiversity loss. These goals are each underpinned by a number of targets and indicators, and are seen as integrated and indivisible, balancing all dimensions of sustainable development (United Nations 2017a).

With the SDGs, for the first time in history, sustainable urban development has been unanimously acknowledged as a central objective of the global community. One of the goals, Goal No. 11, is entirely dedicated to make cities and human settlements more inclusive, safe, resilient and sustainable. The associated targets are quite ambitious: e.g. to ensure access to adequate, safe and affordable housing and basic services; to provide universal access to safe, inclusive and accessible green and public spaces; to promote the construction of sustainable and resilient buildings; to strengthen efforts to protect and safeguard the world's cultural and natural heritage; to substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement holistic disaster risk management at all levels; to support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning; and to enhance inclusive and sustainable urbanization and the capacity for participatory, integrated and sustainable human settlement planning and management in all countries (United Nations 2017a).

The New Urban Agenda (NUA) adopted in Quito in October 2016 (United Nations 2017b) corresponds very well to the SDGs and comes at the right time. Although 40 years after the Habitat I conference in Vancouver and 20 years after the Habitat II conference in Istanbul, the NUA is a document in its own right, yet it can be understood as a basic document to translate the SDGs as a whole to the urban and regional context, and in particular to interpret and concretize Goal No. 11. One of the major principles of the NUA is to foster the environmental sustainability of cities.

The promotion of clean energy, the strengthening of resource and land use efficiency in urban development, the protection of ecosystems and biodiversity, the building of urban resilience as well as the mitigation of and adaptation to climate change are some of its elements. The Quito Implementation Plan lists a number of transformative commitments regarding environmentally sustainable and resilient urban development. Planning and managing spatial development are regarded as decisive tools for an effective implementation (United Nations 2017c).

The NUA will strongly influence urban development worldwide over the coming 20 years. Although it is still much too early to evaluate whether it will—as stated in the document—really lead to the paradigm shift committed to by the global community, the NUA will be a point of reference for urban planners and managers worldwide. The demonstration of good examples towards a more sustainable urbanization in different contexts and under distinct development conditions will be of the utmost importance, e.g. regarding how to deal with environmental challenges, how to prepare for and deal with the effects of climate change, how to establish age-responsive policies and measures; also in the context of risk prevention and mitigation measures, how to implement effective urban rehabilitation, how to foster more energy- and resource-efficient settlements, and how to plan and manage the related processes. With this regard, Germany and Japan have a lot to share with other countries. Both have given special consideration to such issues in the past, and have established related policies and pioneer measures at all levels of government. Both have vast experience in actively promoting urban transformation. As nations with mature economies and aging societies, they also face a number of common challenges to environmentally sustainable and resilient urban development. They have experience in handling related challenges and have collected vast experience regarding age responsive policies. This makes both countries highly instructional cases to help the international community realize the Quito Implementation Plan for the New Urban Agenda. This relates to the transformative commitments of the international community for sustainable development made in Quito, as well as their effective implementation and a related follow-up and revision. Other countries can build on their experience.

2 Sustainability Frameworks in Germany and Japan

The sustainability discussion is not at all new, and in particular was not launched by the Brundtland Commission in the 1980s. In fact, both Germany and Japan gained experience in sustainable development at a very early period in different ways. In Germany, the first written document to lay down sustainability principles was a book on the sustained supply of wood for mining and metal processing, including silver, by the then Chief Mining Officer of the Electorate of Saxony, Carlowitz (1713). He was not only in charge of mining affairs but also responsible for forestry as an important natural resource for mining and processing purposes. In other words: Sustainable development was acknowledged to be a source of wealth and urbanization.

As Wheeler (2013, 248) elaborates, there is a strong case to be made for Japan to have been "one of the world's most sustainable societies during the 300-year Edo period, from the early 1600s to the late 1800s" due to the country's isolation from the outside world during this period when no foreigner was allowed to enter and no Japanese leave. This made it necessary to become self-sufficient and to recycle almost all of its materials. In other words: Sustainability was a matter of survival and resilience.

In modern times, the Rio Conference in 1992 is a reference point for the first international declaration on sustainable development. Later, the Aalborg Charter narrowed sustainable development down to settlements, local action and grass-root initiatives. Many pioneer projects of urban development were initiated in many countries, Curitiba in Brazil being one of the more prominent examples. The Global Conference on the Urban Future (Urban 21) reinforced the principle of sustainable urban development in its Berlin Declaration on the Future in the year 2000, which recommended 19 fields of action ranging from establishing integrated urban development policies and strengthening good governance to promoting comprehensive spatial planning and fostering peer-to-peer cooperation among cities worldwide.

In 2007 the Leipzig Charter on Sustainable European Cities laid a strong foundation for sustainable urbanization in the European context. Its main points are: (I) Making greater use of integrated urban development policy approaches to promote implementation-oriented participatory integrated urban development programs; creating high-quality public spaces, modernizing infrastructure networks, improving energy efficiency, and proactive innovation and educational policies regarded as corner-stones of implementation activities. (II) Giving special attention to deprived neighborhoods to foster social cohesion and integration; pursuing strategies to upgrade the physical environment, strengthen the local economy and local labor market; proactive education and training policies for children and young people, and the promotion of efficient and affordable housing defined as strategies for action. Until now, the Leipzig Charter is a leading document giving orientation to city planners and managers as well as local decision-makers in Europe.

Germany strongly influenced and contributed to the above-mentioned initiatives on sustainable urban development. After including the principle of sustainable development in the German constitution (the *Grundgesetz* or Basic Law) in 1994, it took another four years before sustainable urban development made its way into the German Building and Spatial Planning Laws. This was accompanied by a number of model projects, initiated at the national, regional as well as local levels, on how to operationalize and implement the principle in the urban context. Around the same time like in Germany, Japan established legal stipulations for sustainable development. In 1993, the Basic Law on the Environment was adopted, and sustainable development made a central national priority. The elaboration of local environmental plans was mandated. Environmental initiatives, however, are still mainly based on voluntary compliance, and supported by incentive programs and moderation at the various levels of government (Wheeler 2013, 248).

Meanwhile there is an abundance of sustainability approaches and frameworks worldwide. Environmental sustainability plays a key role. The various approaches have been developed by national, regional and local governments, the construction sector, expert groups, as well as international, national, regional and local non-governmental organizations and initiatives. However, there also exist a number of barriers and practical difficulties. The experiences do not show a common pattern. In some countries, such as Germany, top-down approaches have been much less successful than local and municipal ones, whereas other countries seem to have made the reverse experience. In most cases, however, a national commitment towards sustainable urban development and respective national urbanization policies seems to have been a decisive factor in the promotion of sustainability.

The establishment of Green or Sustainable Building Councils and respective certification systems, such as BREEAM (Building Research Establishment Environmental Assessment Methodology) in Great Britain and LEED (Leadership in Energy and Environmental Design) in the United States, were other cornerstones towards achieving greater urban sustainability. Meanwhile, many countries have developed their own certification systems, such as Germany with its DGNB system (by *Deutsche Gesellschaft für nachhaltiges Bauen*) and Japan with CASBEE (Comprehensive Assessment System for Built Environment Efficiency). However, these schemes have only started to have a major influence on sustainable urbanization schemes as a whole since they have extended the certification from individual buildings to neighborhoods. For example, the German assessment system looks at five categories: environmental quality, economic quality, sociocultural and functional quality, technical quality, and process quality.

In December 2015, a new assessment tool, CASBEE for Cities (in a pilot version for worldwide use) was published and presented at the United Nations conference on climate change (COP 21). It aims to assess the environmental performance of cities around the world. The tool is in line with international documents such as the UN SDGs by adopting the concept of environmental efficiency. It is intended to support users in understanding their local conditions and elaborating and directing action plans for future urban development. CASBEE for Cities was initially developed for Japanese municipalities between 2008 and 2011. Recently, the tool has been used in the "FutureCity initiative" by the Japanese government to monitor the development of Future Cities (JSBC and IBEC 2015) http://www.ibec.or.jp/CASBEE). In Europe, the Reference Framework for Sustainable Cities (RFSC), which was developed with strong influence from France around the same time as the corresponding CASBEE for Cities, has a similar function. RFSC helps key city actors develop and implement plans and strategies for attractive and sustainable cities. It refers to five dimensions (namely spatial, governance, social, economical, environmental) with 30 sustainability objectives, and supports the delivery of the Leipzig Charter and the European common vision for sustainable cities (RFSC 2016). After an intensive testing period, the toolkit of the RFSC has been available to all European cities since 2013. The uptake of the framework by cities, especially in Germany, has initially been rather slow, as many cities have developed their own sustainability policies, strategies, programs and monitoring systems.

3 Super-Aging—New Challenges for the Sustainable and Resilient City of the Future

There is another highly relevant issue common to both countries: demographic change. Japan and Germany (along with Italy, Finland and Greece) are characterized as "super-aged" societies, in which more than 20% of the population is already 65 or older. This is mainly due to long-term declining fertility rates over past decades, which are among the lowest worldwide, resulting in fewer children and relatively small younger population in both countries. By 2030, Japan and Germany are projected to have the highest ratio of 65+ population worldwide at 30.7 and 28.2% respectively (Moody's 2014; O'Connor 2014). And in 2050, two out of five Japanese and more than every third German are expected to be older than 65. By then, the young generation, i.e. persons aged twenty or younger, will have dropped to 16% of the population (Müller et al. 2014).

Moreover, the number of "super-aged" people who reach the age of 100 or more has been constantly rising over past decades. This can be attributed to a number of causes, e.g. better medical and health care systems, healthier nutrition and greater activity, mobility and commitment of individuals during the different phases of life. Life expectancies are much higher, and there are much better chances to live longer than before. It is expected that the number of super-aged countries will increase to 13 by 2020 and to 34 by 2030 (Moody's 2014). And, of course, the absolute limit to human life expectancy is not yet known (Oeppen et al. 2002).

In many German and Japanese regions and cities, aging is compounded by demographic "shrinkage", i.e. the (regional) decline of population due to out-migration and low fertility rates. Cities and towns in the peripheries of both countries and in areas in economic transition with serious structural deficits, such as former industrial regions in decline, suffer most (Wirth et al. 2016). Alongside economic restructuring, they have to cope with the consequences of their demographic imbalances such as a shortage of labor, deficits in infrastructure provision and higher and more (age-)specific demands for dealing with climate change, e.g. the heat island problem in cities, as well as disaster prevention, risk and catastrophe management regarding the elderly. In such areas these challenges are much more prominent than the opportunities of aging societies, e.g. through the so-called "silver economy". It has become an urgent task for Japan and Germany to support cities and regional population centers that are able to maintain or re-gain their economic and social vitality while providing a good quality of life for all generations (e.g. Akademiengruppe Altern in Deutschland/Joint Academy Initiative on Aging 2010; Beetz et al. 2009).

Only a little more than a decade and a half ago, spatial planning in Germany and Japan started to react to the challenges and opportunities of demographic change. Spatial analyses were conducted in order to detect regional disparities of demographic change, and spatial development plans drawn up to deal with specific aspects of aging and population decline. Specific development programs were initiated by the national and state governments as well as by municipalities. They provided incentives in the form of dedicated development funds for mitigation and adaptation measures related to demographic change.

Such programs are important as they confirm the possibility of dealing with demographic change under even rather extreme conditions of aging and shrinkage. And they also demonstrate that aging and depopulation should not only be regarded as problems for societies but offer a number of new opportunities, e.g. related to the "silver economy" or in strengthening voluntarism. However, experience in Japan and Germany also suggests that super-aging will lead to totally new challenges and terms of development. The opportunities will be rather limited in a supposedly "third phase" of aging (we currently still differentiate only between young elderly and late elderly), whereby the costs of supplying the various needs and healthcare-services for the elderly could skyrocket to become a burden and a costly priority for societies.

Although for many countries, especially those of the "Global South", (super-) aging and the decline of population figures may not yet be a pressing problem, they will become so in the future. This is certainly true of those countries which embarked on very strict birth control policies in the past, and which may become aging countries in the near future. The New Urban Agenda has taken up this issue, reflecting demographic change, especially aging, in many aspects.

For example, the NUA contains a commitment "to address the social, economic, and spatial implications of ageing populations, where applicable, and harness the ageing factor as an opportunity for new decent jobs and sustained, inclusive, and sustainable economic growth …". Furthermore the NUA supports the adoption of age-responsive approaches to urban and territorial development. It promotes age-responsive housing policies, age-responsive planning and investment for urban mobility for all, and the integration of disaster risk reduction as well as climate change adaptation and mitigation considerations and measures into age responsive urban and territorial development and planning processes in line with the Sendai Framework for Disaster Risk Reduction 2015–2030. And last but not least, it highlights the necessity of participatory age-responsive approaches at all stages of the urban and territorial policy and planning processes, strengthening the interface among all relevant stakeholders, offering opportunities for dialogue, including through age-responsive approaches, and giving more attention to age-responsive budgeting (United Nations 2017b).

4 Towards the City of the Future: Government Initiatives in Japan and Germany

Japan and Germany are seen as countries already facing a number of challenges, e.g. regarding aging societies that other countries, first of all in Europe and Asia, will face in the near future. Japan's and Germany's experiences in tackling this problem will provide meaningful lessons for these growing common global challenges. Managing the transition towards more sustainable and resilient cities is one of the major challenges in the urban context. Consequently, both countries are great concerned about the transition needs, and both have established respective future cities initiatives.

The "FutureCity" Initiative (FCI) in Japan was launched by the national government in 2011. It was identified as one of the government's 21 national projects in its "New Growth Strategy". Later, in 2013, the government also designated the FCI as a national project of the "Japan Revitalization Strategy". In the meantime, more than 10 model cities have been declared "Future Cities". They will interlock with the designation of special zones, especially those related to revitalization. The national government has also been promoting the Eco-Model City initiative to realize low-carbon cities.

Through its FCI the Japanese government intends "to create cities that embrace new people-friendly values in order to deal with environmental issues and the aging society. Its goal is to solve problems being faced by Japan and the world such as global warming, resource and energy constraints, and aging societies through establishing sustainable social and economic systems and recovering social solidarity. At the same time, it will be necessary to increase the quality of life and make cities into places where anyone would want to live and where everyone enjoys vitality as new sources of value continually come into being" (JFS 2017).

The FCI is oriented towards coping with environmental challenges, e.g. supporting low-carbon urban development, improved waste management as well as nature protection and nature-based solutions. Moreover, it intends to deal with demographic change, especially aging, as it impacts medical and elderly care as well as childcare. And it promotes economic growth and local revitalization.

The FCI follows a highly integrative approach while fostering innovation and institutional reforms. Candidate cities have to develop their own strategic future visions to realize the FCI's basic concepts. They are required to tackle the challenges of the environment and an aging society, and further are "encouraged to take on additional challenges in areas that can enhance their originality and comparative advantages in cooperation with other cities in Japan and abroad."

The FCI is not merely seen as an experiment, but also as a process aiming at "innovation in socio-economic systems that continuously creates new value". The steady implementation of "project management, powerful executive authorities that can act quickly, and strong cooperation among cities" are seen as key factors for success.

Similar to Japan, the German government has launched several initiatives to foster urban revitalization and the transition towards a more sustainable urban development, placing special emphasis on the integration of sectoral concepts into comprehensive planning approaches as well as the mobilization of local participation. Some early initiatives began in the 1990s. For example, they have led to competitively chosen so-called model "Cities of the Future" and "Regions of the Future". Later programs were launched to foster urban (re-)development in eastern Germany when the government started to deal with the specific challenges of urban renovation and revitalization in the aftermath of the German unification.

The most recent initiative started in 2013 when the national government, together with a large number of stakeholders from municipalities, the business sector, academia and NGOs, established the National Platform "City of the Future" (NPZ) and developed a "Strategic Research and Innovation Agenda on the City of the Future" (FINA) as part of its innovation-driven Hightech Strategy from 2006. The aim of the multi-ministerial program under the leadership of the German Federal Ministry of Education and Research (BMBF) is to create CO_2-neutral and energy efficient cities adapted to climate change (BMBF 2017).

The German initiative starts from similar set of key challenges like the Japanese one, e.g. a world population that varies between extreme growth on the one hand, and depopulation and aging on the other; increasing global urbanisation rates; urbanization as a burden on resources; the negative effects of climate change in cities and towns; and the need to change the basic energy supply and distribution system. In Germany, the proclaimed national policy of energy transition (*Energiewende*) places high demands on changing infrastructure systems and developing new concepts concerning the management of the built environment. Moreover, new forms of governance are gaining ground. Against this background, municipalities are regarded as laboratories and "schools" of democracy, while it is acknowledged that the transformation of cities has to be economically viable and socially inclusive.

The Strategic Research and Innovation Agenda has identified nine key topics: (1) socio-cultural quality and urban communities, i.e. the fostering of urban engagement, social innovation and acceptance of new technologies; (2) urban transformation management, i.e. strengthening the role of municipalities, raising local transformation preparedness, developing new forms of governance, implementing pilot projects of transformation, and fostering integrated urban and neighbourhood concepts; (3) city—neighbourhood—building, i.e. innovation in the construction sector, user-oriented rehabilitation and renovation strategies; (4) resilience and adaptation to climate change, i.e. specific analyses of vulnerability, green and blue infrastructure, as well as urban-rural relations; (5) energy, resources and infrastructure systems, i.e. developing intelligent infrastructure systems, energy- and resource-efficient solutions in urban water management, as well as giving more attention to material flows and urban mining; (6) mobility and logistics, i.e. providing new types of offers and new technologies of mobility, mobility data and platforms, as well as giving attention to mobility behaviour and urban logistics; (7) technologies for the city of the future, i.e. providing ICT platforms, ICT services and smart urban services; (8) urban economy, i.e. developing new models of finance, analysis municipal carrying capacity, and the promotion of new business and management models; (9) data, information and knowledge transfer, i.e. promoting data governance, data models and knowledge transfer.

Based on these issues, the Strategic Research and Innovation Agenda addresses the civil society as a driver of urban transformation. It is oriented towards strengthening and supporting urban transformation, the sustainable transformation of urban and regional settlement patterns, implementing pioneer projects for urban infrastructures, developing tools and procedures for planning and knowledge management, establishing new frameworks for urban innovation, and giving special consideration to strategic finance management and business models. In addition to a large number of more specific projects, 52 cities were chosen to participate in the first round of a program consisting of three phases. They were asked to develop strategies for the future in close cooperation with citizens. In a second step, successful cities are supposed to scientifically analyse the programs and complete these before a further reduced number of cities are supported to implement related measures. So far, the interest and participation of cities has been overwhelming. In 2016, an expert commission chose 20 cities and initiatives for the second round of the competition.

These two national initiatives of Japan and Germany show similar features. They were created with the aim of tackling these countries' most urgent future urban challenges, e.g. related to environmental challenges and demographic change, by building on local initiatives and the cooperation between the different stakeholders, by including elements of competition among cities, and aiming at the integration of sectoral actions into comprehensive and strategic urban development programs. Although it is much too early to assess their success, it can already be recognized that they have paved the way for innovation, inclusion and greater urban sustainability. Nevertheless, there are many issues still to be tackled and many experiences to be analyzed. Their results may also have an impact on the implementation of the New Urban Agenda not only in these two countries but on a global scale.

5 Experiences, Ongoing Discussions and Tasks Ahead

Sustainable urban development is one of the priorities of national, regional and local governments in Japan and Germany. Several programs have been initiated and a number of model cities have been identified in both countries. Here the transformation towards environmental sustainability and resilience in (super-)aging societies under the conditions of climate change plays an important role. On the one hand, this makes the two countries somewhat unique. On the other hand, it may make them forerunners in finding solutions to challenges addressed by the New Urban Agenda, which other countries will have to face in the near future. The following six examples which are all highly relevant to the Quito Implementation Plan for the New Urban Agenda shed some light on experiences, i.e. challenges, opportunities and responses, as well as ongoing discussions and tasks ahead, and demonstrate the search for appropriate solutions for the transition towards sustainability.

5.1 Landscape Change and Management

Throughout their history, Japan and Germany have seen a tremendous change in the appearance of urban and rural landscapes. This is closely connected with the emergence and disappearance of different economic activities as well as demographic factors. The once dialectic relationship between cities and countryside was diminished with industrialization and suburbanization. New towns and settlements at the urban outskirts developed during the various phases of economic growth in the second half of the 20th century. Accordingly, agricultural land has been the main source of available land for construction. In both countries, formal planning has been partially successful in steering urban growth. In recent years demographic change and economic stagnation in Japan have led to new challenges for urban development and planning with a need to cope with aging cities, vacant housing and abandoned commercial areas (Katagi 2018). Many regions of Germany face similar challenges. The result is frequently a complex mosaic pattern of shrinkage and growth in close proximity, which has become typical for urban areas and their surroundings. While economic and urban growth have always been interlinked, shrinkage may present an opportunity to "give back" land to nature. Although the New Urban Agenda (NUA) primarily addresses the challenges of urbanization, it also considers the management of urban shrinking where appropriate (United Nations 2017b, 14c). This becomes an important task of sustainable urban development since areas of demographic and economic shrinkage often show continued land consumption for building purposes.

Powerful instruments are necessary to balance human activities and the protection of nature and the environment. Such instruments are related to the various levels of spatial planning including landscape planning. However, they are dependent on the related legal and planning frameworks concerning land-use and land-use change. For example, in Japan, due to the prevalence of private property rights, balancing mechanisms are strongly case-related, i.e. compensation measures are always related to individual larger development projects. On the contrary, the concept of biodiversity offsets concept is applied in Germany. This relatively new and innovative instrument to achieve no net loss of biodiversity and ecosystem services has been adopted by a growing number of countries, including Germany and Japan. Analyses from Germany (impact mitigation regulations) and other countries underline the importance of strong biodiversity offset tools at the landscape level as well as a strict legal underpinning to prevent, manage and develop biodiversity and ecosystem services (Wende and Darbi 2018). While ways have to be found to effectively protect the environment and natural amenities, societies are also challenged to maintain traditional cultural landscapes, which have been a result of centuries-long human interaction with nature. This can be seen as a priority component of urban planning, calling for the safeguarding of our cultural heritage and landscapes as well as their protection from potential disruptive impacts of urban development (United Nations 2017b, 124). Respective examples may pertain to the mixed pattern of small towns, open farmland and forests in many parts of Germany or the hilly Satoyama landscapes of Japan, which traditionally lie between coastal plains and mountains and feature paddy fields. However, the maintenance of such landscapes, which are valuable for both cultural and ecological reasons, is not only challenged by urban growth. It also requires sufficient labor, which clearly becomes a problem in shrinking and (super-)aging regions. Therefore, ideas for solutions range from cooperative management via voluntary work to the promotion of migration to rural areas (Shimizu et al. 2018). Nevertheless, it seems shrinking and aging societies will have to cope with the idea of giving some land back to nature to create new types of "wilderness".

5.2 Climate Change and Urban Green

Weather effects always had an impact on human activities. In times of climate change and increasing environmental risks, it is important to take a closer look at how cities can be developed and transformed to cope with weather effects that threaten human health and the quality of urban life. One of the NUA's objectives, therefore, is to improve human health and well-being by readdressing the way cities are planned, designed and managed (United Nations 2017b, 5). This becomes even more necessary against a backdrop of aging societies. Rising temperatures in many places can be an overlapping effect of global warming and urban heat islands. Many parts of Japan, which already suffer from hot and humid summers, will in future present a climate that could seriously undermine the conditions for human life (Iizuka and Xuan 2018). While Germany has a milder climate, temporal weather extremes and severe local effects are expected to increase. Thermal and wind environments in cities are subject to change. The topography, the type and location of land uses as well as the shape and height of buildings have strong impacts on the local climate (Takatori 2018). Excellent simulation and projection methods, including downscaling from the global scale to the urban scale, are needed as a basis to face these challenges. While such techniques become ever more important as environmental assessment tools and starting points for mitigation measures during hot summer days, they also have to be considered for the necessary adaptation of the urban environment and as a basis for future urban planning (Iizuka and Xuan 2018). In this regard, the compensation and development of urban green to assist in the adaptation of urban patterns is highly important (Takatori 2018).

Green infrastructure with urban vegetation, green spaces and urban ecosystems provide services and a number of benefits to meet the challenges of climate change and urban heat islands. The creation and maintenance of well-connected and distributed networks of public green spaces can help to improve the resilience of cities and to promote attractive and livable cities and urban landscapes (United Nations

2017b, 67). The impacts of demographic change in some areas, in particular shrinking population and economic activities, might become favorable preconditions to implement and further develop urban green spaces (Rößler 2018). However, the implementation of green spaces is related to a number of challenges regarding, for example, existing building and property rights, unstable long-term funding or securing minimum densities for effective infrastructure services. In any case, whether growing or shrinking, cities have to find ways to deal with the demands, opportunities and constraints of green space development.

5.3 Environmental Risks in Urban Areas

With the Quito implementation plan, the international community envisages cities that implement measures of disaster risk reduction and management, reduce vulnerability, build resilience to hazards, and foster mitigation and adaptation to climate change (United Nations 2017b, 13g). Indeed, risk management has become an important part of urban development and planning all over the world. Japan suffers from all kinds of environmental risks, such as earthquakes, tsunamis, typhoons, torrential rains, volcanic eruptions and further more. In Germany, flooding is a major and growing threat causing severe damage. Clearly, it is vital to know where damage to buildings and infrastructure is likely to happen and how cities need to adapt to cope with environmental risks, including the exclusion of building activities from sensitive areas (Naumann and Golz 2018). With its mountainous terrain and narrow lowlands close to the coast, Japan is also exposed to various types of flooding. The causes and process of the Tokai flood in 2000, the most severe urban flood in Japan, have been used to analyze structures of urban flood risks. Simulation models help authorities to reduce flood damage by adapting urban infrastructure and introducing various management measures in flood-prone areas (Tashiro and Min 2018). As described above, due to geographic reasons Japan is not only exposed to major floods, but also a number of major natural disasters that can destroy cities and threaten human lives. In response to such large-scale disasters in the past, there have been recent efforts in Japan to actively draft pre-reconstruction plans. Those plans aim at imagining the circumstances of reconstruction, making projections on systems and plans for reconstruction as well as creating an awareness of the need for preventive measures (Hiroi 2018). As an overall framework, this will support medium to long-term planning processes for adaptation and for building resilience of urban inhabitants (United Nations 2017b, 80).

5.4 Built Environment and Material Flow

It is only relatively recently that we have come to recognize the limited extent of the earth's natural resources. In order to make cities more sustainable, it is vital to develop methods for the efficient use of material and energy. The NUA envisages cities that meet the challenges and opportunities of sustainable economic growth based, among other things, on resource efficiency (United Nations 2017b, 13d). The sustainable management of natural resources in cities is also necessary to protect urban ecosystems and to improve environmental services (United Nations 2017b, 65). Among other fields, urban construction and maintenance require energy and materials. Urban metabolism is a tool to describe, analyze and model the stocks and flows of the urban system. Through human activity, cities accumulate all sorts of durable goods such as metals, plastics, glass, concrete and stone. While some materials may be recycled and reused for building reasons or other products, the input of material into the "anthropogenic stock", even in mature economies such as Japan and Germany, is much higher than the output. The method of material flow analysis stipulates a bottom-up approach to the analysis and modeling of different patterns of urban development in order to deliver the information necessary for a more resource efficient approach to urban development (Deilmann 2018). The material stock of buildings and infrastructure differs according to the adopted materials and construction types. A city's "weight" in regard to the material consumption, stock and release is related to its sustainability (Tanikawa 2018). In Japan the building stock is mainly concentrated within large metropolitan areas such as Tokyo, Osaka, Nagoya, Fukuoka and Sapporo, while in Germany we find a country-wide network of medium-sized cities. In this regard, infrastructure efficiency and costs relating to city size as well as the recycling potentials of building activities are two examples from recent discussions in Germany (Deilmann 2018).

International comparisons show that the longevity of constructions and the average life-span of buildings also differs from country to country, affecting the material stock and material flow of cities (Tanikawa 2018). Due to historic reasons, varying regulation and the different risks of disasters, the life-span of buildings in Germany is higher than Japan. In any case, material flows and related matters are not yet a major item on the agenda of urban planners (Deilmann 2018). The same goes for questions of an urban development that is sensitive to all age groups of the population. According to the NUA, this should be changed in order to create more sustainable cities. The Quito declaration calls for the sustainable use of natural resources and greater efficiency in the consumption of raw and construction materials, prioritizing the usage of local and recycled materials (United Nations 2017b, 76), and thereby making the transition to a circular economy (United Nations 2017b, 71). It also commits to an age-responsive planning and investment in all areas of urban development (United Nations 2017b, 13f). Greater awareness can also help save a nation's cultural heritage and promote the utilization of existing resources (United Nations 2017b, 45). Alongside technical issues and the observation of material flows seen from an engineering perspective, buildings often have a cultural value that is worth protecting. Such historic buildings are not only relics of their construction time and the functions they once fulfilled. They also offer a great potential for reutilization in order to accommodate new functions (Nishizawa 2018). This can help save construction materials and open space as well as contain urban sprawl (United Nations 2017b, 97).

5.5 Urban Energy Concepts

Energy consumption is an important issue for cities and a key factor in improving their sustainability. Here the urban form, infrastructure and building design play a decisive role while simultaneously the focus must be placed on questions of energy efficiency, conservation and the use of renewable energy (United Nations 2017b, 44, 54, 75). In Japan much energy is expended on cooling and heating to cope with the hot summers and cold winters, while in Germany large amounts of energy are consumed to heat buildings during the comparatively long winters. Hence, the reduction of energy consumption is a big concern for individual building owners in both countries as well as in terms of the overall urban management. In Japan about half of the energy consumption of non-residential buildings is dedicated to heating, ventilation and air-conditioning (Tanaka 2018). Given the fragility of the energy supply (which can be easily disrupted by natural disaster), it seems inevitable that the consumption of fossil fuels will be reduced while greater use is made of renewable energy and as yet untapped energy sources (e.g. waste heat from heating and cooling), thereby shifting from centralized to decentralized energy systems. Apart from architectural solutions, one promising approach is to develop and expand area energy management systems at the neighborhood level (Okumiya 2018). Energy saving effects can be achieved through optimal design and operation. Therefore, it is also important to consider the energy consumption during the life cycle of individual buildings and life cycle energy management. This may include a master plan for energy management for the initial equipment and installation, incorporating building energy management systems into the building design process (Tanaka 2018). The NUA encourages solutions to achieve energy efficiency targets, e.g. through revising and adopting building codes and standards, the retrofitting of existing buildings or introducing smart grids and district energy systems (United Nations 2017b, 121). Given the projected temperature rise in Japan's urban areas (Iizuka and Xuan 2018), air-conditioning may soon be more than a pleasant convenience, but will also contribute to human health, especially given the conditions of an aging society. The concept of a "cool room" is proposed to improve thermal comfort after entering buildings in the summer months (Saito 2018). However, an expansion of green areas in cities (Rößler 2018) may be a more suitable and sustainable measure to help reduce the use of air-conditioning systems as well as to limit energy consumption and greenhouse gas emissions.

5.6 Future Challenges of Spatial Planning

Germany and Japan both possess comprehensive legal systems of urban and regional planning. Those systems, however, have been developed mainly to cope with urban and economic growth. Today new steering instruments and different ways of governance are required to combat the changing circumstances and expected challenges of, for example, an aging society, population shrinkage and an increase in the likelihood of natural disaster.

Unexpected and dramatic events can change the general course of development for a single city or an entire region. Urban resilience, therefore, has been pronounced as one of the key elements of goal 11 of the Sustainable Development Goals as well as the New Urban Agenda. However, there still is a lack of operationalizing the idea of urban resilience and its implementation (Schiappacasse 2018). While cities and people are facing a number of new challenges, it is worthwhile to look back to what we can learn from past developments in preparing for the future through learning processes, adaptation and proactive measures. In the example of Dresden, Germany, taken as an “urban laboratory”, three major cases, the resilience of governance domains to bounce back, the capacity of the built environment to multiple shocks and the resilience capacity of various domains to floods, have been analyzed with the help of a methodological framework (Schiappacasse 2018). This multiple step approach to analyze urban resilience, stressing e.g. the spatial and temporal context of development, variables to measure resilience and the available sources of resilience, could prove helpful in supporting the Quito Implementation Plan for the New Urban Agenda.

While many German cities and regions have to cope with previously unfamiliar issues, Japan faces an even more troubled situation, with severe and multiple challenges fostering increased uncertainty with regard to the future development of Japanese cities. Whereas traditional formal planning instruments are based on the notion of “certainty” and universal solutions, today we clearly have a much greater need for informal planning to provide individualized solutions. Urban planning has to be thoroughly revised to reflect the changing environment and increased uncertainty (Murayama 2018). In this regard, community-based approaches as “alternative” ways of planning can offer hints and opportunities for the transition of formal planning. The importance of local governments as well as civil society and relevant stakeholders for the definition and implementation of urban policies and for sustainable urban development has also been recognized by the NUA, which calls for full and meaningful participation of individuals and communities (United Nations 2017b, 15b, 26).

Individual solutions may also be required to cope with financial constraints, e.g. due to demographic and socio-economic change. Local level finances may suffer first and most severely from such developments. On the other hand, strong municipal financing and local fiscal systems are fundamental drivers in creating and maintaining the values of sustainable urban development (United Nations 2017b, 15c/iv). During periods of urban growth in the latter half of the 20th century, the Japanese government and municipalities built a number of public facilities such as community schools across the country. In the coming era of shrinking, the maintenance of all of these public facilities will place an impossible strain on public budgets. One possible solution could be the comprehensive reorganization and introduction of multifunctional facilities as public service hubs (Komatsu 2018). While there is no standard solution, the reconstruction of public facilities has to be carried out in an integrated way, meeting the demands of local sustainable development. In this regard, advanced management methods based on regional databases and GIS can be used to make public services more effective and efficient (Tsunekawa and Saito 2018). They can also be an important input for making cities and regions more resilient.

Urban development and planning in Japan and Germany as well as in other parts of the world increasingly means dealing with uncertainty and preparing for the unforeseen. Therefore, the development of flexible, adaptive and resistant city structures therefore is vitally important in order to adjust or transform to changing conditions (Schiappacasse and Müller 2018). With Habitat III, the international community has agreed to "strengthen the resilience of cities and human settlements, including through the development of quality infrastructure and spatial planning by adopting and implementing integrated, age- and gender-responsive policies and plans" (United Nations 2017b, 77). Experience shows that is still much need for further research and development in order to help implement the New Urban Agenda.

6 Conclusion

As described above, the Japanese and German experience in tackling new challenges of urban development can make a valuable contribution to accelerating the global transition towards more sustainable and resilient cities as suggested by the Sustainable Development Goals and the New Urban Agenda. Both countries, Japan and Germany, have vast experience in coping with change and transition as well as in planning, mitigation and adaptation strategies. This wide-ranging and deep experience is not yet properly reflected in the international debate (Schiappacasse and Müller 2018). There is much room for international comparison and joint research. As proposed here, research should highlight the local level, as local governments and communities are at the frontline of climate and demographic change. This could make a valuable contribution to the implementation of the New Urban Agenda and its environmental pillar under conditions of demographic change. And it could foster discussion on the transformative commitments of the international community regarding environmentally sustainable and resilient urban development, whereby planning and managing urban spatial development are regarded as decisive tools for an effective implementation.

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Part I
Landscape Change and Management

Chapter 2
Dialectic Developments of 'City' and 'Country' in Japan's Metropolitan Regions

Atsushi Katagi

Abstract Japanese city planning in the 20th century reveals the dialectic developments of 'City' and 'Country', particularly around the three major metropolitan regions of Tokyo, Osaka and Nagoya. Since land readjustment under the City Planning Law (1919) was based on arable land readjustment, a method to steer the development of arable land was applied to urban areas. In the 1930s, green area plans were drawn up for the Tokyo, Osaka and Nagoya metropolitan regions and subsequently changed into air defense plans, some of which were realized during the Second World War. These metropolises were completely destroyed by wartime bombing and rebuilt according to reconstruction plans. The green area in the Tokyo Reconstruction Plan (1946–48) and the Suburban Area in the First Metropolitan Area Service Project (1956–58), both of which were based on the former green area and air defense plans, were never realized due to the objection of farmers, who became the owners of agricultural land under the Agricultural Land Reform (1947–). Thereafter, the new City Planning Law (1968) divided the city planning area into so-called 'urbanization promotion areas' and 'urbanization control areas'. While many parcels of agricultural land are included in the former, some building activities are allowed in the latter. 'Agricultural promotion areas' are separately designated through the Agricultural Promotion Area Law (1969). Some challenging experiments to harmonize 'City' and 'Country' have been carried out in peripheral areas, even under the current rather complicated legal system.

1 Preface

Ebenezer Howard (1850–1928) originally conceived the 'Garden City' as a happy marriage of 'Town' and 'Country' and intended to allocate self-sufficient regions, each composed of an industrial town (area 1000 acres, population 30,000) and an agricultural country (area 5000 acres, population 2000), around a metropolis to

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prevent its infinite sprawl. Although realized Garden Cities such as Letchworth and Welwyn did not develop into economically independent regions, the idea of securing open space of agricultural country in advance was later developed into the notion of the green belt in regional planning.

The current conditions of the three metropolitan regions of Tokyo, Osaka and Nagoya in Japan are instances of the 'City' unhappily encroaching on 'Country'. In the following, the development of organizing 'City' and 'Country' in the peripheries of metropolitan regions through the history of Japanese city planning is examined.

2 From Arable Land Readjustment to Land Readjustment

In Japan, under the City Planning Law and the Urban Building Law (1919), land readjustment was introduced as an effective method of city planning. The land readjustment formulated in the City Planning Law was adopted from the revised Arable Land Readjustment Law (1909), which aimed to regulate paddy fields to larger and more regular lots with straight farm roads and waterways. Arable land readjustment was also used to create a new city area for the first time in the First Imamiya Village Land Readjustment, Osaka (1910). It is important to notice that arable land readjustment for agricultural land and land readjustment for city areas were initially conceived as equivalent and hence interchangeable. Even after the enactment of the City Planning Law, arable land readjustment was still applied to city areas until it was finally abolished in 1931.

In the First Imamiya Village Land Readjustment, Osaka, a block of 108 m 108 m was defined with narrow streets of 3.6 m in width and divided into halves by a central waterway of 1.8 m in width. Similarly, in the First Section of the Ayuchi Arable Land Readjustment, Nagoya (1920), a block of 54 m × 54 m was defined with streets of 1.8–5.4 m in width and divided by a central waterway of 2.0 m in width. In the Suwa Section of the Complete Tamagawa Village Arable Land Readjustment, Tokyo (1925), a block of 50 m × 50 m was divided by secondary streets and the building lines were newly introduced for the future widening of streets.

The shape and dimension of blocks, lots and streets were discussed, for example, in the 'Theory of Land Readjustment' (1929, Fig. 1) and officially standardized in the Planning Standard of Land Readjustment (1933). Within land readjustment, land allocation was undertaken in two dimensions, similar to arable land readjustment. There was a distinct lack of future vision for a newly created city area, without any detailed regulations neither on usage nor on the three-dimensional design of buildings. Interesting examples were, nonetheless, realized in Nagoya, such as the Eastern Hill Development, Nagoya (1921, Fig. 2), featuring irregular winding streets to accommodate the undulations and irregular shapes of existing

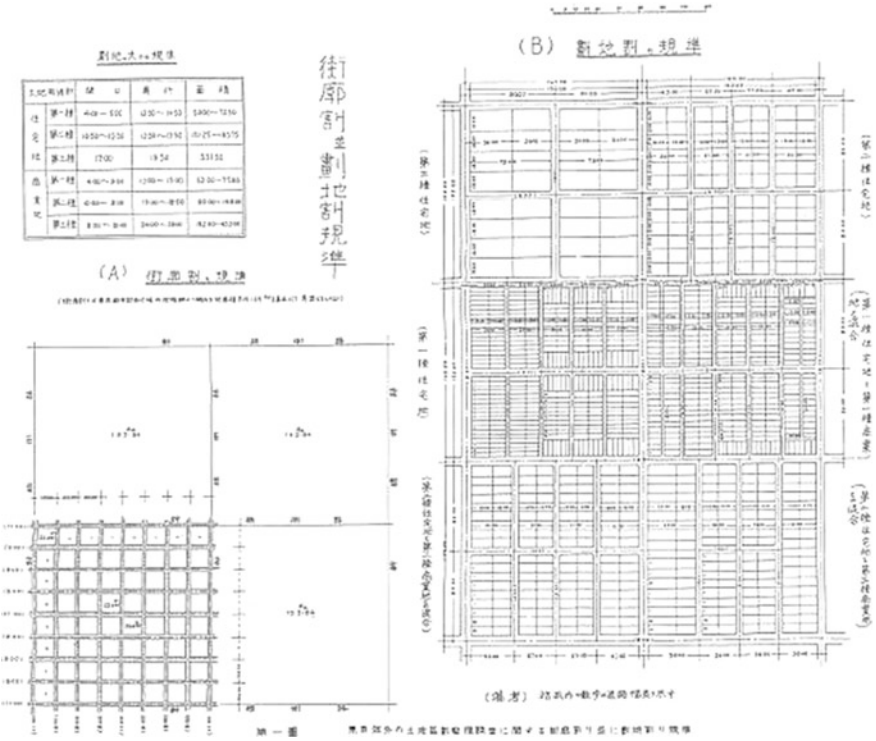

Fig. 1 Proposed Standard of Block and Lot, Teikichi Ibe, 'Tochi-kukaku-seiri-ron (Theory of Land Readjustment)', Kenchiku-zasshi (Journal of the Architectural Institute of Japan), Vol. 43, Nos. 524, 525 and 527, 1929

land, and the Tashiro Land Readjustment, Nagoya (1929), with streets radiating from a central public park.

3 Planning and Execution of Green Areas

Although the concept of the Garden City as well as the example of the First Garden City, Letchworth, was introduced early to Japan through the book *The Garden City* (1907) published by the Department of Local Affairs (Ministry of the Interior), only its image was applied to some suburban developments and was much advertised. Thus, Denen-chofu, Tokyo (1923) was developed by the land readjustment of Denen-toshi (the Garden City) Co. Ltd., which was later absorbed into the Megro-Kamata and Tokyo-Yokohama Railway Companies. After its success, similar suburbs were developed along the lines of both railway companies.

The Garden City Movement in England had grown into the International Federation for Town and Country Planning and Garden Cities (1913, now the

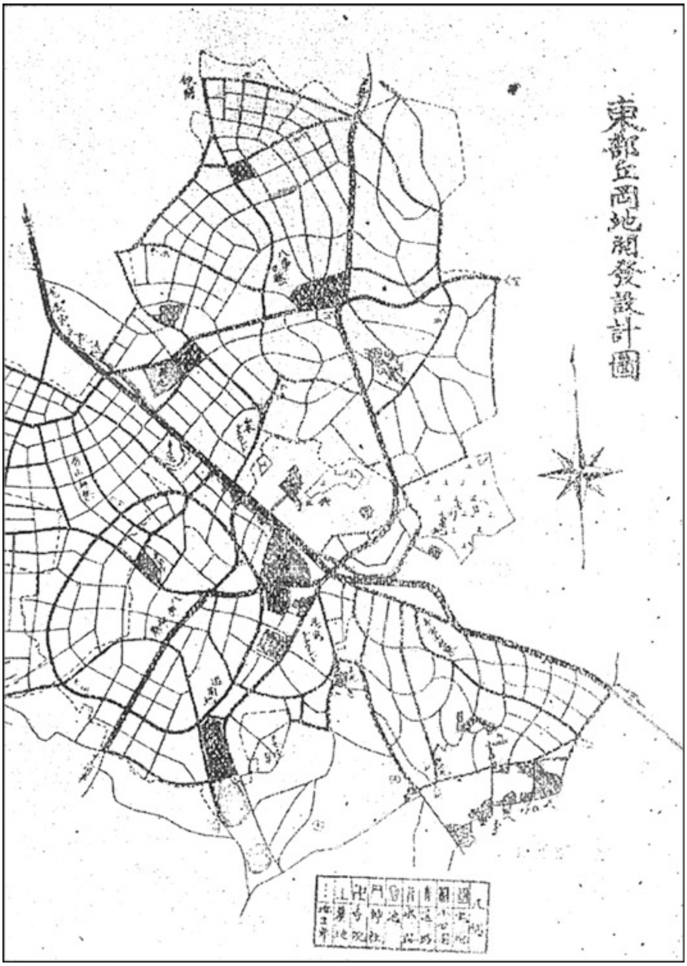

Fig. 2 Eastern Hill Development, Nagoya, c.1925, Hideaki Ishikawa, 'Nagoya no Kukaku-seiri no Tokushitsu (Characteristics of the Land Readjustment in Nagoya)', Toshi-mondai (Urban Problem), Vol. 9, No. 4, 1929

International Federation for Housing and Planning (IFHP)), which started to hold International Town Planning Conferences. Japanese city planners, who joined the conferences from the 1920s, were much influenced by the seven principles of metropolitan regional planning as well as the model of a metropolis surrounded by a green belt and satellite towns discretely sited outside.

The result was the Tokyo Green Area Plan (1932–39, Fig. 3), drawn up by the Planning Committee of the Tokyo Green Area. In it, the English term 'open space' or the German term 'Grünflächen' was translated into 'ryokuchi (green area)'. The green area was defined as 'permanently unbuilt open space', systematically categorized, and planned within a 50 km radius of Tokyo Station. A green belt of 1–

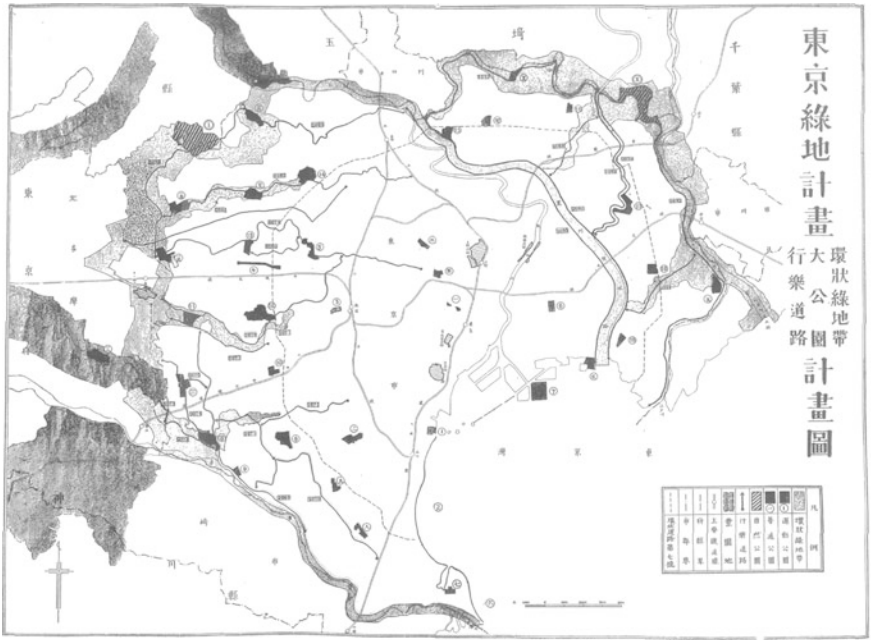

Fig. 3 Tokyo Green Area Plan, 1932–39, Koen-ryokuchi (Park and Green Area), Vol. 2, Nos. 2 & 3, 1939

2 km in width was established on the periphery of the Tokyo city area, with the Arakawa and Edogawa Rivers as the northern edge, the Tamagawa River as the southern edge, and the city boundary (along a 15 km radius) connecting the north and south edges to form a circle. From this circular belt, wedge-shaped belts were specified inwards along the rivers and canals to form a radiating pattern. Outside of these green belts, most of the hillside and riverside lands unsuitable for paddy fields were designated as scenic park areas, for which parkway access was also planned. During the Second World War, the initial planning aim of controlling urban sprawl was replaced by air defense and the Tokyo Green Area Plan was turned into the Tokyo Air Defense Open Space and Open Space Belt Plan (1943). This was based on the newly institutionalized concept of ‘air defense open space’ under the revised Air Defense Law (1941). Under this plan, an inner circular air defense open space belt along a 10 km radius as well as radiating open space belts from it were added to the former green belts in the Tokyo Green Area Plan. The green space was institutionalized in the revised City Planning Law (1940) and six large green spaces (Kinuta, Kojiro, Koganei, Toneri, Mizumoto and Shinozaki) were planned as major projects of the Imperial Era 2600 Anniversary celebrations. Thereafter, further 14 air defense green spaces were added in 1942 and eight in 1943. Since most of those corresponded with the sites for large public parks in the Tokyo Green Area Plan, it

can be said that the Tokyo Green Area Plan was implemented during the war at least in part in the name of the Emperor and air defense.

Under the influence of this plan, the Osaka Green Area Plan (1941, Fig. 4) was drawn up. It a mountain belt for preserving the surrounding mountains and hills along a 15 km radius from the center of Osaka, a circular green belt along a 10 km radius as well as wedge-shaped green belts radiating inwards along the Yodogawa and Yamatogawa Rivers. Four large green spaces (Hattori, Tsurumi, Kyuhoji and Oizumi) were planned and implemented at the intersections of the green belts. It is striking that the swampy lowland was designated as part of the circular green belt connecting the two rivers. The Osaka Air Defense Open Space and Open Space Belt Plan (1943) was made similar to the one in Tokyo. An inner circular air defense open space belt of 300–500 m in width was established along a 5 km radius

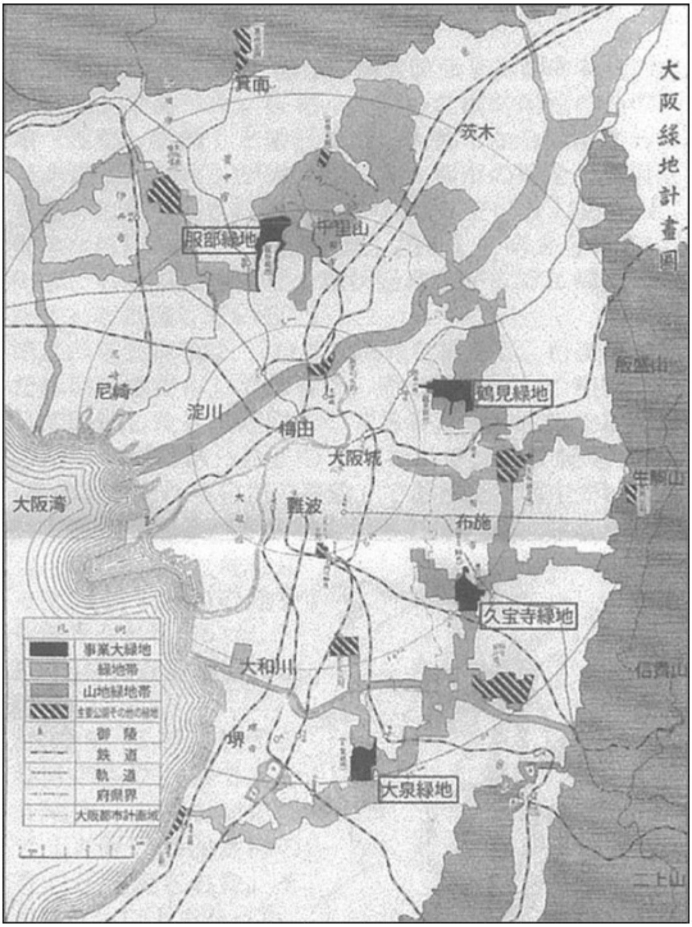

Fig. 4 Osaka Green Area Plan, 1941, Koen-ryokuchi (Park and Green Area), Vol. 5, No. 9, 1941

from the center. As this belt was directly adjacent to the existing built-up area, the inner radiating open space belts could not be included therein.

In Nagoya, a green area plan similar to those in Tokyo and Osaka was not planned. In the Nagoya Green Space Plan (1940, Fig. 5), five large green spaces (the Shonai River, Obata, Makinogaike, Aioiyama and Odaka) and three types of road access to the green spaces were planned and implemented within the combined city planning areas of Nagoya, Moriyama and Narumi. An air defense open space belt was also planned, with a circular and an east-west connecting strip, yet details on this have so far not been uncovered.

Fig. 5 Nagoya Green Space Plan, 1940, Nagoya Toshi-keikaku-shi (History of City Planning in Nagoya), Nagoya Urban Institute, 1999

4 Designation of Green Space in the Reconstruction Plan and Its Annulment by the Agricultural Land Reform

The three metropolitan regions of Tokyo, Osaka, and Nagoya suffered widespread damage by aerial bombing at the end of Second World War, with damaged areas totaling 16,100 hectares (ha), 5000 ha, and 3850 ha respectively. Only a few months after the end of the war, the Bureau of Reconstruction was established in November, 1945. The Basic Policy for Reconstruction of War-damaged Areas, which aimed to control the excessive growth of metropolitan areas and to reconstruct local small cities, was decided by the cabinet in December of that year. This policy announced that the main streets in small or medium-sized cities should be wider than 36 m, while in large cities the main streets should be wider than 50 m and broad streets or plazas should display 50–100 m in width. Furthermore, the total extent of parks and green spaces should exceed 10% of the city area, and where possible they should be linked to green belts in the periphery. Under the Special City Planning Law (September, 1946), reconstruction plans were implemented in 115 war-damaged cities.

The Tokyo Reconstruction Plan (1946–47, Fig. 6) assumed a population of 3.5 million in the special ward area of Tokyo and a further 4 million in satellite towns and their accompanying smaller satellite towns in the outer periphery. The special ward area was organized by the street plan with seven broad streets of 100 m in width and two broad streets of 80 m in width and by the land use plan with several urban units surrounded by green areas originating from the wartime air defense plan. In this green area, less than 20% of the building coverage ratio is permitted for houses of farmers' families and other agricultural facilities, and less than 10% for detached and semi-detached. Although this strong restriction was intended to control urban sprawl, the designated green areas were gradually diminished before being completely abolished by the new City Planning Law (1968). Furthermore, the air defense green spaces, which were once purchased by the authorities and then used for food production during the war, were included as objects of the Agricultural Land Reform by the Law on Special Measures for Establishment of Landed Farmers (1946). In the Tokyo Metropolitan Area, 63% of 746 ha of land purchased for air defense open spaces were sold to cultivators at extremely low prices and repurchased later. In the meantime, the so-called 'Dodge Line' of March, 1949, a policy drafted by an economic adviser to the General Headquarter of the Allied Forces (GHQ), Joseph Dodge, called for stabilization of the economy as well as budget reductions. The cabinet then issued a basic policy to re-examine the reconstruction plan in September, forcing a considerable reduction in the reconstruction projects. The Tokyo Metropolitan Area, where the reconstruction projects were much delayed, suffered under this radical change of policy. From the initial land readjustment area of 20,166 ha, only 1652 ha of land next to national railway stations was in fact reconstructed.

In the Osaka Reconstruction Plan (1940, Fig. 7), the former air defense open space belt was not preserved, resulting in extensive urban sprawl towards the

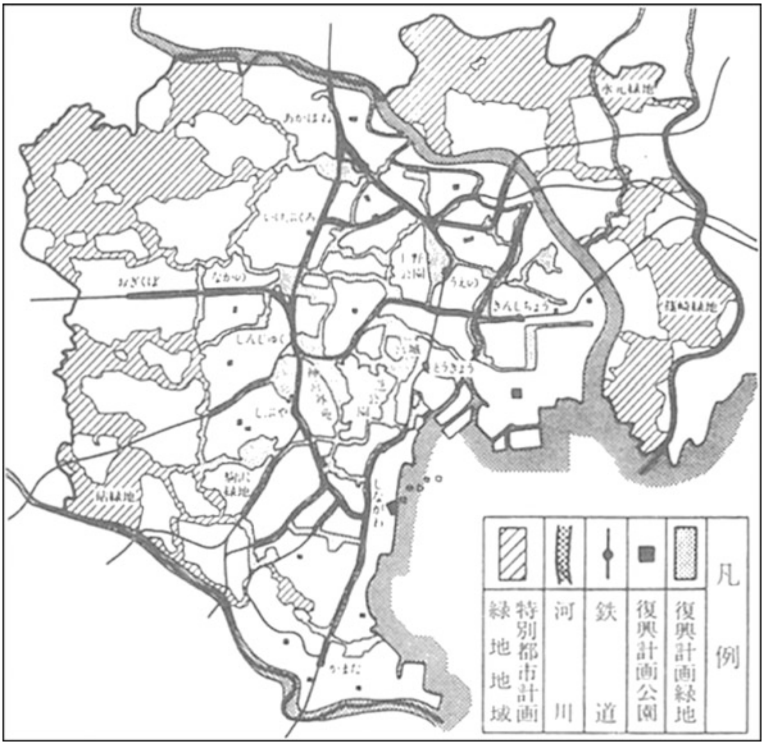

Fig. 6 Tokyo Reconstruction Plan, 1946/47, Akira Koshizawa, Tokyo no Toshi-keikaku (City Planning in Tokyo), Tokyo, 1991

swampy lowland connecting the two rivers and hence the breakdown of the encircling open space belt. After the land originally purchased in order to establish three green spaces was sold (except Hattori Green Space), most of the land for the Tsurumi Green Space was repurchased, though only 70% of the Oizumi Green Space and 30% of the Kyuhoji Green Space were obtained.

The Nagoya Reconstruction Plan (1947, Fig. 8) was regarded as one of the successful examples of urban development. Its grid pattern street plan, with two parkways of 100 m in width and nine main streets of 50 m in width, as well as the relocation of the temple graveyards scattered in the downtown area to a suburban cemetery park, were highly praised. The Nagoya Reconstruction Plan was quickly devised and executed. In spite of the reduction of the land readjustment area from 4407 ha to 3491 ha, two parkways, Hisaya Odori and Wakamiya Odori, and a cemetery park, Heiwa Park, were realized as planned. Here again, 48% of 830 ha of land originally purchased for air defense green spaces were sold to cultivators.

Dissatisfied with the First Agricultural Reform initiated by the Agricultural Land Adjustment Law (December, 1945), the GHQ proposed the notes on agricultural land reform. Based on this, the Law Concerning Special Measures for

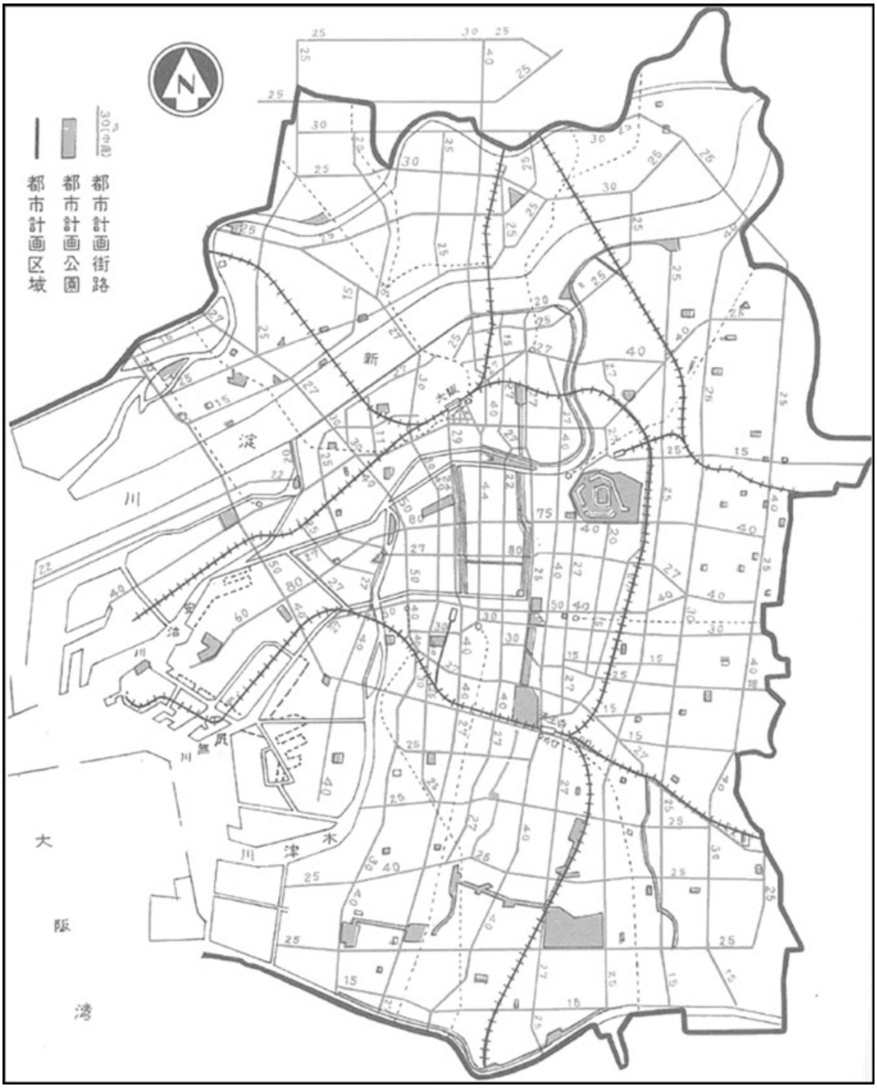

Fig. 7 Osaka Reconstruction Plan, 1940, Osaka-shi Sensaifukko-shi (History of War Damage Reconstruction of Osaka City), Osaka City, 1958

Establishment of Landed Farmers and the revised Agricultural Land Adjustment were promulgated in October of 1946. This led to the Second Agricultural Reform, which stipulated that large agricultural areas owned by large estate owners are to be subdivided and transferred to the farmers who cultivated them. The new small landed farmers were willing to meet the rising demand for food production but unwilling to facilitate the land readjustments in the post-war years.

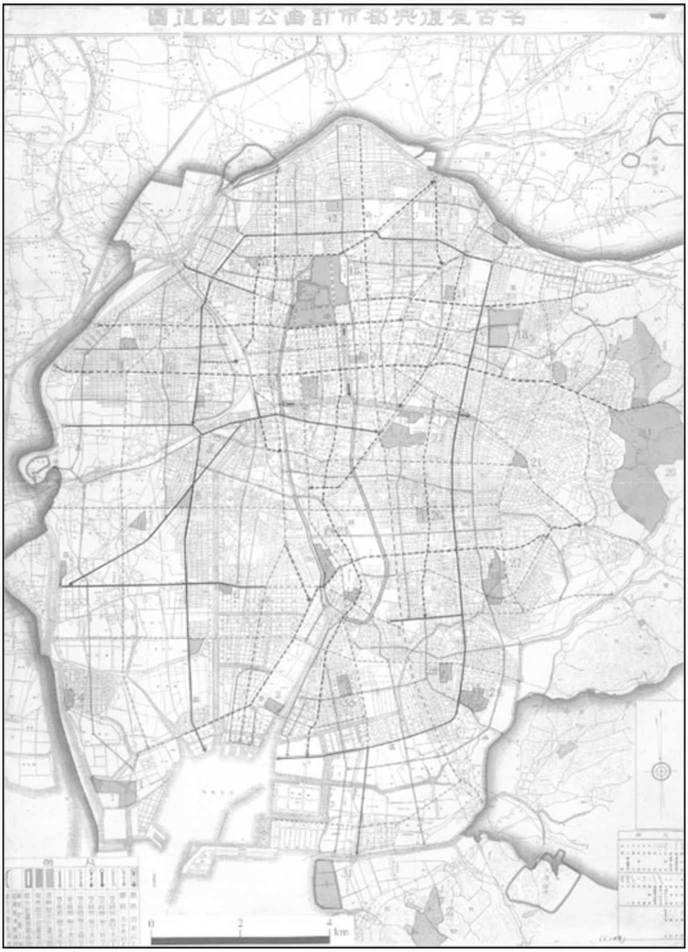

Fig. 8 Nagoya Reconstruction Plan 1946, Nagoya Toshi-keikaku-shi (History of City Planning in Nagoya), Nagoya Urban Institute, 1999

Such difficulties can be found in the First Capital Region Development Plan (1958, Fig. 9). Similar plans for Tokyo’s metropolitan regions such as the Kanto Regional Plan (1936) were conceived before the war and the Tokyo Reconstruction Plan presupposed these regional plans as mentioned before. Although the Tokyo Metropolitan Government was forced to abandon its Reconstruction Plan, it tried again to reconstruct the capital by means of a national project. The Committee for Capital Construction organized under the Capital Construction Law (1950) proposed the Draft for the Capital Region (1950). Subsequently, the Committee for Capital Region Development organized under the Capital Region Development Law (1955) drew up the First Capital Region Development Plan (1958). The plan was said to be much influenced by the Greater London Plan (1940), featuring a

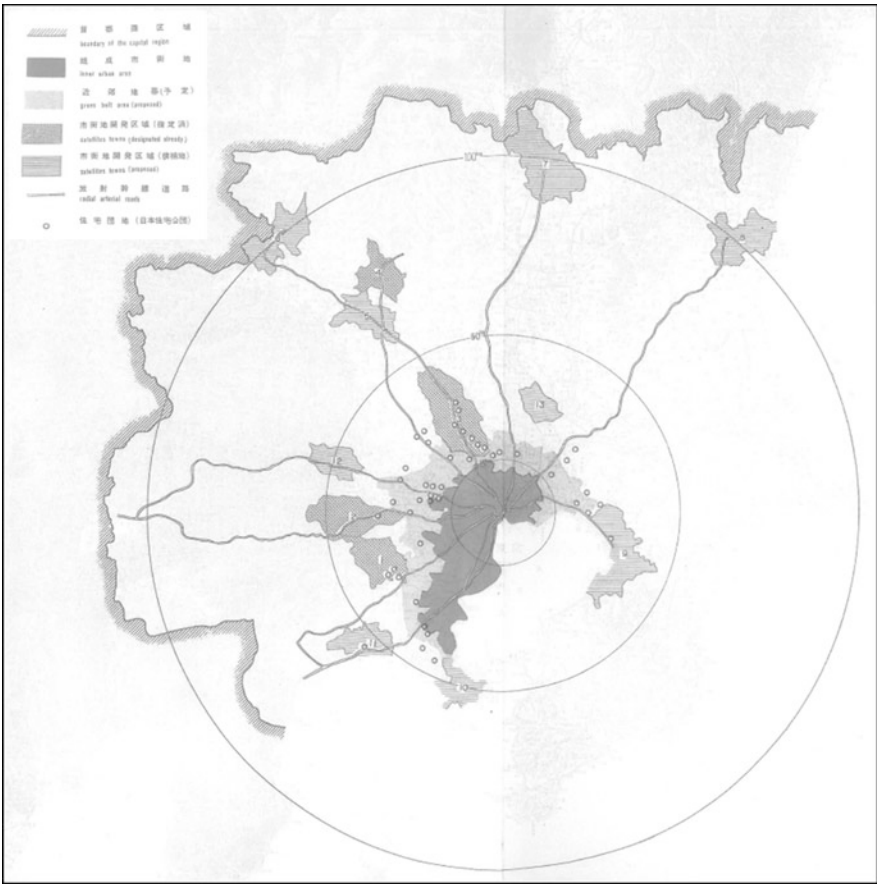

Fig. 9 The First Capital Region Development Plan 1958, Shuto-ken Seibi-keikaku Shiryo-zushu (Map Documents of Capital Region Development), Tokyo Metropolitan Government, 1961

concentric pattern of the metropolis, green belt and satellite towns within an almost 100 km radius from the center. Here the green belt was misleadingly called the ‘Suburban Area’. When the detailed plan was announced to connect the Koganei and Jindaiji (former Kojiro) Green Spaces by an additional green space, the farmers who were opposed to this plan agreed to convert 20–30% of agricultural land to other uses and actually built small apartment houses within the planned area. Furthermore, the Japan Housing Corporation and Tokyo Metropolitan Government, which were expected to supply a large amount of houses, sought to obtain the sites for large residential complexes in the Suburban Area. In the end, the Committee for Capital Region Development officially shelved the plan and the Tokyo Metropolitan Government reclassified the Suburban Area to an ordinary residential area. When the Capital Region Development Law was revised in 1965, the Suburban Area was replaced by the Suburban Development Area, an ambiguously defined zone that aimed to develop built-up areas and to preserve green areas at the same time. A compensatory law, the Suburban Green Area Preservation Law in the Capital Region (1966), could designate only limited green areas.

Under a burgeoning capitalism based on landownership, the regional plan to control metropolitan sprawl was destined to fail. The Tokyo Plan 1960 by Kenzo Tange, published in 1961, criticized this situation. It planned the further extension of the metropolis not overland but overwater, with multi-story highways and high-rise buildings lightly floating on the waters of Tokyo Bay.

The Kinki Region Development Law (1963) and the Chubu Region Development Law (1966) did not propose any substantial regional planning. In the Chubu region, the Future Plan for Greater Nagoya (1955) envisaged an extensive green belt including the five large green spaces along the eastern hill of Nagoya. The eastern hill was, however, rapidly developed by land readjustment after the success of the Idaka Nishiyama Land Readjustment (1969, Fig. 10), which proved

Fig. 10 Land Readjustment Plan, Nagoya 1969 (History of City Planning in Nagoya), Nagoya Urban Institute, 1999

that even land readjustment with a quite high ratio of land decrease could be profitable. The Urban Green Area Preservation Law (1973, now renamed the Urban Green Area Law) obliged each local authority to formulate a master plan of green areas to define a vision for the future as well as the means to secure it within the city planning area. However, this has not worked well in practice.

5 Conflict Between the New City Planning Law and the Law Concerning Maintenance of the Agriculture Promotion Area

The new City Planning Law (1968) institutionalized a division of the city planning area into two areas: the urbanization promotion area, which encompasses already urbanized areas as well as those which are primarily to be planned and urbanized within about 10 years, and the urbanization control area, where urbanization should be controlled, with accompanying development permission. Because of the loose demarcation between urbanization promotion and control areas, agricultural land totaling 0.31 million ha remained within urbanization promotion areas of 1.24 million ha. At the same time, small development activities of less than 0.1 ha were promoted in the urbanization promotion area, whereas extensive (more than 20 ha) and exceptional development activities were carried out in the urbanization control area. Therefore, the long cherished ambition to control urban sprawl has never been realized.

In the meantime, the Law Concerning Maintenance of the Agriculture Promotion Area (1969) designated the agricultural land promotion area of 17.58 million ha, which includes the agricultural land area of 547 ha outside the city planning area and inside the urbanization control area.

Regarding the agricultural land inside the urbanization promotion area, taxation based on residential land was applied to promote residential developments under the Law Concerning Temporary Measures for Promotion of Residential Land (1973). On the other hand, the Production Green Area Law (1974) designated the first (permanent) grade to agricultural land plots of more than 1.0 ha and the second (10 years) grade to agricultural land plots land of more than 0.2 ha in order to preserve the production green area.

Even though taxation based on residential land was nullified by various legal measures, the revised Production Green Area Law (1991) enabled specific cities within three major metropolitan regions to clearly discern the agricultural land inside of the urban promotion area to be urbanized and to be preserved (i.e. production green area per se) and then to apply tax equivalent to residential land on the former.

Finally, the peripheries of metropolitan regions have been subject to three ambiguous and inadequate regulations, namely the new City Planning Law and the Production Green Area Law by the Ministry of Land, Infrastructure, Transport and

Tourism, as well as the Law Concerning Maintenance of the Agricultural Promotion Area by the Ministry of Agriculture, Forestry and Fisheries. Under such a complicated legal system, Kohoku New Town, Yokohama (1975, Fig. 11) was developed under the land readjustment plan of the Japan Housing Corporation in which the exclusive agricultural district of 917 ha could be preserved through incorporation into the urbanization control area. Such a successful example is rare and even after revision of the Production Green Area Law, agricultural land plots to be urbanized and those to be preserved were mixed up with residential lots, resulting in a mosaic-like chaos in the peripheries of metropolitan regions.

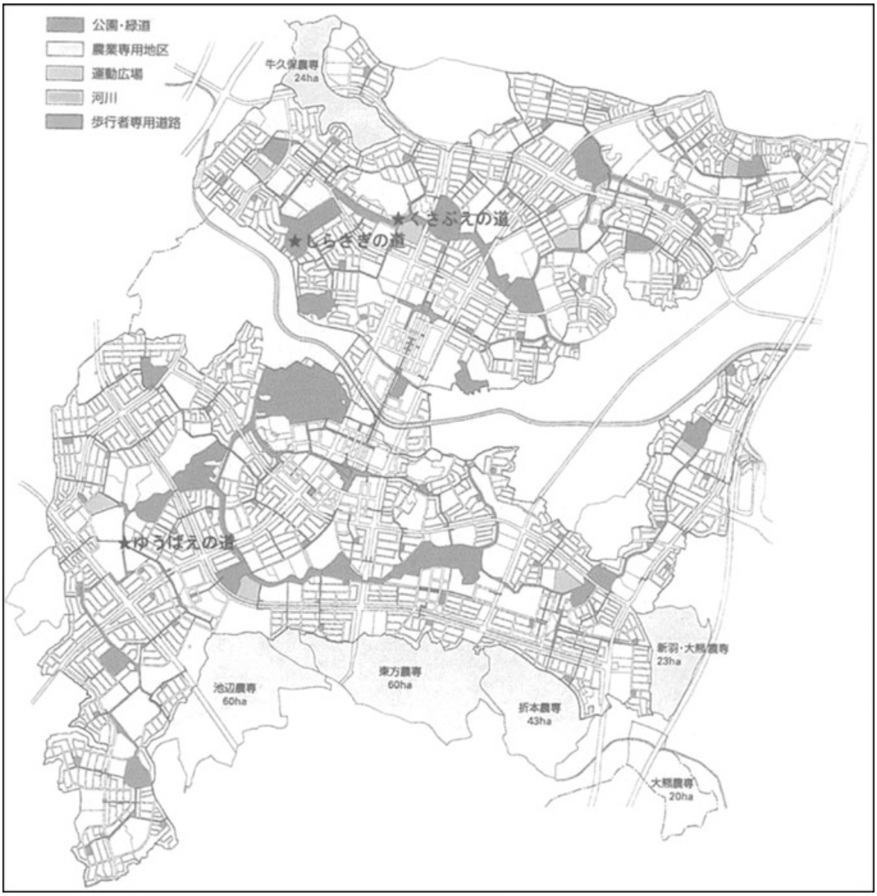

Fig. 11 Kohoku New Town, Yokohama 1965, Urban Development Bureau, http://www.city.yokohama.lg.jp/toshi/chiikimachi/nt/, June 13, 2017

6 Conclusion

Against the backdrop of declining birthrate and growing aged population, the periphery between 'City' and 'Country' in Japanese metropolitan regions has been transformed to a new outlook.

In the 'Country' side, post-war Agricultural Land Reform saw agricultural land divided into small lots with strict regulations placed on the leasing of lots. As each holding of agricultural land was based on a family unit, its labor force depended solely upon the family members and the necessary capital was borrowed from the Agricultural Cooperative Association. This led to a situation in which the established farmers were discouraged to introduce mechanized agricultural management in large lots of land and they worked on small lots to produce small amount of agricultural products of high quality and high prices. Along with the processes of industrialization and urban sprawl, Japan has thus seen a drop in the numbers of people employed in agriculture as well as in the total area of agricultural land. The food self-sufficiency rate is the lowest of all industrialized nations at 39% (2014). As small landed farmers reach retirement age, the abandoned and derelict agricultural lands is to increase.

In the City, as residents in the public housing complexes built by the Japan Housing Corporation and local authorities, Senri (1958), Kozoji (1961) and Tama (1965) New Towns, and suburbs developed in the age of the 'Bubble Economy', become old, the abandoned houses are to increase. Along the main roads leading from the urbanization control area outside the city planning area, shopping centers as well as numerous shops and restaurants have arisen to form built-up 'strips'. While today they give the impression of intense commercial activities, they too will soon be abandoned when the aged population is no longer fit to drive.

Viewed from the perspective of the 'Country' and the 'City', abandoned lots of land will become ever more prevalent and more mixed up like an intricate mosaic. While it is vital that shrinking cities are moving towards a low carbon society here in Japan where there is a declining birthrate and a growing proportion of the elderly, the problem of reorganizing the periphery of the 'City' and 'Country' should be solved in a manner different to that proposed by Ebenezer Howard.

Chapter 3
Urban Ecosystem Services and Biodiversity Offsets

Wolfgang Wende and Marianne Darbi

Abstract With the adoption of the 2020 Biodiversity Strategy, the EU has made a commitment to halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020. EU-wide actions include the development of an initiative to ensure that there is no net loss of biodiversity, ecosystems and their services e.g. through compensation or offsetting schemes by 2015 (Action 7b; initiated by the European Commission). In this chapter we intend to examine one relatively new and innovative instrument that can be applied to achieve no net loss of biodiversity and ecosystem services: biodiversity offsets. We focus on the German system as a kind of role model and example that shows challenges and advantages of a biodiversity offsetting system within the European context. However, a brief outlook on comparable offsetting systems in other countries will also be raised. Particularly, the urban stage is to be addressed.

Keywords Impact mitigation regulation · Biodiversity offsets
Ecosystem services · Biodiversity · Planning and assessment tools

1 The EU's Biodiversity Strategy 2020 and Biodiversity Offsets

With the adoption of the 2020 Biodiversity Strategy, the EU has made a commitment to halting 'the loss of biodiversity and the degradation of ecosystem services[1] in the EU by 2020, and restoring them in so far as feasible'. In particular, this is to be achieved through Target 2, which is to maintain and enhance ecosystems and their services 'by establishing green infrastructure and restoring at least 15% of

[1]For a comprehensive definition of ecosystem services see: Grunewald and Bastian (2015): Ecosystem Services—Concept, Methods and Case Studies. Springer Berlin, Heidelberg.

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degraded ecosystems'. Supporting actions include the development of a strategic framework to set priorities for ecosystem restoration at sub-national, national and EU level (Action 6a), a Green Infrastructure Strategy by 2012 (Action 6b), and an initiative to ensure that there is no net loss of ecosystems and their services (e.g. through compensation or offsetting schemes) by 2015 (Action 7b; both initiated by the European Commission). In this chapter we intend to examine one relatively new and innovative instrument that can be applied to achieve no net loss of biodiversity and ecosystem services: biodiversity offsets. Biodiversity offsets seek to physically compensate for unavoidable, residual impacts to biodiversity in order to ensure overall 'no net loss'. In the past decade this tool has been employed by a growing number of countries worldwide, (Gardner et al. 2013 and Business and Biodiversity Offsets Program BBOP 2012) including Japan (Ito et al. 2014). In Europe, France is currently developing and implementing new legislation and strategies for the establishment of biodiversity offsets (Quétier and Lavorel 2011). Considering the EU's commitment and actions to assure no net loss of biodiversity and ecosystems, on the one hand, and the growing interest of developers on the other, it is vital to investigate the feasibility and conditions as well as the legal underpinning of the implementation of biodiversity offsets and green infrastructure in EU member states. This refers to both existing legal and political requirements and instruments (e.g. environmental impact assessment, environmental liability and spatial planning) and potential new compensation regulations (as in the aforementioned case of France) (Darbi et al. 2016).

2 Ecosystem Services and Biodiversity Offsets

Around the world, species and ecosystems are facing a wide range of environmental and other threats to survival. As a result we can detect ongoing biodiversity loss and severe damage to ecosystem services (ESS). This is of concern both for the intrinsic value of biological diversity as well as for the goods and services that it provides for human wellbeing such as food and water, natural protection against floods and storms, and climate regulation. Due to the complexity of ecosystems and the variety of interactions with the natural and human (socio-economic) environments, until now it has proved impossible to identify all the benefits that accrue from biodiversity, or to predict the consequences that the loss of a single species or a population and/or ecosystem services can have. One core challenge at a global, EU and country level is to protect against such loss and thus safeguard ecosystem services. Given that biodiversity and ESS are not evenly spread, and that trends differ from one region to another, the burden of tackling the challenge is also unequally distributed. However, regardless of these regional differences and the question as to how to assure equity and shared responsibility, two major tasks emerge: First, the establishment of a scientific baseline on the state of biodiversity (and its interactions) as well as the valuation of ecosystem services; and second, the application of biodiversity offset tools to intelligently manage biodiversity and ESS.

2.1 Establishing a Scientific Baseline

Effective biodiversity and ESS management can only be realized through the establishment of a common scientific baseline. Specifically, it is necessary to assign a value to biodiversity and the provided ESS, and thus to measure loss or gain both quantitatively and qualitatively from an ecological and societal perspective. This should allow an estimate of the economic costs associated with biodiversity loss and ecosystem degradation, which have, until recently, been largely overlooked. Assessing the value of biodiversity/ESS also provides us with a means to measure progress.

Moreover, knowledge of the interactions between the biosphere, ecosystems and human activities must be enhanced, especially with regard to tipping points and critical transitions. As stated by the European Commission,[2] there is mounting evidence that the status of many ecosystems is reaching or has already reached the point of no return. In the same way that a rise in global temperatures of 2 °C above pre-industrial levels would lead to catastrophic climatic change, the loss of biodiversity and ESS beyond certain limits would have far-reaching consequences for the basic ecology of the planet. While these limits are still being defined, it is already clear to the scientific community that the current rate of biodiversity and ESS loss puts the future well-being of citizens at risk, both in the EU and worldwide.

In order to establish a scientific baseline, it is necessary to define criteria for the valuation of biological diversity and ESS, as well as criteria that define specific thresholds for irrecoverable loss. The baseline will be based on the current status of the core features of biodiversity: conservation of species and habitats, of ecosystems, and of the most critical ecosystem services. Although sufficient data is already available to set a clear and reliable baseline, further work is needed to translate this data into measureable and policy-responsive indicators. To this end, a set of European indicators is being developed which, together with data gathered for implementation of the Habitats Directive, is likely to be the most advanced in the world. In 2010 the EEA finalised the first EU biodiversity baseline and launched a Biodiversity Information System for Europe (BISE).[3]

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[2] Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee of the Regions: *Options for an EU Vision and Target for Biodiversity beyond 2010*, Brussels, COM (2010) 4/4.

[3] http://biodiversity.europa.eu/.

2.2 *Biodiversity and ESS Offsets as a Tool for Governance/Management*

The short-term goal of biodiversity management is to prevent a decline in biodiversity and ESS. Over the long term, the goal is to effectively preserve biodiversity and ESS. This encompasses the requirement to physically compensate for biodiversity and ESS loss. Therefore, biodiversity management cannot simply focus on conservation, but must also consider restoration activities in order to counterbalance biodiversity and ESS loss. The central factor here is the skilful management of impacts and offsets (including trade-offs) that aims to provide a full like-for-like or better compensation for unavoidable residual damage to biodiversity and ESS. Discussion of the use of such a management tool addresses a number of core issues inherent to biodiversity and ESS:

- **Appropriateness**: What is the relationship between prevention and restoration/offsetting?
- **Scale**: At which scale and under which functional and spatial conditions must biodiversity and ESS loss be addressed?
- **Responsibility**: Who implements and finances restoration activities?
- **The type of biodiversity and ESS management**: How are offsets to be determined and stipulated? Through regulative measures and policy and planning instruments, or through market, social or other mechanisms?

Here the most important issue regarding biodiversity and ESS offsets is the question of responsibility. The specific question to be answered is: Who should be held responsible for the implementation and (above all) for the financing of restoration measures? In general, reference is often made to the polluter-pays-principle, which, however, sometimes proves less effective than expected. This can be attributed to the aforementioned complexity of ecosystems and their spatial, functional and temporal relations, as well as to the fact that it is not always possible to precisely identify the responsible party. Furthermore, the question arises as to whether and how the beneficiaries of certain ecosystem services should be responsible for maintaining or restoring the biodiversity that serves as a basis for these services (e.g. payments for ecosystem services). This can be seen in an even broader context with regard to the climate protection function (climate change mitigation and adaptation) of biological diversity, which implies a shared global responsibility. Consequently, a single isolated approach will fail to comprehend the complexity of biological diversity and ESS. Similarly, the multitude of benefits from biodiversity/ESS and the threats resulting from any loss mean that the maintenance of biodiversity can no longer be the task of nature conservation programs alone. More needs to be done to systematically engage other sectors in formulating responses to the biodiversity challenge, underpinned by clear indicators for measuring progress (cf. establishment of a scientific baseline). Policies for biodiversity/ESS must be coherent and mutually reinforcing. Moreover, we require an integrative cross-sectoral management approach.

Biodiversity and ESS offsets are at the cutting edge of economic development and nature conservation. They do not follow a sectoral approach, and should not be viewed in isolation as a mere tool of impact mitigation, but have the potential to serve as an integrative biodiversity/environmental management tool. This must include a whole range of instruments from legal, policy and planning requirements, from restricted and protected areas and items, through economic incentives and market-based approaches, to social mechanisms and participatory approaches, depending on the specific circumstances. One study on international approaches to compensation for impacts on biological diversity (Darbi et al. 2010 and also Herbert 2015) found that some offsets are closely linked to legal provisions (e.g. the German Impact Mitigation Regulation) or Environmental Impact Assessments; others build on market mechanisms (e.g. biobanking in New South Wales, Australia), while another set are linked to protected areas (developer's offsets in Brazil) or have even been established voluntarily (e.g. the Rio Tinto Ilmenite Mine in Madagascar).

With reference to the ecosystem approach, offsets must be further evaluated at the level of landscapes. Hence, biodiversity and ESS offsets must be integrated into general land use and environmental planning. This should consider:

- all sectors, especially those that have been neglected in the past such as agriculture and forestry (e.g. soy bean farming in the Amazon),
- the various interactions, particularly with climate change (e.g. reducing emissions from deforestation and forest degradation), and
- socio-economic aspects, especially livelihood requirements of the local population (cumulative small scale impacts).

From the perspective of biodiversity and ESS, such an integrative approach may lead to the aggregation of offsets, which has the advantage of reducing fragmentation, conserving priority areas, ensuring that offsets satisfy minimum viable area requirements, and creating ecological corridors in the landscape to enable ongoing adaptation of biodiversity and ESS to the anticipated effects of climate change. Offsets also tie in well with land use planning at the strategic level, where biodiversity/ESS conservation is one of a number of key considerations. Recently, a study has been conducted on the feasibility of habitat banking in Europe (Eftec 2009). The results should be further enhanced, and research continued with regard to transferability to other geographical contexts, e.g. Japan.

3 The Example of Germany's Impact Mitigation Regulations (Wende et al. 2005)

Germany's Impact Mitigation Regulations (IMR) provide a good example of a relatively strict and mandatory policy implementation (Albrecht et al. 2014). These were adopted in 1976 as part of the Federal Nature Conservation Act. The regulations address the mitigation, compensation, and offset of impacts from developments and projects. They are of a precautionary nature and not only related to biodiversity but also constitute an instrument of landscape conservation. The IMR have to be applied at the level of individual projects, such as the development of new residential areas or the construction of roads or railways.

The main objectives of the IMR are the avoidance of significant negative effects and to ensure compensation for impacts on natural assets such as habitats, soil, water, climate and air quality as well as the aesthetic quality of the landscape. At a minimum, the existing ecological situation is to be preserved ('no net loss' principle).

Although it has taken a number of years, the IMR are now applied in a professional manner in all of Germany's federal states. The regulations must be obeyed if a planned project *might* cause a change in the surface of a plot of land or in the groundwater level with major negative effects on the functioning of natural systems or on the landscape scenery. IMR are not limited to defined project types but are applied to all kinds of projects which could have a significant impact on nature and the landscape. The planned compensation and offset measures (for example, the restoration of habitats) in the context of IMR are mandatory and legally binding. The measures must be realized before or during the project implementation phase. Legally, impact mitigation regulation is regarded as practice-oriented, and is a very strict planning instrument. Nevertheless, the objective of preventing any deterioration in the conditions of nature and landscapes has still not been completely achieved. The continuing decline of species and several other criteria indicate that, to date, the results of the implementation of impact mitigation regulation have not been fully satisfactory. For this reason, Germany's Nature Conservation Act was amended in 2002 to optimize the enforcement and implementation of compensation measures. These actions, as well as new experiences in planning practice, paved the way for innovative and highly effective solutions such as habitat banking systems. One major example of new planning practice was the establishment of compensation pools (habitat banks). A pool or a bank (as defined in Germany) is a well mapped-out collection and concentration of usable sites and measures for the compensation of impacts. A strategy for land collection must be established in every pool, and the IMR process must be carried out more flexibly. With this transition to a more flexible application of IMR in practice, and with the opportunities offered by compensation pools and habitat banks, higher quality compensation results have been achieved. The German system thus illustrates an approach of more or less strict policy implementation.

The following example of sustainable urban planning in Berlin visualizes such a general offset strategy in the context of urban ecosystem services and/or urban biodiversity (see Fig. 1). In order to concentrate and manage compensation measures, the Berlin Senate Department for Urban Development has developed a so-called General Urban Mitigation Plan to complement the Berlin Landscape Program 2004 (For landscape planning in the German-Japanese context see:

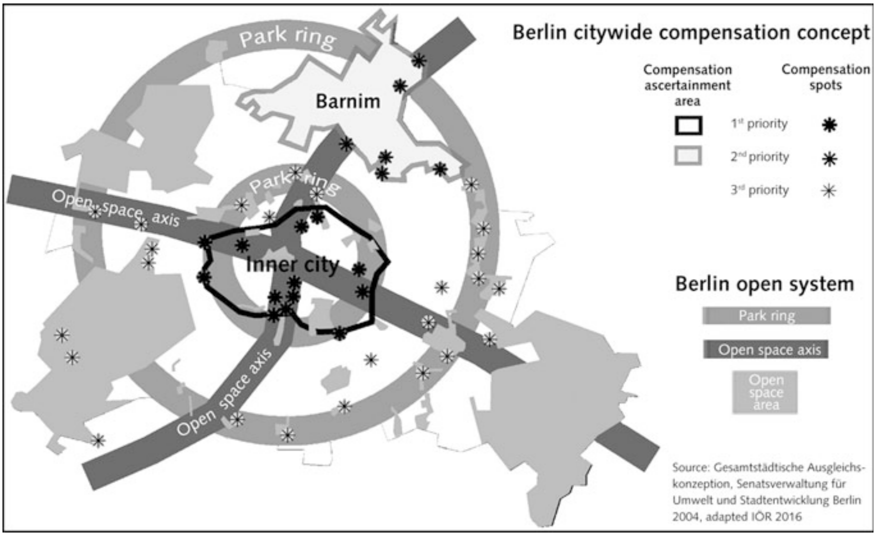

Fig. 1 Berlin citywide compensation concept. *Source* Senatsverwaltung für Stadtentwicklung und Umwelt Berlin (2004) (translated)

Shimizu and Murayama 2014). The development objectives and measures were grouped according to type of impact and type of compensatory measure. From the city perspective, areas and measures have priority when they qualify and complement components of Berlin's open space system. Special priority is given to measures that improve the quality of the inner city. Compensation areas of secondary priority are areas of the green and open-space system within the Berlin-Barnim Recreation Area in the northeast of Berlin (Fig. 1). There exist two further compensation ascertainment areas to be developed and completed—the Green Axis Cross and the Inner and Outer Park Rings—where tertiary-priority compensation areas are located.

Generally, these areas should be selected for their demonstrable potential to improve the environment and strengthen conservation. In cases of structural interventions in the urban open space as well as environmental impacts, compensation measures are now to be developed according to this strategy. The respective 'perpetrator' of the impacts (generally a private investor) must bear the costs for these measures in such cases. The measures are checked and documented in the Berlin register of compensation areas maintained by the Senate Department for Urban Development. This will ultimately safeguard these environmental and nature-improving measures for the long term.

4 Conclusion

The main results of this analysis underline the importance of strong biodiversity offset tools at the landscape level. Other existing instruments in the field of impact mitigation (e.g. environmental impact assessment, environmental liability and spatial planning) alone are not sufficient to address the loss of biodiversity comprehensively. Therefore, the political and legal establishment of biodiversity offsets as part of the mitigation hierarchy (including measures for prevention and minimization), is an important prerequisite to achieve no net loss (Darbi et al. 2016). Germany's Impact Mitigation Regulations can serve as a kind of role model for the implementation of comparable offset tools around the world, particularly in Japan. General principles such as the strict adherence to the mitigation hierarchy and the preference for natural compensation (leaving monetary compensation as ultima ratio) as well as methodological guidelines provide useful experiences to learn from, Nevertheless, the German IMR cannot simply be transferred one-to-one to other compensation schemes. A sound consideration of the specific terminology and context (political, economic, planning culture and administration) is crucial (Darbi et al. 2016). In particular, a strict legal underpinning is also necessary to prevent, manage as well as to develop biodiversity and ecosystem services.

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Chapter 4
Sustainable Landscape Management and Landscape Management Labor Accounts

Hiroyuki Shimizu, Chika Takatori and Nobuko Kawaguchi

Abstract There exist many kinds of landscape elements such as garden trees, roadside trees, urban gardens, parks, paddy fields, other farmlands, bamboo bushes, forest and so on. Human labor is required to maintain these green features. In this article, the concept of 'landscape management labor accounts' is proposed and investigated through some case studies. An annual personal labor account is a personal labor account required to maintain a targeted landscape element for 1 year. A personal labor account per area is the annual personal labor density needed to maintain one area for 1 year. Annual personal labor accounts range widely from 3 to 2340 man-hours per year. Also personal labor densities also show wide variation from 0.01 to 85.8. Five working style types can be distinguished according to the relationship between annual personal labor accounts and personal labor densities.

1 Introduction

It is an obvious truism that landscapes need to be managed to ensure their sustainability. But how can sustainable management be measured in a standard manner for different landscapes? Until now no suitable method has been available. Therefore, our research group has developed 'landscape management labor accounts' as a suitable indicator for sustainable land management. This indicator is an account of the human labor needed to maintain a certain landscape. It allows us to compare maintenance intensities for different landscape types in the form of manpower at a uniform scale. A suitable measure of landscape labor is especially important in an age of shrinking and ageing populations. Most of the pressing issues around the sustainability of land management are related to a shortage of the labor force. Many of the world's advanced nations have populations that are not only shrinking but also aging. Japan joined this group around 2008.

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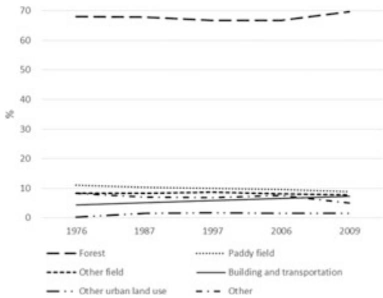
Fig. 1 Basic landscape types in 1976 and 2009



2 Land Uses and Landscapes in Japan

The Japanese population is forecast to decrease from 126,597,000 in 2015 to 86,737,000 in 2060, a drop of no less than 31%. Obviously, such a drastic change would have a huge impact on local activities, social systems and the wider economy. Shortages in the labor force would also affect the adequate management of landscapes to ensure their sustainability.

Figure 1 shows changes in land use between 1976 and 2009. While forests are largely unchanged, paddy fields and other fields have been replaced by built-up areas and transportation infrastructure, i.e. urban land uses.

Figures 2 and 3 show the basic landscape types in 1976 and 2009, extracted using the same land use ratios as the land use tertiary mesh data.[1] That is: an urban ratio of 0.19, field ratio of 0.45 and forest ratio of 0.86. Only areas with some level of population have been extracted. Five types are determined: the forest type, farmland type, farm urban complex type, urban type and other type. The forest type is a landscape dominated by forest, generally found in highly mountainous areas. The farmland type is a landscape dominated by paddy fields or other fields, found in flat or gently sloping areas. The urban type is a landscape of cities and towns with a high density of artificial land, such as industrial areas, residential areas and commercial areas. The farmland urban complex type is typical to Japan, being a landscape with a mixture of urban and farmland areas. The other type is mostly restricted to landscapes that are a mixture of the forest type and the urban type. This type could also be called a Satoyama landscape type, which is a mixture of a forest, a paddy and other field, and a small settlement area.

Table 1 shows the change in landscapes types between 1976 and 2009. It can be seen that most of forest types and urban types are unchanged in 2009. However, a

[1]Land use tertiary mesh data, National Land Numerical Information Download Service, Ministry of Land, Infrastructure, Transportation and Tourism, http://nlftp.mlit.go.jp/ksj-e/index.html (June 14, 2017).

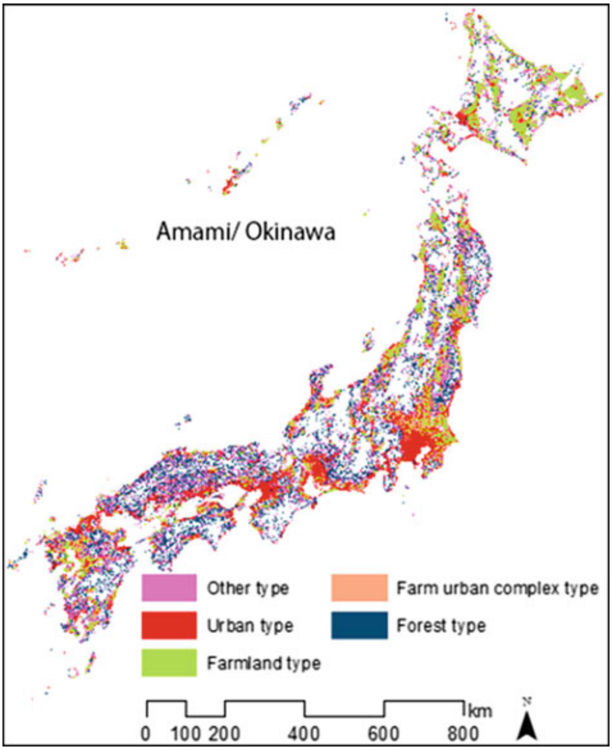


Fig. 2 Basic landscape types in 1976

large proportion of the farmland types of 1976 have been turned into farmland urban complex types by 2009, whereas the farmland urban complex types of 1976 have rather changed into urban types. This reflects the ongoing process of urbanization in the flatlands between 1976 and 2009.

There is a close link between population trends and urban land use trends. Figure 4 shows the cumulative changes of population and urban land use between 2005 and 2010 in the Nagoya region.

The integrated categories are defined as follows: 'shrinking 2' is a population decrease and urban land use decrease; 'shrinking 1' is a population stabilization and urban land use decrease; 'scattering 2' is a population decrease and urban land use increase; 'scattering 1' is a population decrease and urban land use stabilization; 'expanding 2' is a population increase and urban land use increase; 'expanding 1' is a population stabilization and urban land use increase; 'compacting 2' is a population decrease and urban land use decrease; and 'compacting 1' is a population decrease and urban land use stabilization.

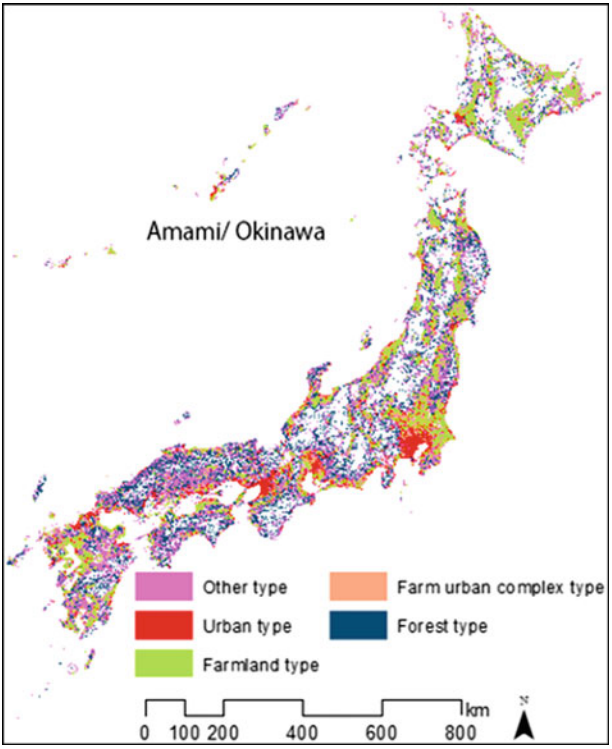


Fig. 3 Basic landscape types in 2009

Figure 5 shows combined changes of population and urban land use between 2005 and 2010 according to the distance from the center of Nagoya. The thresholds between 'stable' and other categories are +5 % and −5 %. The area from 0 to 20 km can be called an urbanized area, in which expanding 1, stable and expanding 2 are dominant. This implies that this area is formed of matured or developing urban areas with population stable or growing.

In the area between 20 and 40 km from the center, there are high ratios of expanding 1 and 2 remain and a decrease in the stable trend. At the same time, shrinking 1, scattering 1 and scattering 2 are growing. This area might be called the urban periphery, displaying a mixture of expanding, scattering and shrinking trends. From 40 to 100 km, shrinking 1 and 2 become dominant. In the coastal zone of this area, we find a large urban area in the form of small cities. However, the inner areas consist of so-called Satoyama areas with forests, small fields and small dwellings. These areas are suffering strong shrinking or scattering tendencies as shown in Fig. 4.

Table 1 Change in landscapes types between 1976 and 2009

Chi-square test**		Landscape types in 2009						
			Other type	Urban type	Farmland type	Farmland urban complex type	Forest type	Sum
Landscape types in 1976	Other type	Frequency	64078	10251	4907	153	24209	103598
		Rate (%)	61.9	9.9	4.7	0.1	23.4	100.0
	Urban type	Frequency	689	20872	166	207	145	22079
		Rate (%)	3.1	94.5	0.8	0.9	0.7	100.0
	Farmland type	Frequency	5231	4438	36940	8447	232	55288
		Rate (%)	9.5	8.0	66.8	15.3	0.4	100.0
	Farmland urban complex type	Frequency	40	6257	350	5179	6	11832
		Rate (%)	0.3	52.9	3.0	43.8	0.1	100.0
	Forest type	Frequency	6640	1387	248	1	63991	72267
		Rate (%)	9.2	1.9	0.3	0.0	88.5	100.0
	Sum	Frequency	76678	43205	42611	13987	88583	265064
		Rate (%)	28.9	16.3	16.3	5.3	33.4	100.0

3 Land Degradation and Management

Under the impact of changes in land use and population trends as shown above, land degradation such as paddy field abandonment, forest abandonment, and the abandonment of bamboo shrubs is progressing in peripheral areas. However, the abandonment of private green sites is also progressing in mature urban areas under the influence of the aging society (Fig. 6). Clearly, this will have a negative impact on ecosystem services and biodiversity in all landscape types.

To prevent such deterioration of landscapes, it is vital to introduce appropriate land management policies. Such policies must take account of the wide variety of green spaces, from Japanese gardens in urban areas, various kind of fields, secondary and plantation forests in the countryside, as well as areas of wilderness in natural parks (Fig. 7). Until now there has been no appropriate tool to permit comparison of the management situation of these different green spaces. In the next section 'landscape management labor accounts' are proposed as a new tool for the management level of different green space types.

4 Landscape Management Labor Accounts

Human beings exploit land for housing, for nutrition or for profit. As all of these activities have some impact on land, degradation will occur if appropriate land management is not undertaken. However, such measures tend to be hidden or costs

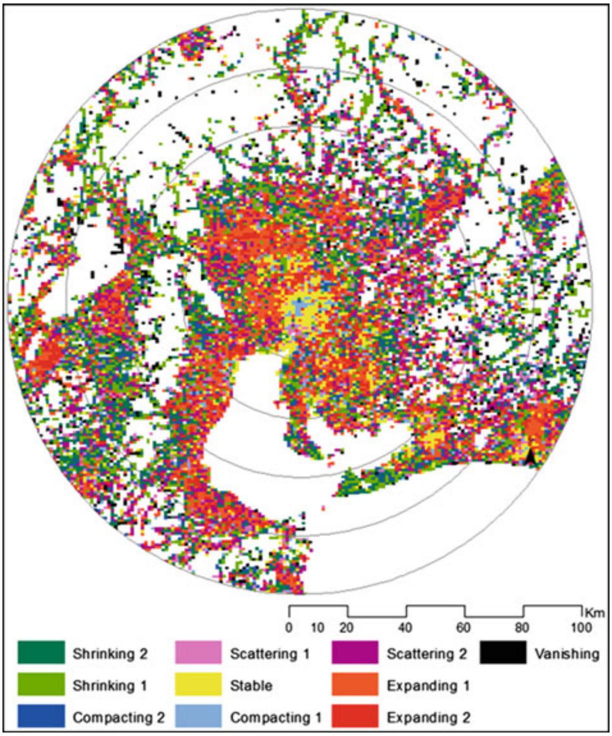


Fig. 4 Cumulative changes of population and urban land use between 2005 and 2010 in the Nagoya region

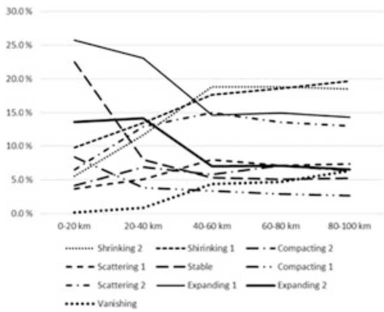


Fig. 5 Combined changes of population and urban land use between 2005 and 2010 according to the distance from the center of Nagoya

are externalized. For example, Japan possesses many beautiful landscapes, which attract large numbers of tourists. Yet most visitors give scant attention to the daily efforts of local residents to conserve these beautiful landscapes. Furthermore, this work by local people is often not directly reflected in their incomes. Of course, agricultural labor will bring profit. On the other hand, many beautiful urban private gardens are maintained by owners at their own expense. Such work remains hidden, with costs being externalized for many users.

Fig. 6 Land degradation both in urban areas and in country sides

Such hidden costs or labor must be clarified. This entails viewing the cost balances of all types of green space at the same level, as such cost balances will determine the management level of the landscapes. To deal with the difficulty of handling costs, our focus here is on the accounting of labor force.

This approach to landscape management is vital against a backdrop of a shrinking population and aging society because labor shortages are perhaps the most important factor for the degradation of landscapes in the light of such global trends.

Taking the specific example of an abandoned paddy field in a shrinking village, this abandonment can be due to the lack of any suitable person to take over from an elderly farmer. The abandoned field may eventually give way to woodland, although in some cases bamboo may take hold. The invasion of bamboo shrubs is one of the most serious problems in southern Japan. Previously, bamboo was used as a building material as well as to make everyday goods such as tubs and baskets. Today, however, most of these forms of use have died out, so that the shrubs are left alone without maintenance. Bamboo grows rapidly, invading other habitats and thereby reducing biodiversity. Human labor is required in order to prevent such invasion. Because there is no additional labor to be had in a shrinking village, workers are required from outside.

Therefore, immigration to the shrinking region must be promoted in order to revitalize the abandoned paddy field. In this form of revitalization, two kinds of

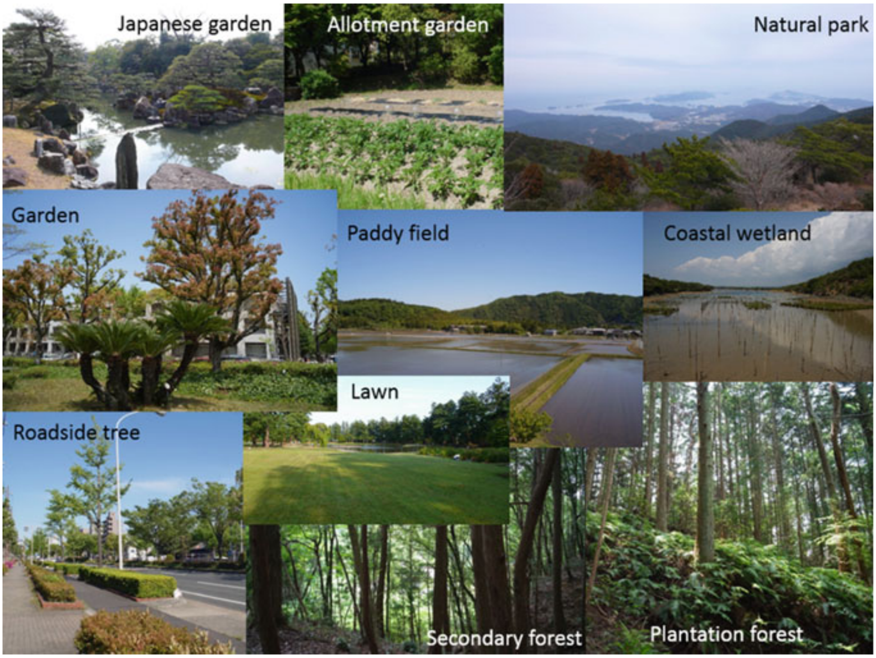


Fig. 7 Various landscape types in Japan

labor must be considered. One is the initial labor required to turn an abandoned field into a productive field. The other is the annual labor for the sustainable maintenance of the field.

Landscape management labor accounts are calculated annually. Four factors are introduced as landscape management labor accounts: annual personal labor accounts, personal labor accounts per one are (annual personal labor density), integrated annual labor accounts and density per landscape unit. Annual personal labor accounts are personal labor accounts for the work required to maintain a targeted landscape element for 1 year. Personal labor accounts per area record the annual personal labor density required to maintain one area for 1 year. Integrated labor accounts and density per landscape unit are calculated as the total labor force or labor density with multiple people and integrated multiple landscape elements in a landscape unit. This report focuses on personal labor accounts and personal labor density.

Next, targeted landscape elements and units must be considered. As shown in Fig. 6, there are many types of green spaces, which can be classified to different landscape elements such as a paddy field bed, paddy field ridge, irrigation channel, secondary forest, roadside tree, garden tree, lawn and so on. These landscape elements can be integrated into a landscape unit with homogeneous features such as a paddy field, a private garden, a park, a forest and so on. In turn, these landscape units can be integrated into an entire landscape such as a neighborhood living space

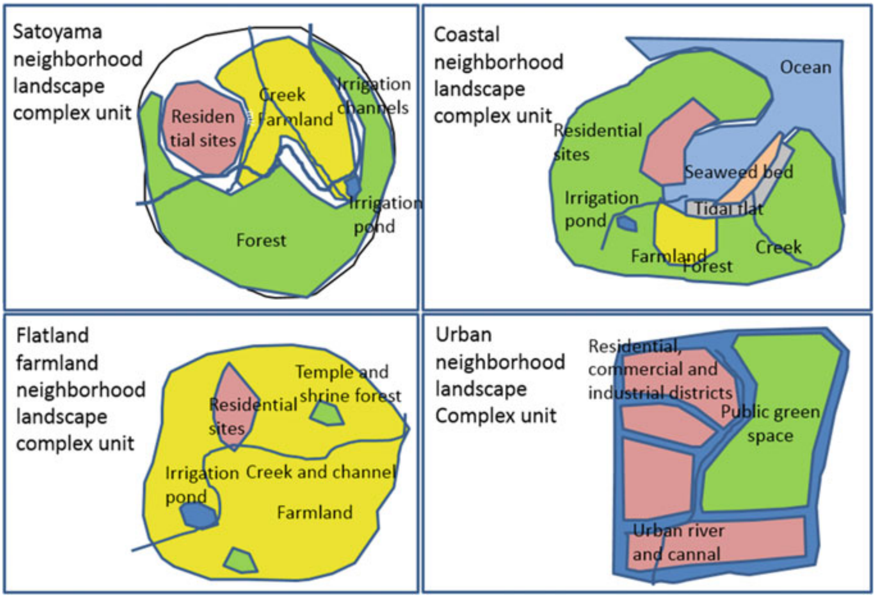


Fig. 8 Neighborhood landscape complex units typical to Japan

for residents. This kind of integrated landscape can be defined as a neighborhood landscape complex unit.

Neighborhood landscape complex units typical to Japan are urban neighborhood landscape complex units, flatland farmland neighborhood landscape complex units, Stoyama neighborhood landscape complex units and coastal neighborhood complex units (Fig. 8).

In these typical neighborhood complex units, annual personal labor accounts and personal labor densities are examined as case studies (Table 2). Annual personal labor accounts range widely from 3 to 2340 man-hours per year. Also personal labor densities also range widely from 0.01 to 85.8.

Figure 9 shows five types of working style that could be distinguished according to the relation between annual personal labor accounts and personal labor densities.

One is a corporate organization type in which employees work every day. The worker of this type shows high annual personal labor accounts but relatively low labor density, reflecting the daily work in a rational company system. In contrast to this type, we find a voluntary type with very low labor density and labor intensity. The worker of this type works several times a year for short times and at low intensity. Other types of working style can be seen in farmland or Satoyama landscapes.

One is a self-employment type. Most such self-employed workers are older individuals who are unable to work as intensely as employees in a company or cooperation, but who are constantly in their fields. The other is self-help type 2, which is a weekend working type. Here the worker spends time in his fields with

Table 2 Annual personal labor accounts and personal labor densities in typical neighborhood complex units

		Annual personal labor accounts	Personal labor accounts/area (a)
Case study 1 (Satoyama landscape)	Paddy field/self-employment 1	420	2.8
	Paddy field/self-employment 2	163	1.63
	Forest land owner 1	1250	2.5
	Forest land owner 2	542	13.53
	Forest land owner 3	370	1.23
	Forest land owner 4	28	0.28
	Private garden 1	6	6
	Private garden 2	5	2.94
	Kitchen garden 1	60	12
Case study 2 (Flatland paddy field landscape)	Paddy field/self-employment 3	823	3.33
	Paddy field/self-employment 4	342	2.46
	Paddy field/self-employment 5	262	2.23
	Paddy field/cooperation 1	2340	1.19
	Private garden 3	50	41.1
	Kitchen garden 2	248	68.74
Case study 3 (Satoyama landscape)	Paddy field/ cooperation 2	2193	2.02
	Tea plantation/ cooperation	2173	9.11
	Tea plantation/self-employment	359	7.36
	Paddy field/self-employment 6	68	5.42
	Private garden 4	52	6.42
	Kitchen garden 3	585	117|
Case study 4 (Coastal landscape)	Kitchen garden 4	1116	85.8
	Governmental road maintenance 1	173	0.3
	Governmental road maintenance 2	22	0.02
	Promenade management/volunteers	48	0.003
	Beach management/volunteers	3	0.01
	Beach management/fisheries	5	0.01
	Sea weed maintenance/women	19	0.01
	Hotel gardener	2351	8.51
		30	0.27

(continued)

Table 2 (continued)

		Annual personal labor accounts	Personal labor accounts/area (a)
Case study 5 (Urban forest landscape)	Govern mental roadside management		
	NPO forest management	11	0.07
	Volunteer forest management 1	88	1.31
	Volunteer forest management 2	144	0.87
	Volunteer forest management 3	240	1.83

Fig. 9 Five types of working style

relatively high labor densities but only at weekends. Such a working style is possible with short-term employment agencies. This can be an important working style in the countryside around cities. The third type is a self-help type 1. In this type, individuals work with high labor density and relative high annual labor accounts. This type can be seen in the working style of kitchen gardens. The individual works several times a week with very high labor densities. His concern is not to ensure working efficiency, but to spend free time in a field for reasons of health and pleasure. This type is also important for the older people living on a pension.

5 Further Lines of Research

As any group of individuals will display a mix of working types according to their various lifestyles, an appropriate mixture of working types is needed to maintain each neighborhood landscape unit. Therefore, our next topic of research will be how best to determine an appropriate mixture. Against a backdrop of population loss and an aging society, a particular mix of working styles could influence the total amount of workable areas and the distribution of landscape elements in the neighborhood landscape complex units.

Let us consider a scenario of a shrinking Satoyama landscape, whereby the average population of Satoyama landscapes decreases by 50% to the year 2050 from its current level. Under such conditions, it will be impossible to afford a sufficient labor force to maintain the entire existing farmland. Forest management, which even today is inadequate, will be practically abandoned in this scenario.

Furthermore, many Satoyama landscapes maintained by the effort of residents will disappear, transformed by natural succession into areas of wilderness. Of course, work will be undertaken to protect many valuable Stoyama landscapes (from the viewpoint of culture or ecology). Yet how can these landscapes be sustained at a time of a shrinking and aging population. One solution is to promote the use of employees in an efficient corporative management of fields and forests. Professional employees can work with higher labor efficiency, thereby compensating for a reduction in the working-age population. In this way, many fields could be managed by a small number of people.

But this approach has one disadvantage. Japanese rural society and its environment rely to a large degree on the collaborative work of residents, such as for the clearing of irrigation channels and roadside grass. These forms of collaborations have an important role to play in unifying village societies. If all fields become cooperatively managed, the effect can be to dangerously undermine this social cohesion. Thus to maintain vibrant communities, it will be necessary to preserve some level of self-employment working type.

An effective way to preserve this kind of working style is to encourage the immigration of young workers. Indeed, there are growing numbers of young people who wish to work in the countryside. Some countryside villages or municipalities have actively begun to attract such young people.[2] In aging villages, many elderly people need assistance in their daily lives or for shopping in distant towns. Under such conditions, young workers are greatly needed to act as handymen. In this way they can enjoy a double income from a mixture of self-help employed farming while simultaneously working as handymen. By engaging in such multiple activities, young people can be gradually integrated into rural communities. This is an alternative approach to help sustain shrinking Satoyama landscapes and societies.

[2]Tottori prefecture, Home town Tottori settlement organization, http://furusato.tori-info.co.jp/?id=1433 (June 14, 2017).

The third approach is to exploit voluntary workers from cities. Japan has many beautiful paddy field terraces that are regarded as important landscapes worthy of preservation. Yet, as mentioned, the population is both rapidly shrinking and aging in these areas. Shiroyone Senmaida is one such landscape.[3] This village has introduced an ownership system to allow city residents to participate in the management of fields as voluntary workers, paid 20,000 yen (approx. €160) per annum. Such volunteer systems are now being developed in many Stoyama landscapes.

In future research it will be important to examine in detail the condition of affordable labor in these shrinking and aging societies, as well as a suitable method to forecast the likelihood of survival. To help weigh up the probabilities of these options, landscape management labor accounts can provide basic data on how much labor is needed to maintain landscapes and society.

[3] Shiroyone Senmaida, http://senmaida.wajima-kankou.jp/en/ (June 14, 2017).

Part II
Climate Change and Urban Green

Chapter 5
Modeling the Current and Future Urban Climate Using Downscaling Techniques

Satoru Iizuka and Yingli Xuan

Abstract Temperatures rises observed in urban areas can be attributed to global warming as well as the heat island effect. Therefore, these two phenomena must be jointly considered when researching the urban climate. Computer simulations based on downscaling techniques (downscaling simulations) are sufficiently powerful to investigate these two types of warming effect in combination. In particular, downscaling simulation is the only feasible method to make climate forecasts that consider global warming trends and the likely prevalence of urban heat islands. In this chapter we introduce a downscaling simulation to model and project the urban climate using examples from Japan's third largest metropolitan area (Nagoya). Downscaling simulations from a global scale to the urban scale can function not only as environmental assessment tools but also as tools for urban planning.

1 Global Warming and Urban Heat Islands: Two Kinds of Warming Problems

In recent years, global warming has become a major environmental concern. At the beginning of 2015, the U.S. National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA) reported that 2014 had been the warmest year on record (NASA 2015). It seems that 2015 will be even hotter (as of November 25, 2015) (WMO 2015). In actual fact, the record high air temperatures (global average surface temperature) in the period 2014–2015 can be largely attributed to a very strong El Niño episode. Yet, in addition to this natural effect, there is little doubt that human activities are helping to drive high air temperatures.

According to the Fifth Assessment Report (AR5) published by the Intergovernmental Panel on Climate Change (IPCC) in 2014 (IPCC 2014): 'Human influence on the climate system is clear, and recent anthropogenic emissions of

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greenhouse gases are the highest in history.' Furthermore, it warns that: 'Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.' The ongoing impact of global warming is a significant concern for us all. Severe strains on the global environment are largely due to human activities. As reported in IPCC AR5, the increase in the globally averaged combined land and ocean surface temperature over the period 1880–2012 was 0.85 °C (a warming of 0.64 °C over the past 100 years). Although this temperature rise may seem rather insignificant, it has led to an increased frequency of extreme weather events around the world.

At the same time, it must be recognized that temperatures in urban areas are usually higher than the current rate of global warming. In particular, urban heat islands are common in high-density urban areas such as in Japan's large cities. Needless to say, the causes of the urban heat island are fundamentally different to that of global warming, which is associated with an increased concentration of greenhouse gases in the atmosphere. Although greenhouse gases are essential to ensure a comfortable and warm global environment, the increased emission of such gases through human activity over the course of the last centuries until today has resulted in this undesirable temperature rise. Urban heat islands, on the other hand, are caused by changes in the heat budget of urban areas. These changes are due to a build-up of waste heat from human activity (industrial processes, air-conditioning, and traffic), the use of building materials with a large heat capacity (concrete, asphalt, etc.), as well as a decrease in the extent of green space and water surfaces. Clearly, different measures are required to mitigate the urban heat island as opposed to global warming.

With regard to higher temperatures in urban areas, the cause must be attributed to a mix of global warming and the urban heat island. Unsurprisingly, it is rather difficult to make a clear distinction between the two effects. Yet when attempting to model temperature rises in urban areas, we must try to take account of both global warming and the urban heat island. One sufficiently powerful tool to deal with the two kinds of warming problems simultaneously is a computer simulation based on downscaling techniques (downscaling simulation). In particular, downscaling simulation is the only feasible method for making forecasts that integrate the impact of future global warming and urban heat islands.

In this chapter some examples of present and future projections of urban climate based on downscaling techniques are introduced. The target urban area is the Nagoya metropolitan area, Japan's third largest conurbation. Located roughly the centre of the country, Nagoya's summer climate is generally very hot and humid. Figure 1 compares the cumulated frequency of daily maximum temperatures in Japan's three largest metropolitan areas (Tokyo, Osaka, and Nagoya) for the months of July and August over the last 20 years (1996–2015). The Japan Meteorological Agency defines an extremely hot day as one in which the maximum temperature reaches 35 °C or over. Using this definition, the total number of extremely hot days in Tokyo, Osaka, and Nagoya are 88, 246, and 266, respectively. Clearly, Nagoya can be called the hottest metropolitan area in Japan in terms of the number of extremely hot days.

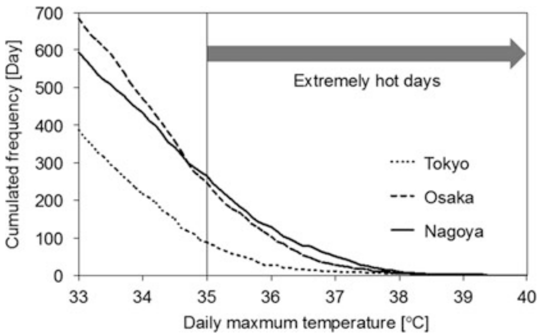

Fig. 1 Cumulated frequency of the daily maximum temperature in Tokyo, Osaka, and Nagoya for July and August over the last 20 years (1996–2015)

2 Outline of Downscaling Simulation from Global to Urban Scale

Exploiting the rapid growth in computer resources and the power of parallel processing, computer simulations based on downscaling techniques (downscaling simulations) from the global to urban scale (cf. Fig. 2) have been developed, especially in the research fields of climatology and meteorology. There exist two downscaling simulation techniques: 'dynamical' and 'statistical' downscaling. In

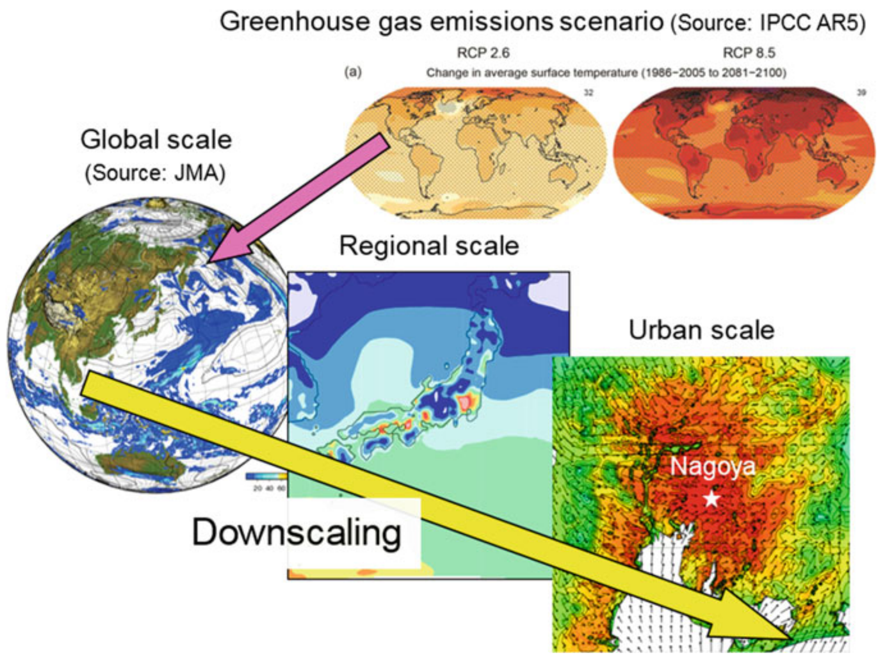

Fig. 2 Concept of downscaling simulation from global to urban scale

dynamical downscaling technique, downscaling is based on several nested simulations using a general circulation model (GCM) and a regional climate model (RCM). In statistical downscaling technique, on the other hand, downscaling is based on empirical and statistical assumptions between climatic elements in large and small (local) scales. A dynamical downscaling technique is adopted in the examples introduced in this chapter.

Dynamical downscaling is divided into two methods, namely 'direct dynamical downscaling' and 'pseudo global warming'. The latter method, proposed by Kimura and Kitoh (2007), is mainly used for future climate projections. In the examples in this chapter, we introduce the pseudo global warming method. In the method, pseudo global warming data is generated by combining objective analysis data or reanalysis data with climate differences between future and present climatic elements (or present and past climatic elements) using the results of GCM. The generated data is used to determine the initial and boundary conditions in RCM simulations. The pseudo global warming method is much simpler to handle than direct dynamical downscaling. Unlike direct dynamical downscaling method, which involves large volumes of data, the pseudo global warming method only requires pseudo global warming data based on climate differences.

For future climate projections based on downscaling techniques, we need to elaborate several future scenarios such as on greenhouse gas emissions, on land use, on urban/city-block/building structures, and on energy systems. The most influential scenario for future climate projections is that dealing with greenhouse gas emissions. In this chapter we use the Representative Concentration Pathways (RCP) 8.5 scenario (Van Vuuren et al. 2011) as the greenhouse gas emissions scenario for future climate projections. The RCP scenarios (RCP2.6/RCP4.5/RCP6.0/RCP8.5) were newly introduced in IPCC AR5 (IPCC 2014), rather than the Special Report on Emissions Scenarios (SRES) (Nakicenovic et al. 2000) adopted in the IPCC's Fourth Assessment Report (AR4) (IPCC 2007). Unlike SRES, various socio-economic scenarios can be assumed for each RCP scenario. The scenario RCP8.5, which is used for the future climate projections in this chapter, is the worst-case scenario among the four RCP scenarios.

Our examples of downscaling simulations from global to urban scale are part of a sophisticated downscaling simulation technique from global to building scale developed by the authors. Figure 3 shows an example of the analysis of the wind environment around high-rise buildings near Nagoya station based on this sophisticated downscaling simulation.

3 Modeling the Current Urban Climate

Before conducting climate projections, it is important to verify the predictive accuracy of a computer simulation based on downscaling techniques. As an example of verification, Figs. 4 and 5 show the horizontal distributions of the monthly-averaged air temperature (2 m height) and wind velocity (10 m height) at

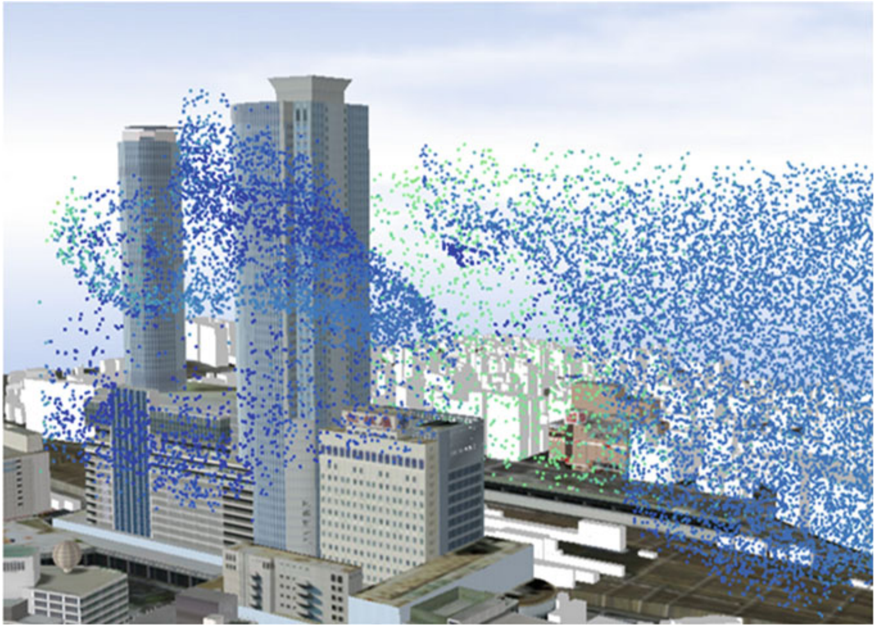

Fig. 3 Wind environment around high-rise buildings near Nagoya station

2 p.m. in August 2009 and August 2010, respectively. Japan had a very cool summer in 2009 and an extremely hot summer in 2010. Although the observation data (Figs. 4a and 5a) only provides information for a limited number of points, detailed spatial distributions can be obtained from the simulation results, as shown in Figs. 4b and 5b. This is the great advantage of computer simulations.

In both cases, the observation data (Figs. 4a and 5a) and simulation results (Figs. 4b and 5b) clearly show an urban heat island in and around Nagoya. Although the simulation results slightly underestimate the temperature in comparison with the observation data, basically there is good correspondence between the observation data and simulation results. Moreover, the simulation results closely reproduce the changing urban climate from one year to the next, i.e. the cool

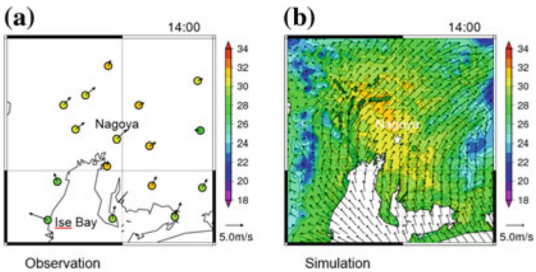

Fig. 4 Horizontal distributions of the monthly-averaged air temperature (2 m height) and wind velocity (10 m height) at 2 p.m. in August 2009

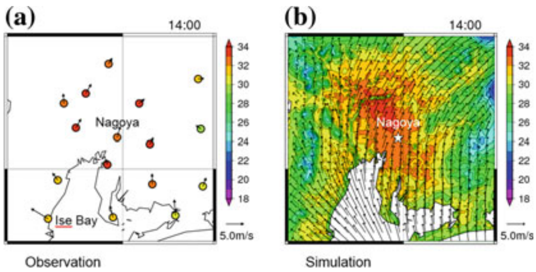

Fig. 5 Horizontal distributions of the monthly-averaged air temperature (2 m height) and wind velocity (10 m height) at 2 p.m. in August 2010

summer of 2009 and the extremely hot summer of 2010. With regard to wind direction and velocity, simulation results also largely agree with the observation data.

4 Forecasting the Urban Climate

In this section we present an attempt to forecast the changing urban climate in the Nagoya metropolitan area from the 2030s to the 2070s using downscaling techniques. The pseudo global warming method proposed by Kimura and Kitoh (2007) was adopted to perform the climate projections, as described in Sect. 2. The pseudo global warming data was generated by linear coupling of an objective analysis data, specifically the U.S. National Centers for Environmental Prediction (NCEP) FNL (Final) Operational Global Analysis data, and climate differences. The climate differences between future and present climatic elements (future 30-year averaged data minus current 30-year averaged data) were determined by the results of a GCM (GFDL-CM3) (Donner et al. 2011) based on the RCP8.5 scenario (Van Vuuren et al. 2011). Six climatic elements, i.e. horizontal wind components, potential temperature, geopotential height, as well as sea and ground surface temperatures, were considered as the pseudo global warming data. The generated pseudo global warming data was used to determine the initial and boundary conditions in RCM simulations.

The Weather Research and Forecasting (WRF) model (Skamarock et al. 2008) was utilized for the RCM simulations. The model is now a state-of-the-art RCM used around the world. It has two dynamics solvers: the Advanced Research WRF (ARW) dynamics solver (Skamarock et al. 2008) and the Nonhydrostatic Mesoscale Model (NMM) dynamics solver. These ARW and NMM dynamics solvers are mainly used for research and operational applications, respectively. The ARW dynamics solver was applied for the future climate projections introduced in this chapter.

Three nested computational domains (Domains A–C) were introduced for the WRF simulations, as shown in Fig. 6. The horizontal domain sizes and grid resolutions were 1975 km × 1975 km and 25 km in Domain A, 500 km × 500 km

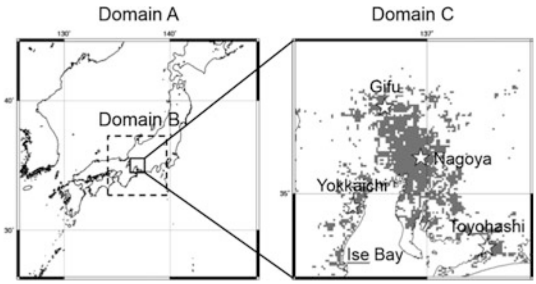

Fig. 6 Computational domains for WRF simulations (*gray* in Domain C indicates urban areas)

and 5 km in Domain B, and 120 km × 120 km and 1 km in Domain C. The number of vertical layers in Domains A–C was the same (34 layers) and the vertical height was about 21 km. The WRF model with the same conditions was also applied in the RCM simulations for the predictions shown in this section and Sect. 3.

Figure 7 shows the horizontal distributions of the monthly-averaged air temperature at a height of 2 m at 2 p.m. in August 2013 (Fig. 7a) and Augusts of the 2030s (Fig. 7b), 2050s (Fig. 7c), and 2070s (Fig. 7d). (Note that the color temperature bar in Fig. 7 differs from those of Figs. 4 and 5.) August 2013 was an extremely hot month in Japan compared with recent summer seasons. The forecasts show that the urban climates in the 2030s, 2050s, and 2070s will become even hotter than the extremely hot summer of 2013. It is also predicted that the region of high temperature will gradually expand during the investigated period. In particular,

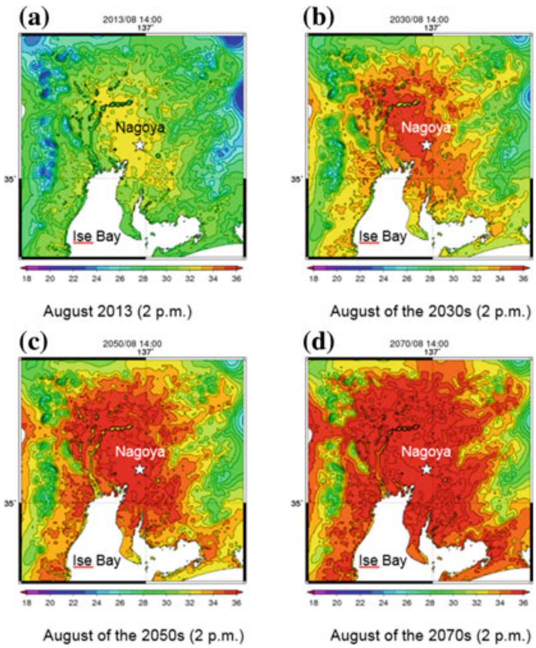

Fig. 7 Horizontal distributions of the monthly-averaged air temperature at a height of 2 m at 2 p.m. in August 2013 and Augusts of the 2030s, 2050s, and 2070s

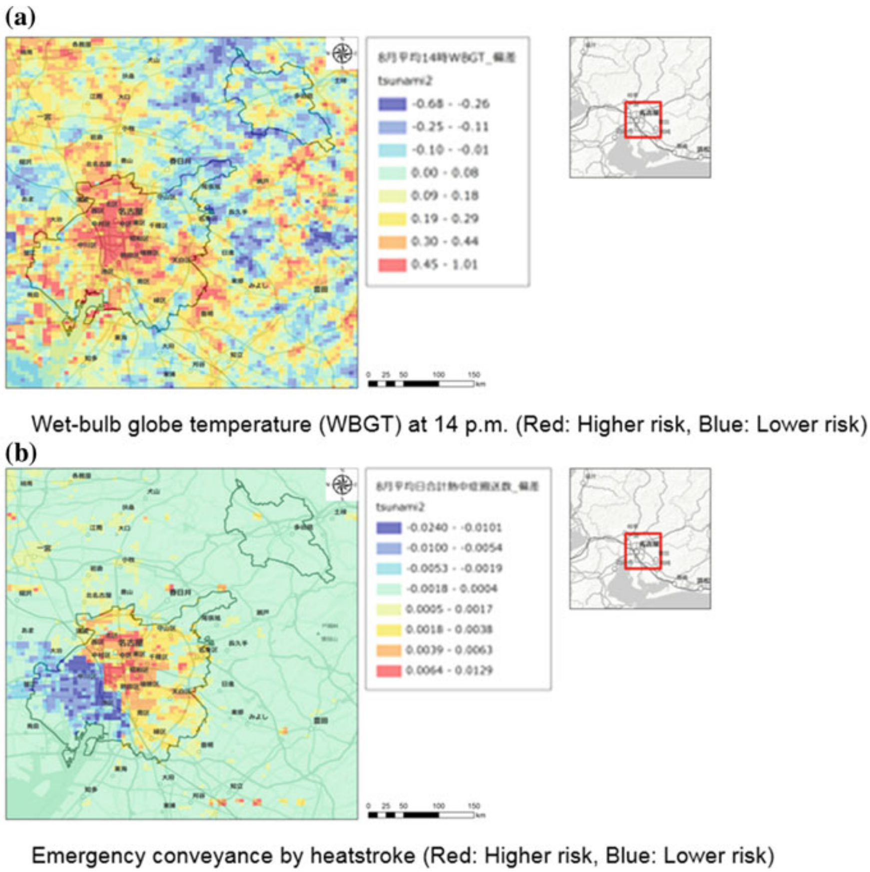

Fig. 8 Examples of the projected human health risks in Augusts of the 2050s

the high temperature region in the 2070s is much larger than at the current time. The temperature in central Nagoya (cf. star-shaped symbol in Fig. 7) is forecast to rise from 2013 to the 2070s by 5.5 °C.

Downscaling techniques allow us to forecast the urban climate under the progress of global warming. In turn, such forecasts are essential to help design useful mitigation measures and also future urban planning. Of course, many factors must also be considered in urban planning, such as the situation of economic growth or recession, the impact of natural disasters, and environmental protection laws. When conducting climate forecasts, we have to pay sufficient attention to uncertain factors. The biggest factor is the large variation in projections depending on the selected RCP scenario and the particular GCM. Therefore, climate forecasts based on downscaling techniques must pay close attention to these factors and try to quantify the ranges of the uncertainties.

5 Summary

In this chapter we have presented some examples of current models as well as forecasts of the urban climate using downscaling techniques. Such projections of the likely urban climate are needed to devise measures to mitigate hot environments in the summer seasons as well as to draw up sensible urban planning. Furthermore, such forecasts can be used to assess the risk to human health of a hot urban climate. Figure 8 shows two examples of the projected human health risks in Augusts of the 2050s. These assessments can also support future urban planning. Against a backdrop of continuing global warming in the years to come, a downscaling simulation from the global to the urban scale (or building scale) will not only be a useful tool for environmental assessments but also a kind of urban planning tool.

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Chapter 6
Urban and Green Planning Based on an Evaluation of Urban Climate

Chika Takatori

Abstract Global warming and the increased prevalence of heat islands are seriously undermining human health in metropolitan areas. An appropriate adaptation strategy is needed to address these effects. In this study, we have simulated thermal and wind environments using a supercomputer, and clarified the dominant factors behind the rising temperature by comparing the thermal and wind environments of two periods: the Meiji Period (1884) and the recent past (2006) using geographic information software. The simulation area is 7.5 km $\times$ 7.5 km and 400 m in height with a mesh resolution of five meters. The simulation model simultaneously handles flows of wind in the upper boundary layer and the microclimate in the canopy layer, in which the heat exchange of different layers actively occurs at an altitude of 50–100 m above ground level. The model provides statistical clarification of the dominant factors behind the rise of temperature and changes in wind velocity between the two periods. Regression analysis was conducted, in which the change of land cover on the microtopography and the change of wind flow in the upper layer were set as independent variables. The change of temperature and wind velocity in the canopy layer were set as explained variables. Results show how the changing green space and buildings influence the temperature rise in hierarchical scales. Effective indicators and metrics were devised and applied to inform the next step, which is to devise adaptation strategies to climate change that take account of future changes in land use.

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1 Mitigation of the Heat Island Phenomenon

1.1 Background 1. Mitigation of the Heat Island Phenomenon

Global warming and the increased prevalence of heat islands have serious effects on human health in metropolitan areas. An appropriate adaptation strategy is needed to address these effects. Over the past century, the center of Tokyo has seen a temperature rise of 2–3 °C. Of this increase, around 1 °C can be attributed to global warming and 2 °C to heat islands. However, there exist few studies that closely examine the change in temperature before and after industrialization due to a lack of precise data for the earliest time periods. No analysis has been conducted on the impact of heat islands over the past 100 years in order to clarify which locations have experienced specified temperature rises. In the described research, the thermal and wind environments have been simulated for two periods: the Meiji Period (1884) and the recent past (2006) by creating a detailed database for one specific location.

1.2 Background 2. Impact of Urbanization

The second research focus is on the impact of urbanization. On this exists a range of previous studies on how the change of the microenvironment influences the microclimate in the canopy layer. However, wind from the horizontal direction and wind from the upper boundary layer on an urban scale are also assumed to affect the microclimate. Until now it has proven difficult to analyze the interactive effect between different climate layers due to the lack of a simulation model as well as the considerable processing power required. In this research, the dominant factors that influence the rise of temperature have been statistically determined using a supercomputer (Fig. 1).

For purposes of comparison, we can consider the two contrasting cities of Tokyo and Berlin (Fig. 2). In Japan most cities lie on the coast, while the majority of Germany's cities are located in main-land areas, some in the valley. This determines the way in which the cities can make use of natural climate regulation. In Japan, cold air at a height of 100–1000 m above ground can help to cool urban areas. In Germany, wind at a lower altitude of 10–50 m can be utilized.

1.3 Background 3. Patterns of Urbanization

Japanese and German cities differ also in another way: In Japan the urban skyline is quite diverse, whereas in Germany it is much more uniform. In Berlin we can find

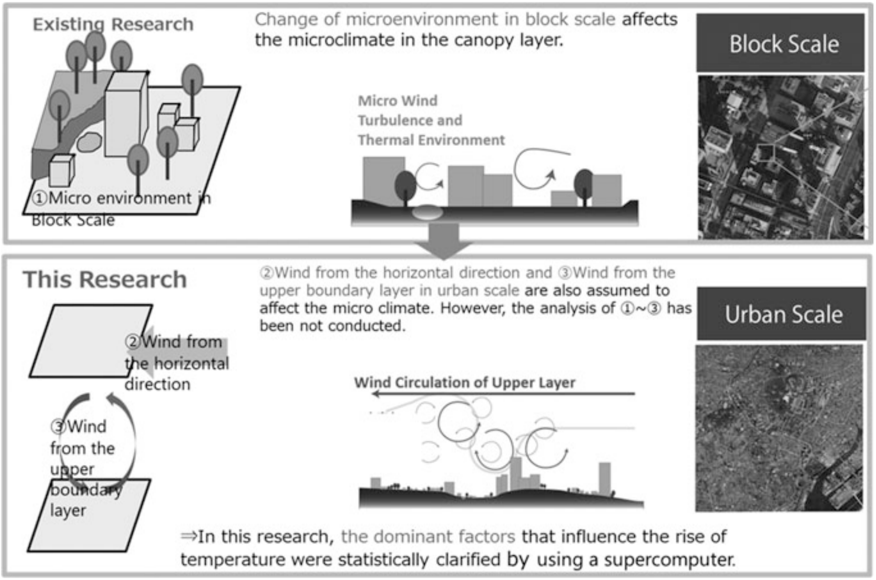

Fig. 1 Factors leading to a rise in temperature. *Source* Self designed

Fig. 2 A comparison of Tokyo and Berlin, location and patterns of settlements. *Source* google earth

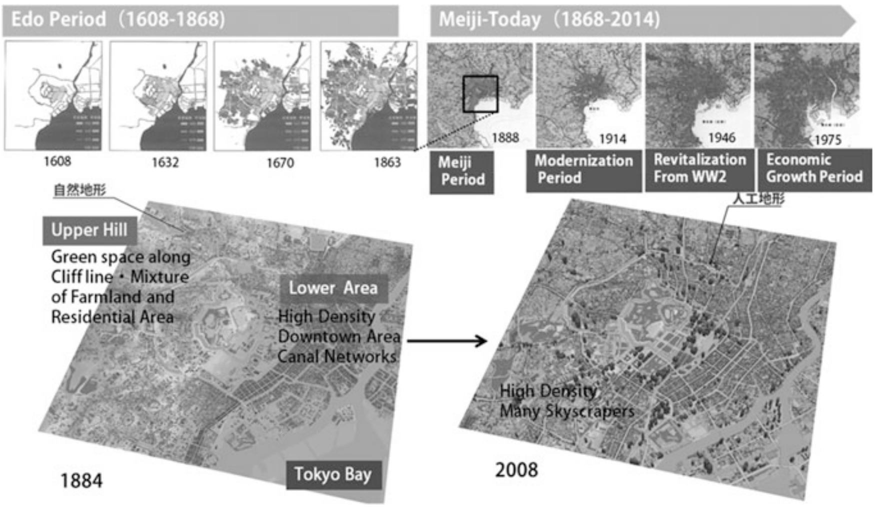

Fig. 3 Historical context of Edo and Tokyo. *Source* Self designed

large contiguous green areas, while Tokyo has a mosaic of small patches of green. These differences in land cover and the scale of buildings can be attributed to the different development histories of these cities. In the center of today's Tokyo Metropolitan area lies the old city of Edo (which gave its name to the Edo period). Before the modern period, the microtopography of Edo strongly influenced the development of forms of land cover such as green spaces and buildings. Rich green spaces could be found on the plateau towards the line of cliffs, while networks of canals were distributed in the lowlands. More densely constructed areas were located in mixed-use areas where, until recently, traditional residential buildings and farmland existed. During the period of Japan's rapid modernization and economic growth, high-rise buildings were erected on the old layer of mixed-use land, creating the modern urban skyline of central Tokyo (Fig. 3).

Based on these historical considerations, our research focused on the following three aims: Firstly, to analyze the pattern of urbanization and to specify landscape units as the basic planning units. Secondly, to analyze the impact of urbanization by simulating and comparing the thermal and wind environments in two periods (1884 and 2006), thereby clarifying the dominant factors causing the rise in temperatures from the block scale to the urban scale. Thirdly, to develop adaptation strategies in landscape planning to help mitigate the impact of climate change and the heat island phenomenon tackling the dominant factors.

2 Patterns of Urbanization: Creating a Database and Specifying Landscape Units

The first research goal was to create a database and choose the landscape units to allow an analysis of the urbanization pattern. Firstly, it was necessary to classify the microtopography by an openness index, indicating the degree to which the sky can be seen from any fixed point without being disturbed by the surrounding topography. In the case at hand, the cliff line created a sloping green cover while the major feature of the lowland area was the canal network. Regarding land cover in the mid-19th century (early) Meiji period, the settlement was distributed along the cliff line while the mosaic of small farm-holdings was located within the city area. Today these have been replaced by a densely built-up city with many high-rise buildings. At the same time some parks and small patches of green persist. The canals have all been reclaimed or filled.

In the 1880s the Japanese Army conducted detailed surveys of the center of Tokyo. Figure 4 shows the original hand-drawn map (top) created out of these surveys. The green areas and settlements indicated on the map have been extracted and are displayed along with the GIS data. In the Meiji era, various crops such as tea or potatoes were cultivated in the green fields. These green areas are indicated and re-categorized on the modern map to provide some comparison with current land use.

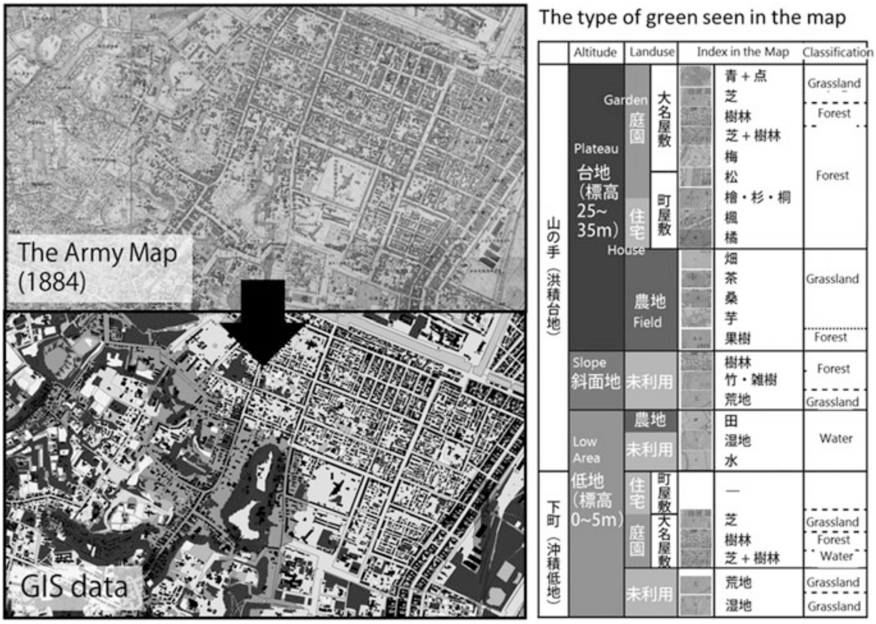

Fig. 4 GIS data extracted from the Army map. *Source* Self designed

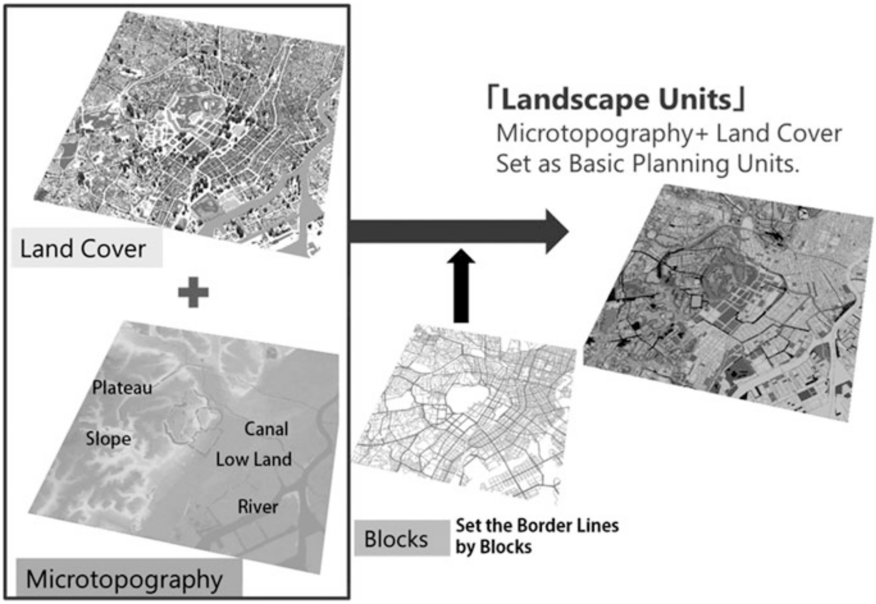

Fig. 5 Classification of landscape units in the two periods. *Source* Self designed

By assigning different types of land-use to categories, a cluster analysis was made on the basis of landscape units. On the block scale, land cover or land usage was combined with the microtopography to produce 26 landscape units in the Meiji period and 31 landscape units today. The relations between the green areas and the settlement were clarified. Even today, a green slope remains, clearly reflected in the microtopography. Currently, 50% of the canal network has already been reclaimed or filled, eroding this original web of waterways (Fig. 5).

3 Impact of Urbanization: Simulating the Thermal and Wind Environments

Alongside analysis of the pattern of urbanization, the impact of urbanization on temperature was investigated using a supercomputer simulation in a joint research project with JAMSTEC. The selected resolution was 5 m within a range of 7.5 km^2. The urban center was specified as the Imperial Palace. The initial modeling conditions inputs were the temperature conditions on a typical heat island day with the wind blowing from the south-east. The model simulates both the horizontal and the vertical wind flows. The heat index was determined according to the use of the buildings and the street widths (Table 1).

Table 1 Initial state of thermal simulation

Resolution	5 m
Range	7.5 km × 7.5 km in the horizontal direction, 400 m in height
Time	Typical Heat Island day of 17th August, 2010 (MSM Data), 15:00–15:30
The direction of sea breeze	From the south-east (The typical wind in the site)
Model	MSSG (Multi Scale): a integrated model of canopy model, turbulence model, and the 3D model and can calculate the upper wind and the micro climate at the same time
Heat index	We set the parameters (the right table) of the artificial heat from the buildings (residential, commercial, industrial buildings) and road (Highway, Trunk, Community roads) in 2008 by referring to the Architecture Research Center

Source Self designed

The model gives a wide variation in temperatures between 1884 and today as calculated at ground level up to an altitude of 200 m (Fig. 6). There is also a considerable difference between the horizontal sea wind and the ground microclimate. The distributions of temperatures in the upper boundary layer (with horizontal wind flow) are quite different from the canopy layer, which has a near-ground wind movement in both periods. Also, the heat exchange between the upper boundary layer and canopy layer is activated at an altitude of 40–70 m.

Now our attention turns to changes in the passage of the sea breeze and wind turbulence from the Meiji period to the modern day. Figure 7 shows the vertical air movements in these two periods at an altitude of 70 m. On the left we see the Meiji period. Here the boundary between the sea and the ground is at an early stage of development and a weak down flow can be observed at the river basin. The later model indicates a major change in the wind landscape. Now considerable wind

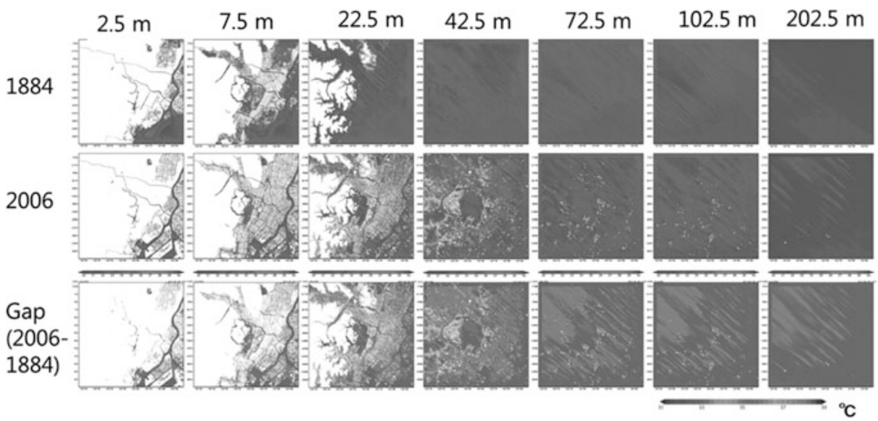

Fig. 6 Modeled temperatures at various altitudes for 1884 and 2006. *Source* Self designed

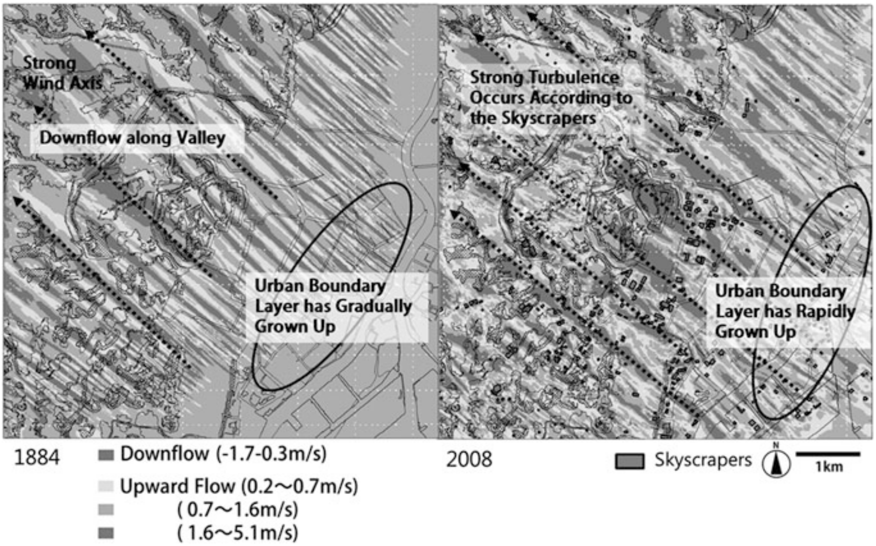

Fig. 7 Vertical wind velocity in the two periods at an altitude of 72.5 m. *Source* Self designed

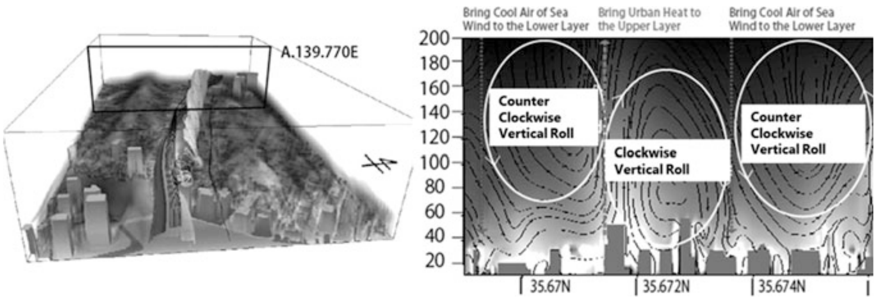

Fig. 8 Strong turbulence in Kyobashi District (data from 2008). *Source* Self designed

turbulence is indicated at areas where skyscrapers are grouped. The coastline of Tokyo Bay, for example, has many such skyscrapers. This can be one factor behind the rapid establishment of the land-sea boundary and the spread of down flows and up flows. Today pockets of wind turbulence can be found over almost all urban areas. Figure 8 provides a 3D representation of one coastal section viewed from the sea. The Imperial Palace can be seen on the far side. Clockwise and counter-clockwise turbulence is clearly indicated, although here the wind flow decreases at an altitude of 50–100 m.

Comparing the Meiji period with the situation today, we see significant differences at the canopy layer and at ground level. In the Meiji era, the microtopography of the plateau area was a mosaic of various forms of land use, giving free passage to strong winds. Today, however, the area is densely built up. This serves to decrease the overall wind velocity while pockets of turbulence are concentrated around high-rise zones. Here wind velocities of more than 4 m/s are observed due to the influence of skyscrapers. The average wind speed is lower in the lowlands as well as at the riverside (although the highways have not been factored in). Again, gusts of strong wind can be observed around sky-scrapers. Based on these findings regarding the canopy layers, the microenvironment and the macro-impact of the sea breeze, a regression analysis was conducted to determine the dominant factors af-fecting temperature.

4 Dominant Factors Affecting the Temperature in the Canopy Layer (Regression Analysis)

As a third step, we have investigated the dominant factors affecting the temperature in the canopy layer by means of regression analysis. The variable to be explained was the temperature at 2.5 m above ground. Figure 9 shows the temperature difference in the two periods measured for each urban block. The average temperature rise was calculated to be 1.6 °C. However, certain blocks show lower temperatures today than during the Meiji period. These are indicated in blue, such as Ueno Park, the north side of the Imperial Palace and the Hamarikyu garden. One explanation for this effect is that the downward wind produces lower ground temperatures today as well as in the canopy layer than during the Meiji period. Here the temperature of

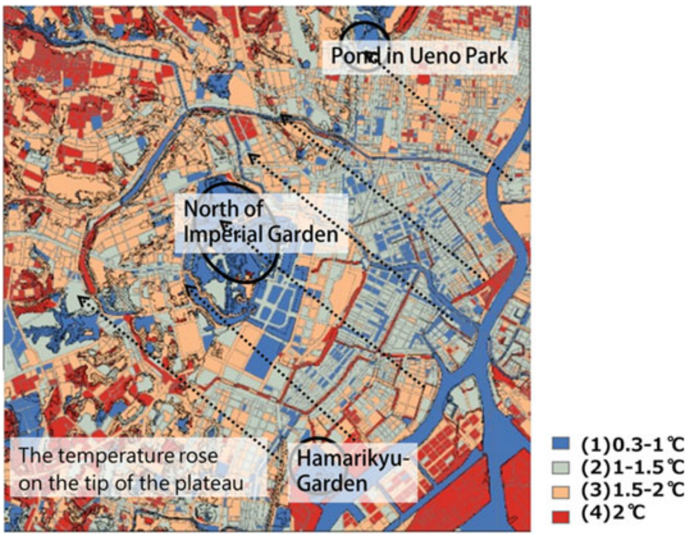

Fig. 9 Explained value—temperature (1884–2006) in each block (altitude: 2.5 m). *Source* Self designed

the canopy layer is the factor to be explained. We can specify three variables as influential factors.

The first explanatory variable is the microenvironment within the block, such as Tokyo's microtopography, the slopes, the built-up environment, the distribution of the various forms of land cover and green areas as well as the proximity to water. Then we attempted to find the cause of the impact. The second variable is the wind from the horizontal direction and its cooling capacity. The third explanatory variable is the impact of vertical wind flows and the impact of the sea breeze on the canopy layer through heat exchange. Today's skyscrapers also have a large impact on temperature through the buildings' downdraughts.

Table 2 shows the factors determined to have a temperature-raising impact of more than 1%: (1) the landscape units; (2) wind from the horizontal direction; and (3) wind from the vertical direction. We then tried to single out the most significant factors for each period: (1) the microenvironment has the largest impact, as well as the building cover ratio and the water cover ratio. Today, the extent of green land (or green cover) also has an influence. However, we determined that: (3) the impact of the wind's vertical downflow from the higher layer at 70 m significantly cools

Table 2 Factors that raise the temperature in the canopy layer by more than 1%

	Factors from Inside of Units	Factors from Outside of Units	
Factors	①景観単位Landscape Units 	②水平方向からの移流 Wind from the Horizontal Direction 	③上空との熱交換 Wind from the Vertical Direction 
R^2 =0.74 1884 Effective index	Standardizing Coefficient Building Cover Ratio 0.367 Water Cover Ratio -0.219 Altitude -0.111 Tree Cover Ratio -0.092 Openness Index 0.073 Direction of Slope 0.043	Next to Water -0.26 Next to Buildings 0.23	70 m Vertical Flow 0.084
R^2 =0.42 2008 Effective index	Building Cover Ratio 0.29 Tree Cover Ratio -0.278 Water Cover Ratio -0.222 High Building Cover Ratio -0.199 Skyscraper Cover Ratio -0.125 Grassland Cover Ratio -0.109 Openness Index 0.074 Direction of Slopes 0.038	Next to High Buildings 0.13 Next to Tree -0.122 Next to Water -0.118	70 m Vertical Wind 0.111 40 m Upward Flow -0.111 Downflow -0.097 (+:temperature rose −:temperature fall)

Source Self designed

the temperature of the canopy layer. Regarding the block landscape, it is possible to determine that, of these three variables, the major factors are (1) the landscape variables at block scale.

5 Urban and Landscape Planning (Heat/Wind Evaluation Method)

Finally, some adaptation strategies to climate change were devised in the form of a heat and wind evaluation method. The three influential variables were determined, and subsequently the dominant factors that can raise temperatures by over 1 °C. Reflecting these dominant factors, planning maps were drawn up for the preservation, maintenance, and creation of green space. In this chapter we propose the potential application of thermal and wind environments in urban green planning using dominant factors. However, this is still a hypothetical model (Fig. 10).

Regarding the three influential factors, the first step is to draw up a plan based on landscape units. In this plan, it is important to compensate for green space that has been lost, leading to extraordinary temperature rises. Here the microtopography must be acknowledged. In the center of Tokyo we note a temperature increase of more than 1 °C due to the erosion of the cliff line and a rise of more than 2 °C due to

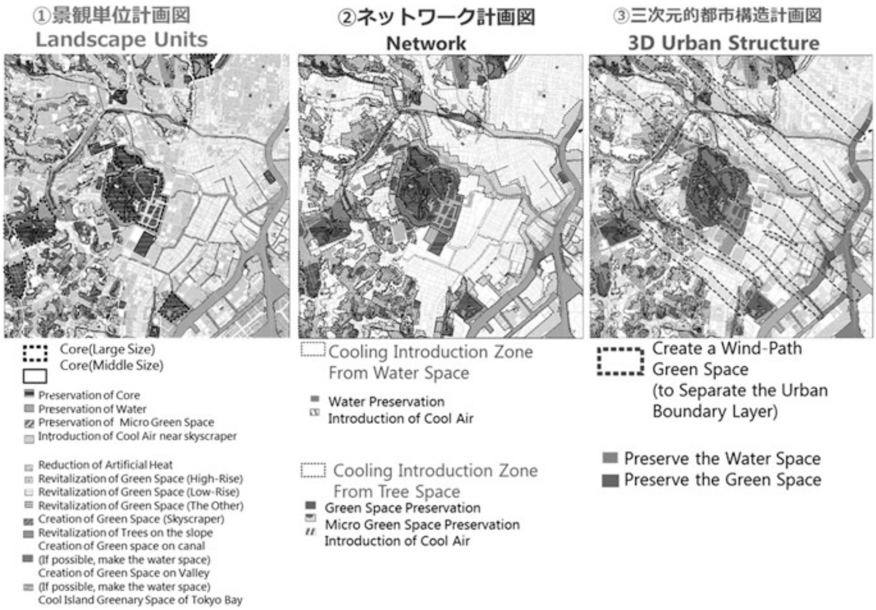

Fig. 10 Planning map of dominant factors of the thermal and wind environment. *Source* Self designed

the loss of water canals. One way to mitigate these effects is to introduce compensatory measures such as expanding green areas or bodies of water. The second plan is to establish networks of incoming cool air from the horizontal direction. Green slopes, canals or other waterways are the main conduits of laterally-flowing cool air. Hence, it is important to spatially arrange buildings (within urban blocks) close to green areas or water networks in such a way as not to hinder the pas-sage of cool air. The third plan is the movement of sea wind in three dimensions. If strong air turbulence occurs above large green areas then this can help to reduce the occurrence of heat islands. Therefore, a 3D model of the urban structure should be created for the purpose of urban planning. Such a model is still under development. However, there is no doubt that knowledge of the 3D characteristics of Tokyo City will be essential for intelligent urban planning in the future.

In conclusion, the described research investigated adaptation strategies to climate change as well as strategies to mitigate the heat island effect. In the above, we considered three aspects of adaptation. The first was the pattern of urbanization: Landscape units based on topography and land cover were determined by analyzing the historical context of the Edo period as well as the situation today. The second aspect was the impact of urbanization: Thermal and wind simulations were used to evaluate the effectiveness of landscape units as basic planning units for the thermal and wind environment. And finally, three adaptation strategies (1: Landscape units, 2: Network, 3: 3D Urban Structure) were proposed in regard to urbanization patterns and the impact of urbanization. The next challenge will be to conduct an analysis of the gap between environmental plans and existing policies in order to determine the likelihood that these environmental policies will be applied to the real world.

Chapter 7
Demands, Opportunities and Constraints of Green Space Development for Future Urban Development under Demographic and Climate Change

Stefanie Rößler

Abstract Impacts of demographic change—shrinking population, vacancies in the building stock and an increasing amount and expanding areas of open spaces—are changing the quantitative framework of green spaces. With regard to an ageing population as well as the ongoing individualization and diversification of urban lifestyles, we can also to point changing qualitative requirements. Demographic change clearly has various repercussions for green space: The demolition of surplus residential and commercial buildings increases the number of vacant lots, which serves to open up new opportunities as well as requirements for green space development. Against this background of varying requirements, it is vital to address a number of issues around the function and design of green spaces as well as access to such open spaces. The impacts of climate change such as rising average temperatures, the increasing number and intensity of heat waves and heavy precipitation events, influence the quality of life and well-being of residents, particularly in densely settled urban areas. Various forms of urban vegetation, green spaces, and urban ecosystems, together provide benefits and ecosystem services to meet these challenges. Such green infrastructure is a crucial element in urban climate adaptation strategies by helping to regulate the micro- and bioclimate, thereby mitigating heat islands as well as reducing the extent of storm water and flooding. Otherwise, implementing green spaces is often considered as a competing objective while developing compact cities in terms of climate mitigation and resource efficiency. Thus, the scientific debate is characterized by arguing about the 'right' urban form to help protect and expand green infrastructure within the manifold, sometimes competing, demands of urban development. The article will focus on the demands, opportunities and constraints of green space development resulting from demographic change and the need to adapt to the impacts of climate change in urban areas. Firstly, the requirements of green space development with regard to adaptation to climate change and demographic change will be introduced. Secondly, synergies and conflicts concerning the urban form will be examined. Thirdly, the

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opportunities and constraints of green space development with regard to this framework will be discussed.

1 Introduction

The impacts of demographic change and the need to adapt to climate change are two major challenges of current urban development. Green infrastructure, specifically the manifold elements of urban vegetation, green spaces, and urban ecosystems, provides an opportunity to address both of these challenges (Rößler 2013). Although the drivers behind these changes are rather different, the answers and approaches to dealing with them share some common features. Hence, future urban planning should focus on these commonalities by green space development. Currently, there is some consensus that shrinking cities offer better conditions for adapting to the impacts of climate change. This is due to the opportunity they present of developing less dense urban structures with a high proportion of green space (Endlicher and Kress 2008; Overbeck et al. 2008; BMVBS 2011; Emmanuel and Krüger 2012; Blanco et al. 2009).

1.1 Impacts of Demographic Change

Demographic change is characterized by a range of processes and phenomena. One typical process is a shrinking population due to migration and low fertility rates, effects that are rooted in wider societal changes and economic downturn. So-called shrinking cities can be found all over the world, they are concentrated in industrial countries (Rienits 2009). In Germany we can see heterogeneous patterns of population decrease. In particular, wide swathes of eastern Germany are affected by an ongoing loss of population. Also, old industrialized areas and rural regions on the periphery are seeing their populations fall.

Shrinkage affects urban development in various ways. From a spatial perspective, the most urgent problems are vacancies in housing and commercial properties. In Germany, attempts are being made to combat the spatial effects of shrinkage through various policy measures and joint federal and state programs. For example, the government gives financial aid to affected property owners and housing companies to demolish surplus housing stock and obsolete infrastructure, thereby enhancing affected neighborhoods (the program is called 'Urban Restructuring in Eastern Germany'). Such urban restructuring is regarded as a strategic response to the current situation. It aims to improve the quality of life and to enhance sustainable development in shrinking cities by revitalizing urban areas. Under this program, some 300,000 apartments were demolished between 2002 and 2012. Due to ongoing processes of shrinkage, it has been forecast that another 200,000–250,000 apartments will need to be taken off the market. Such measures create more empty space, thereby transforming the urban fabric (BMVBS 2012). Thus, part of the visible reality of shrinking cities is a significant increase in vacant lots, and hence opportunities for new urban structures. The fact that 85% of the sites of demolished (vacant) housing initially remain undeveloped (BMVBS and BBR 2007) highlights the importance of developing alternative strategies to handle such lots. Green spaces are one way of using the resulting open spaces. This approach is also a core element towards achieving the sustainable city.

Alongside quantitative considerations, demographic change also brings qualitative change to the population. Ongoing processes of individualization, a growing variety of lifestyles and, in particular, an ageing society, are all changing the framework for urban development. Perhaps the most obvious aspect of demographic change is ageing. This phenomenon is found around the world and is not exclusively linked to a decreasing population.

The transformation of urban land use offers a great opportunity or even a "luxury" to develop urban green spaces, thereby bringing ecological and social benefits as well as meeting aesthetic demands (Yokohari and Bolthouse 2011; Schilling and Logan 2008; Rößler 2007). Besides bringing opportunities to support urban biodiversity strategies, environmental justice as well as safeguarding healthy urban environments, such transformation can also help in the adaptation to climate change.

However, the framework for development is characterized by a number of limitations. Demographic change also brings shifts in the quantitative and qualitative demand for green spaces. The distribution of sites is more a result of economic interests than of conscious green space planning. Also the availability of sites for green space development can be restricted by building codes and property rights. Transforming built-up areas into green spaces can lead to a drop in land value. Additionally, in the light of tight public budgets, questions of the (long term) funding and responsibilities for emerging green spaces must be addressed.

1.2 Demands of Climate Change Adaptation

Cities are both the generators and victims of climate change. Here we can see how globally rising temperatures and changing precipitation regimes affect the local scale in various ways. The main challenges for urban areas are likely to be (1) urban heat islands and (2) heavy precipitation events (IPCC 2012).

(1) In the years to come, the phenomenon of the urban heat island (caused by densely built-up urban areas) will become more prevalent by rising temperatures during the summer months. Such an increase in the number of hot days (defined as having a maximum temperature >30 °C; Bernhofer et al. 2011: 33) will negatively affect the quality of life and human well-being. In particular, the health of high-risk groups such as infants (children under 2 years) and elderly is thereby endangered (Claßen et al. 2013; Krüger et al. 2013). One approach to

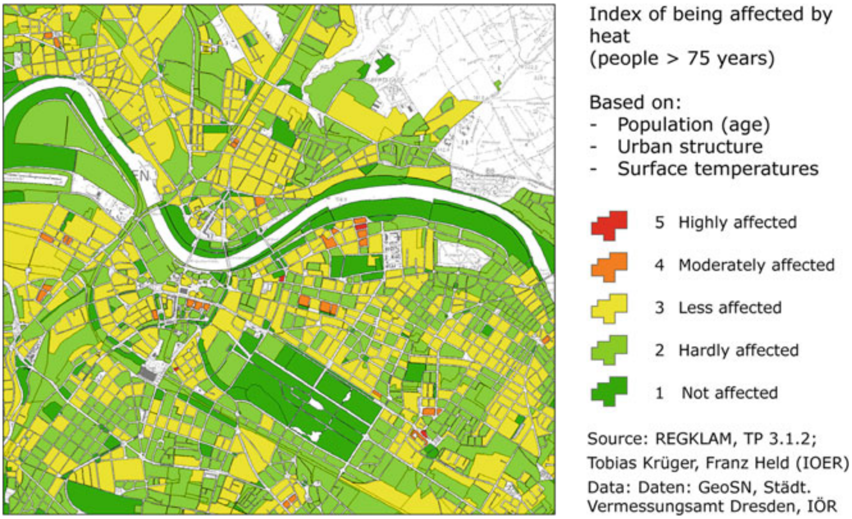

Fig. 1 Map of Dresden city center—index of being affected by heat (elderly > 75 years). *Red/orange* sites show areas where sensitive population, densely built-up areas and high surface temperatures overlap (Krüger et al. 2014)

investigating these impacts at the urban scale is to analyze the connection between population structure (in demographic terms), temperature and building structures. In terms of bioclimatic indices, a small-scale analysis can be undertaken to determine those areas where people will be affected by heat waves and rising summer temperatures (Fig. 1). Using the example of Dresden city center, temperature variations within the urban area are obvious. This allows the identification of hotspots which have to be carefully considered in future urban planning activities also concerning ageing.

(2) In addition to rising temperatures, we can observe an increase in heavy precipitation events. These can lead to flooding, also independent from urban waterways, damaging buildings and infrastructure.

2 Synergies and Conflicts

In urban development, there is an ongoing discussion about the ‘right’ or appropriate urban form regarding building density and the ratio of green spaces. While attempting to adapt to climate change, conflicts can arise between (1) concepts which foster the development of compact urban structures in order to reduce urban sprawl, create efficient infrastructures, and avoid increased traffic emissions; and (2) concepts that favor lower building densities and an enhancement of open and green spaces to combat rising temperatures, strong winds and flooding (Pizarro

2009; Hamin and Gurran 2009). The issue of optimum density (Boyko and Cooper 2011), and hence the proportion of open and green spaces, may be among the most relevant in the context of climate-appropriate urban development (Dosch and Porsche 2009). Following this debate, a so-called 'climate proof' model of urban development is proposed. This entails the establishment of resilient spatial structures that both mitigate climate change and adapt to its unavoidable impacts. This discussion needs to take account of different urban contexts. The main question to be answered is: Which potentials and constraints for adaptation to climate change are provided by the development of green spaces when cities are undergoing spatial and physical transformation?

2.1 Requirements for Green Space Development to Adapt to Climate Change

Urban green space provides manifold ecosystem services to deal with the named impacts of climate change. The positive effects of urban green space on the micro-climate have been confirmed by a number of studies (overview in Bowler et al. 2010; Lehmann et al. 2014). Additionally, a network of green spaces that is also connected to open areas in the urban surroundings ensures the passage of cold and fresh air to inner city areas. The ability of vegetation and green spaces to store rainwater can help reduce the impact of heavy precipitation events as well as dry periods during the summer months. To ensure 'water-sensitive urban development', it is necessary to provide retention areas along waterways for flood protection, decentralized rainwater management and increasing storage capacity for surface water (Hoyer et al. 2011). Green space planning under climate change should address these demands (Gill et al. 2007).

Bearing in mind these regulating ecosystem services, the following requirements for green space development when adapting cities to climate change can be summarized (Mathey et al. 2011):

- A network of regularly distributed and connected green spaces;
- Additional, unrestricted cold air corridors from outlying areas;
- Large and coherent areas with high vegetation density and a heterogeneous vegetation inventory (trees, bushes, lawns) to ensure maximum cooling effects;
- A small-scale network of compact green spaces to ensure neighborhood access to small cooling islands;
- A wide variety of green spaces, green features and manifold vegetation inventory on built-up sites (see Fig. 2).

Fig. 2 Variety of green infrastructure. *Photos* S. Rößler

2.2 Urban Forms in Shrinking Cities

In the context of the process of spatial shrinkage, reduction of the housing stock and of infrastructural facilities follows two basic principles: Either surplus buildings and facilities at the outskirts of urban areas are demolished, and the remaining facilities, equipment and potentials for use are concentrated in one or more urban cores; or vacant and unnecessary buildings are eliminated more or less at random, often for a range of individual reasons, resulting in a kind of perforation of the existing urban structure. The consequences for the spatial structure can be described in terms of three basic types of shrinkage: (1) the contracting city, (2) the fragmented city, and (3) the perforated city (Rößler 2008, 2010; Doehler-Behzadi and Schiffers 2004; Blume 2005).

(1) Contracting city: Shrinking cities that succeed in concentrating remaining functions and buildings into a contracting urban core may achieve a compact urban structure in which an inner core of densely built-up land is clearly delimited from the surrounding landscape. This form of shrinkage is characterized by a lack of green space in the centers, as there is often no opportunity to develop a network of green spaces. However, natural open space can be preserved outside the city borders.

(2) Fragmented city: By concentrating shrinkage in distinct areas of the city, stable fragments with standard urban densities can be retained. The islands of decreasing use thus formed provide an opportunity (and necessity) to consolidate separate open spaces as green surroundings or even stable networks, thereby ensuring their cohesion and retention in the urban area.

(3) Perforated city: Although neither planned nor managed, the spatial reality in shrinking cities can sometimes be described as perforation. Uncontrolled demolition of empty buildings and infrastructure leads to a perforated city. Open or green spaces arise on sites where buildings have been demolished, not in accordance with any planning strategy or real demand. Simultaneous processes of suburbanization will produce dispersed urban structures. Green spaces are often temporary fragments, which, if well designed or maintained at even a low level, can bring short-term improvements to the provision of green space.

2.3 Advantages and Disadvantages for Climate Change Adaptation of Green Space Development in Shrinking Cities

The particular type of spatial shrinkage will influence the framework for urban green space development, and therefore the specific capacities to develop green space adaptation strategies for climate change. With respect to the shrinkage types discussed above, the opportunities for implementing strategies and measures of green space development in order to realize the goal of climate-resilient cities can be evaluated. Such evaluation investigates the various opportunities for green space systems at the municipal level as well as the requirement for fresh and cool air, normally provided by large open spaces in the suburban and to some extent the rural surrounding of urban areas. In sum, the two core elements of effective green space provision to enable regulatory effects, and hence positively influence the urban micro-climate, are: (1) small-scale green space development in residential areas; and (2) large-scale green space development of fresh-air corridors from outlying areas. The concepts for urban structure introduced in Sect. 0 are discussed below with respect to their conditions, advantages, and disadvantages for the implementation of these two main requirements for green space development in order to adapt to climate change (Table 1).

Table 1 Implementation of green spaces to adapt to climate change with regard to urban models in shrinking cities (advantages and **disadvantages**)

	Central demands for green space development to adapt cities to climate change	
Urban models under shrinking conditions	(1) Small-scale green space development	(2) Large-scale green space development at the urban-regional level
Contracting city	**Larger green spaces within the urban fabric become ever rarer**	Green spaces outside the city borders can be preserved to offset the impacts of climate change
		Development of an urban-regional green space system (for the accumulation of cold, fresh air and air flows)
Fragmented city	Concentration in urban islands offers opportunities for a coherent green space network, with easy access	Coherent green spaces can be realized by concentrating building development
	Individual urban Islands are highly dense, green spaces nearby to housing areas may get lost	
Perforated city	Low densities offer the opportunity to closely link and integrate building and green space development	**Extensive and coherent green spaces in the urban surroundings are swallowed up by further suburbanization**
	Large proportion of temporary green may bring only short-term improvement	Remaining open areas at the urban fringe nearby settlement areas (accumulation of cold, fresh air, air flow)

3 Planning Approaches

Different planning approaches for green space development are addressing the background of the shrinking framework and the demands of climate adaptation.

3.1 General Models of Urban Form

The opportunities for the long-term development of green spaces greatly depend on the ability to steer the processes of urban shrinkage. The spatial framework of shrinkage, characterized by an increase in open spaces, has promoted urban structural concepts that include proposals on the redistribution of open and green spaces. The extent, distribution, function, and characteristics of green spaces is thus closely related to the spatial structure of a shrinking city.

The urban development models for shrinking cities more or less reflect one of the forms of shrinkage in their basic concept, depending on the historic urban structure, the local topography, the distribution and location of shrinking districts and vacant housing stock. In most cases, shrinking cities are associated with the 'European city' model, namely a compact, urban, dense, and mixed city. At the same time, attention is once again being paid to the concept of a less dense urban structure, with extended open spaces between built-up areas. Increasingly, we can observe the parallel implementation of both approaches: For the inner city, the goal is to achieve a compact urban structure by reducing the number of houses to be demolished and enhancing inward development. Since there is no way to entirely avoid reducing the building stock, major changes in the urban structure are accepted at the urban fringe, leading to perforation or fragmentation of the urban fabric. If these strategies are successful, the shrinking city can be described as possessing a compact and dense core of mixed uses, surrounded by a fragmented 'shrinkage belt' (Rößler 2010).

On the one hand, this strategy can serve to develop and protect corridors for cool and fresh air to flow from the urban fringe to the city center. On the other hand, a (re-)densification of the inner urban areas can exacerbate the negative impacts of climate change by encouraging the formation of urban heat islands. Thus, small-scale opportunities to establish green spaces and green elements should also be supported in the urban cores.

3.2 Types of Green Spaces

In order to realize such strategies, it is necessary to establish new types of green space, particularly at a time when the forces of demographic change are transforming the quantitative and qualitative demand for urban greenery. Additionally, as a result of the general economic downturn, less money is available to maintain green spaces in the traditional manner.

Depending on the extent of derelict land and the complex spatial framework, various approaches to the development of green spaces can be applied in shrinking cities. As some standard models for the design, utilization, and financing prove unsuited to certain areas, new types of urban green space are appearing to complement such traditional forms as urban parks (Mathey and Rink 2010; Rößler 2010). Some examples of these new types of green spaces can be seen in Fig. 3. They display a wide range of shape/design and function, which is also reflected in their potential for climate adaptation in shrinking cities (Mathey et al. 2015).

Gardens are a familiar type of urban green space now appearing in a new guise (Rosol 2010). In this way, urban gardening is helping to enhance the quality of life in some neighborhoods. The topic of the urban forest can be found in various contexts: From green strips replacing built structures, to the reforestation of sites at the urban fringe (Burkhardt et al. 2008). By reinventing urban agriculture, owners hope for added value also in economic terms (Yokohari and Bolthouse 2011). Although the urban wilderness (Vicenzotti and Trepl 2009; Rink 2009; Kowarik 2005) has not yet been implemented as a deliberate planning approach in shrinking cities, areas of wilderness may in fact spontaneously emerge if no interventions are made to design or maintain such sites. Depending on how long a vacant plot remains undisturbed, and on the manner in which it is used, different stages of vegetation development will predominate (Mathey and Rink 2010).

From the perspective of their potential to regulate the micro-climate, urban forests are a great way to deal with large areas that are no longer used as traditional

Fig. 3 Emerging types of green spaces in shrinking cities. *Photos* S. Rößler

green spaces. This enlarging of the green volume can make a major contribution to the reduction of temperatures in nearby residential areas. Even brownfields, with their varying developmental stages of vegetation, may potentially provide cooling effects. In view of current constraints on the development of permanent green spaces as well as the high proportion of temporary green spaces, the question remains as to whether any long-term improvement of the climatic situation can in fact be achieved.

4 Conclusions

A number of approaches of green space development have been created in an attempt to meet the twin challenges of demographic change and climate change. While these approaches follow different rationales in terms of the location, distribution, perception and even temporal perspectives of urban green inventory, there is little doubt that green space development can adequately meet both of these challenges.

In view of their spatial framework, shrinking cities offer favorable preconditions for the creation of green inventory, which, of course, can help to tackle the impacts of climate change. However, despite these obvious advantages, the establishment of green cities under processes of demographic and climate change has to overcome quite similar challenges of:

- Building codes and property rights restrict the development of existing neighborhoods;
- Feasible approaches have to be found, to ensure long term funding.
- Besides enlarging green spaces, minimum densities have to be acknowledged and preserved;
- Synergies in establishing green spaces have to be addressed by appropriate planning approaches.

Hence, even though shrinking cities offer good preconditions for green space development, the realization of green inventory as part of a strategy to adapt to climate change depends on steering opportunities, the availability of funding as well as the particular interests of affected stakeholders. At present, it is not entirely clear if shrinking cities will indeed prove more successful at adapting to climate change than stable or expanding cities.

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Part III
Environmental Risks in Urban Areas

Chapter 8
Environmental Risks in Urban and Regional Development—Assessing the Effects of Flood Resilient Technologies

Thomas Naumann and Sebastian Golz

Abstract Flood resilience strategies that seek to mitigate the vulnerability of receptors exposed to flooding are becoming an increasingly important issue in flood risk management in Europe. Significant receptors within flood-prone built-up areas are, amongst others, buildings with their many constructive forms. Building vulnerability thus has a strong effect on economic losses. Key criteria for the implementation of Flood Resilience Technologies (FReT) are their potential to improve the resilience of building types. For this purpose, detailed knowledge about the effects of FReT in terms of vulnerability mitigation is indispensable. Within the EU-research project "Smart Resilience Technology, Systems and Tools" (SMARTeST), innovative and smart flood resilience technologies have been identified and tested by experimental studies with regard to their reliability and level of performance. To analyse the flood vulnerability of built-up areas and to assess the impacts of FReT on damage reduction, the paper presents a methodology that uses a synthetic approach to the calculation of flood damage. As a result of this engineering approach, specific depth-damage functions can be derived synthetically for building types to describe the degree of damage at varying water levels. Research findings in European case studies have proven that the structural design and the building fabric have considerable impacts on the flood vulnerability of building types. In this way the effects of different FReT can be analysed and compared ex ante based on detailed estimates of damage costs. A number of synthetic depth-damage functions have been implemented in the GIS-based flood damage simulation model HOWAD. This expert tool spatially interlinks hydraulic modelling results with detailed information on the physical vulnerability of buildings; it then calculates the damage for each building with its site-specific water level, taking account of the impacts of implemented FReT. The calculated damage costs at object-level can be aggregated for different areas of interest. High-resolution modelling is a prerequisite for cost-benefit analyses of measures and also supports decision-makers in finding cost-effective technologies and appropriate technology combinations to improve the resilience of buildings. This

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model has already been applied in European case studies in Germany, the Czech Republic, the United Kingdom and Spain, taking account of the various national and local contexts as well as different flood types.

Keywords Flood damage assessment · Flood vulnerability · Flood risk Flood resilience technology · Vulnerability mitigation · Flood damage modelling · Flood-resilience technologies · Synthetic depth-damage functions

1 Introduction

It is beyond dispute that a forward-looking disaster risk management is necessary to ensure the sustainable development of both urban and rural areas worldwide. Following this precept, the Sen-dai Framework for Disaster Risk Reduction 2015–2030 describes several priorities for action to be focused on at the local, national, regional and global levels (UNISDR 2015). One of these priorities is an understanding of disaster risks and the investment in disaster risk reduction for resilience with regard to environmental risks. Within the current German expert discussion on research and innovation on the way to achieving sustainable future cities, both resilience and climate change adaptation strategies have been pointed out as important features for further development (BMBF 2015). Due to these facts methods, approaches and experiences regarding the analysis of environmental risks, such as floods, in urban and regional development seem to stay under way.

One current effect of climate change is more frequent and intensive heavy rain events. Further-more, population growth in cities is increasing the level of run-off from paved surfaces and encouraging floodplain development in settings where land is scarce. This combination of factors has led to catastrophic flood losses throughout Europe and around the globe.

The EU Floods Directive and the EU Water Framework Directive are forcing EU members to take a fresh look at flood defence. In the past, levees and flood control structures were designed to check storm waters with known frequencies of occurrence. Today these are liable to overtopping, causing flood damage in areas thought to be protected. In past years the general approach has been to rely almost exclusively on physical infrastructure improvements for flood risk management. Now there is an acceptance of the need for flood resilience, the wisdom of "living with floods", planning for a minimisation of damage and a speedy recovery.

Flood damage is a social issue that calls for a social response. We have learned that flood resilience not only involves structural aspects but also encompasses problems of social and city planning. Hence, "capacity building" and "social capital" must be sufficiently addressed, an approach that demands an educated and committed constituency in communities. Specifically, this requires:

1. spatial/ecologic,
2. structural,
3. social and
4. risk management levels of planning.

Planning for resilience is bound to fail if it ignores any one of these components. What do the various levels of planning entail?

Spatial planning refers to the way we locate and arrange land uses (preferably not on floodplains). It also relates to our management of run-off from surfaces, causing flash flooding in cities. Peak flows not only depend on the intensity of storms but also to a large degree on the run-off coefficient of surfaces. Many cities across Europe are making efforts to introduce green roofs, porous pavement and other sustainable drainage (SUD) measures to maintain the natural water cycle.

Structural planning for flood defence is not the exclusive responsibility of governments but also needs private action. Permanent, demountable and temporary measures can be built by private owners (to keep basements dry), by transportation authorities (to keep facilities from flooding), by utility companies (to enhance flood performance) as well as by other stakeholders.

Social planning includes timely flood warning, emergency planning and stakeholder participation by public agencies, and most importantly the building of "social capital", i.e. an educated constituency with a network of connections between individuals and representatives.

Risk management is aided by the availability of flood insurance to compensate for losses and by the public dissemination of information on measures that can be taken to reduce risks.

2 Flood Risk Modelling

2.1 Current State of Research

In recent years, several tools for flood damage assessment have been developed and tested (Messner et al. 2007; Merz et al. 2010). Although flood damage assessment is an essential part of flood risk management by supplying crucial information for decision-making processes, it has not yet received much scientific attention.

Most of the available models and tools for the assessment of economic flood damage use absolute or relative damage functions to quantify the flood vulnerability of elements at risk. Essential knowledge regarding these elements at risk is necessary for the assessment of the effects of flood resilience measures. Most of the existing tools are unsatisfactory to the extent that they cannot simulate the damage reduction potential, do not enable the quantification direct tangible damage to buildings and constructed assets and cannot be used to determine the impacts of measures concerning vulnerability mitigation.

Flood damage models usually adopt the concept of damage functions to describe the degree of damage to elements at risk depending on different water levels. These specific damage functions represent the flood vulnerability of each element. The review report of Merz et al. (2010) has presented two main approaches to the development of flood damage models (Table 1): (a) empirical approaches, which use damage data collected after flood events (ex-post analyses) and (b) synthetic approaches, which analyse damage processes including refurbishment measures ex ante (Neubert et al. 2016; Naumann et al. 2009).

Table 1 Advantages and disadvantages of empirical and synthetic flood damage models (Merz et al. 2010, modified)

	Advantages	Disadvantages
Empirical damage models e.g. RAINS	Real damage information possesses apparently a greater accuracy than synthetic data (Gissing and Blong 2004)	Detailed damage surveys after floods are uncommon, so that models may be based on poor quality data (Smith 1994)
		Statistical data about flood damage is often available only for coarse statistical units (e.g. German federal states). Hence, the data are often vague and have a high range of variability
	Effects of damage mitigation measures can be quantified and taken into account in damage modelling (Kreibich et al. 2005; Thieken et al. 2008)	Paucity of information about floods of different magnitude and often a lack of damage records with high water depth require extrapolations (Smith 1994; Gissing and Blong 2004)
	Variability within one category and water depth is reflected by the data, and uncertainty can be quantified (Merz et al. 2004)	Transferability in time and space is difficult due to differences in warning time, flood experience, building type and contents (Smith 1994)
Synthetic damage models e.g. HOW-AD-Prevent, FLORETO-KALYPSO	In each building, damage information for various water levels can be retrieved (Penning-Rowsell and Chatterton 1977)	High effort is necessary to develop detailed databases (inventory method) or undertake large surveys (valuation survey method) to achieve sufficient data for each category/building type (Smith 1994)
	Approach does not rely on information from actual flood events and can therefore be applied to any area (Smith 1994)	What-if analyses are subjective, resulting in uncertain damage estimates (Gissing and Blong 2004; Proverbs and Soetanto 2004)
	Higher level of standardisation and comparability of damage estimates	Premises within one classification can exhibit large variations, which are not reflected by the data (Smith 1994)

An example of the first approach is the German flood damage database HOWAS (Merz et al. 2004), from which the damage functions MURL (1999) and Hydrotec (Emschergenossenschaft and Hydrotec 2004) have been derived. Further examples of synthetic approaches are the damage functions for the UK (Penning-Rowsell et al. 2005) as well as the flood damage simulation model HOWAD (Neubert et al. 2016). Basically, it is possible to evaluate synthetic models using empirical data or to combine both approaches, e.g. to supplement empirical data with synthetic data, a method that has already been applied in the USA (USACE 1998), Australia (NRE 2000) and Germany (ICPR 2002). Table 1 gives an overview of the advantages and disadvantages of both approaches.

2.2 Models and Tools

A key criterion for the implementation of flood resilience construction and technologies is sufficient evidence about their level of performance (Golz 2016). Therefore, within the SMARTeST project, a set of innovative and smart flood resilience technologies has been identified and tested by experimental studies. Following Gouldby and Samuels (2005), performance is defined as the degree to which a process or activity succeeds when evaluated against some stated aim or objective. Performance indicators for FReT are their reliability and efficiency.

Reliability is understood as the capability of FReT to perform their required functions under stated conditions. Based on harmonised test methods, consistent reliability studies were conducted for selected FReT within the SMARTeST research project in order e.g. to analyse their capacity to withstand hydrostatic and hydrodynamic flood actions (failure) or to determine their intrinsic parameters such as the leakage rate. Efficiency generally relates the positive effects (benefits) to the expenditures (costs) of FReT implementation in monetary terms. The resulting cost-benefit ratio is an indicator that serves as a basis for the selection of the most efficient FReT options to improve flood resilience. However, there is currently a significant uncertainty regarding FReT efficiency due to a lack of scientific data of their positive effects (benefits).

To overcome this obstacle, models and tools already developed and approved by project partners were extended and enhanced to analyse the potential of FReT implementation. The SMARTeST toolkit:

i. Supports the assessment of individual FReT or the combination of several FReT options,
ii. permits the derivation of optimised FReT alternatives, and
iii. supports decision-making processes.

The models and tools of the SMARTeST toolkit have been tested in selected European study sites to analyse their functionality in regard to various flood types as well as different national and local contexts. The case study approach is used to demonstrate and compare the effects of different FReT implementation alternatives at a preferably high spatial and contextual resolution.

Moreover, the SMARTeST toolkit supports the improvement of the flood resilient system design. Following the SMARTeST document "Guidance for Resilience Systems", a "system" is an assembly of elements such as buildings or infrastructure (including their interconnections) that may be exposed to various flood scenarios, e.g. fluvial, pluvial, coastal or groundwater. The system approach embraces all flood management elements at various spatial and time scales. As resilience is a system property, it should be applied to flood risk management by adopting a systems approach. Basically, resilience is defined as the ability and the ease with which a system can recover from flooding. The resilience of a system can be assessed by qualitative or quantitative means. For example, the enhancement of flood damage simulation models (e.g. HOWAD) can be used to provide information on the extent and costs of damage to properties after flooding. The impacts of FReT can lead to reductions in physical damage and reduce the repair costs for a property.

Flood risk systems describe the complex interacting processes that influence the magnitudes and patterns of flood events and their adverse consequences. They provide a sound basis for a broad understanding of systems behaviour. The conceptualisation of flood risk systems is a major challenge, comprising the identification of relevant system elements, processes and structures depending on the functional and spatiotemporal extent as well as on the applied scales in space and time (Luther and Schanze 2009).

The source-pathway-receptor-consequence (SPRC) concept is accepted as a simple interrelation representing the risk generating process.

- Sources (S) indicate the flood generation due to heavy rainfall, snowmelt or storm surges.
- Pathways (P) mean the flood propagation in the river network or at the coastline, including the inundation processes.
- Receptors (R) are all physical entities exposed to flooding, such as human beings, buildings, infrastructure or sensitive ecosystems (e.g. in terms of flood pollution).
- Negative consequences (C) specify the adverse physical, social, institutional, economic or environmental effects of flooding.

In terms of flood risk, sources and pathways represent the flood hazard, whereas receptors and negative consequences state the flood vulnerability. Sources, pathways, receptors and consequences are not only closely connected but also spatially and temporally overlaid. Thus, the division between sources, pathways and receptors is not strict but depends upon the scale and context of the research (Hall et al. 2003).

The analysis of an entire flood risk system requires the linking of various approaches. The flood damage simulation model HOWAD can be embedded in a comprehensive flood risk modelling methodology to analyse potential economic damage to buildings and constructed assets and to assess the impacts of FReT.

2.3 Coupled Models

A report produced by Luther and Schanze (2009) has looked at the analysis of a flood risk system for the Elbe River. The authors argue that the coupled modelling of entire flood risk systems with the large number and particularities of involved processes, especially at larger scales, provides a basis for analysing the system behaviour, while exceeding the traditional disciplinary perspective of flood research (Fig. 1).

This requires the linking of methods of hydro-meteorological flood hazard determination with social science approaches of flood vulnerability analysis since risk comprises social, economic and environmental aspects. The lack of complete information also presents a specific challenge. The interlinking of various approaches is hindered somewhat by the wide range of modelling concepts. However, hard and soft coupling of individual models are common ways of trying to comprehensively simulate flood risk systems. Due to the inherent complexity and reduced methodological flexibility, it is currently rather challenging to devise a unique model to simulate the entire flood risk system.

McGahey et al. (2009) have already indicated principal modules for the representation of the flood risk system in the methodological framework for decision support in flood risk management. The modules relate to the description of sources, pathways, receptors and consequences and to the risk analysis. There are numerous tools available to model these compartments of the flood risk system. They pertain to different mathematical and technological solutions. Thus, the simulation of a flood risk system requires a choice of appropriate models. This may be influenced by the personal preferences and possibilities of the investigators as well as by previous work and results. Beyond modelling the physical processes, the resulting consequences and the flood return period (recurrence interval) needs to be tackled by involving stochastic approaches.

The SMARTeST toolkit is not an all-in-one tool, as a broad range of complex processes needs to be considered in flood risk assessment. Hence, selected

Fig. 1 Coupling models and tools for flood probability assessment and flood damage assessment to assess flood risk (Luther and Schanze 2009)

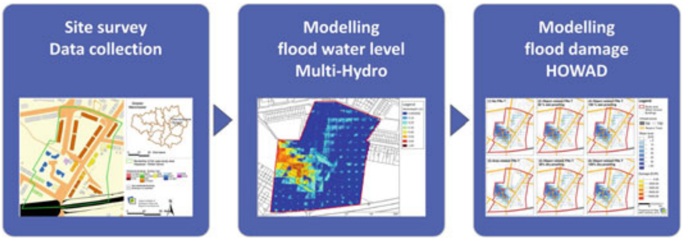

Fig. 2 Modelling the effects of selected FReT regarding vulnerability mitigation considering different flood scenarios and various levels of FReT implementation using the case study Heywood/Greater Manchester (UK) (Golz et al. 2015)

SMARTeST models and tools are coupled to analyse flood risk in particular case studies. For example, an approach to linking methods for hydro-meteorological flood hazard determination (Multi-Hydro) with methods for flood vulnerability analysis (HOWAD) to support decision-making processes was tested for the town of Heywood as a case study (Golz et al. 2015) (Fig. 2).

2.4 *Flood Resilient Technologies*

Flood resilience technologies (FReT) are specified as any method, product or material that improves the resilience properties of the built environment (Lawson, 2011). The EU-FP7 funded research project Smart Resilience Technology, Systems and Tools (SMARTeST) is intended to facilitate the uptake of innovative flood resilience technologies and to address issues of integrating these technologies into the overall approach on flood risk management (Garvin 2013). The SMARTeST research report by Gabalda et al. (2012) identifies a broad range of FReT, assigning them to three predefined categories according to the spatial scale of their deployment:

- Perimeter technologies.
- Building aperture technologies.
- Building technologies grouped into flood resilient building products and flood resilient building constructions.

At the urban scale, perimeter technologies such as mobile flood barrier systems, which are installed at some distance from groups of buildings, are particularly suited to protecting specific locations up to a certain threshold. It should be noted that this FReT category is outside the scope of this paper, as it emphasises the effects of FReT at the property level.

At the scale of individual buildings, the set of FReT comprises, first, building aperture technologies for the temporary watertight closure of façade openings such as doors, windows or ventilation elements, and, second, building technologies that address either flood resilient (FRe) building products or FRe building constructions. FRe building products embrace:

i. materials or systems for the permanent sealing of the building envelope such as membranes or hydrophobic impregnations,
ii. anticorrosive coatings that prevent the triggering of destructive processes as well as,
iii. smart domestic flood warning systems that operate flood barriers automatically.

In general, the implementation of building aperture technologies and FRe building products intends to keep flood water outside buildings up to a defined design level. It is obvious that an effective dry proofing strategy requires a holistic approach, because the implementation of single building aperture technologies or FRe building products are often insufficient to block all potential water entry routes into the building. Furthermore, it is apparent that this dry proofing strategy is limited by the individual strength of the particular external wall constructions to withstand flood actions, e.g. hydrostatic pressure, without structural failure.

In contrast, FRe building constructions are related to the wet proofing strategy. Despite the availability of building aperture technologies and FRe building products on the market to help to stop floodwater entering buildings, there remains a significant risk that building assemblies in flood-prone areas have to cope with floodwater, e.g. due to overtopping or failure of flood defences. Hence, FRe building constructions provide advice on how to design new or how to modify existing building assemblies, e.g. through the use of adequate external wall or floor constructions to enhance cleanability, to promote fast drying and to minimise the extent of necessary repair works in the case of flood water has entered the building. The recommendation of FRe building constructions considers material interrelations in composite building constructions as well as their structural integrity and inherent resilient characteristics. Laboratory tests to determine the resilience properties of building assemblies have also been conducted, e.g. by Gamerith and Hoefler (2006), Bowker et al. (2007), Escarameia et al. (2007), Gabalda et al. (2012), and Garvin (2012). However, there are no regulations available for FRe building constructions at national or European level, despite the increased endorsement of resilience in flood risk management (Escarameia et al. 2012).

3 Flood Damage Simulation Model HOWAD

The presented synthetic approach to flood vulnerability analysis is implemented in the GIS-based flood damage simulation models GRUWAD (Schinke et al. 2012) and HOWAD (Neubert et al. 2016). The latter expert tool spatially interlinks hydraulic modelling results with specific information on the flood vulnerability of building types in order to assess flood impacts on the built environment also for selected development scenarios and their repercussions, e.g. projections of societal or climate change. Such flood damage simulations support the preparation of flood risk maps as legally required in EU member states by the European Floods Directive 2007/60/EC (European Union 2007).

Figure 3 provides an overview of the conceptual design of HOWAD that embraces three input modules, a calculation module and an output module. Depending on the considered flood type (e.g. pluvial, fluvial or groundwater flooding), the flood hazard module characterises the magnitude, i.e. surface water depths or minimal depths to groundwater, as well as the associated annual probability resulting from hydro-meteorological, hydraulic and hydro-dynamic modelling to a high spatial resolution. The input module urban structure provides a classification of the built environment within a flood-prone study area. The elaborated synthetic depth-damage functions for building types are processed within the input module vulnerability.

The calculation module draws on the three input modules to compute damage costs for each exposed building related to its site-specific water depth and specific vulnerability. These high resolution modelling results at property level can be aggregated for any spatial units of interest, e.g. for administrative or statistical areas, for districts or for definable raster cells. Results are either visualised as flood risk maps or stored in data files for further statistical analysis. Furthermore, HOWAD not only enables a detailed assessment of the impacts of current flood hazards, it can also simulate future risks for different scenarios (e.g. climate change, socio-economic development) and strategic alternatives.

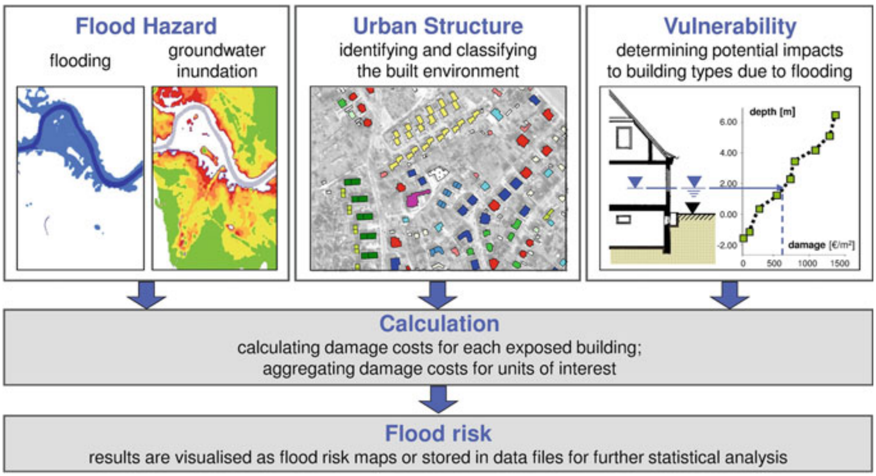

Fig. 3 Modular structure of the flood damage simulation models GRUWAD (Schinke et al. 2012) and HOWAD (Neubert et al. 2016)

3.1 Considering Flood Resilience Technologies in Flood Damage Assessment

As previously described, the implementation of flood resilience technologies generally addresses two different spatial scales: the urban scale or the individual building scale. At the urban scale, flood resilience technologies (e.g. flood barrier systems) particularly reduce the exposure of buildings and transport infrastructure to flood risk (Fig. 4). Effects are quantified through the lowering of water levels, for instance, so that receptors are not affected by prospective inundation.

On the contrary, the implementation of FReT at the individual building scale is explicitly aiming at flood vulnerability mitigation of buildings that temporarily have to cope with flooding. Effects are usually quantified by slower increasing depth-damage functions.

Following Golz et al. (2015), the introduced synthetic approach to flood vulnerability analysis (Fig. 1) has been extended by four generic processing steps in order to assess *ex ante* the impacts of FReT implementation at the individual building scale. Based on the analysed flood vulnerability of a representative building type, the required processing steps are as follows:

1. Assessing the level of risk. Compiling information about the flood hazard characteristics within the study area such as expected water depths and flood duration, about the predicted flood warning times, and about any technical issues that may severely constrain the implementation of particular FReT. This information is combined with the flood vulnerability of the building type to determine the level of risk.

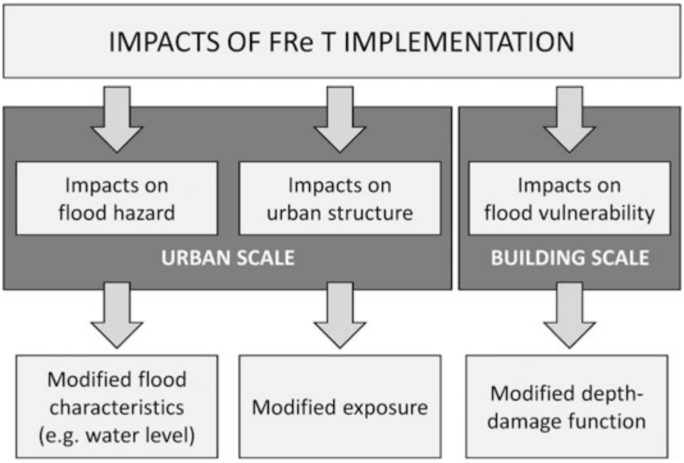

Fig. 4 Impacts of FReT implementation at the urban and building scales (Golz et al. 2015, modified from Schinke et al. 2012)

2. Exploring and specifying appropriate, reliable FReT for the building type depending on the determined level of risk.
3. Analysing the flood vulnerability of the building type's representative with FReT in place and deriving an adapted depth-damage function based on modified cost estimations due to a changed range of flood repair requirements.
4. Assessing the effects of FReT integration by comparing the original and the adapted depth-damage function.

These four proposed processing steps are considered to be an iterative process, developed to determine the most effective FReT alternatives at the scale of individual buildings.

Figure 5a indicates the effects of building aperture technologies and FRe building products that prevent water ingress up to a predefined design level (dry-proofing strategy). The presented depth-damage function proves that flood damage to building fabric and building services can be significantly reduced. However, if the intake threshold is exceeded, these FReT are ineffective. In this case, the depth-damage function returns to its original course. Impacts of FRe building constructions that adopt the wet-proofing strategy are characterised by the diminished slope of the adapted depth-damage function (Fig. 5b). The flood damage simulation model HOWAD considers the effects of FReT within the input module vulnerability employing the adapted depth-damage functions. Therefore, HOWAD enables the GIS-based modelling of flood damage to buildings for various levels of FReT implementation.

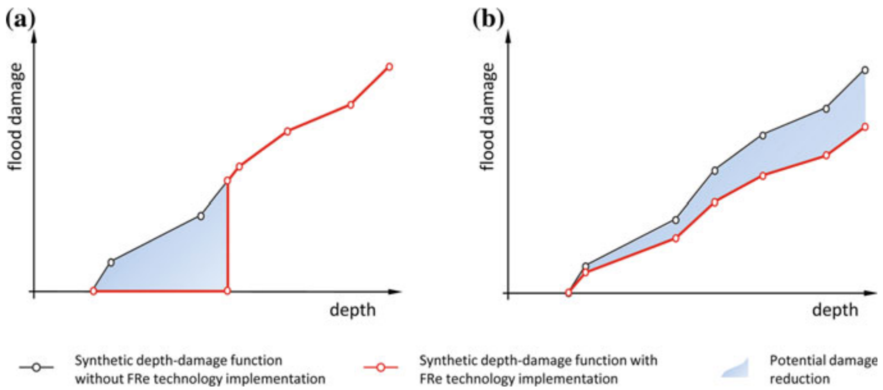

Fig. 5 Impacts of FReT implementation on the depth-damage function (Naumann et al. 2010). Effects are qualified through the *blue-coloured* area between the depth-damage functions. **a** Dry-proofing strategy. **b** Wet-proofing strategy

4 Summary

The assessment of flood resilience technologies (FReT) at the scale of individual buildings is gaining greater importance because the targeted uptake of such technologies is often constrained by a lack of informed knowledge about their performance. Therefore, the paper proposes a four-step extension of the synthetic approach to flood vulnerability analysis in order to provide evidence on potential effects of FReT implementation concerning flood damage mitigation.

It can be argued that the extended approach has proven its potential to take account of the impacts of FReT implementation within flood damage calculations. It is expected that the extended approach will support decision-making processes for the use of flood resilience technologies.

As previously described, the benefits of FReT are defined as direct tangible damage avoided to properties at risk. Further work needs to be done to include approaches to value indirect tangible damage costs and to specify the expected expenditures of FReT in monetary terms, e.g. investment and maintenance costs, in order to estimate the efficiency of their prospective implementation. The cost-benefit ratio will indicate if the benefits outweigh the expected costs. Then, the efficiency and the reliability of FReT will be linked to obtain an indication of their performance upon which to base informed and quantifiable decisions.

Ultimately, it should be noted that the presented methodology is not only applicable to the issue of flooding. Naumann et al. (2010) and Nikolowski et al. (2013) have shown how the methodology can be applied to other hazardous events, for instance heavy rainfall or heatwaves.

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Chapter 9
Flood Risks and Their Management in Urban Japan—Modeling Inner Flooding in Tsushima City, Tokai Region

Takashi Tashiro and Aung Khaing Min

Abstract The topography of the Japanese archipelago is largely mountainous with only narrow strips of lowland. These lowland plains are exposed to various types of flooding such as river floods due to rapid runoff from steep highlands as well as inner (urban) flooding due to water retention. In this chapter we look at the issue of flood disasters, describing the causal structure of flood risk along with the concepts and processes of the phenomena of urban flooding. There already exists a range of infrastructural and software measures to attempt to mitigate the occurrence and resulting damage of urban flooding. In order to discuss the risks of floods in lowland urban areas, we review the processes of the Tokai flood of 2000 by conducting a series of inundation analyses of the downtown area of Tsushima city, where a combined sewerage system is in place. These results provide a better understanding of the process of urban flooding as well as effective mitigation measures.

1 Changing Patterns of Flood Damage in Japan

The relatively narrow Japanese islands possess extremely mountainous terrain. This explains the country's steep and turbulent rivers. In general, the topographical and meteorological features conspire to generate significant flood threats to urban areas, which are largely located in narrow plains and basins. Figure 1 illustrates the impact of flooding in Japan during the period 1946–2013 in terms of the numbers of dead and missing as well as the economic impact. The data was drawn from flood statistics compiled by the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT). The large spike in 1959 represents the Isa Bay typhoon, which killed more than 5000 people. Before this event, a number of previous floods had also claimed

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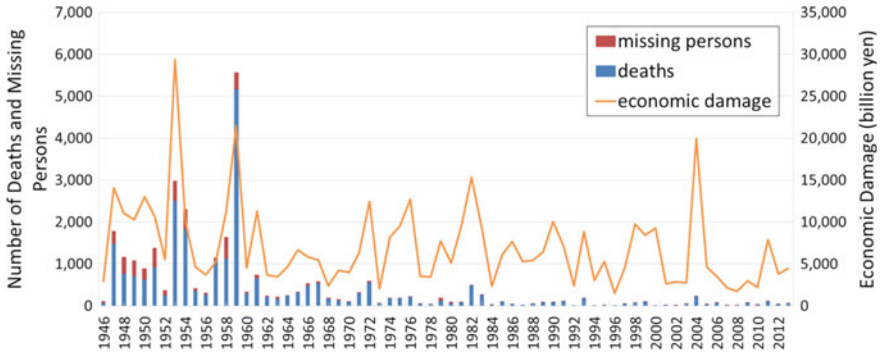

Fig. 1 Numbers of dead and missing as well as economic costs of flooding in Japan between 1946 and 2013 *Data source* MLIT, 'Suigai-Toukei-Chosa, Flood Statistics')

the lives of several thousand people. However, the death toll after the 1959 disaster fell rapidly due to the effective management of rivers and landscapes, decreasing the likelihood of severe inundations. In Japan, river floods are regulated by the Basic Policy for River Management and the River Improvement Plan of the national government or the prefecture, whereas urban floods are mitigated by sewer systems. Planners and engineers have been able to limit flood damage through infrastructural measures such as the construction of levees, flood diversion channels, and discharge water systems for sewer networks as well as software measures such as the implementation of flood hazard maps and emergency alert systems to evacuate local residents. However, the economic impact due to physical damage has not decreased since 1960. It is important to analyze the reasons behind the continuing high destructive power of floods. Over past decades, as alluvial floodplains have undergone rapid urbanization, natural streams and their vegetative surroundings have been replaced with artificial drainage systems. This has led to a decrease in natural water absorption and retention capacities (and thus concentration times) as well as an increase in impermeable surfaces and runoff volumes. Together, these factors can overwhelm the urban storm-water drainage system, leading to urban pluvial flooding (Waley and Aberg 2011). Consequently, clustered assets and properties are exposed to flood hazard.

2 Causal Structure and Concepts of Flood Risk in Urban Area

Sato (2015) has suggested that flood risk can be split into four components: hazard, exposure, damage, and social resilience, which apply to both natural and artificial environments. Thomas et al. (2015) relate these components to the concept of vulnerability. They describe flood processes as the continuous relation between the

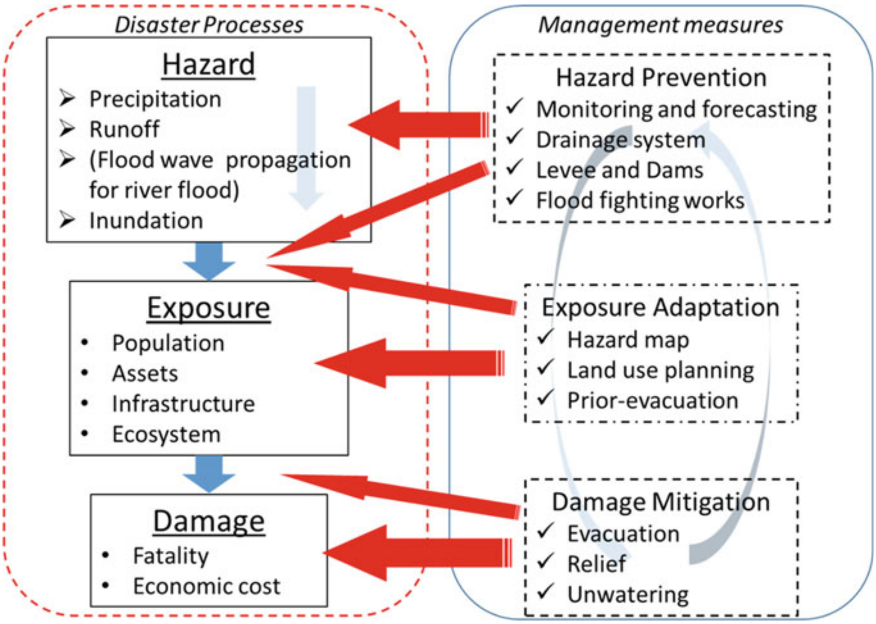

Fig. 2 Causal structure and concepts of flood risk in urban areas. *Source* Self-designed

hazards, exposure, and damages due to floods. In this article, we refine these components with respect to both structural and non-structural measures of disaster management in order to clarify the cause and effect relations in flood disasters as shown in Fig. 2. In this concept, flood disasters can be managed with such measures as hazard prevention, exposure adaptation, and damage mitigation. To reduce the risk of flooding in urban areas, we need to combine these measures at different stages in order to improve social resilience and decrease the vulnerability to flood hazards.

When discussing flood risk in urban areas, attention must be paid to the effects of land surface conditions on runoff processes. In pre-industrial Japan, inhabited areas generally featured paddy fields, irrigation ponds and wide unpaved surfaces. In these circumstances, rainwater will not immediately drain into the nearest river; instead, the paddy fields act as natural retention basins while the vegetative groundcover absorbs some of the rainwater. A certain percentage of the rainwater will find its into the groundwater. However, once processes of urbanization have taken hold and the roads become paved, the rainwater can no longer be absorbed into the ground. Any excess water on level ground will cause urban flooding because it cannot drain into a nearby river. In the case when runoff is directly guided into a watercourse, the riverbed may be flooded. Furthermore, as previously mentioned, Japanese rivers are generally steep and short. Natural retention is minimal in the upstream mountainous sections of river basins. This necessitates the construction of dams to ensure some water retention capacity. Levees may also be built to prevent the overflow of water. Despite these measures, the natural capacity of watercourses is frequently exceeded. Excess water then overflows the banks into adjacent low-lying floodplain areas, a phenomenon called river flooding. Japan's cities therefore face the particular risk of simultaneous river flooding and urban flooding.

3 The Tokai Flood: Japan's Worst Urban Flood

The Tokai flood is recognized as one of Japan's worst urban floods in recent years. Here we give a brief overview of its characteristics. On 11 and 12 September, 2000, the Nagoya metropolitan area suffered extreme rainfall. Over these two days, approximately 500 mm of rain fell, about one-third of the area's annual total. Figure 3 shows the hourly and cumulative rainfall recorded at Nagoya Local Meteorological Observatory run by the Japan Meteorological Agency (JMA). On September 11 the observatory recorded the highest hourly and daily rainfall (97 mm/h and 428.0 mm/day respectively) since July 1890. The cause of this extreme weather was the autumn rain front, boosted by warm and moist air from a typhoon approaching the Japan archipelago from the southwest Pacific Ocean. Figure 4 shows the JMA weather map as of UTC 0:00 (JST 9:00) on September 11, 2000. On the ground, the urban drainage systems and small catchment areas overflowed in Nagoya as well as its neighboring cities and towns. This led to urban flooding over wide lowland areas. Secondly, rivers overflowed and breached their levees in some basins such as the Shonai, Yahagi, Sakai, and Tenpaku river basins. The total area eventually affected by flooding reached 275 km^2 with more than 600,000 houses inundated. Happily, there were only ten fatalities. However, the physical damage was estimated to be around 700 billion yen (six billion USD).

Figure 5 illustrates a typical urban landscape and river system affected by the Tokai flood. Some of the small rainwater drainage systems and the medium and large river infrastructures are shown. Regarding the river system, the Gojo River is one of the branches of the Shinkawa River, which flows into and is diverted from the Shonai River. Hence, the Gojo River was affected by backwaters from the Shinkawa River, while the Shinkawa River received floodwater from the Shonai

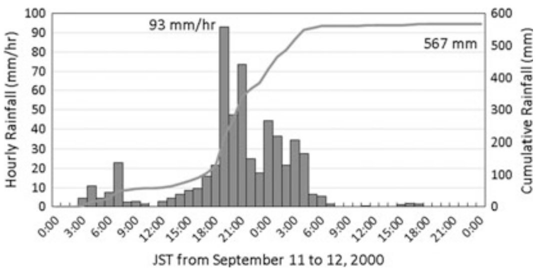

Fig. 3 Rainfall measured at Nagoya local meteorological observatory during the Tokai flood of 2000. *Data source* Japanese Meteorological Agency (JMA)

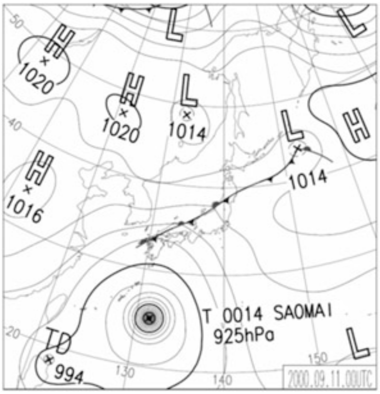

Fig. 4 Weather map of the Japanese archipelago as of UTC 0:00 (JST 9:00) on September 11, 2000. *Source* JMA

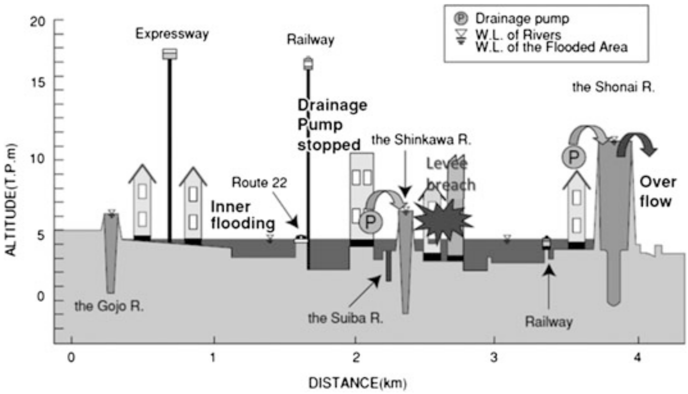

Fig. 5 Schematic diagram of topographic relation between rivers and neighboring facilities illustrating the consequences of the Tokai flood. *Source* MLIT 2000 and Sato 2006

River. In this example, the inner flooding of the residential area was due to the breaching and overflowing of the levees as well as the fact that one of the drainage pumps was turned off to prevent the water level of the Shinkawa River from increasing even further. Because the drainage capacity depends on the rivers, a proportion of inner flooding is strongly linked to the flood processes of these rivers. This can be viewed as a cascade effect of multiple flood hazards (Sato 2015). Furthermore, there is no integrated system to manage these drainage systems and rivers. Therefore, urban flood risks depend on a complex mix of inner and river flooding in lowland areas. This is a difficult situation to manage.

4 Modeling the Inner Flooding in Tsushima City (Min 2015)

To better understand urban flooding and the development of countermeasures, here we introduce a case study conducted in the downtown area of the city of Tsushima, which is located in the Noubi plain, the western lowland area of Aichi prefecture. The study area features a small combined sewer system without any other drainage system or river basin.

4.1 Materials and Methods

4.1.1 Study Area

Lying 35° 10′ 37′ North and 136° 44′ 29′ East, Tsushima City has a total area of 25.09 km^2. In 2012 the total population was 65,118, giving a population density of 2596 inhabitants per km^2 (data: Tsushima City 2013). Due to its location in the East Asian monsoon region, the city experiences a rainy season in June. Annual precipitation is approximately 1500 mm. Topographically, this is a low-lying area at an elevation of 3.6 m below to 8.2 m above mean sea level. The typical forms of land cover have undergone rapid change. For example, urbanized land increased from 30% in 1976 to 51% of total area in 2009, whereas the extent of crop fields decreased from 65% in 1976 to 42% in 2009 (Min 2015). Most inundation is in the form inner flooding. River flooding has hardly been observed in this area since the Isewan Typhoon of 1959.

The sewer system is composed of sewer pipes, manholes, storm drains, and pumping stations. Data on the position of each component, including the slope, shape, and diameter of pipes, was obtained from the Tsushima city authorities. Drainage infrastructure of the sewer system encompasses 796 manholes, 28 km of storm sewers, and 3159 flow regulators. The main sewer network in Tsushima city was built 1964.

4.1.2 The Simulation Model

A new integrated lowland inundation model (NILIM ver. 2.0, National Institute for Land and Infrastructure Management) is used in this study. This is an integrated flood model that combines three separate modules: a one-dimensional unsteady river flow model, a sewerage network model, and an urban floodplain overland flow mesh model. An overview of the NILIM model is shown in Fig. 6. The model is able analyze the complex hydraulic interactions between the surcharging flow from sewer pipes and the flow of overland surface flooding by considering the detailed conditions of surface topography and the features of the underground sewer

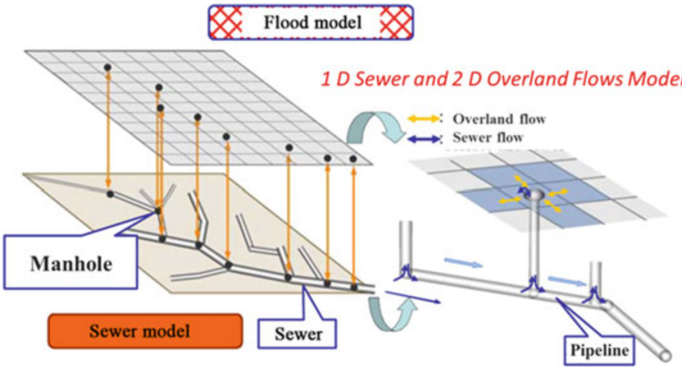

Fig. 6 Structure of the adopted NILIM model with one-dimensional sewers and two-dimensional overland flows. *Source* NILIM; Min (2015)

network. In the sewer system, two flow conditions are considered: open channel state and pressure state. The open channel state is considered when the water level is lower than the pipe crown and the pressure state is considered when the water level is higher than the pipe crown. The selection of basic equations for the simulations depends on this situation. Regarding the floodplain surface conditions, a variety of structures and drainage facilities can be specified on the mesh and regarded as the roughness or boundaries of the surface water calculation.

4.1.3 Designing the Simulation Domain and Conditions

The domain to be calculated is decided by considering the distribution of the sewer network and by reviewing flood data from the Tsushima City authorities in order to cover the areas that frequently experience inner flooding. This domain includes Tsushima station and some of the core downtown areas, giving a total area of 101.12 ha (as shown in Fig. 7). A two-dimensional surface model (20 m $\times$ 20 m) is established using the digital elevation model (DEM) of LiDAR data (5 m resolutions) with a vertical resolution of ± 0.1 m and the actual building distribution of the period 2014–2015. Both datasets are part of the basic geographic data for Japan provided by the website of the MLIT's Geospatial Information Authority (GSI).

The rainfall event to be considered in this simulation is the 9-h rainfall from 12:00 to 21:00 on September 30, 2012. This is the period when the study area was most recently damaged by severe inner flooding (as shown in Fig. 7). A hyetograph was drawn from data recorded at the nearest weather station (Aisai, Aichi prefecture). This data is provided by the JMA website.

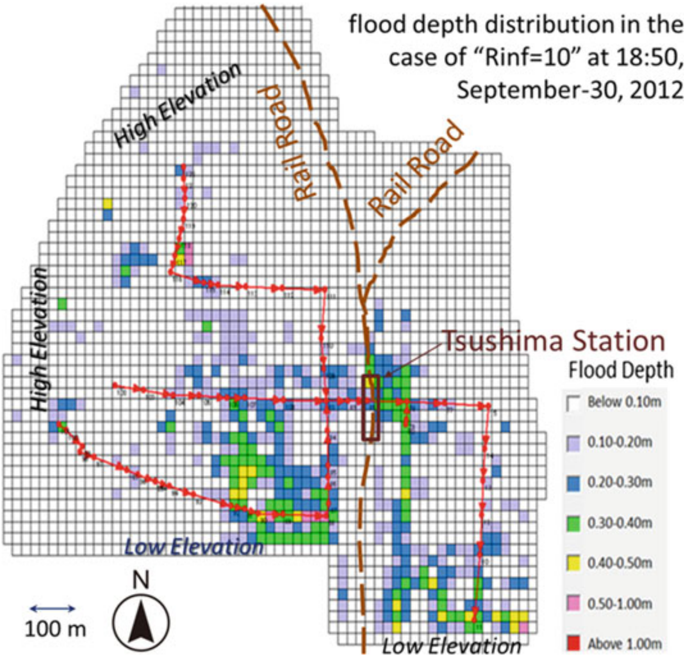

Fig. 7 Inner flooding depth distribution in the study domain of Tsushima city: One of the worst cases (in the control case with Rinf = 10) of the simulation results (the network *of red arrows* and *points* indicates flow directions and manholes in the sewer system, respectively)

4.1.4 Measures to Mitigate Inner Flooding

One effective flood mitigation strategy is to increase rainwater catchment and absorption. Therefore, we examined the effectiveness of increasing soil infiltration, which can be achieved by replacing paved areas with loose materials such as gravel. In the rainfall-runoff model, runoff is assumed to issue only from impervious areas, while the reduction due to soil infiltration is expressed by a single hydrological reduction factor ('Rinf', measured in mm per hour). In the flooding simulation, a factor of 10 is applied as the control case. Here a further three cases of hydrological reductions of factors 0, 20, and 40 are examined.

4.2 Results and Discussion

The simulations provided information on the overland flooding processes and the performance of the existing drainage network. Figure 7 shows a snapshot of the extent of flooding and the inundated depth distribution in the study area. We see that towards the west there is an area of higher elevation. Storm water is collected by the sewer network, leading to inundations in the south or east flatland at lower elevations. The risk of inundation can also be clearly seen in the city center around Tsushima rail station. Although the distributions of inundated depths need to be validated, we can simulate and describe the spatiotemporal processes of detailed inundations (in 20 m meshes with 10 min intervals) in the case of urban flooding due to heavy rainfall.

4.2.1 Effects of Surface Infiltration Conditions on Inner Flood Mitigation

Figure 8 shows the results of temporal changes in the inundated meshes as per the hyetographs of rainfall distributions (actually observed on September 30, 2012, as mentioned above). This figure also shows that the area of inundation can be reduced by controlling the land surface infiltration factors. Therefore, an increase in surface infiltration can be a concrete countermeasure to mitigate inner flooding. Measures such as the construction of swales, infiltration trenches, and pervious pavements may encourage the slow discharge of storm water. Land use planning and the regulation of new developments are key components of integrated urban flood risk management and storm-water management. Here it is vital that regulations serve to reduce the imperviousness ratio and create pervious pavement and surfaces in newly planned urban areas. The above simulation results indicate that increasing the area of pervious surfaces as well as the infiltration rate of storm water are important measures to mitigate urban flooding.

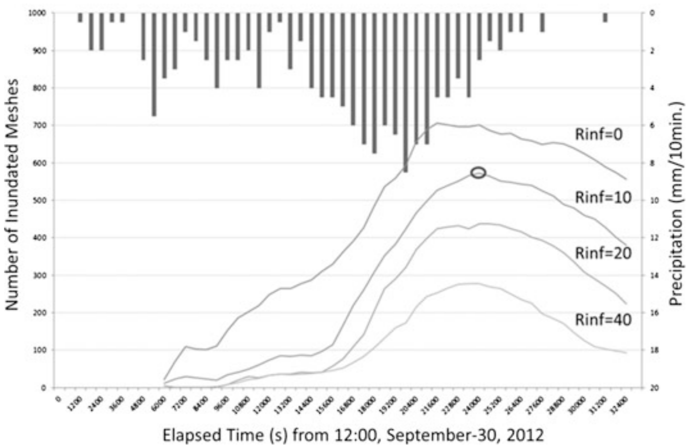

Fig. 8 Comparisons of the effects of surface infiltrations on temporal expansions of inundated area in the four cases Rinf = 0, 10, 20, and 40 (the *red circle* indicates the time-point of Fig. 7)

5 Concluding Remarks

In this chapter we have reviewed flood risks and their management in Japan's urban areas. Flood statistics were used to provide a clear overview of trends and characteristics of the country's flood disasters. Moreover, the causal structure of urban flood risk was described, followed by the specific causes and processes of the Tokai flood of 2000, which was the Japan's severest urban flood.

Then a numerical flood simulation was presented in order to discuss measures of flood mitigation. According to the case study in Tsushima city, results from the NILIM model describe the spatiotemporal processes of inundations due to heavy rainfall and describe the positive impact of controlling surface infiltration on inner flooding. These simulation results can help authorities safeguard against flood damage by redesigning and enlarging the capacities of storm sewer systems as well as suggesting other preventative measures in flood-prone areas.

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Chapter 10
Pre-reconstruction Plans for Urban Areas in Japan

U Hiroi

Abstract Since ancient times, Japan's urban areas have suffered from a variety of natural disasters such as earthquakes, fires and floods. This can be attributed to the specific geographic and cultural conditions of the country, in particular the frequency of earthquakes combined with the large number and density of wooden houses. Particularly since the Edo period (1600–1867), when cities expanded due to various political and economic forces, there have been a number of disasters, demonstrating the vulnerability associated with high urban densities. Such events include the Great Fire of Meireki of 1657, the Great Kanto Earthquake of 1923, and the Great Tokyo Air Raid of 1945. In these cases conflagrations caused enormous damage to urban areas, each claiming around 100,000 victims. The Hanshin-Awaji Earthquake that occurred in 1995 and the Great East Japan Earthquake of 2011 also caused widespread damage to entire urban areas through the collapse of buildings, the tsunami that followed and the nuclear incident at Fukushima. In response to such large-scale disasters that can destroy cities, efforts have been made to actively draft pre-reconstruction plans in order to facilitate speedy urban reconstruction. While the aims of these pre-reconstruction plans may be diverse, the primary focus is on: (i) imagining the circumstances of reconstruction, (ii) making projections on the systems and plans that will be required for reconstruction, and (iii) fostering awareness of the need for preventative measures when considering reconstruction, while providing details about such.

1 Great East Japan Earthquake

On 11 March 2011 Japan was hit by a massive earthquake and ensuing tsunami, as a result of which more than 20,000 people were killed or went missing. The relatively low number of injured people (6217) can be attributed to the deadly

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nature of a tsunami: either you escape, in which case you remain uninjured, or you are drowned. Some districts were completely destroyed by the floodwaters. Whilst many efforts were made to save the afflicted, these were hampered by the huge amount of debris. The building shown in Fig. 1, which was destroyed by the impact of the tsunami, was the local Disaster Prevention Office Building of Minamisanriku-Town. As the primary disaster prevention and control center, this office was supposed to help save lives. Clearly, when such a center is destroyed in this fashion, there is insufficient disaster response.

An earthquake of magnitude 9.0 leading to enormous physical damage was never predicted for Japan. The resulting massive tsunami struck a huge area, practically the entire eastern seaboard of Japan. Furthermore, the disaster at the Fukushima nuclear power station was also a first for the country. Hence, reconstruction efforts have been spread over a very wide area. Many of the affected urban sites were in fact areas already undergoing decline, with largely elderly populations and few children. These cities are not strong enough to be able to revive themselves. In many metropolitan areas, the earthquake and tsunami completely disrupted the railway network. Public life in some areas (including Tokyo, Yokohama) came to a complete standstill. While Tokyo itself was not hit by a major tremor, communication networks went down and public transportation ceased, leaving commuters unable to get home because of the highly restricted transportation network. This was the unique social phenomenon of the earthquake.

Fig. 1 The Disaster Prevention Center in Minamisanriku, after earthquake and tsunami in March 2011. *Photo* U Hiroi 2011

2 Stranded Commuters

Directly after the earthquake, many commuters in the Tokyo metropolitan area became stranded, unable to return home due to the lack of available transportation. In order to improve this situation for similar events in the future, we are now generating and analyzing evacuation simulations for stranded commuters. While there already exist some evacuation simulations for various types of disaster (conflagrations, tsunami or flood damage), the simulation of stranded commuters is a novel form of research. For large cities, it is necessary to analyze how people leave their offices and how they move through the urban area. Figures 2 and 3 show risk maps for stranded commuters. Within the densely populated city, which in this case is Tokyo metropolitan area, we are investigating the density of pedestrians on public footpaths. In Fig. 2, the map on the left shows the density of pedestrians one hour after the disaster. The map on the right shows density at 5 h after the disaster. The black cells indicate a very high density of six people per square meter. Each 1 m × 1 m cell is about the size of a standard Japanese telephone box. Clearly, more than six people in such a small area constitutes a "risk" in large cities.

This type of pedestrian congestion will quickly dissipate. Automobile congestion, however, is a quite different situation. Results show that motorway or roadway congestion persists following a disaster. Figure 3 shows a major traffic jam blocking the roadways, which 5 h later has not dissipated. If a serious fire occurs in such a situation, no cars can pass and also the firefighting trucks cannot get through. Ambulances will also be unable to reach the injured. One lesson that we have learned from the 2011 earthquake is that an extreme roadway traffic jam is a very serious problem. The Tokyo metropolitan government has introduced legislation requiring stranded commuters to remain where they are immediately after a disaster or an earthquake. Currently, people spend long periods commuting in the morning and at night in Tokyo because of the well-developed public transportation.

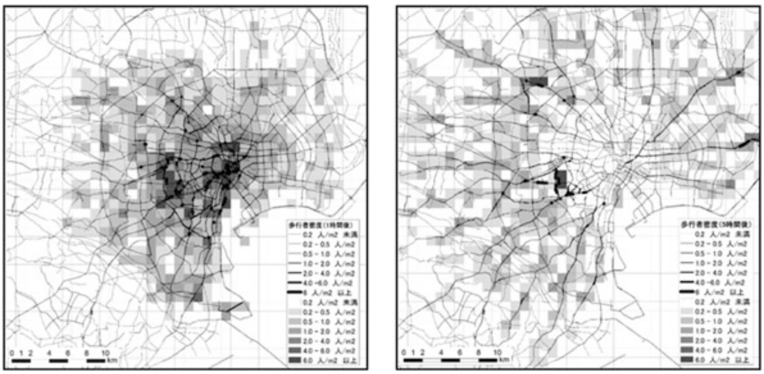

Fig. 2 Simulating the density of pedestrians on footpaths when a huge earthquake hits Tokyo. *Left* 1 h after the disaster, *Right* 5 h after the disaster (Hiroi et al. 2016)

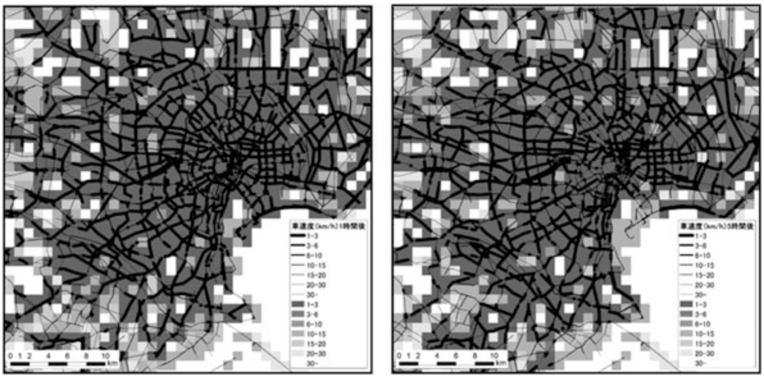

Fig. 3 Simulated average speed on roadways when a huge earthquake strikes Tokyo. *Left* 1 h after the disaster, *Right* 5 h after the disaster (Hiroi et al. 2016)

However, when this public transportation network broke down at the time of the earthquake, there was a huge congestion of people.

3 Post-earthquake Fire

Figure 4 shows the probability of post-earthquake fires afflicting the country within a 30-year period (in this case on a springtime afternoon). In Japan, a major

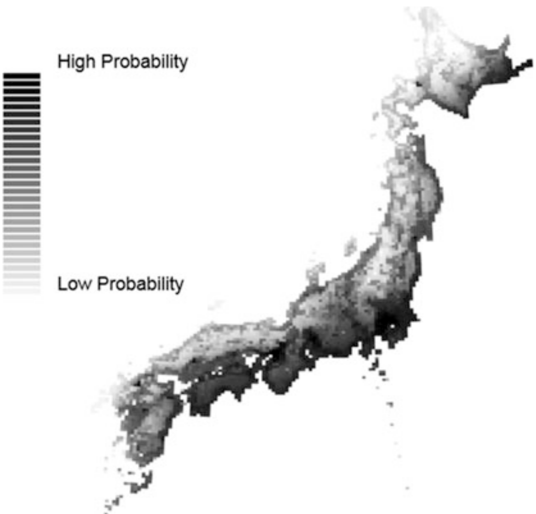

Fig. 4 10 km mesh showing the probability of an earthquake fire occurring at least once in a 30-year period. The *black cells* are high probability; the *white cells* low probability (in the case of a spring afternoon earthquake) (Hiroi 2015)

earthquake will lead to many fires. Hence, we have investigated the number of post-earthquake fires resulting from the 2011 earthquake in east Japan. Using these results, we are able to estimate how many fires can be expected in the country at large. In Tokyo, Nagoya and Osaka, the probability is almost 100%. This means that there will certainly be at least one earthquake fire within the coming 30-year period. Using a Bayesian statistical model, we are now creating a system of real-time prediction analysis.

There were many tsunami-induced fires following the Great East Japan Earthquake. The term “tsunami fire” is one coined by the current author to describe the fires spontaneously arising within inundated areas. 159 tsunami fires were recorded after the Great East Japan Earthquake. What is the cause of such fires? Many highly combustible forms of debris such as propane gas tanks or heavy oil containers as well as wooden houses including stoves and electrical appliances are transported inland by floodwaters, where they crash into higher ground. Also fires are sparked by electrical appliances that become soaked with saltwater. The 159 tsunami fires constituted about 40% of all post-earthquake fires caused by the Great East Japan Earthquake. Current forecasts indicate that a major earthquake will hit this area in 20–30 years. When this Nankai Trough earthquake occurs, this is likely to result in many tsunami fires. According to our statistical model, somewhere between 93 to 270 tsunami fires will be caused by the Nankai Trough earthquake. To what can we attribute this wide variation in the number of projected fires? In the case that heavy oil leaks out around the flood area, we can expect a larger number of tsunami fires. On the other hand, if such heavy oil containers are not destroyed (as well as containers for other poisonous and dangerous materials), then the number of tsunami fires will remain low. This is the kind of unique research that we are currently undertaking.

4 Study on Pre-reconstruction Plans for Urban Areas

Drawing up a pre-reconstruction plan is a very difficult and challenging undertaking. Reviewing the history of disasters in Japan, we note two important events, one from the distant past and the other from more recent times, and both highlighting the risk of urban fire. In 1657 a huge conflagration destroyed large areas of Edo (modern day Tokyo). Called the Great Fire of Meireki, this urban fire is estimated to have killed 100,000 people in one night. After the fire, a reconstruction plan was drawn up. This plan, which was probably Japan’s first large-scale reconstruction plan, determined that roads should be widened and temples and shrines relocated from near Edo Castle to outside the urban area in order to improve safety. Thus as early as 1657 we see efforts to create a disaster prevention plan in Japan.

At the time this was a highly innovative idea. Yet from our current perspective, these steps appear insufficient. It is interesting to compare the historical development of fire prevention in Japan with that of other countries, which in some cases was more successful. For example, the Meireki Fire and the Great Fire of London occurred only a few years apart (the former in 1657 and the latter in 1666). The latter resulted in the destruction of 85% of the City of London. In view of this massive damage, the authorities drew up a reconstruction plan. While in Edo roads were widened yet houses and bridges continued to be constructed from wood, the English government adopted Sir Christopher Wren's idea of banning the erection of wooden housing. While this reconstruction plan was criticized by the local people, nonetheless wooden houses disappeared from London's streets. Subsequently, London never again suffered a major fire. In the case of Edo, the reconstruction plan only foresaw the widening of roads or the relocation of feudal lords to outside of Edo Castle, alongside other minor measures. Over the years Tokyo was repeatedly hit by major conflagrations.

The next example of a reconstruction plan is the Imperial Capital Reconstruction Plan of 1923 following the widespread devastation of the Great Kanto Earthquake. In the aftermath of this earthquake, in which 100,000 people died, there was a clear need for a reconstruction plan. The Great Meireki Fire killed 100,000, while the fire caused by the Great Kanto Earthquake killed another 100,000. Furthermore, the firebombing of Tokyo in World War II caused the death of 100,000. When the 1923 reconstruction plan was drawn up, Shimpei Goto (the plan's designer) requested that the government buy all burnt-down areas for redevelopment. However, this was hindered by budgetary constraints as well as the negative reaction of landowners. Therefore, Goto introduced the land readjustment method to plan for Tokyo's reconstruction. He also devised other measures, for example the novel idea of doubling the roadway width during reconstruction. In 1923 Japan was still in the early stages of motorization, so that few cars were present on Tokyo's roads. However, Goto predicted that motorization would increase in the years to come, and therefore planned for the construction of wider roads. His forecast proved to be accurate. Today, despite these wider roads, our urban streets are still jammed. This case underlines the fact that reconstruction is not only for the present but also for the society of the future.

It is important to ensure that a reconstruction plan is drawn up in a highly organized manner so that even non-specialists can comprehend the major elements. After the 2011 earthquake, which was a wide-area disaster, it became clear that we must consider the evacuation of such large areas. However, in regard to wide-area evacuation, we face the problem that reconstruction or evacuation plans are generally conceived by local municipalities; thus, it is very difficult to go beyond the administrative boundary of the individual city or municipality. For this reason we needed a method of producing a wide area reconstruction plan. Furthermore, in preparation for the data to produce scenarios and data visualization, we required a tool that could be widely used and shared. To this end, we set up a workshop to discuss the wide-area reconstruction plan and wide-area evacuation plan (Fig. 5). The scenarios, the hazard maps and hazard data were prepared during the workshops, which overlapped as regards topics for discussion, and which also involved business and industrial partners. The resulting reconstruction plan is still an ongoing process.

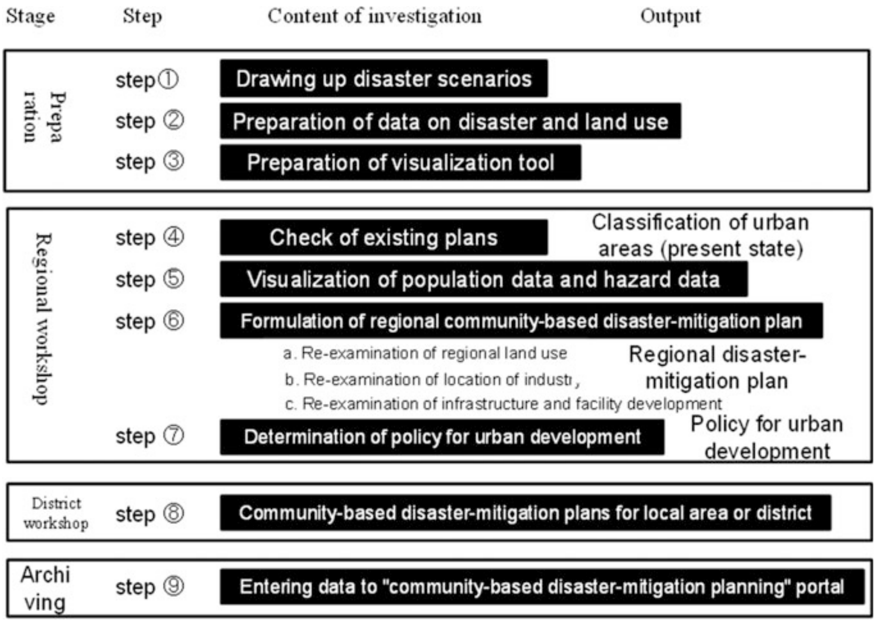

Fig. 5 Method of multi-scale urban disaster mitigation planning (Hiroi et al. 2015)

Due to its location near the ocean, the southern part of Nagoya is at great risk of tsunami. At the same time, it is a center of commerce and industry due its natural harbor. Of course, this function as a port area cannot be easily relocated. Therefore, in this southern part of Nagoya, it is important that residential areas be moved out whilst industry remains. Hence, the port function will be maintained. Urban green space is to be found in east Nagoya in line with the city's green zone plan. Using these current green areas, we would like to develop the new city land use plan in accordance with the existing green zone plan. Clearly, areas which contain historical assets cannot be relocated. Instead we have to preserve both residential areas and the historically important assets of Japan.

In the future, we need reconstruction plans not only for wide-area relocation but also reconstruction plans that involve local residents. The current workshops are focused on scientific discussion and cannot yet be easily implemented elsewhere in Japan. However, our plan can succeed by gathering more data and fostering wider discussion. To this end we have already created a portal site to invite more people to get involved in the urban evacuation plan. The author believes that this portal site can be easily transformed into a pre-reconstruction plan if used wisely.

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Part IV
Built Environment and Material Flow

Chapter 11
The Efficiency of Settlement Structures

Clemens Deilmann

Abstract The anthropogenic stock of nations accumulates from year to year materials (metals, plastics, glass, concrete, stones, etc.) for all sorts of durable goods. Some materials might be recycled and used as secondary raw material for new products. But the input into the anthropogenic stock is even in "old" developed economies with ambitious recycling targets five times larger than the output. The anthropogenic stock of Germany grows by 550 million tons per year. The building activities are responsible for almost 85% of a nation's material flow of all durable goods with life expectancy longer than 1 year. In view of the projected urbanization until 2050—a doubling of urban population according to UN estimate from 3 to 6 billion people—the material input into the built environment is a key issue with regard to our material resource use in the future. After a brief explication of terms, the paper introduces the method of Material Flow Analysis of Urban Form. It stipulates, that only a bottom-up approach, which analyses and models the different patterns of land development along with building types, can deliver the information necessary for a more resource efficient way of urban development. The settlement structure can vary considerably in terms of material input per service unit and the urban structure predetermines for a long time span, how expensive maintenance of surfaces of built assets, interaction, transport, social, and technical infrastructure will be. Two examples of research findings generated by the approach are presented (infrastructure efficiency and costs; recycling potentials along different paths of building activity in Germany).

1 Introduction

The physical growth of settlements is a direct result of human activities in the fields of housing, production, consumption, education, health, planning, administration, policy, etc. Settlements can truly be called the 'sediment of history' in the sense that

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90% of material, which persists longer than a year in the society, is mineral-based building material. At the same time the settlement itself is an active factor in human life, forming the basis for the economic and ecological performance of society. We can say that it provides the framework for social life. As such the settlement can be a barrier for change or can be a transformative force into an unknown future.

Great quantities of material and energy resources are consumed and accumulated in the building, maintenance and development of settlements. This also requires continuous and large-scale capital investment. In Germany the building sector accounts for 10% of total annual gross domestic product. At the same time the net value of the built environment is estimated at €7981 billion. This is 82% of the nation's net total noncurrent assets of €9717 billion (of which animals, plants, durable means of production and intellectual properties contribute €1736 billion) (DESTATIS 2016). The main noncurrent assets are residential buildings (46%), nonresidential buildings (20%) and roads/infrastructure (15%). The productive capabilities of a country are largely determined by the built environment (as a source of services) and by the fact that a great deal of capital and resources are bound into the built environment (as a sink for investment which is lacking elsewhere). As the built environment makes up no less than 82% of all noncurrent assets, it is certainly worthwhile investigating its main features. The settlement structure predetermines the efficiency of the system for considerable time spans (maintenance of surfaces of built assets, interaction, transport of goods, social and technical infrastructure).[1] The efficiency of settlements (urban fabric[2]) depends on their structure, the ability to adapt to change, as well as the management of the stocks and flows within the urban fabric. Together these factors determine the competitiveness of societies.

This chapter considers settlements from the perspectives of spatial planning and technical engineering. Regarding the first of these, settlements are characterized by a specific spatial and functional order of built-up elements and open spaces, which together determine the design quality in terms of buildings, technical and green infrastructure, layout patterns, density of elements, functional assignments, etc. From the perspective of the material sciences (Material Flow Analysis, Life Cycle Assessment), the settlement fabric is part of the existing anthropogenic stock of durable goods such as buildings and, infrastructure: 'The use of stocks by society determines the resource flows needed to operate, maintain or expand the physical stock (…). Flows of resource inputs and waste outputs are driven by the need for services provided by stocks rather than the demand for flows themselves' (Müller 2006; Pauliuk and Müller 2014; Baynes and Müller 2016: 124).

[1] http://ec.europa.eu/environment/archives/greenweek2011/content/prof-clemens-deilmann.html.

[2] The urban fabric is defined as the aggregated stocks and structures of the built environment in a city, including buildings (residential, commercial and industrial), transportation infrastructure (roads and rails) and technical infrastructure (energy supply, water distribution and collection networks).

2 Resource Efficiency

In order to understand the concept of resource-efficient settlement structures, we must first give a clear definition of the terms ‘resources’ and ‘efficiency’.

In a broad sense, **resources** are any kind of capital available for human use. More specifically, we can distinguish between manufacturing capital as any material or energy available for use in manufacturing, including industrial nutrients that are used for and recovered from manufacturing processes’ and natural capital as ‘natural materials (including sunlight, air, and water) used in an organization or society’s operation or production.’ Furthermore, intellectual capital is a resource provided by humans. (All definitions borrowed from www.sustainabilitydictionary.com/resource; accessed 29.02.2016.)

In the following, the meaning of **natural resources** will be more closely defined.

After exploring various uses of the term in national and international discussion, Schütz and Bringezu (2008) recommend that the Environmental Agency of Germany (UBA) adopt a two-step terminology for natural resources.

‘Natural resources in a broader sense encompass all functions of the eco-system earth and the solar-system, which are used by humans and which form the basis for our survival in coexistence with nature. This includes functions such as climate stability, protection against harmful radiation, the carrying capacity for hazardous substances, as well as the stability and capacity of the eco-system to regenerate and maintain biologically diverse habitats.

Natural resources in a narrower sense are biotic/abiotic raw materials (biomass and minerals) and water, which are extracted from the natural environment for various socio-industrial purposes (i.e.nutrition, substances for the production of goods and energy generation, etc.), as well as land, which is used in different ways and intensities in settlements, agriculture and forestry, mining and quarrying and for recreation’ (both definitions from Schütz und Bringezu 2008, 45 f.).

The last definition of natural resources is appropriate to the spatial science perspective, as here the focus is on the impact of settlement activities on natural resources in a narrow sense (land, material and energy) as well as discussions on the resource efficiency of settlement structures. Of course, some consideration must be given to the built environment, as questions of resource substitution need to be considered. “Abolished” materials, building elements or entire buildings can be understood as (potential) resources for future development (Lichtensteiger 2006). In regard to recycling, the recovery of secondary materials from obsolete products is a core element of (urban) mining and an important contribution to resource conservation.

Efficiency, sufficiency and consistency are basic normative concepts that inform the discourse on strategies of sustainable development (Rogall 2009, 175 ff.). The idea behind efficiency strategies is to decouple wealth creation from resource consumption, i.e. to generate more using less resource input. While dematerialization can be a suitable paradigm for industrial production, this is certainly the wrong approach for buildings and construction products for which stability and long-term usage are paramount.[3] An important question is whether efficiency gains in building products will in some way be counterbalanced by an increase in the overall inefficiency of urban fabric, e.g. loss of density of settlement areas. To guard against this, a further goal should be to achieve less material input for settlement areas per service unit (housing, production assets, etc.). This leads to questions about the density and allocation of functions, which fundamentally determine the resource efficiency of service units within settlement areas.

3 Settlement Analysis

The theoretical foundation for settlement analysis in the context of resource use was laid down by Baccini and Brunner (2014) in the book 'The metabolism of the anthroposphere' (revised edition: Baccini and Brunner 2014). Today material flow accounting under the label of metabolism is characterized by a high level of diversification. Accounting is conducted at the level of national economies (Müller 2006; Fishman et al. 2014; Schiller et al. 2015) for example in Denmark or for Germany's housing stock (Buchert et al. 2003) as well as the entire built environment of Japan (Hashimoto et al. 2007). These national perspectives are complemented by studies at the regional or city level such as those by Daxbeck et al. (2001) on Vienna or Kennedy (2003) on the Greater Toronto Area. While these studies provide a quantitative background for more spatially differentiated studies, only a handful reach the level of districts or neighborhoods. Yet high-resolution spatially differentiated analysis (bottom up) are required to answer questions on the resource efficiency of settlement areas, which is greatly determined by the spatial patterning of urban areas. For this spatial scale, the IOER has developed an approach using Urban Structural Types (USTs) by making use of advanced GIS-tools, which can be integrated into the concept of resource flow analysis.

A practical way to describe the specific properties of settlements is to devise typologies for buildings and urban areas by considering the characteristic layout of buildings and open spaces. These typologies can be used to describe buildings, infrastructure and the urban structure. Urban structure types (USTs) are basic spatial units with homogenous spatial features, defined by characteristic formations of buildings and open space (Schiller 2007). They describe land use areas with similar environmental and infrastructure conditions and similar uses (functions) while also indicating the time of origin. In this way USTs provide a picture of the morphological situation of the urban area (Duhme and Pauleit 1999) while at the same time representing core characteristics synthesized from representative objects and databases for application within structural analyses. The resulting 'city map' allows calculation of resource intensity and expenditure at city level, for districts,

[3]With one exception: dematerialization in the sense of reducing the carbon footprint or substituting products with high embodied energy (carbon emission).

neighborhoods or at the micro-scale (1–5 ha). The empirically-based specification of urban types can be realized by the visual inspection of maps and aerial photography or by using GIS tools (Fig. 1).

The analysis of settlement structures is not just aimed at investigating the status quo, but can also be used to clarify the dynamics of change as well as to support development scenarios for ex-ante studies. By creating instructive scenarios in cooperation with planning authorities, technical experts and research partners, it is possible to illustrate the effects of different development paths. This can help raise the awareness of urban administrators and planners as well as politicians of the importance of managing natural resources as well as the efficient use of existing built resources. Such awareness-raising is the particular challenge for researchers in this field.

4 Some Exemplary Results

4.1 Who Pays for Infrastructure at a Time of Population Decline?

A joint project of the IOER and the Halle Institute for Economic Research (IWH) in collaboration with the Dresden engineering firm Baur + Kropp has addressed the issue of urban density and infrastructural costs. Demographic change in the form of population decline (a phenomenon not restricted to eastern Germany) means that the costs of network infrastructures must be borne by an ever-decreasing group of people. In the project, possible changes to the urban space up to the year 2030 were reflected within the various USTs. Population density in these USTs was linked to the technical infrastructure provided in these areas. Expected costs were estimated for technical infrastructure (drink water and sewerage network as well as local roads) over the period in question. The aim was to assess the development of infrastructural costs in municipalities with a declining population, in particular to examine whether local authorities can cushion any rise in infrastructure costs by targeted urban redevelopment, densification and downsizing.

In order to take sufficient account of institutional restrictions on infrastructure adaptation, workshops were organized with representatives of the cities concerned, with urban planning authorities, as well as with the competent utilities, in order to develop urban redevelopment scenarios. These spatial development scenarios were deliberately diversified to demonstrate the maximum room for maneuver available to municipalities. The results of the different scenarios are illustrated in the figure below. The discouraging finding was that even densification strategies are unable to reverse the rising costs which have to be shouldered by citizens due to population decline. Hence, urban planning has almost no impact in slowing the growth in infrastructural costs. Strategies for maintaining and financing existing networks can have greater impact, especially as these networks are unlikely to undergo extensive

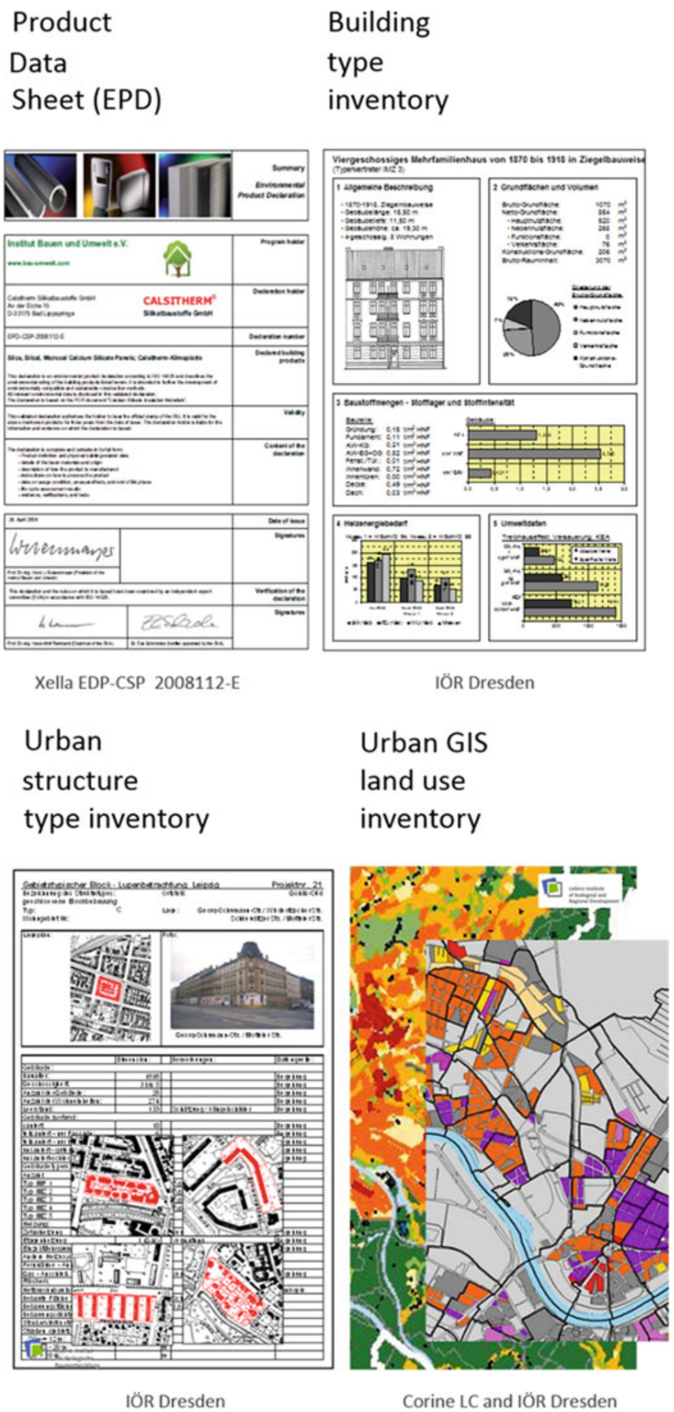

Fig. 1 Multilevel analysis of urban space. *Source* IOER

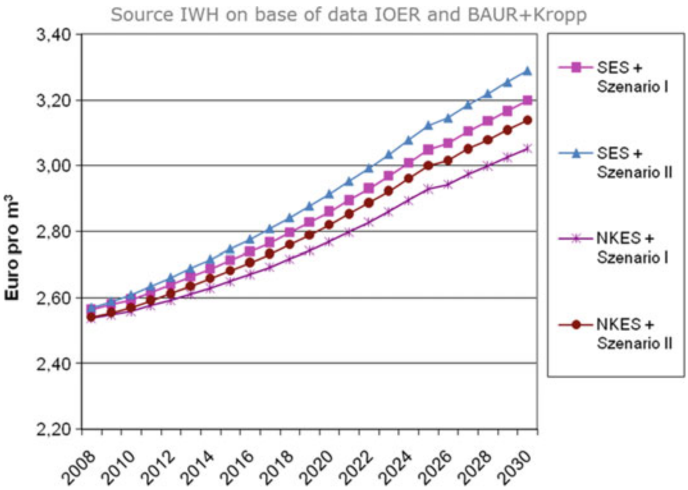

Fig. 2 Rising costs of drink water per cubic meter due to urban sprawl or population loss

change. Where the population is declining, it is more important than ever for municipalities, municipal enterprises, and joint authorities to cut operational costs, optimize financing modalities, and stabilize revenues. Given the estimated average rise in costs and consequently prices, as well as the problems to be expected in financing future investment, additional financial aid will inevitably be required in order to avoid an excessive rise in infrastructure costs (Fig. 2).

4.2 Resource-Saving Potentials of Secondary Raw Materials

The project ‘Resource Efficiency Potential in the Waste and Recycling Economy’ (run in cooperation with intecus gmbh Dresden) investigated ways of increasing the high-value recycling of rubble and waste materials from building sites. Building types and USTs were used to model the existing built environment of Germany. This classification was necessary to take account of the considerable differences in material composition between high-rise buildings and single-family houses, especially regarding associated infrastructural expenses. The application of USTs is the only way to link buildings and technical infrastructure. Several sensitivity studies were undertaken on the consumption of secondary raw materials for the period up to 2050, specifically concrete, brick, sand-lime brick, aerated concrete, gypsum, wood, mineral wool and rigid-foam insulation, glass and plastics. These studies pinpointed economic bottlenecks in the form of typical obstructions to increasing the recycling rate of building materials. In order to estimate each recycling potential, the origin, composition and recycling paths of the building materials first had to be determined. Current innovative technologies of recycling were evaluated as well as the technical processes of recycling and the potentials for optimization. To estimate the capacity of the construction market to absorb recycled materials for the timeframe 2010–2050, it was necessary to discuss and agree with representatives of the building industry on the ratios of secondary materials that can be admixed in new building products (a discussion process that proved rather challenging). The spatially-related research also revealed that recycling potentials should be discussed at a regional rather than national scale as the transport distance for mineral aggregates is generally 25 km or less. A regional material flow balance is required to prove whether supply meets demand for secondary material and whether these figures are realistic. According to the sensitivity studies, it should be possible to increase secondary raw material use in building construction from the current 6 to 16% by 2030 and 20% by 2060. The final figure will largely depend on the future demand for new buildings. Over the long term, building activities in Germany are expected to fall in line with the declining population. As a result, the 20 million tons of secondary raw material used in 2030 is estimated to shrink to 12 million by 2060.

4.3 A Final Remark on the Efficiency of Settlement Structure

The resource efficiency of settlement structure has one key aspect: density. The population density of settlement areas represents land use per person and the number of connected services per meter of technical infrastructure. Research carried out at the IOER by Siedentop et al. (2006) shows that a drop of 1% in population density per km^2 leads to a 1% rise in infrastructure costs per inhabitant (ibid p. 220). This is true for settlement areas with a population density of 400–2400 inhabitants per km^2 settlement and traffic area. Above 2400 inh./km^2 one finds the large German cities (‘Großstädte’ with pop. > 250,000) such as Aachen at 3000 inh./km^2, Berlin at 5600 inh./km^2 or Munich with the highest density at 6120 inh./km^2. The simple equation no longer applies to large cities (or indeed rural areas) so that the question of economies of scale has to be analyzed in more detail. Here resource efficiency comes into conflict with a series of other issues such as the scarcity of open green spaces, criminality, congestion, etc. The relevant question for megacities is: ‘For how long is bigger really better?’ The IOER will continue its research in this field and looks forward to a closer cooperation with Nagoya University.

5 Conclusion

The growing stock of urban fabric, along with its changing characteristics, design and management challenges, will continue to grow in importance as cities strive for greater sustainability and attempt to raise their competitiveness. We require instruments to anticipate the consequences of change in the urban metabolism, as well as robust tools and sources of information to support decisions towards resource optimization of the urban metabolism. Improvements towards a more sustainable city in the pursuit of planning visions (e.g. zero emission cities) must not exceed the transformative capacities of the urban metabolism. The methodology presented here can deliver highly aggregated pictures of the urban built environment of a national economy or an entire city as well as micro-scale pictures of stocks and flows at neighborhood level or indeed segments of the housing market. It can also illustrate short- and long-term effects. This allows metabolic constraints and requirements to be considered in the planning of the urban fabric, providing concrete guidance and reference tools for planners and engineers in the design and maintenance of sustainable buildings and infrastructures.

In general, the predominant concern in urban planning is land use and the allocation of functions. City planners and managers often lack precise knowledge of flows of material and energy as well as the material stocks related to the built environment, i.e. the buildings and infrastructure systems, the various urban forms and management practices in regard to construction, use, repair, renovation, recycling and disposal. The urban design defines the types of buildings and infrastructure that determine a significant share of overall resource consumption of the urban fabric, and thereby the overall resource efficiency of the urban system.

Until now material flows and related topics have not been a direct concern of town planners. The results of urban material flow analyses can, therefore, be a useful addition to the general discussion on land use and energy issues of urban planning, which are quite well understood. In general, material flow analyses (MFAs) and energy analyses (EAs) will strengthen the orientation of planners towards qualified urban density and deliver a whole new set of arguments for more resource-efficient settlement structures.

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Chapter 12
Weight of Cities—Material Stock and Flow Analysis Based on Spatial Database over Time

Hiroki Tanikawa

Abstract To establish a "true" sustainable society, we need to measure not only GHG emission but all anthropogenic disturbance. The physical weight of industrial life is reflected in buildings, roads, cars, furniture and other durable materials which provide services we need. Reducing accumulated weight and improving efficiency by weight are vital in achieving a more sustainable society. Multi-scale Material Stock Analysis with regard to heavy anthropogenic disturbance, on national, regional and city scales, is an essential to de-carbonization and de-materialization of our society. Material Stock Analysis of urban infrastructures and buildings is not only focusing on its stocked weight but on its in-flow and out-flow which includes hidden material flows. As to in-flow of construction materials, anthropogenic disturbance by extracting sand, gravel and limestone should be considered due to huge flow of materials. As to out-flow, recyclability and cascade use of demolition material should be taken into considerations. Furthermore, for stocked material as a fundamental service provider, we need to consider stock/flow productivity and material saturation—how much material we need—with change of population, development of society. This study shows the scheme of Material Stock Analysis and its possibilities with case study of Japan by using statistic and 4d-GIS database. This database provides the material stock of building and infrastructure classified by region, materials and construction types. Furthermore, using this database, the relationship of material stock and economic growth and its disparity was analyzed. 4d-GIS database are established for several cities in Japan, U.K., and China. One of the results of this study showed about 21.8 billion tons, and that material stock growth contributes to improved productivity.

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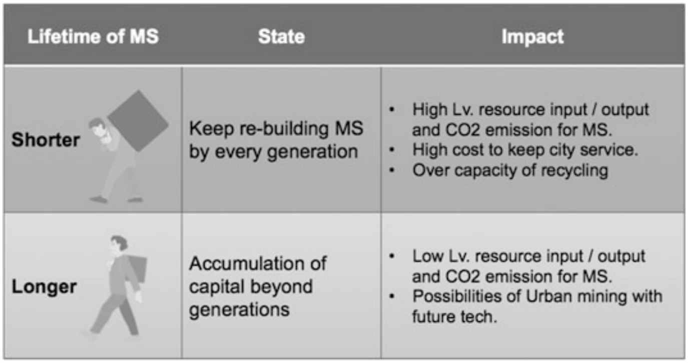
1 Weight and Sustainability: Stock-Based Society

We usually measure our weight of body for examine our health condition. In the same way, measuring the weight of the cities is to link to examine somehow related to its sustainability. Cities are organic entities and have organic metabolism. Cities consume enormous kind of materials, and accumulate as well, Cities release material after processing or using those materials. Material Stock and Flow Analysis is to measure physical material balance of the city to understand its metabolism which is related to environmental impact such as CO_2 emission, waste management and biodiversity issues.

Figure 1 shows the panoramic view from Nagoya University. There are many high rise buildings especially in city center, Sakae and Nagoya station area in the middle far in this picture. And there are many kind of infrastructures such as roads, water system, sewer networks, and electricity distribution systems, which support human activities in the city for our industrial life. To arrange those kind of infrastructures and buildings needs enormous amount of construction materials, such as cement, steel, brick, wood, aluminum, sand and gravel, etc. These materials are stored/accumulated in our society for providing us basic service for many years, basic service is related to keep our safety and resiliency against natural disaster. But on the other hand, production of construction materials, especially steel and cement, is highly related to carbon emissions. So metabolism of city is of course directly link to climate change issues. One of the aspect of city metabolism is represent life span of structure.

As shown in Fig. 2, if we arrange "shorter lifespan" buildings and infrastructures, we need to keep re-building material stock by every generation. Such society keep consuming not only enormous energy but huge amount of materials. And it costs a lot to keep providing city service, and needs huge capacity of waste dumping site and recycling system. That is so-called "Flow-based" or "Flow-type" society. On the other hand, society with "longer lifespan" buildings and infrastructures is opposite to Flow-type society. Longer life span structures could avoid re-building city by every generation, but could accumulate capital beyond generations, so-called "Stock-based" or "Stock-type" society. Longer lifespan material

Fig. 1 Panoramic city view from Nagoya Univ. Our life is supported by variety of materials (by author)



Lifetime of MS	State	Impact
Shorter	Keep re-building MS by every generation	• High Lv. resource input / output and CO2 emission for MS. • High cost to keep city service. • Over capacity of recycling
Longer	Accumulation of capital beyond generations	• Low Lv. resource input / output and CO2 emission for MS. • Possibilities of Urban mining with future tech.

Fig. 2 Lifespan of material stock and its impacts (Okamoto 2011)

stock causes lower level of resource input and output, furthermore CO_2 emission as well. There are possibilities of urban mining with the future technology to keep recyclable material in society.

1.1 Longevity of Buildings and Metabolism of Society

As to average building age of demolition, Japanese houses, generally said, last only 30 years in average, and U.S. 55 years and U.K. 77 years (Fig. 3). If the longevity is short, then material stock need to be updated again and again in order to provide the basic service to society. So we need to clarify what the difference of both societies and its influence to our life. If the city population is decline in the near future, the burden of one person would become much bigger with flow-type society. Also, when it comes to recycling, flow-type society require continuous mass recycling system and final disposal site or dumping site as well. So if the lifespan of buildings and infrastructure is longer in the society, there are possibilities to avoid the issues mentioned above. Furthermore, share of pre-owned house over whole housing sales is quite low (13%) in Japan relative to 78% in U.S. and 89% in U.K. These data are

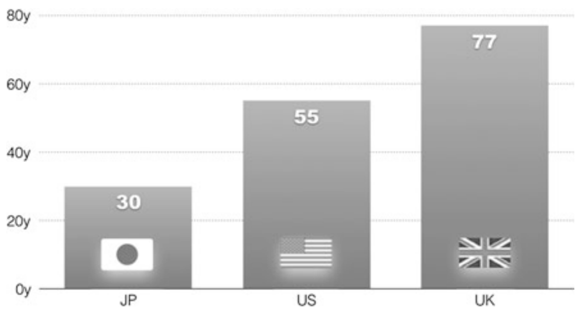


Fig. 3 Average life span of buildings (Japan: MIAC 1999; MIAC 2004; U.S.: U.S. Census Bureau 2002; U.S. Census Bureau 2006; U.K.: Office for National Statistics 1997)

also related to metabolism of city and material turnover of society. Japanese market share of pre-owned house is only 13%, it means that construction material for building houses need to keep producing to provide new houses. Of course, construction code of buildings is kept improving after serious disaster in Japan, such as earthquakes typhoon and high tide. As shown in Fig. 5, material intensity of building is increasing last 80 years. Quake-resistance standards of construction was introduced in 1925 after the Great Kanto Earthquake of 1923 with a magnitude of 7.9, which killed over 100 thousand people by earthquake and fire. First improvement of construction code was in 1950 after Fukui Earthquake of 1948 with a magnitude of 7.1. Construction code was keep improving after serious damage by natural disaster. It will cost a lot to strengthen building which built before improving construction code, and those buildings are tend not to meet a demand of current life/business style. So many people try to have a newly constructed residential house with more safety and comfortable function. Institutional development sometime affects to accelerate material metabolism of society (Figs. 4, 5 and 6).

1.2 Construction Material and Sustainability

Society's metabolism as to construction activity needs huge amount of material compare to commodities' material flow. For example, to build a main structure of reinforced concrete building, it needs Cement, Steel and Aggregate for Concrete pillar/beam and foundation of building. There construction materials occupy major part of annual material flow of country, especially in developing countries. The amount of production on global scale will be increasing because of strong demand of new buildings and infrastructure in developing countries, and maintenance demand of those structures in developed countries. Cement and Steel is high carbon intensive products, so it seems to be difficult for reducing carbon dioxide emission overall from the production process.

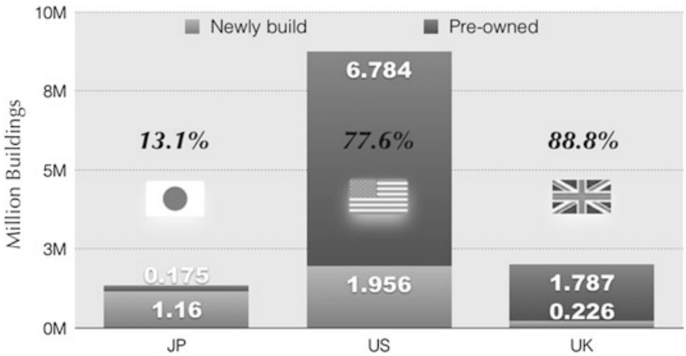


Fig. 4 Annual share of pre-owned house over whole housing sales (Ministry of Land, Infrastructure, Transport and Tourism, Japan: (2003); U.S.: (2006); U.K.: (2006))

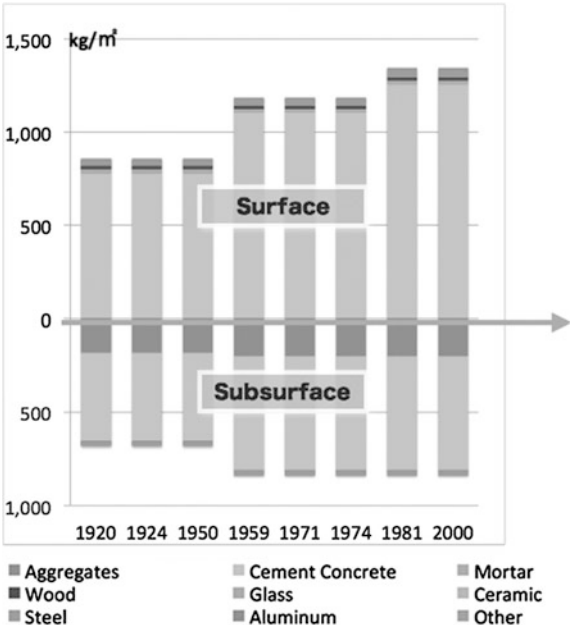


Fig. 5 Material intensity of reinforced concrete building overtime (*upper side* on-surface material, *underside* subsurface material) (Tanikawa and Hashimoto 2009)

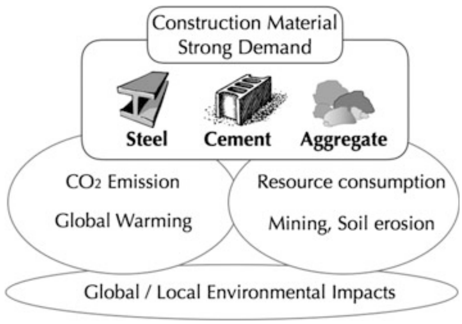


Fig. 6 Environmental impacts of steel and cement production (by author)

1.3 Production of Construction Material in Developing Countries

In developing countries, arranging new building and infrastructure system are the urgent issues to support economic growth. Many people want to have new house, and government need to arrange new infrastructure, such as roadways and railway network for reducing traffic congestion. But most of developing countries have big economic disparity between urban area and local area. Most of construction material are produced in local area where have cheap labor cost. This chapter introduce the situation of production of construction materials in Myanmar, which is quickly developing among Southeast Asian countries. Production of construction material, especially aggregate production is relatively low-technology, crush and align the particle size. Normally the process of aggregate production use crushing and sorting heavy machines in developed countries, but handmade aggregate is sold on the market even very low productivity under the situation of extremely cheap labor cost and abundance of labor in local area. Popular handmade aggregates for construction in the country side of Myanmar is named “Potato Stone”, a kind of sandstone which is relatively soft enough for splitting by hand hammer (Figs. 7 and 8). Many people engage to produce construction aggregate during big construction projects in that area with cheap labor cost. For example, there are huge construction projects around the capital area of Myanmar, and there is a strong demand of construction materials. Aggregate are corrected in the suburb area and use trucks to construction site. Many local people in the suburb area crush stone by hammer all day, and sell daily crushed stone for 2 US$/day in 2014. Mining sites of those stone located close or inside small village in the suburb area where was originally agricultural based local village, but change into mining based village. “Potato Stone” is soft enough to hand mining, many villagers are engaged to collecting stones with cheap cost. But once running out lands with easy mining part, people cannot back to original agriculture business and try to find a new job in the city area. Figure 9 shows family hand mining in the suburb area, this family collect and mining all day for providing stone to crushing site. Land scape after mining is only remain spiritual religious temple building on the original ground level, shown in Fig. 10 (same place of Fig. 9). Furthermore, it’s also related to social issue, children of those family hardly have a chance for education, so they hard to escape from poverty cycle.

Fig. 7 “Potato Stone” for producing construction aggregate (photo by author)

Fig. 8 Handmade construction aggregate from "Potato Stone" (photo by author)

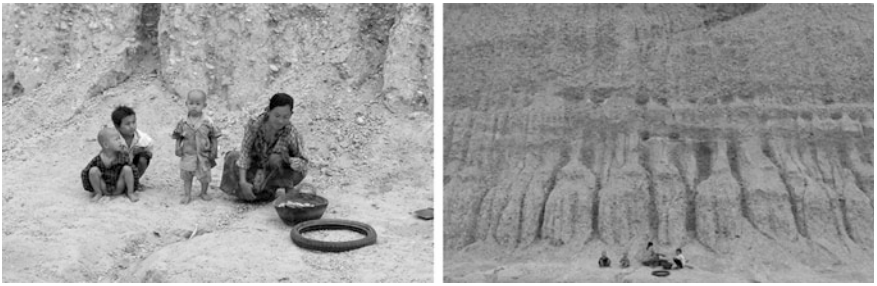


Fig. 9 One Family mining "Potato Stone" with 2 US$ per day (photos by author)

1.4 Estimating Material Metabolism for Build Environment

Arranging building and infrastructure affect natural environment of mining place and its society, and also affect construction waste and recycle management. So we need to understand the metabolism of build environment correctly. One of useful understanding methodology of metabolism is Material Stock and Flow Analysis. For evaluating material use in buildings and infrastructure, it is important to consider many issues systematically and simultaneously. As shown in Fig. 11, three aspects are examined when we considering metabolism of society. First aspect is multi spatial scale analysis which is using geographical data from national scale to city block scale. It is possible to identify the gap between national policy goal and city with multi-scale analysis. Second point is to consider the time scale,

Fig. 10 “Potato Stone” mining site, same site of Fig. 9 (photo by author)

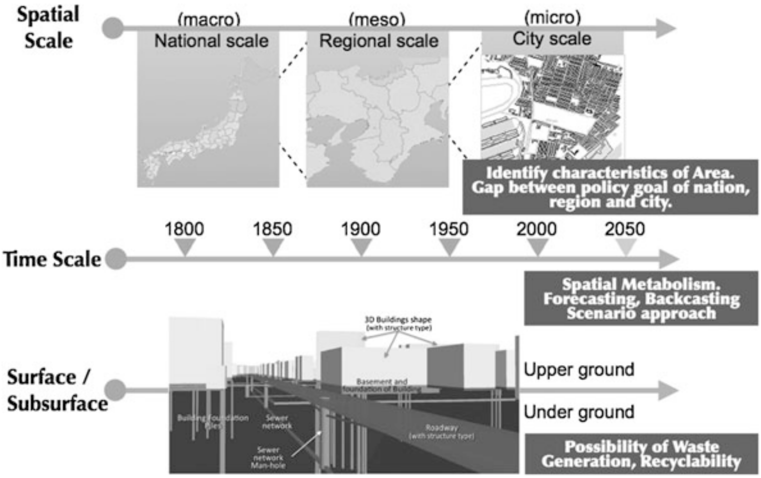


Fig. 11 Multi-scale material stock and flow analysis for build environment (Tanikawa and Hashimoto 2009)

characteristics of area is highly related to metabolism speed of construction materials. Buildings in commercial area or city center of Japan, have generally short life span because of quickly change of land use. Third point is the vertical location of accumulated material that is related to recyclability and waste generation. Material used in underground is tend to have difficulties of recycle. Four dimensional geographical information system (4d-GIS) is help to considering these three aspect

(Tanikawa and Hashimoto 2009; Tanikawa et al. 2015). 4d-GIS is integrated 3D-GIS data overtime on same GIS system. It makes possible to analyze metabolism with historical attribute of each buildings and infrastructure. So historical change of material metabolism by economic development could be examined using 4d-GIS.

1.5 Physical Weight of Japanese Society

Total material stock of Japan, in other words, the weight of Japan—which is include infrastructure and housing—is about 18 billion tons of materials (141 tons per capita) are provides basic service to whole Japanese society in 2009 (Fig. 12, Tanikawa et al. 2015; Fishman et al. 2014; Tanikawa et al. 2014; Shi et al. 2012). And distribution of material stock is of course concentrated urbanized metropolitan area, such as Tokyo, Osaka, Nagoya, Fukuoka and Sapporo, and heavy component is mainly concrete. These analyses could support the next generation plan of The Fundamental Plan for Establishing a Sound Material-Cycle Society by the Ministry of Environment, for ensuring sustainability of society.

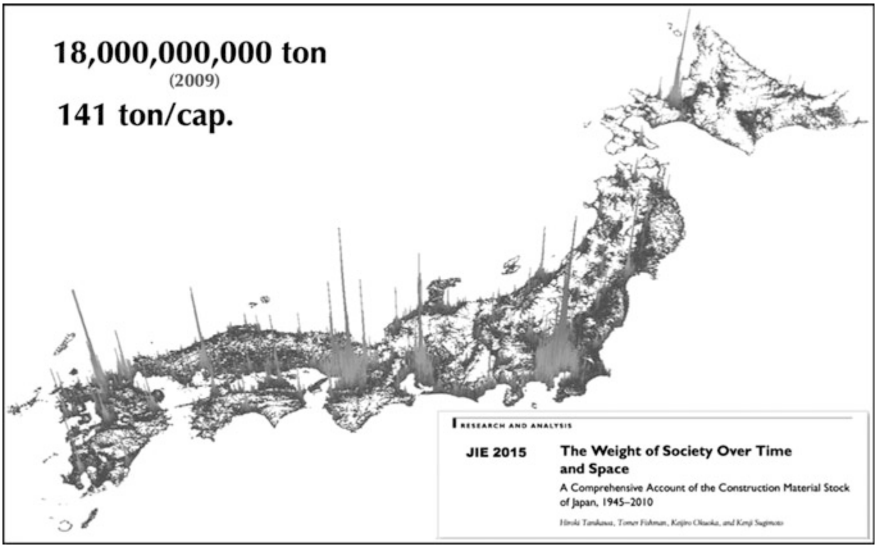


Fig. 12 Material stock distribution of Japan (Tanikawa et al. 2015)

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Chapter 13
Preservation and Utilization of the Urban Heritage of East Asia and Japan

Yasuhiko Nishizawa

Abstract This paper focuses on the tangible heritage of historic buildings that exist in every urban area of East Asia and Japan, showing how the preservation and utilization of these structures can contribute to the establishment of a new urban planning theory as well as a method towards sustainable and resilient urban planning. In particular, emphasis is placed on evaluating historic buildings from diverse new perspectives. Generally, such buildings were constructed for some original purpose that has been lost, thereby turning them into relics, a form of 'historic detritus' in urban areas. It is vital that we change our perspectives and reevaluate these objects by recognizing some alternative value. If they can be utilized for a new purpose then they will gain added value, and will no longer be mere relics. Therefore, we should strive to recognize their inherent potential. We should evaluate such buildings through various perspectives, not only in terms of their functions but also their structure, material, style, design, relationship to the surrounding environment, and social function. This paper introduces nine examples of historic buildings that were formerly relics and are now reutilized. Finally, new principles are presented for the preservation and utilization of relics in urban areas.

1 The Relationship Between Relics, Heritage and Properties in Urban Areas

Almost all historic buildings were constructed for some original function that, over time, has become lost. Now such buildings are relics, instances of 'historic detritus' in urban areas. It is vital that we change our perspectives and reevaluate these objects based on their current features in order to recognize a new or alternative value. If they can be utilized as new facilities, they will become 'new' properties

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rather than just relics. This would constitute a novel urban planning method. On the other hand, if we are unable to change our perspectives and reevaluate these objects, they cannot be turned into physical heritage or valued properties.

At the very least, however, we can recognize that these buildings are symbolic of people's activities. The famous architectural historian Teijiro Muramatsu said in his book 'A History of Japanese Modern Architecture' (1977) that all buildings are an expression of the time in which they were built (Muramatsu 1977). We can detect historic remnants in almost all cities of East Asia. Such examples of our tangible heritage are the Bund of Shanghai, the Central Avenue of Harbin, the Presidential Office Building in Taipei, and the Seoul Plaza.

2 Evaluation of Relics and Architectural Heritage

Objects of tangible heritage have some value attached to them. However, we generally lack guidelines on how to determine the value and potential utilization of historic buildings. Various methods and perspectives must be applied in order to provide sufficient evaluation. Currently, there are no appropriate regulations on how to evaluate relics and the architectural heritage of East Asia and Japan. This gap must be filled by a scientific evaluation method.

In Japan, there is only one scientific evaluation method for historic buildings, developed by the Architectural Institute of Japan (AIJ) in 2007. Entitled 'Guideline for Building Assessment, Preservation and Utilization,' the AIJ announced the method on its own website. It consists of three chapters: The first chapter states that the buildings must be properly valued and assessed. The second chapter suggests five fundamental values, namely historical value, cultural and artistic value, technological value, scenic/contextual and environmental value, and social value. Finally, the third chapter states that the AIJ shall provide expert assistance and consultation to assess historic buildings and establish programs for their preservation and utilization. This guideline has no legal backing from the Diet or the government, but is merely a scientific method to help evaluate historic buildings (AIJ 2007).

In this paper I propose some new evaluation methods for historic buildings using various methods and perspectives. The methods are intended to ensure objectivity and universality, independent of the skills of evaluators (Nishizawa 2009). To this end, I suggest that objective methods be combined with sensuous ones. While objective methods use specific facts to make evaluations, sensuous methods use the senses or memories of individual persons to make evaluations. Sensuous methods are important because they provide a useful complement and alternative perspective to purely scientific methods.

2.1 Objective Methods

Objective method no. 1 is based on the facts and characteristics of tangible heritage and is expressed by the following formula:

$$v = vt \times vi = vt \times vc \times vh$$

vt: value of tangible, based on structure, function, and style

$$vi = vc \times vh$$

vi: value of intangible, based on cultural or social viewpoint (vc), and historical viewpoint (vh).

Objective method no. 2 is based on the historical viewpoint and is expressed by the following formula:

$$v = ve \times vh = vt \times vc \times vh$$

$$ve = vt \times vc$$

ve: value of existence, based on architectural viewpoints such as structure, function, or style (vt), and cultural or social viewpoint (vc).

vh: historical value

These methods can be likened to the three axes of a cube, with their synthesis providing the total valuation of the building. These axes, however, are independent of one another, so that the evaluation along one axis is independent of the other axes. In this concept, the total valuation of a certain tangible asset is the total value of these axes. Since 2007, I have used this example to argue for a new perspective in the objective evaluation of our tangible heritage (Figs. 1 and 2).

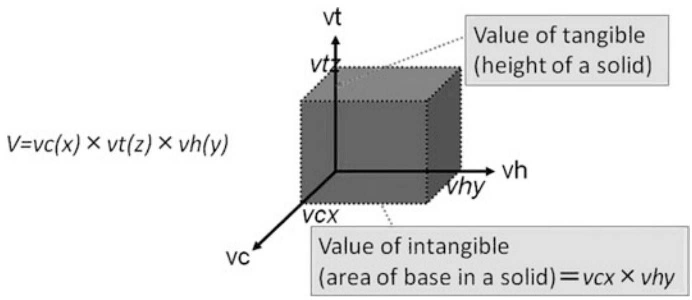

Fig. 1 Objective method no. 1

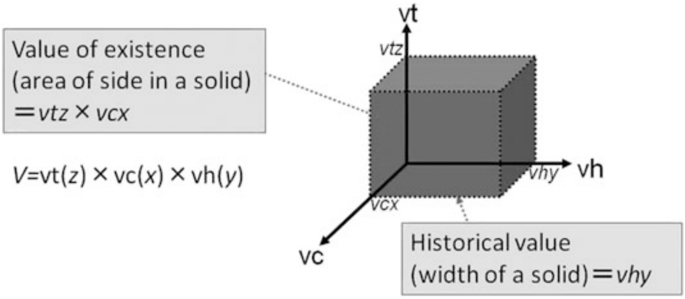

Fig. 2 Objective method no. 2

2.2 Sensuous Methods

In some cases, the value of historic buildings can be felt with our senses. I believe that this factor should not be ignored when evaluating buildings.

Sensuous method no. 1 is based on four of our five senses, namely sight, hearing, smell, and touch. We can recognize heritage through these senses.

Sensuous method no. 2 is based on an individual's memories of heritage sites. If the heritage is lost then all of these memories will be lost—an unbearable thought to many people. Historic buildings symbolize people's memories, and in fact we can evaluate physical heritage through these memories. In many cities, social movements have arisen with the aim of preserving old buildings. Local residents who love the architecture of historic buildings are motivated to join historical or cultural organizations, thereby working actively toward preserving both this tangible heritage and our collective memories.

3 Transformation from Dereliction to Valued Heritage and Useful Properties

This section introduces nine examples of the preservation and utilization of historic buildings. These examples show that all derelict buildings or structures have the potential to be turned into valued architectural heritage and useful properties.

3.1 The Nihonbashi Bridge in Tokyo

The Nihonbashi Bridge is located in the center of Tokyo, at the intersection of National Route 1 and the Hirakawa River. The zero milestone of the Japanese national routes is set at the foot of this bridge, which was first constructed in the

Fig. 3 The Nihonbashi Bridge in Tokyo

beginning of the 17th century. The existing bridge was completed in 1911. From these facts we can derive the following three values attached to this bridge:

1. The history of Tokyo's system of transportation;
2. Its central position in Tokyo's economic life;
3. Its central position in the life of Tokyo residents.

In the run-up to the Tokyo Olympics Games of 1964, the Japanese government decided to construct urban highways in an attempt to relieve the city's traffic problems. One of these highways ran directly over the Nihonbashi, destroying not only the view of the bridge but also the surrounding landscape (Fig. 3). However, at that time there was no suitable method to evaluate the historical or cultural importance of the Nihonbashi.

3.2 'Acthenon' Nagoya City Performing Arts Studio, Formerly Inabaji Water Supply Tower

The 'Acthenon' is a building with a highly interesting past. In 1937, it was erected by the Nagoya city government as the Inabaji Water Supply Tower, providing water to the west of Nagoya. When a more modern water tank was built in 1944 at another location, the original tower was preserved rather than being destroyed. In 1965, the Nagoya city government converted it into the Nakamura Library. However, in 1991, the library was relocated, leaving the tower once again with no specific function. In 1995, the city authorities converted it into a performing arts studio (Fig. 4).

Fig. 4 The 'Acthenon'

The building is thus enjoying a third lease of life. Its inherent value is being continuously evaluated and assessed. When converted into a library, only the first four floors were occupied, while the fifth floor and the water tank were left unused. Although there was always the option to demolish the sixteen large columns surrounding the structure as well as the water tank, this was never proposed. When it started its third incarnation as a studio for the performing arts, the tank was converted into a rehearsal studio. The building's nickname, 'Acthenon', is a blend of 'aqua' and 'Parthenon'.

I predict that in the next 20 years the tower will be converted back into a water tank: It is likely that the performing artists will relocate to more modern studios in the coming decades, while at the same time the need for water storage will rise as a result of earthquake or flood damage. Therefore, perhaps around 2030, which would be around 100 years after the original construction, the building could return to its original purpose. I have tried to show that this is a good example of new values and functions being attached to old buildings, in this way giving them a new lease of life.

3.3 Tokyo Station

Designed by Tatsuno and Kasai Architects, Tokyo Station was completed in 1914. Towards the end of the Second World War, some parts of the station were destroyed by firebombs, leading to the removal of the third floor. In the post-war years, two projects were proposed to rebuild the station. In 1968, Prime Minister Sato said: 'If it is important, you can bring it to the Meiji-mura Museum.' Nonetheless, the proposed demolition of the building was not carried out.

In the mid-1980s, Prime Minister Nakasone proposed that the station should be entirely rebuilt. However, these projects met with considerable public resistance. Finally, in 2003, the Japanese government designated it an important cultural property. In 2012, major restoration work to the station building was completed (Fig. 5).

Fig. 5 Tokyo Station

3.4 Toyoda Auditorium of Nagoya University

Constructed in 1960, the Toyoda Auditorium won the AIJ Prize in 1963. In 2008, the auditorium was completely restored (Fig. 6). In 1980, when I was a student at Nagoya University, it was considered one of the least successful campus buildings. Nobody liked it; not even the professors in the architectural department praised it. The auditorium was criticized for being a faceless concrete mass, for its poor acoustics, for the narrowness of the stage, etc. Some people suggested that the concrete exterior be cladded with marble or red brick. When, however, DOCOMOMO Japan (Documentation and Conservation of buildings, sites, and neighborhoods of the Modern Movement) proclaimed it to be a representative building of a very important movement in 2005, the university decided to preserve, reinforce, and refurbish the auditorium. Finally, the Toyoda Auditorium was registered as a national cultural property in 2011.

This confirms how the value of a building, its recognition and people's evaluation of it can change over time.

3.5 National Taiwan Museum's Nanmen Park

The building in Nanmen Park was originally constructed by the Taiwan Government-General as a camphor and opium factory, which operated from 1899 to 1945. After the Second World War, the Taiwan Government maintained the

Fig. 6 Toyoda Auditorium of Nagoya University

Fig. 7 National Taiwan Museum's Nanmen Park

Monopoly Bureau of Taiwan, which continued to operate the factory. The Monopoly Bureau of Taiwan later turned it into a brewery, and in 2005 this business was moved to the suburbs. The National Museum acquired the building in 2009. After undertaking some historical research, they refurbished and reopened it in 2013 as an external site of the museum (Fig. 7).

In 2009, an old foundation, rails, and remnants of a lift were found. These are now displayed in the museum. The space around a lean-to roof is utilized for visitors' facilities, shops, and restaurants. The old trusses have been reused and displayed.

3.6 Former Chinese Settlement in Incheon

When Incheon became an open port in 1883, foreign settlements were quickly constructed in the surrounding area.

In these settlements, many shop houses with verandahs in the 'Veranda Colonial Architecture' style were built until the beginning of the twentieth century. For the Chinese, verandahs came to symbolize the Western style of architecture. In 1949, when the People's Republic of China was established, Korea broke diplomatic relations with the Chinese mainland. Thereafter, Incheon's Chinatown went into decline until 1990. Then, in 1991, Korea reestablished diplomatic relations with

China, giving a huge boost to trade. The Chinese rushed back to Incheon and purchased many of the aforementioned properties, helping to revive the fortunes of Chinatown.

3.7 Central Avenue in Harbin

Around 1900, Harbin was under the rule of the Russian Empire. Due to the many Chinese navies and other workers who walked every day from the pier to the new town of Harbin, the Russians came to call this avenue 'Kitayskaya,' meaning 'Cathay Avenue'. From the 1910s to the 1920s, foreign banks and companies opened branches along this street. In the latter half of the 1920s, this avenue was considered one of three most flourishing international streets in East Asia.

In 1984, Harbin city government drew up legislation to preserve the historic buildings built between 1898 and 1949. According to this legislation, 74 historic buildings, one street and a roundabout were designated as cultural heritage because they represented the history of Harbin and its various cultures. It was not until 1997 that the city government started to restore the Central Avenue and some designated buildings along this avenue. The Architectural Arts Museum of Central Avenue opened in 2007 (Figs. 8 and 9).

Fig. 8 The Central Avenue in Harbin

Fig. 9 A signboard of the Architectural Arts Museum of Central Avenue

3.8 The Zero Milestone in Tsushima

In 1920, the municipal authorities of Tsushima were ordered to lay down the Zero Milestone in the town. This was set in the center of downtown, at the intersection of the old main street 'Hon-machi' and the prefectural road from Nagoya to Tsushima built by Aichi Prefecture. It meant that this place was the central point of downtown in Tsushima in 1920. However, once the straight avenue called 'Ten-no-dori', which stretched from the station to the Tsushima Shrine, was completed in 1929, the central point of the town moved the intersection of 'Ten-no-dori' avenue and 'Hon-machi' street. Nonetheless, the old Zero Milestone was left in place as an historically important object (Fig. 10).

3.9 The Headquarters of Kankyo Mirin Company

The Headquarters of Kankyo Mirin Company was completed in 1938 (mirin is a sweet rice wine normally used for cooking). In 2005, the local government of Kanie Town gave me permission to research and evaluate this building. From this work, I was able to make the following four objective evaluations:

1. Reinforced concrete building
   The Headquarters was the first reinforced concrete building in Kanie Town. The floor plan is that of a typical office building with a core. However, it is somewhat smaller than most office buildings made of reinforced concrete, and therefore should be called a 'Mini Office Building.'

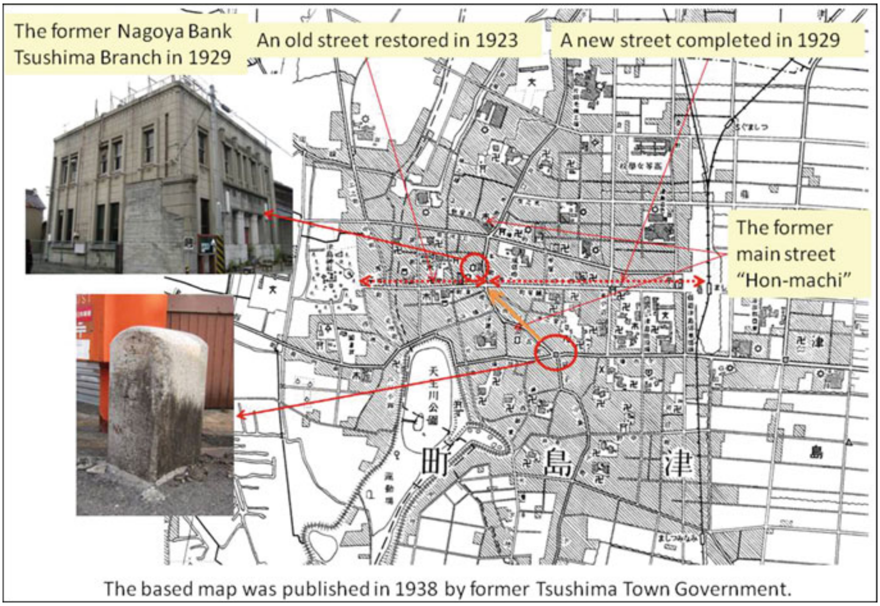

Fig. 10 The Zero Milestone and the changing landscape of old Tsushima

2. Renaissance style exterior
   The exterior presents a simplified Renaissance style typical of Japanese architects of the 1920s and 1930s. An accurate adoption of the Renaissance style would have resulted in a three-story building. However, the façade of this two-story building is divided into three parts, reflecting the Renaissance style.
3. Riverside location
   Due to the prominent location at the center of Kanie Town (a former port) along the Kanie River, it has become a landmark building.
4. Beautiful landscape
   Figure 11 shows the beautiful landscape surrounding this building, consisting of traditional buildings, trees, a river, and the blue sky. This building is one element of this beautiful landscape.

Because of these factors, this building was designated a 'cultural property' in 2006. After concluding my research, I expressed respect for the owner of this building by designing a New Year's card for 2009 in the form of a woodblock print.

In 2012, the president of Kankyo Mirin Company decided to undertake extensive renovations in order to move the company headquarters back into the building. He told me that a major motivation had been my positive evaluation. This example shows how evaluations through various perspectives can encourage the preservation and utilization of historic buildings.

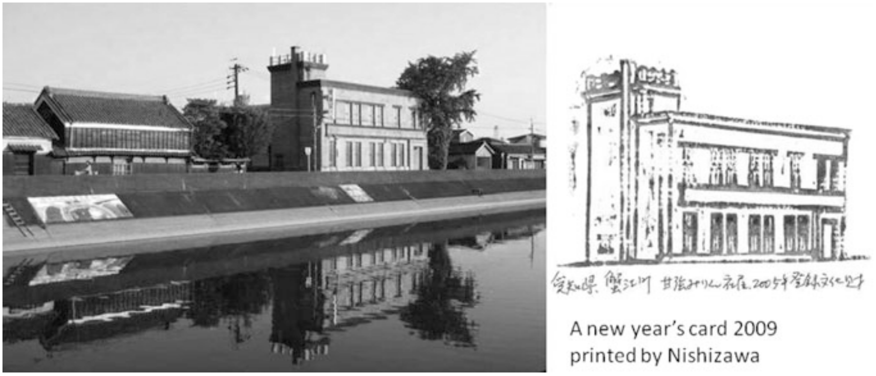

Fig. 11 The Headquarters of Kankyo Mirin Company (*left*) and a New Year's card for 2009 designed by Nishizawa (*right*)

4 Conclusion

These examples convey the following four points:

(1) All historic buildings have some value, which may, however, not be immediately apparent. It is necessary to discover the (new) values of these buildings through various perspectives.
(2) We should never destroy historic buildings before investigating or evaluating them. Such abandoned relics have the potential to be transformed into heritage sites or valued properties in urban areas.
(3) We should seek to discover new values of historic buildings and talk or think about their revival or utilization. If we cannot find any new values to attach to them, they are almost certain to be demolished. Continuing to use old buildings is one way of promoting sustainable development in the world.
(4) We should not take the preservation and utilization of historic buildings lightly. The cases of 'Acthenon' and Toyoda Auditorium of Nagoya University are striking examples of buildings that were once slated for demolition and which have been preserved and reutilized, yet.

Therefore, it is vital that we determine the inherent values of historic buildings through research and evaluation based on various perspectives in order to preserve and utilize them. These buildings have been built by human beings and hence symbolize their successes and failures. In the same way that every person has positive qualities if we take the time to look, buildings possess important values that are waiting to be discovered.

Acknowledgements Parts of this paper are based on results of the Historic Buildings Research Project by the Research Center for the designated important cultural property Baba's residence of Nagoya University. I would like to thank Editage (www.editage.jp) for their English language editing.

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Part V
Urban Energy Concepts

Chapter 14
Revolution of Urban Energy System

Masaya Okumiya

Abstract Fragility of energy supply structure in Japan was exposed with Great East Japan Earthquake as a turning point. Then it is required to reduce consumption of fossil fuel and utilize renewable and unused energy for securing the safety of society. Also shift of energy supply from centralized system to decentralized one for improving efficiency of system. There are many kinds of unused energy such as river/sea water and waste heat in city. However, it is difficult to use these energy by individual buildings. Therefore area energy system and energy network play an important role. Also networking of energy system functions as a mutual help system in the city at an emergency. Under this background in this paper energy interchange in urban central district and utilization of waste heat from heating/cooling of building are discussed with the results of studies on these topics.

1 The Frame Supporting Urban Life and Design Procedure of Environmentally Friendly Building and Area System

Urban life consists of "Life space", "Work space" and "Mobility" those are producing amenity and productivity. And these are supported by energy which is supplied by fossil fuel and renewable energy. At present fossil fuel is dominant. While future affluent urban life will consist of intellectual "Life space", "Work space" and "Mobility" which are supported by renewable energy dominant energy supply.

The flow to form an environmentally friendly building system starts from the reduction of cooling/heating load and illumination demand by using architectonic energy saving method (passive method: appropriate thermal insulation, solar shading, natural ventilation and natural lighting). High-efficient Heating,

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Ventilation and Air Conditioning (HVAC) and artificial lighting are applied to this ultimately reduced load, then active utilization of renewable energy should be included sufficiently. Also at operation phase, indoor environment and energy consumption should be monitored appropriately and it is very important to improve a operation of a system based on the analysis of monitored data (Fig. 1).

Waste heat from underground power transmission line and waste incineration plant are energy which have not been used up to now. River water, sea water and treated waste water can be used as heat sink/source of heat pump. These waste heat and heat sink/source are called as unutilized energy. However unutilized energy is difficult to handle to use by individual building and facilities. The area energy system such as district heating and cooling system (DHC) can play an important role for efficient use of unutilized energy.

As well as achieving the energy conservation by above mentioned environmental friendly building and area energy system at regular operation, the system can correspond to business continuity planning (BCP) in case of emergency. The natural ventilation which is an architectural energy conservation measure is effective to ease indoor environment even in the case HVAC system cannot operate. Renewable energy (photovoltaic generation and solar heat) will play an important role in case of emergency. Networking of an energy system functions as a mutual help system in the city. Planning/Design to link BCP of the long span and BCP in case of emergency seamlessly is essential.

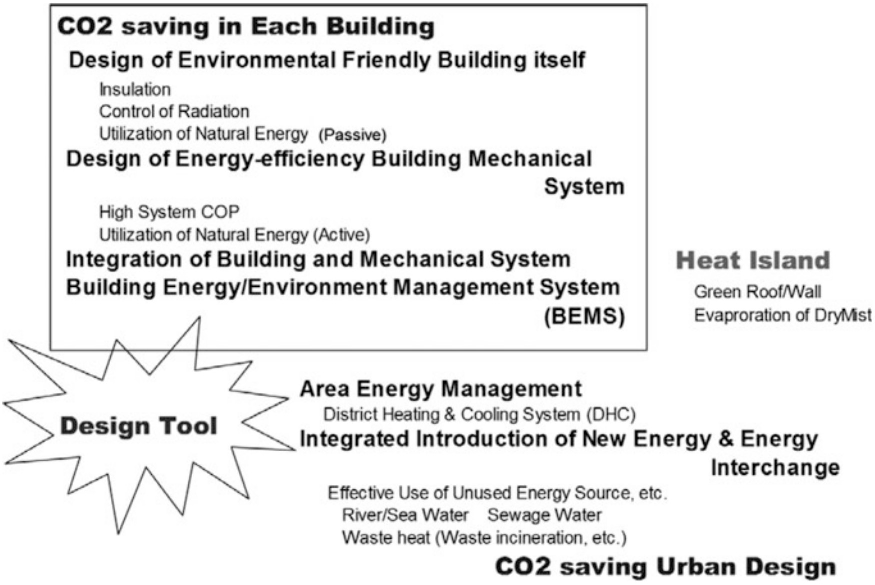


Fig. 1 Flow to form environmental friendly building and area energy system

2 Energy Supply Among Multiple Heat Source Plants in Central City Area

Recently in Japan, energy savings and reduction of CO_2 emission, the Area Energy Network has become increasingly important, from an environmental protection perspective. The Area Energy Network can also play an important role with respect to risk reduction during disasters. The DHC system in which hot/cold water or steam are supplied to each building and facilities in the area from central heat source plant is representative of the Area Energy Network. However, DHC has a tendency to stagnate due to the difficulty to secure the space for central heat source plant in the central district of city and the decrease new development of district. Therefore, a new Area Energy Network model is required in order to solve these problems. The purpose of the case study is to demonstrate the validity of an area energy system that interchanges energy among multiple heat source plants.

2.1 Outline of the Case Study

It is assumed there are four buildings and the energy performance of system which interchange heat among buildings are investigated by using simulation. Case 1 is conventional heat supply system in which each building has its own heat source equipment and heat is not exchanged among buildings. In case 2 to case 5, four buildings interchange heat among themselves. In case 6 and 7, three buildings (A, B, C) interchange heat and building D operates individually. Moreover, the case study investigates the influence of the existence and size of heat interchanging pipe on total energy performance.

2.1.1 Load Pattern

The four chosen buildingtypes are complex buildings (office, hotel, commercial facility). The load patterns were for a representative day of each month were calculated by using load calculation tool. Table 1 shows an outline of each load.

2.1.2 Heat Supplying System

In the individual system (Case 1), each load corresponds to the load for an individual plant. The distributed system contains distributed heat sources for four plants and energy interchange. In the represented study, Cases 2 through 7 differ from existence of interchanging pipe or these pipe sizes. Figure 2 shows variation of energy network.

Table 1 Characteristics of the four building types

	Cooling load		Heating load		Application	Total floor space (m^2)
	Peak (GJ/h)	Annual (GJ)	Peak (GJ/h)	Annual (GJ)		
Building A	140	332,218	43	126,156	Office, hotel, department, restaurant	450,000
Building B	49	136,698	42	89,125	Office, hotel, department, restaurant	190,000
Building C	135	178,902	77	203,319	Office, hotel, restaurant	260,000
Building D	52	57,203	12	8500	Office, commercial	150,000

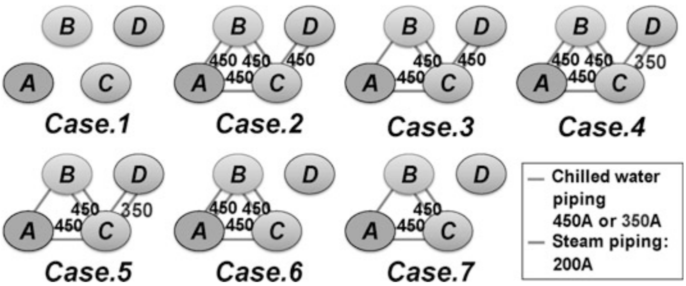


Fig. 2 Variation of network

2.2 *Results and Discussion*

Figure 3 shows the results for the annual primary energy consumption and the energy saving rate for each case. The energy saving rate indicates the primary energy reduction rate based on the individual system (Case 1). All cases for the distributed system are anticipated to provide energy savings of more than 4%. Cases 6 and 7, in which Plant D is not incorporated in the energy network, shows relatively small energy savings. Therefore, the energy network is expanded to Plant D, and a higher energy saving effect is obtained.

3 Application of Annual Cycle Energy System to District Heating/Cooling and Domestic Hot Water System

In this case study, performance of three types of district heating cooling and hot water supply system with natural and unused energy utilization was examined by using system simulation. An area designed for both, commercial and residential

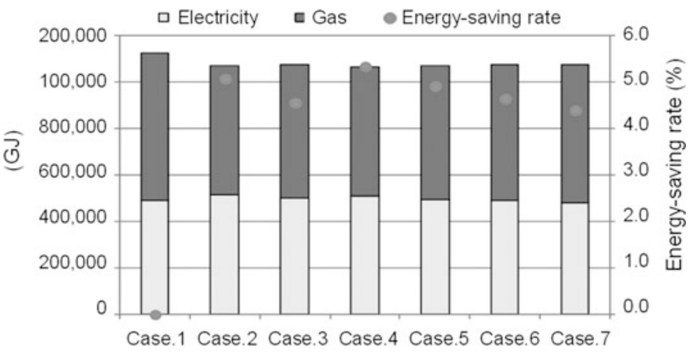


Fig. 3 Comparison of primary energy consumption and energy saving rate

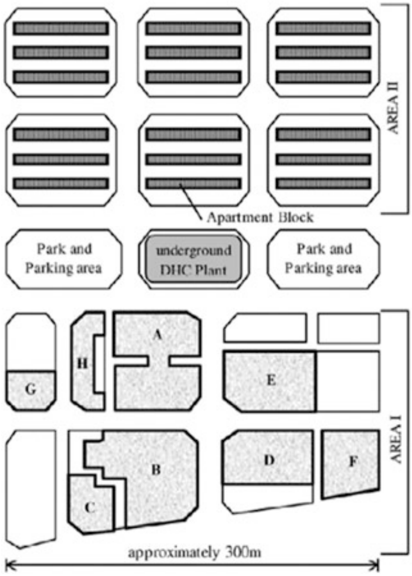
buildings, was chosen for this study. The first system is the conventional system in which an electric driven turbo chiller and a gas-fired boiler are installed as the heat source. This is considered as the reference system. Two alternative systems utilize waste heat from space cooling and heating. One is designed based on short-term heat recovery and the other employs the concept of an annual cycle energy system (i.e. seasonal heat recovery). All of the three systems use solar thermal energy for hot water supply of the residential zone. The index for evaluation is the coefficient of performance of the overall system, based on primary energy.

3.1 Outline of the Area

Figure 4 shows a summary of the study area assumed in this case study. The site consists of AREA I which is a redevelopment area in urban communities with office buildings, department stores and so forth and AREA II which is an apartment building area.

An underground DHC plant is proposed to be located under the park situated between AREA I and AREA II. The plant supplies heating and cooling for all buildings. The buildings are A–F buildings in AREA I (see Fig. 4) and 18 apartment blocks containing 1800 households in AREA II.

Figure 5 shows the estimated monthly heat load. In AREA I, the load density is high. Because several buildings have large interior heat gains, cooling loads appear even in winter. In AREA II, which is the residential area, heating and cooling loads do not occur in the same month.



AREA I (Commercial Zone)

building	purpose	floor area (m²)	story
A	department	25,000	5F
B*	department	30,000	7F
C	shop	5,000	5F
D*	department	18,000	6F
E	department	18,000	6F
F	shop	10,000	5F
G	shop	4,000	5F
H*	shop	10,000	12F
	office	10,000	
	hotel	10,000	
total area		140,000 m²	
virtual subject area		110,000 m² (commercial : 88,000, office : 13,000, hotel : 9,000)	

* Assumed high internal heat generation building

AREA II (Residential Zone)

floor area / apartment	75 m²
apartment / apartment block	100
number of apartment blocks	18
total area	135,000 m²

Fig. 4 Summary of the area assumed in the case study

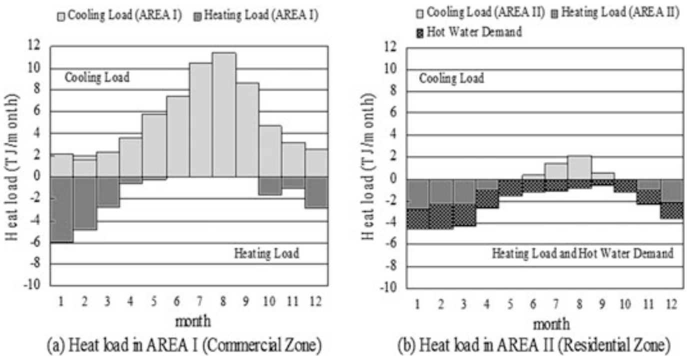


Fig. 5 Estimated monthly heat load for AREA I and II

3.2 *Outline of the Systems Examined*

Three DHC systems shown in Fig. 6 are considered to supply the heat demand of the study buildings. The first one is the conventional system in which an electric driven turbo chiller and gas-fired boiler are installed as heat source equipment.

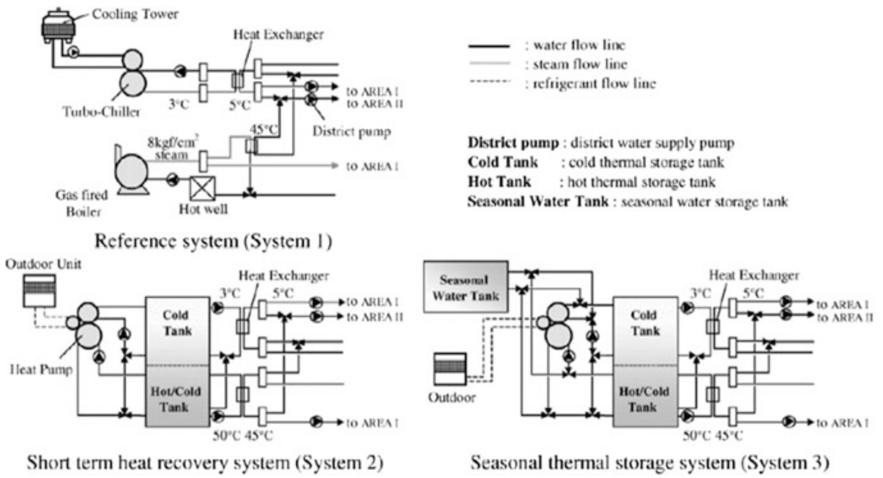


Fig. 6 Three DHC systems examined in the case study

This is considered as the reference system in this case study (System 1). The second system is a system that recovers the waste heat from space cooling and heating in a daily cycle (System 2). The third system is a long-term heat recovery system with a seasonal water thermal storage tank (System 3). Figure 6 shows the list of system components and their design conditions.

3.2.1 Reference System (System 1)

In this system, the turbo chiller meets the cooling demand and the boiler meets the heating demand for the whole study area. The chiller generates cold water of 3 °C and the plant supplies cold water of 5 °C to the demand side after passing through a heat exchanger. The district cold water supply pumps are controlled using speed control so that the return water temperature is maintained at 12 °C. For the heating demand of the commercial area (AREA I), steam of 785 kPa (8 kgf/cm) is supplied directly. At the same time, the plant supplies hot water of 45 °C to the residential area (AREA II) after passing through a steam to heat exchanger.

3.2.2 Short-Term Heat Recovery System (System 2)

Because the cooling demand occurs in winter in the commercial area, a heat recovery system in a daily cycle is considered. A storage tank is installed for heat recovery and this tank can be separated into two parts in the season when both cooling/heating demands occur. The heat is transferred from one part (cold water tank) to the other (hot water tank) by heat pumps. When the cooling load is larger than the heating load, the excess heat is released through the outdoor air unit (operating as a condenser). When the heating load exceeds the cooling load, it operates as an evaporator to gain heat from outside air. Cold water at 3 °C is stored in the cold water tank and hot water at 50 °C is stored in the hot water tank. The cold and hot water are delivered to a heat exchanger. The outlet temperatures of the heat exchanger on the district side are 5 and 45 °C. Thermal storage operation starts at 22:00 h each day and stops at a point in time when there is no longer a demand for storing heat.

The thermal storage tanks and heat pumps are designed on the assumption that the heat pump operates 24 h on the peak load day.

3.2.3 Seasonal Water Thermal Storage System (System 3)

This system is a long-term heat recovery system with a seasonal water thermal storage tank. It is the same as the short-term heat recovery system (System 2) except that a seasonal thermal storage tank is also installed as the heat source/sink of the heat pump.

During the season when short-term heat recovery is possible, heat is recovered from the cold water tank and delivered to the hot water tank. For example, when the heating load is larger than the cooling load, the seasonal tank is used as a heat source after completion of the short-term heat recovery. Alternatively, heating can be extracted from the outdoor air. The criterion to judge which heat source/sink is used is the coefficient of performance of the heat pump.

When the seasonal storage tank is chosen as the heat source/sink, cold and hot exhaust heat is stored in this tank and shifted to the cooling and heating season.

3.2.4 Hot Water Supply System for AREA II Calculations

Hot water to the apartment buildings is provided by a solar hot water supply system. The system is designed to provide a 60% design solar fraction. Flat-plate solar collectors and hot water storage tanks are set up on the rooftop of each house. Also, it is assumed that each residence has a hot water boiler as an auxiliary heat source.

3.3 Comparison of Systems Performance

3.3.1 Performance Index

Performance of each system is evaluated by the Seasonal COefficient of Performance (SCOP) of the overall system on a monthly and yearly basis.

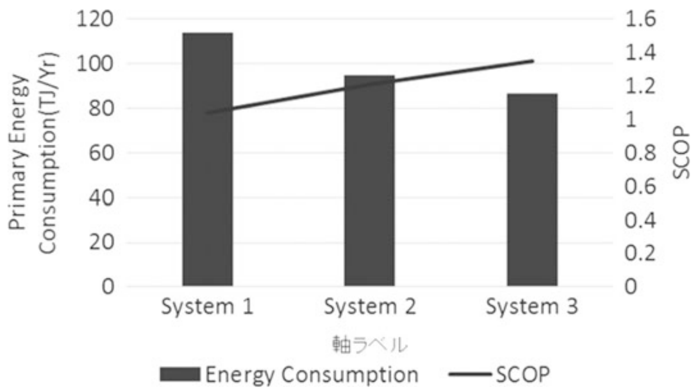


Fig. 7 Annual energy consumption and SCOP for each system

This index is based on primary energy and defined as follows:

$$\mathrm{SCOP} = (\mathrm{Qh} + \mathrm{Qc} + \mathrm{Qd})/(\mathrm{Wc} \times \mathrm{Pw} + Gc \times \mathrm{Pg})$$

where Qh is the heating load, Qc is the cooling load, Qd is the hot water supply load, Wc is the electric power consumption, Gc is the gas energy consumption, Pw is the conversion factor of electric power into primary energy and Pg is the lower heating calorific value of natural gas.

3.3.2 Comparison of System Performance

Figure 7 shows the annual energy consumption and SCOP for each system. From this figure, it is found that System 3, which is the system with the seasonal storage, shows the highest SCOP. The second highest system is System 2, which adopts only the short-term heat recovery. System 3 could reduce energy consumption by about 26% and System 2 could decrease it by about 16% against System 1 (reference system). These improvements in the system performance are mainly due to the reduction of energy consumption of the heat source equipment.

4 Concluding Remarks

Low carbon type abundant urban life consists from intellectual life and work, and these are supported with the new energy and renewable energy.

It's indispensable to reduce a load as much as possible using an architectural energy saving method to achieve environmental friendly building. Then it's necessary to design a building mechanical system suitable for the profile of the load and it's necessary to include renewable energy properly. It's effective to build an area energy management system (ex. District Heating & Cooling System) at the area scale, and there is an option that unutilized energy can be utilized effectively.

When applying the district heating & cooling system in which energy is supplied to buildings from central plant, there are sometimes restrictions on the space. As a measure to solve the problem the exchange of the energy between more than one plant can be considered. The energy saving effect as like the distinct heating & cooling system can be achieved with optimal design and operation.

The annual cycle energy system which is a combination of a seasonal and short term heat recoveries also can achieve the energy saving effect in district heating & cooling system.

It is one of the methods to utilize unutilized energy.

Chapter 15
Building Energy Management: Performance Verification and System Simulation

Hideki Tanaka

Abstract One crucial approach to the global challenge of transforming into low-carbon societies is to ensure, energy conservation in various sectors of the economy. In Japan, the building sector produces about 40% of overall CO_2 emissions, while the energy consumption of buildings accounts for 25%. Around half of the energy is consumed by non-residential buildings for heating, ventilation, and air-conditioning (HVAC). Therefore, it is important to carefully consider energy use and consumption at each stage of the design, construction and operation of buildings. This chapter discusses energy management in HVAC systems over the life cycle of buildings, in particular the contribution that can be made by system simulation support. Performance verification and examination of operational improvement are conducted for an HVAC system using operational data and system simulation. In case studies, a system simulation modeling procedure using the Life Cycle Energy Management (LCEM) tool is described for the heat source system and the HVAC air-side system in office buildings. Finally, based on actual operational data from Building Energy Management System (BEMS), the usefulness of the simulation model is analyzed and assessed.

1 Background to Energy Management

Looking at annual CO_2 emissions in Japan in relation to various industrial sectors, we find that the building sector produces over 40% of total CO_2 emissions. Therefore, the construction industry has a major role to play in reducing the pace of global warming. CO_2 makes up around 95% of greenhouse gases emitted by Japan (and around 60% of the global average). Therefore, a reduction in Japan's CO_2 emissions can make a real contribution to efforts to reduce global warming. Of course, one way to lower CO_2 emissions is to make energy savings, which is our object of interest here.

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Based on a survey of energy consumption by buildings, annual energy consumption is found to correlate directly with total floor area. Thus total floor area can serve as an indicator for energy savings. Here energy consumption per unit of floor area is used as a primary index for building energy management.

One government-affiliated company in Japan is currently collecting building energy data in order to establish a classificatory system for buildings. A resulting database of average energy consumption per unit of floor area has been compiled for each class of building. In general, this efficiency index for energy use is applied to existing buildings to determine whether they are operating with good energy efficiency. The government has already enacted the Energy Conservation Act to promote energy saving, in particular regulating for the suitable energy management of large buildings. The law also requires a 1% reduction in energy consumption per year. Annual energy consumption per unit of floor area is used as the main indicator in this Energy Conservation Act. An affiliate company of the Japanese government provides various tools for energy management free of charge, for instance Energy Specific Unit Management (ESUM) and Energy Conservation Target Tool (ECTT). These are just two of the software tools offered by governmental agencies. ESUM is intended for professional use and ECTT for non-professionals (both free of charge).

2 Problems and Methods of Energy Management

Many factors obstruct the uptake of sensible energy management policies. Firstly, building owners are generally uninterested in energy conservation. For instance, in the case of leased buildings, the owner's focus is on maximizing rental income. Furthermore, s/he may lack knowledge of how to make energy savings through improved building operations. Secondly, the working time of the building owner and operator may be largely spent on handling complaints and claims from occupants. When an organized management group is established, this may have a formal rather than a functional structure; the group may consist of a small number of engineers with poor specialized knowledge of energy saving, so that the focus of activities is rather on issues of maintenance and repair. Also there may be a lack of available measurement equipment or systems to confirm operational statistics. If the management group does show some interest in energy saving, the qualitative measurement of savings is difficult to achieve, and there is a lack of visual tools to help understand how much energy is being saved. However, after the Great East Japan Earthquake of 2011, a change in the law established many incentives and aids to energy management. This has helped to transform the general state of energy saving.

3 Energy Management with BEMS

Government subsidies have fostered wider adoption of the Building Energy Management System (BEMS). The three core elements and functioning of BEMS are shown in Fig. 1: Improvement of the indoor environment, energy management to improve the indoor environment with minimum energy consumption, and improvement of operational maintenance activities. The BEMS scheme encompasses the Building Automation System (BAS), which actually operates the HVAC system, and the Building Management System (BMS). Building energy consumption is monitored by the Energy Management System (EMS), which conducts an analysis of the system energy performance. The Facility Management System (FMS) includes building life-cycle costs in its operation. The entire system of BAS, EMS, BMS and FMS, is called BEMS (or BMS).

The management system is largely software-based. The maintenance of equipment is organized by the Computerized Maintenance Management System (CMMS). For facility management, there is the Computer-Aided Facility Management (CAFM), which includes the management of blueprints. The system also includes a Building Information Model (BIM), which captures building equipment specification data.

Figure 2 shows an example of the configuration of the Integrated Management Support Tool with CAFM. These are linked through the database to create a single integrated system which is required prospectively. In recent years, BEMS has been increasingly employed in energy conservation activities. Firstly, Key performance Index (KPI) and the improvement plan (**P**lan) is determined by the owner or operator; then the plan is implemented (**D**o), KPI is checked (**C**heck) and the action plan is reviewed and developed (**A**ction). In this way the PDCA management cycle is rotated using the actual building system operational data obtained from BEMS.

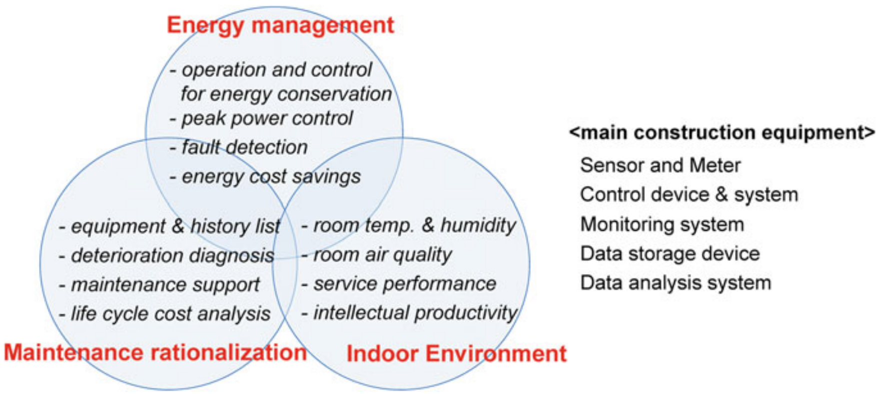

Fig. 1 Overview of the Building Energy Management System (BEMS)

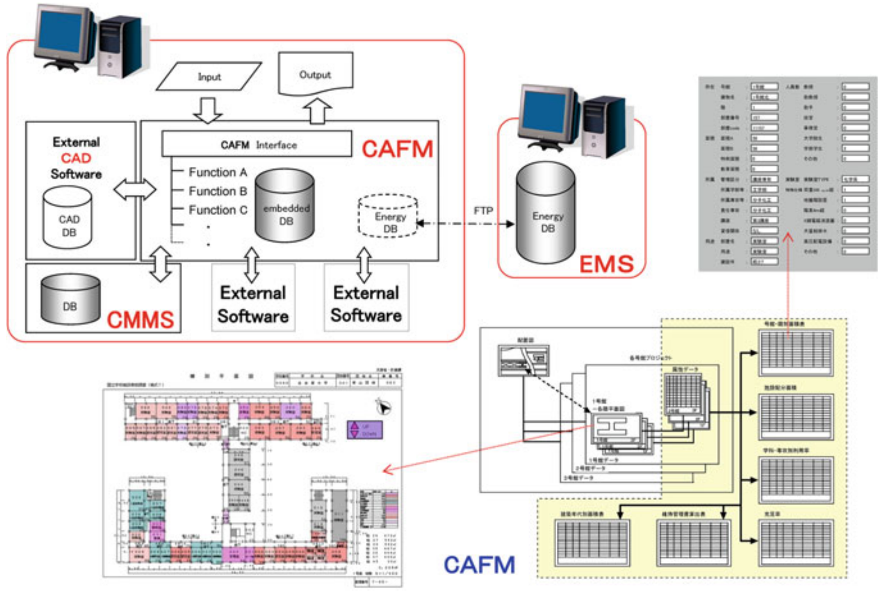

Fig. 2 Configuration example of integrated management support tool with CAFM

4 Life Cycle Energy Management of HVAC with Simulation Tool

Half of the annual energy consumption in office buildings is from HVAC and the production of hot water. These are areas requiring expert knowledge and tools, and a suitable target for energy management. In general, the selection of air-conditioning heat-source equipment in the design process focuses only on the maximum heat load, with importance attached to meeting this peak load with high performance. Using analysis of BEMS data on the frequency of the hourly heat load of an office building over the year, it can be seen that for 77% of the year, operation is at less than one-third of the peak machine capacity. This indicates that it is more important to focus on annual system performance in the design process than on system performance at peak load. Therefore, design tools are required to consider the annual system energy performance indicator for the HVAC system (Ito et al. 2007).

Figure 3 shows a flow diagram for energy management of the HVAC system over the building life cycle. Different players, designers, constructors and operators are involved in the flow. In the current situation, insufficient information on energy performance is passed from one player to the next during transition. Against the background of an individual contract for each phase of the building construction (design, construction, and operation), this means that the owner's performance requirements, design concept and construction information are often not adequately

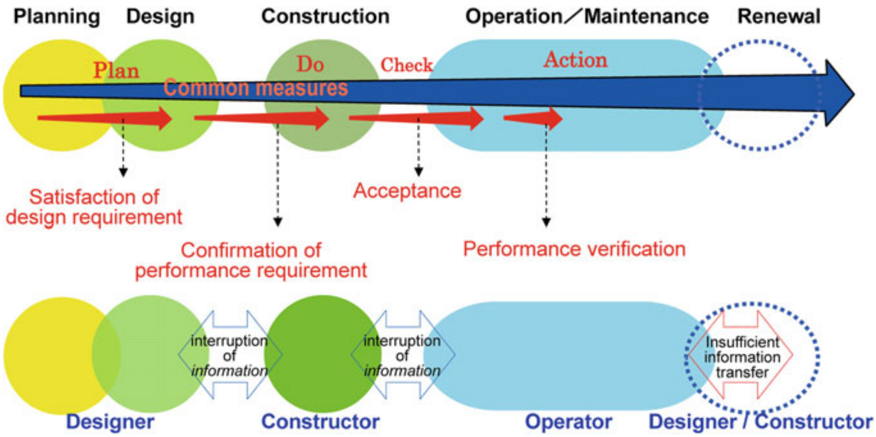

Fig. 3 Flow diagram of building construction and evaluation of energy performance

transmitted to personnel at the construction and operational phases in the building construction process. With life-cycle energy management, this building information transmission issue is eliminated; the building energy performance in each phase of the design, construction and operation is checked to maintain and improve the energy performance of the building. Therefore, the HVAC system, which requires a high level of expertise, needs to be managed in such a way that each expert transmits information to the next with the support of the tool. The adoption of a system simulation program has been considered for this information aggregation and transmission tool.

The Ministry of Land, Infrastructure, Transport and Tourism of Japan has encouraged the life cycle energy management of HVAC systems in public buildings using the system simulation tool (MILT 2014). This has led to widespread adoption of the technology. Furthermore, the ministry had developed a free simulation tool for the life cycle energy management of air-conditioning systems, called the Life Cycle Energy Management Tool (LCEM Tool). Figure 4 shows an example of a simulation model of a cooling tower, which is one HVAC system element. A simulation model of a system element (called an 'object' in the LCEM Tool) is coded using Microsoft Excel, with equations provided in individual cells in the Excel sheet.

Each system element is described as one object, and each object is divided into four parts, specifically the 'Communication, Control, Method (Calculation) and Property (Specification)' sections. Every object only exchanges information with the neighboring objects on each side. The calculation adopts a static simulation and its time-step is one hour. The general system simulation model is developed by connecting objects to one another. In Fig. 4, the elements of a system are shown by boxes corresponding to respective equipment objects, with the gray boxes

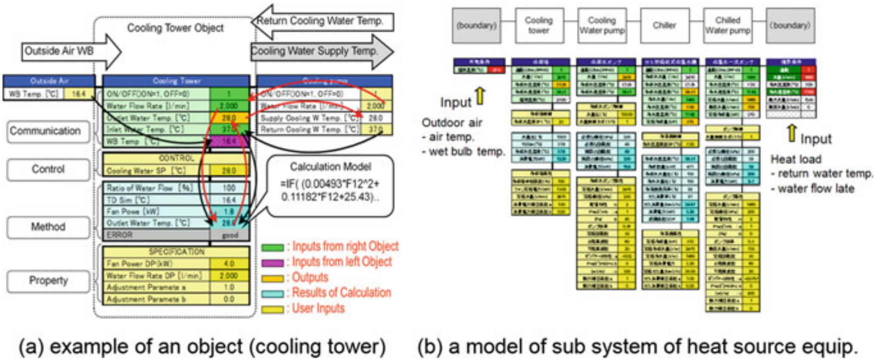

Fig. 4 Flow of building construction and evaluation of energy performance

representing the input boundary conditions for simulations. To conduct the simulations, it is necessary to provide data on outside air temperature and humidity, thermal load and control parameters as boundary conditions. For this boundary data, actual operation data measured by BEMS is used in the operational phase. In the simulation process, objects reflecting the actual characteristics of individual items of equipment calculate outputs based on an energy balance for the overall system.

5 Example of Energy Management of HVAC Using BEMS

5.1 Utilization to Promote the Spread of Energy Conservation

Taking the example of a ‘green’ hospital as a representative building, life-cycle energy management is supported by both the BEMS and LCEM tools. The actual operational data from BEMS is used to verify energy performance of the heat source system and equipment by checking the difference between actual operation and simulation results. Figure 5 shows an example of actual operation compared with system simulation results. In energy management, when the real performance coefficient of a heat source machine deviates from the simulation result, the management group conducts a thorough investigation to determine the cause. After the system simulation model is modified to produce an accurate energy simulation, it can be usefully applied to ensure optimal system operation and control. It is good practice for the PDCA management cycle to be rotated using the actual building system operation data from BEMS.

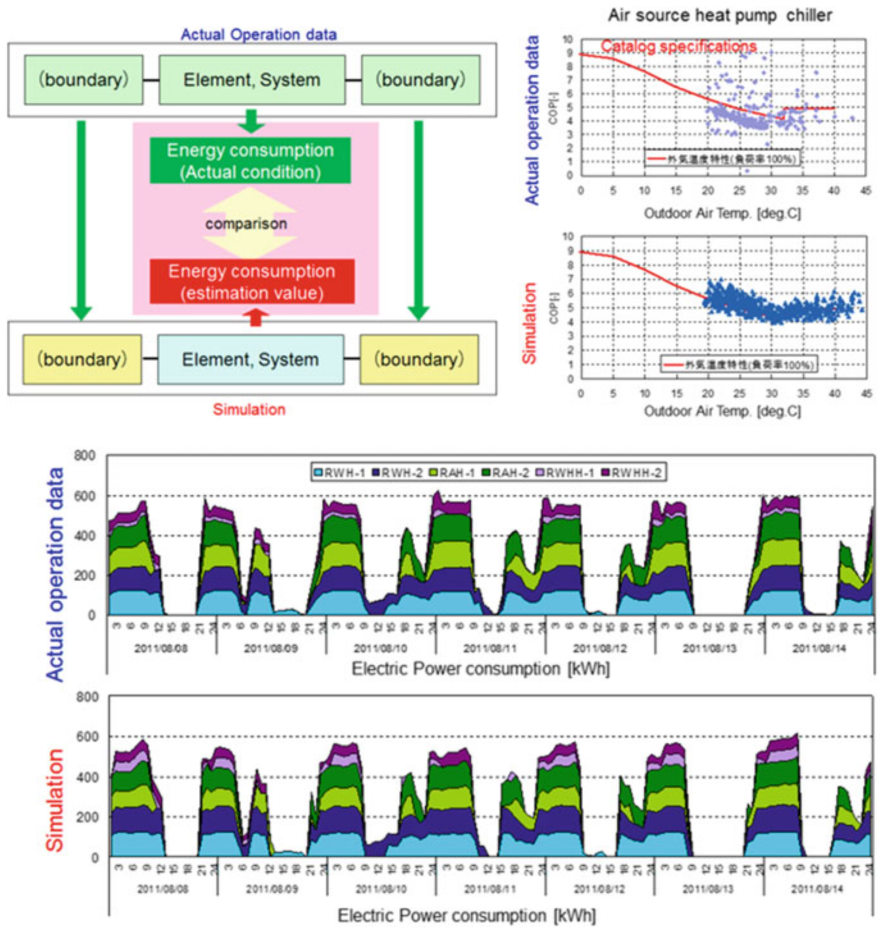

Fig. 5 Example of actual operation compared with system simulation results

5.2 Utilization for an Appropriate Operation

By using system simulation based on actual operational data, it is possible to estimate the power consumption of auxiliary machinery (not obtainable from operational data) to show how operational techniques can be improved. Such an approach has already been used to enhance the energy management system of the TOKYO SKYTREE power plant. In this building, the operator has introduced a simulation system alongside the actual operation monitoring system to determine the appropriate operation method by examining simulation results. For instance, when the outlet temperature of the chiller is raised from 7 °C (actual condition) to 8 °C or 9 °C, the impact on general energy performance due to this change in the control setting can be estimated on the basis of real operational conditions by examining BEMS data in advance. Thus the operator is able to select the best operational conditions by comparing simulation data with real data.

5.3 Utilization for System Commissioning

In regard to energy management in an existing building in which HVAC equipment is due for replacement or renovation, this section refers to the examination of performance verification in the operational phase using system simulation and BEMS data.

An effective use of system simulation in retro-commissioning an HVAC system is illustrated by the case of an 80-year-old building subject to continuous improvement efforts. In the process of retro-commissioning this building, a simulation study on the heat-source system was undertaken in order to determine the effects of operational improvements already carried out as well as forecasts on useful operational improvements in the future. The reliability of the simulation model was tested on actual operational data provided over the years by BEMS. The operational improvement of the following steps (which have not yet been implemented) was estimated: (a) Raising of chilled water outlet temperature for heat source equipment, and (b) Adoption of a variable water flow control for the chilled and heated water pump. A simulation was also performed using the LCEM tool to estimate the effect of switching from the old to the new heat source equipment. The system simulation using BEMS data was able to provide quantitative predictions of the effects of these improvements by identifying the electric power consumed by auxiliary equipment (i.e. percentage of power consumption that had not been measured and could not be identified from operational data alone), quantifying the effect of existing operational improvement methods and estimating the future effects of operational improvement methods.

In another retro-commissioning project, the performance of air-side HVAC systems was verified using operational data derived from BEMS as well as simple short-term measurements. System simulations were conducted for the air-side HVAC system using operational data to evaluate the effect of a future retrofit. The LCEM tool was used to examine and simulate the effect of reducing the electricity consumption of fans by replacing the Constant Air Volume (CAV) air distribution control system with the Variable Air Volume (VAV) system. The results indicated that VAV retrofitting could cut energy consumption by 52% in the summer months and by 62% in the winter months for a typical office floor. The behavior of the air-side HVAC system as well as energy performance after retrofit improvement could be estimated by a system simulation based on actual operational data. With a view to employing VAV for air-side HVAC systems to improve operations, it was demonstrated that system simulation using actual operational data provides more reliable results for the design of improvements.

6 Concluding Remarks

A large proportion of the total energy consumed during the life cycle of a building is for daily operations. Clearly it is important to implement life-cycle energy management to try to reduce such consumption. Under such careful management, actual operational data and a system simulation tool are required to improve operations. BEMS data can be easily captured and operational data can be used effectively. Using data from BEMS, the management group can easily evaluate the current system. Energy management methods and energy simulation tools are already widely employed in Japan. While BEMS has had a large and positive impact, it is generally used merely for data collection. The data obtained in this way is not successfully utilized by building owners. Therefore, the building owner or designer must draw up an intelligent master plan for life-cycle energy management at the initial stages of equipment design and installation, which means introducing BEMS to the building design process.

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Chapter 16
A New Concept for Air-Conditioning in Japan: An All-Air Supplied Induction Radiant Air-Conditioning System and Cool Room

Teruyuki Saito

Abstract In recent years, all-air supplied induction radiant and laminar flow air-conditioning systems have been developed in Japan and are increasingly adopted. This chapter provides an overview of these air-conditioning systems, their performance in terms of energy savings as well as the results of subjective experiments regarding thermal comfort. Furthermore, the concept of a 'cool room' is explained as a way to improving thermal comfort when passing from the exterior to the interior of a building in the summer months. The results of subjective experiments on the effect of such a cool room are discussed as well as guidelines for their design.

1 Introduction

Office air-conditioning systems can be divided into convective and radiant types. In Japan convective types have traditionally been the main type of air-conditioning systems. Radiant types are less suited to the hot and humid summer climate, leading to a risk of condensation on the surface of the cooling panels. In recent years an all-air supplied induction radiant and laminar flow air-conditioning system, called Induction Air Beam, has been developed in Japan and is gaining widespread popularity. This is a hybrid convective air-conditioning system with a radiant effect for dehumidification in summer and humidification in winter, both of which are essential in Japan.

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2 Outline of an All-Air Supplied Induction Radiant and Laminar Flow Unit (Ooura and Urano 2014)

Figure 1 provides an overview of the all-air supplied induction radiant and laminar flow unit (the Induction Air Beam). As can be seen, supply air from the air-handling unit is mixed with the induced room air inside the unit. Subsequently, air is blown into the room from the unit surface after cooling or heating by the radiation panel. A draft is not felt inside the room because the air supply velocity is between 0.2 and 0.8 m/s. In this way the room can be sufficiently cooled without the occupants feeling an uncomfortable draft.

The air-handling unit introduces outdoor air and controls its humidity. The air is cooled to about 13 °C or heated to about 40 °C before travelling to the Induction Air Beam. When cooling, energy consumption of the supply fan can be reduced due to the fact that the supply air temperature of this system is lower than that of a general air-conditioning system. This helps to reduce air volume by 30%. Furthermore, the Coefficient of Performance (COP) of the heat source is improved if an air handling unit can cool the air to 13 °C using water at a temperature of 10 °C.

In the Induction Air Beam, the room air is induced and mixed with the supply air. When the air is returned to the room, its temperature is either 19 °C for cooling or 37 °C for heating. This prevents the occurrence of condensation in the room when cooling.

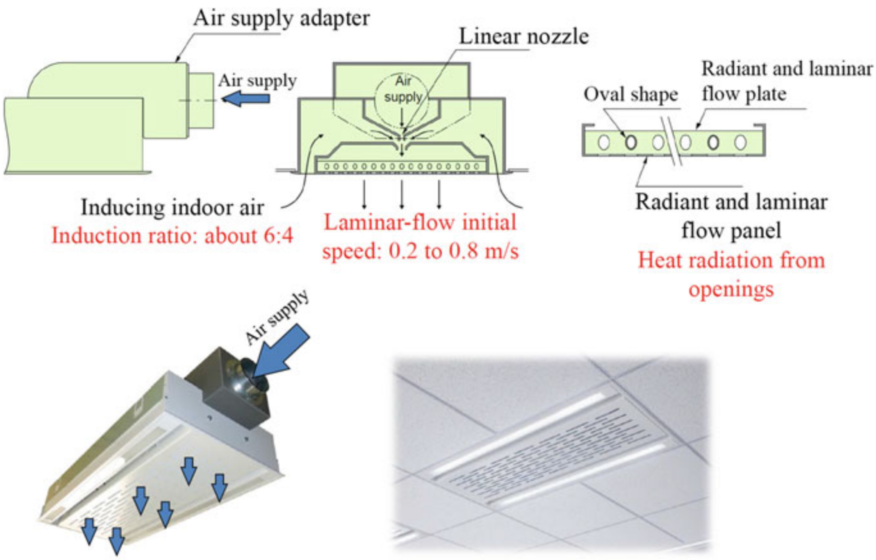


Fig. 1 Overview of an all-air supplied induction radiant and laminar flow unit (Induction Air Beam)

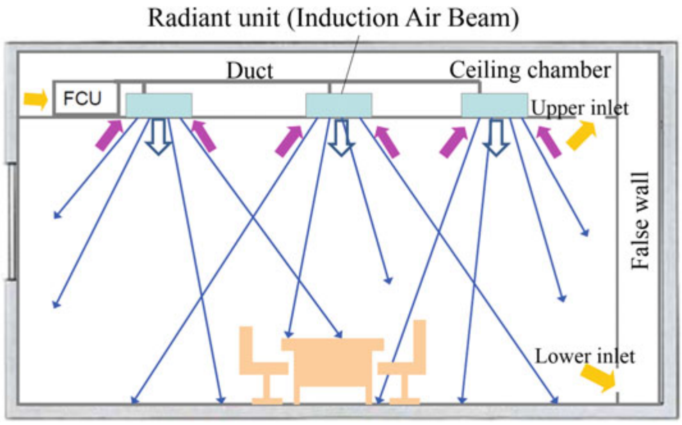
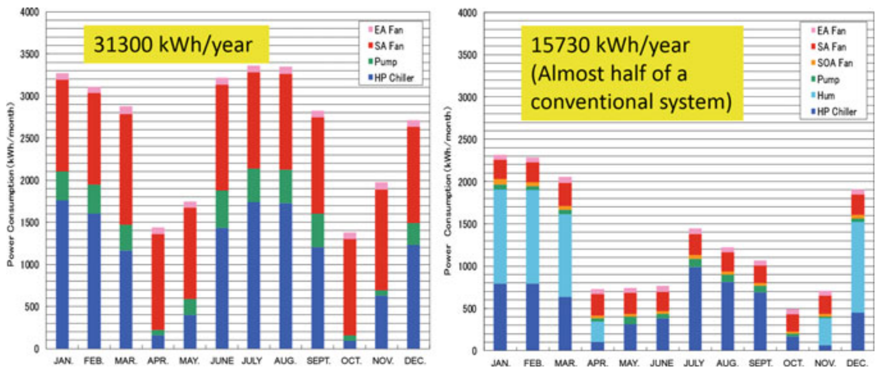


Fig. 2 Illustration of air conditioning using the Induction Air Beam

A relatively uniform thermal environment is formed by the effect of convection and radiation, with little temperature differences across the room. The basic system and resulting airflows are illustrated in Fig. 2. The Induction Air Beam is highly compatible: It can be connected by a duct to a Fan-Coiled Unit (FCU) and a packaged air conditioner in addition to an air handling unit.

In a case study, the energy consumption of an Induction Air Beam was measured in a Tokyo office from July 2011 to June 2012. Figure 3 compares the simulated data for a conventional system with these measurement results. It can be clearly seen that the measured values for power consumption in each month are less than the simulation values. In particular, the energy consumed by the SA fan and HP chiller are much lower, presumably due to the effects of lower air volume,



(a) Simulation for conventional system (b) Real office using an Induction Air Beam

Fig. 3 Comparison of the energy consumption of a conventional air-conditioning system (simulated) and measurements in an office using an Induction Air Beam high-temperature cooling and low-temperature heating. The high power consumption for humidification during winter is due to operation of an electrode-type steam humidifier to maintain relative indoor humidity of 45% or more in the office, although the simulation for the conventional system includes a commonly used vaporizing humidifier. In this comparison, the annual energy consumption for an air-conditioning system using an Induction Air Beam is 50% lower than a conventional system.

3 Measurement of the Thermal Environment in an Experimental Room Equipped with an Induction Air Beam

While the energy savings of the system using an Induction Air Beam have previously been confirmed, before we began our study there was insufficient evaluation of thermal environment and thermal comfort of this air-conditioning system. To this end, we installed the Induction Air Beam in an experimental room in Nagoya University in order to carry out measurements of the indoor thermal environment as well as the subjective experiment (Urano et al. 2014).

The experimental room had one north-facing window. Three Induction Air Beams were placed side-by-side on the ceiling. The water flow rate from a boiler or chiller to a ceiling-embedded FCU was regulated by the radiation temperature of the occupied zone. The FCU heated or cooled return air from the room before passing this to the Induction Air Beam. In addition, a ceiling-suspended indoor unit of another package-type air conditioner was installed on the window side of the room separately from the Induction Air Beam to provide comparison with a conventional air-conditioning system (Fig. 4).

Figure 5 shows the relationship between dry-bulb temperature and globe temperature during air heating. When the three units are running and the room

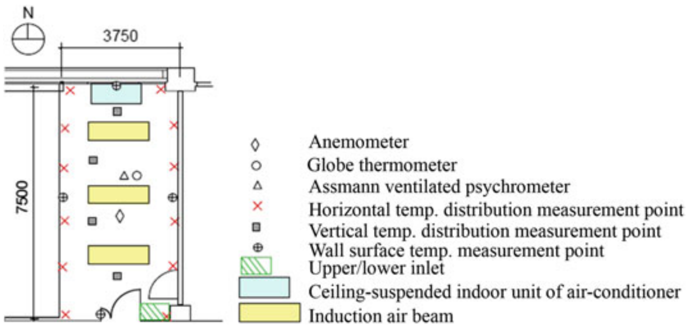
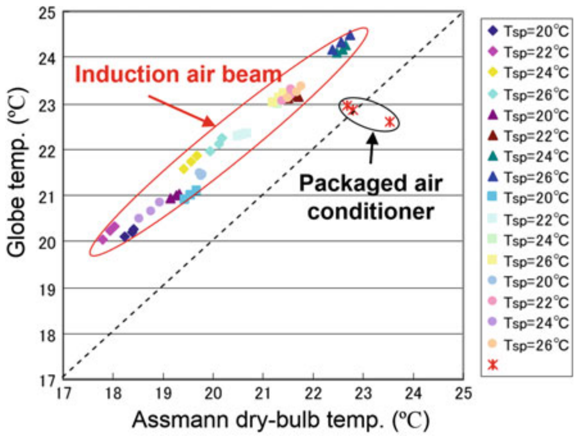


Fig. 4 Experimental room in Nagoya University equipped with an Induction Air Beam and a ceiling-suspended indoor air-conditioning unit

Fig. 5 Relationship between dry-bulb temperature and globe temperature when heating



temperature is stable, a temperature difference of about 1.5 °C exists between the dry-bulb temperature and globe temperature. This is certainly due to the radiation effect from the warmed panel and ceiling surface. When the air conditioner is operated at a similar level to the outdoor air temperature and room temperature setting, the dry-bulb temperature and globe temperature are almost the same. Therefore, it can be stated that an Induction Air Beam provides an indoor environment that feels warmer but is the same level as the dry-bulb temperature.

Figure 6 shows the indoor temperature distribution across the room based on 18 measurements at 1.1 m above floor level using 30-minute average values at stable room temperature. When the number of operating units of the Induction Air Beam is reduced from three to two (at the center of the room and towards the window), the temperature becomes slightly lower and the temperature distribution more uniform. The results for a standard air conditioner are also shown in Fig. 6. Although in this case the area of lowest temperature is also located towards the window, the temperature gradually drops from the center to the periphery, and the temperature gradient is larger than with the Induction Air Beam.

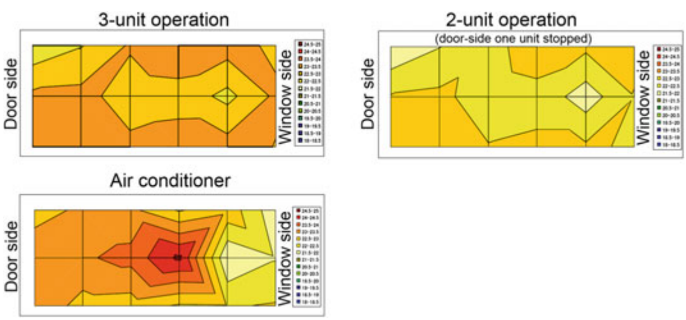


Fig. 6 Horizontal indoor temperature distribution during heating

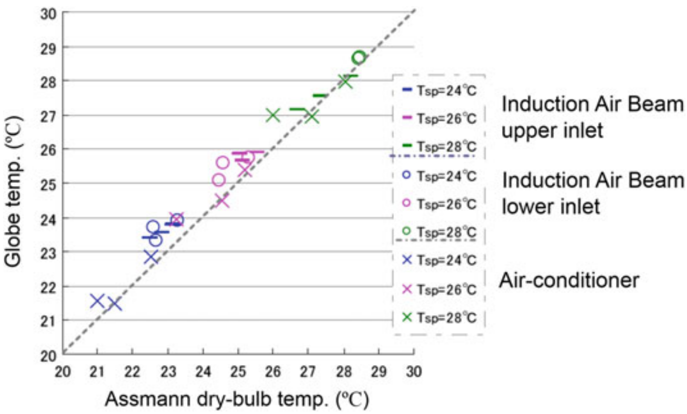


Fig. 7 Relationship between dry-bulb temperature and globe temperature when cooling

From these results, it can be expected that heating by an Induction Air Beam has the effect of radiating heat from the unit and the entire ceiling surface, making the surrounding wall and floor surfaces warmer, and resulting in a uniform horizontal indoor temperature distribution.

Figure 7 shows the relationship between dry-bulb temperature and globe temperature when the room temperature is stable (under cooling) by examining different AC systems and temperature settings. The faster air current from the air conditioner causes the globe temperature to easily match that of the dry-bulb temperature. On the other hand, since the Induction Air Beam produces a much slower air current, the globe temperature is slightly higher than the dry-bulb temperature. Also in the case of cooling, the dry-bulb temperature of the Induction Air Beam reflects the temperature setting more closely than when heating.

Figure 8 shows the horizontal indoor temperature distribution based on 30-minute average values of 18 measurements at 1.1 m above the floor of the stable room temperature. The Induction Air Beam produces the lowest temperature in the

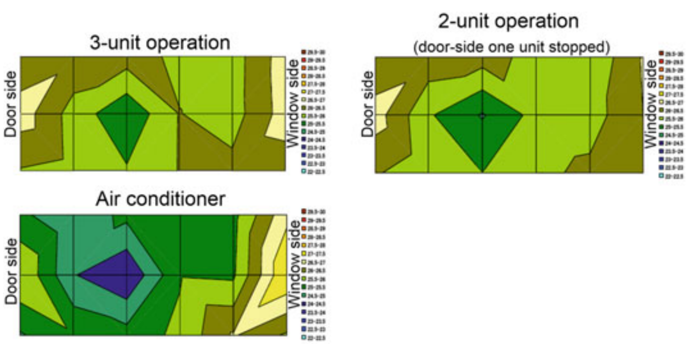


Fig. 8 Horizontal indoor temperature distribution during cooling

center of the room with the door-side/window-side temperatures about 1 °C higher. However, this temperature range is relatively uniform compared to the case of the air conditioner, which has a temperature difference of about 3 °C.

These results suggest that the Induction Air Beam can form a uniform horizontal indoor temperature distribution when cooling.

After evaluating the thermal environment of the experimental room, we carried out a subjective experiment to determine the thermal comfort of subjects entering the room from an adjacent room or from outdoors. When moving from an adjacent room, subjects felt more comfortable when the temperature was regulated by the Induction Air Beam than by an air conditioner.

Figure 9 shows the results of thermal sensation, thermal comfort and room temperature preference after entering this room from outdoors. Subjects feel a certain coolness for 30 min after entering a room in which an air conditioner is set to 25 °C. However, after 40 min, the difference between the three experimental setups is minimal. Subjects feel thermal comfort in the case of the air conditioner immediately after entering a room, but feel more comfortable after 25 min with the Induction Air Beam set to 25 °C. When the Induction Air Beam is set to 25 °C, subjects would like the room temperature to be lower for the first 15 min after entering the room; thereafter, they are happy with the room temperature. On the other hand, they felt the need of an increase in temperature after 40 min when an air conditioner is used.

It can thus be stated that air conditioning using the Induction Air Beam is desirable for occupants who remain for longer periods indoors. However, the dissatisfaction felt immediately after entering a room from outdoors needs to be resolved.

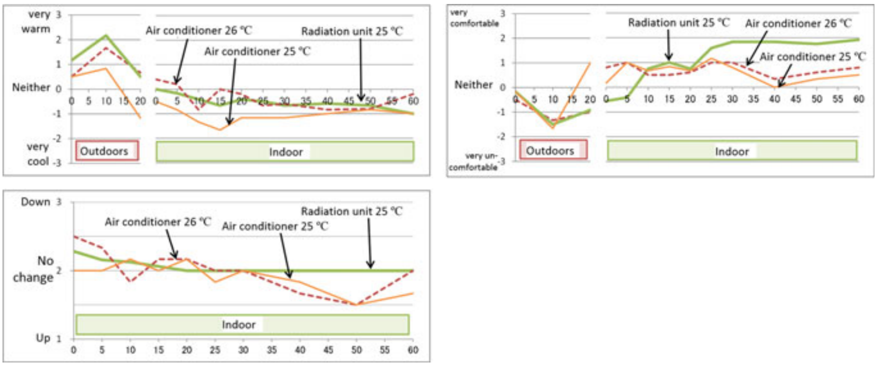


Fig. 9 Experimental results on thermal sensation, thermal comfort and room temperature preference during room cooling after entering from the outdoors

4 The Psychological Effects of Entering a Cool Room in Summer

In Japan, room temperatures are generally maintained at a pleasant 25 °C or 26 °C in the hot summer months. This leads to high energy consumption by air-conditioning systems, accounting for about 50% of the total energy consumed by buildings. In view of the growing need to conserve energy, the Japanese government has recommended maintaining an indoor air temperature of 28 °C with workers encouraged to wear lighter clothing. However, 28 °C is only a comfortable temperature for humans when naked and at rest. The subjective feeling of workers entering an office space at this temperature from outdoors is that the room is simply too hot. This led to the notion of a 'cool room' (Kuno 2007).

A cool room is another room set at a lower temperature than the office space. People who feel that the office space is too warm can simply step into the cool room for a brief period to eliminate their thermal strain. Figure 10 illustrates the use of a cool room.

Since 2009 we have conducted experiments at Nagoya University to investigate how a cool room can help to ensure longer-lasting thermal comfort in office space kept at a temperature of 28 °C. For example, a study conducted in 2010 confirmed that the most effective use of a cool room set to 24 °C was a 20-minute break (Iwata et al. 2011). However, this would be considered an excessive interruption of the working day. To shorten the time needed to bring about thermal comfort, we conducted a new experiment in 2011 using additional fans in the cool room (Matsubara et al. 2012).

Figure 11 illustrates the experimental conditions. The cool room was set at either 24 °C or 26 °C. The subjects were required to remain there for 5, 10 or 20 min. In the experiment in 2011, a fan was installed in the cool room for each subject. To compare results, we investigated thermal comfort when no cool room was provided. In the experiment conducted in 2010, subjects were ask to remain outside in the shade for 30 min before entering the first room set at 28 °C for 5 min. After that, they moved to the cool room set at 24 °C or 26 °C and stayed there for a time specified before returning to the first room for 60 min. In the case of no cool room, the subjects stayed in the first room for 80 min after entering from outdoors.

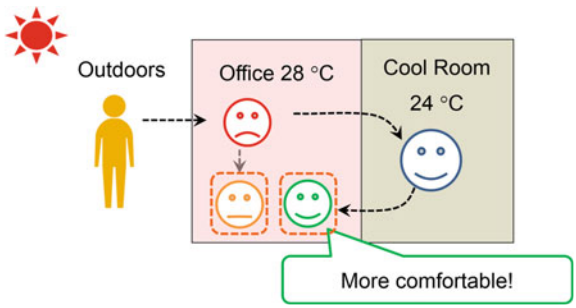


Fig. 10 How a cool room works

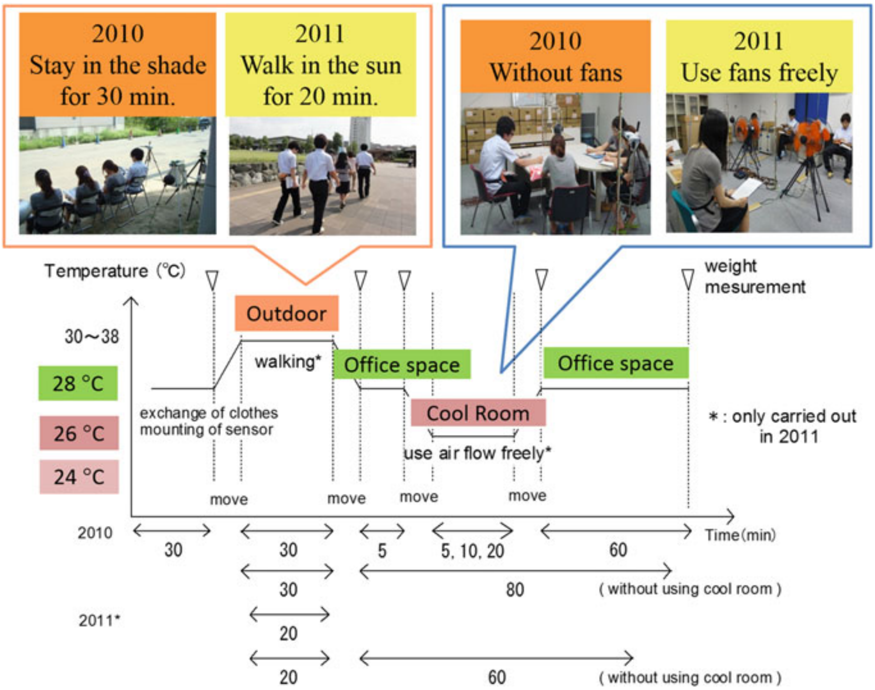
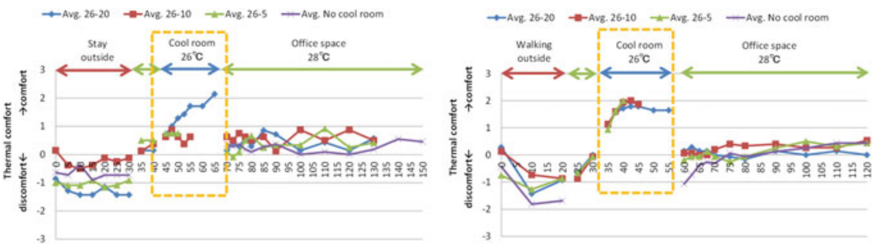


Fig. 11 Experimental conditions

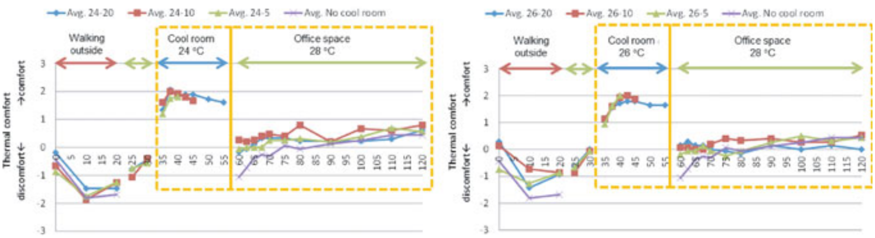
In the experiment conducted in 2011, subjects walked outdoors in the sun for 20 min. In the cool room each subject had a fan whose speed they could freely regulate. The time spent indoors in the case of no cool room was 60 min. Otherwise the conditions were identical to those in 2010.

Figure 12 shows the results of thermal comfort in 2010 and 2011. Comparing 2010 with 2011, subjects felt more comfortable when fans were provided (in 2011), even though the cool room was set to the same temperature of 26 °C.



(a) Results in 2010 (b) Results in 2011

Fig. 12 Results of thermal comfort testing in 2010 and 2011



(a) 24 °C cool room (b) 26 °C cool room

Fig. 13 Results of thermal comfort under two different cool room temperatures (2011)

Figure 13 shows the results of an experiment on thermal comfort from 2011 using a cool room at temperatures of 24 °C and 26 °C. Subjects expressed a similar comfort rating while staying in the cool room regardless of the room temperature. This result can be attributed to the availability of fans.

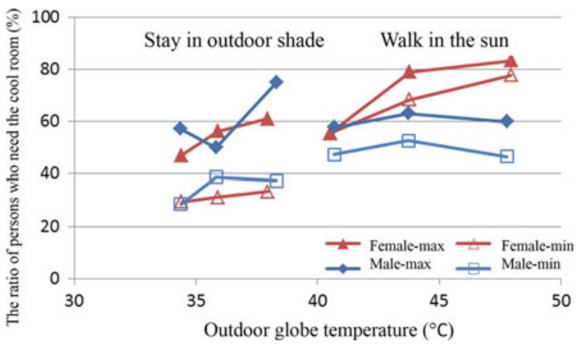
When the office space temperature was set above 26 °C, subjects felt some thermal discomfort. However, they felt more comfortable for a short period on entering the office space after staying in the cool room set at 24 °C for 10 min. They continued reporting higher comfort when the cool room was used, confirming the effectiveness of staying in the cool room for 10 min.

Subsequently, we summarized the experimental results and considered how to draw up planning guidelines for a cool room. According to our results, some people express no need of a cool room. Hence, we calculated the proportion of individuals who require a cool room depending on the outdoor conditions. The results are shown in Fig. 14. We estimated that a maximum of about 80% of women and 60% of men would use a cool room when passing from the outside to the inside of a building.

Subsequently, we devised a formula to calculate the appropriate size of a cool room in consideration of various conditions shown in Fig. 15.

Figure 16 is an example of a chart used to estimate the relative size of a cool room. This figure shows that the required size of a cool room is about 10% of the

Fig. 14 Proportion of people who need a cool room



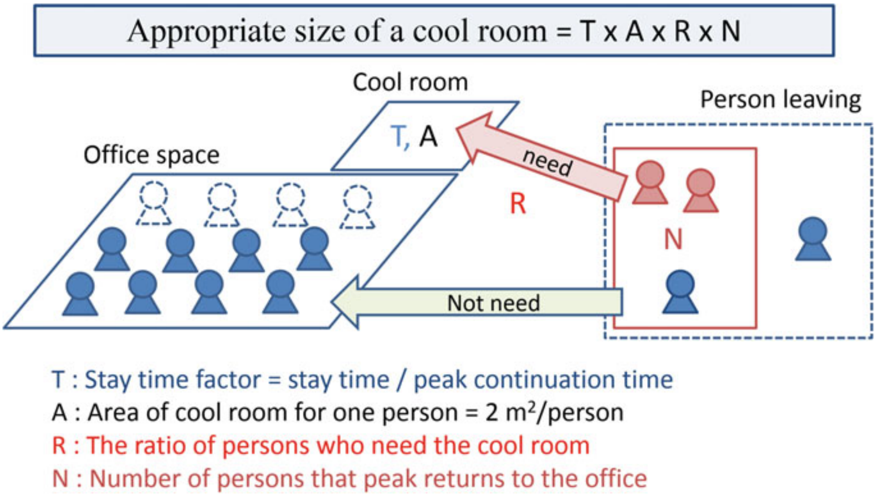
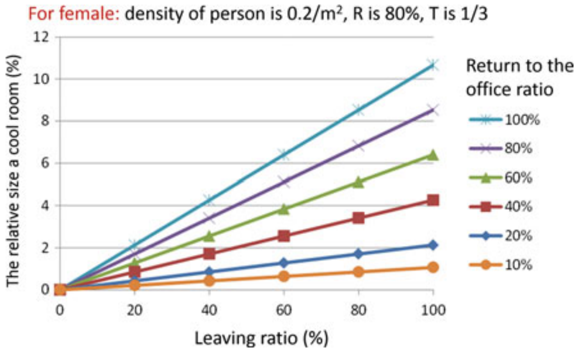


Fig. 15 Calculation of the appropriate size of a cool room

Fig. 16 Example of a chart to estimate the relative size of a cool room



total floor area, even in a situation when people leave an office and then return at the same time to an office in which are many women. In an office which a person leaves and then returns separately, the required area decreases to less than 10% of the total floor area. Therefore, the use of a cool room can decrease the energy required to cool the entire office space while also improving the thermal comfort after entering a room from outdoors.

5 Concluding Remarks

I began this chapter by introducing an all-air supplied induction radiant and laminar flow air-conditioning system, Induction Air Beam, developed in Japan. This is gradually becoming adopted throughout the country. Later I explained the concept of a cool room, showing how this can help to improve thermal comfort in an office setting where the temperature is set to 28 °C in summer. I also proposed some guidelines for planning a cool room. It is proposed that the use of a cool room is able to decrease thermal discomfort immediately after entering a room from outdoors when an all-air supplied induction radiant and laminar flow air-conditioning system is installed.

Currently, we are investigating thermal comfort and energy conservation in the university lecture room by installing the all-air supplied induction radiant and laminar flow air-conditioning system in addition to the one used in the office. However, it should be noted that the use of a cool room can be obviated by better regulation of the outside environment in urban areas through, for example, increasing the size and number of green areas. Even though this would negatively impact the relevance of our research, I sincerely hope that such urban planning measures can be implemented.

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Part VI
Future Challenges of Planning

Chapter 17
Operationalizing Urban Resilience—Learning from the Past while Preparing for the Future. The Case of Dresden, Germany

Paulina Schiappacasse

Abstract Alongside inclusive prosperity and social inclusion, urban resilience is one of the key transformative commitments for promoting and ensuring environmental sustainability in the Quito Implementation Plan. Urban resilience emphasizes the importance of learning and being proactive, in creating responses that prepare cities and communities for unexpected events. However, there still exists a considerable gap between ideas of resilience and their implementation, especially regarding how resilience can be measured and how it can be rendered observable. The article discusses how the notion of resilience can be applied to cities in order to identify principles for the replication or scaling up of urban reaction and/or adaptation responses. During the course of the 20th century the city of Dresden was frequently affected by dramatic events (wartime bombing and firestorms, political upheaval and flooding) and thus seems a suitable laboratory to understand the methodological difficulties in identifying sources of urban resilience. Findings may have repercussions for the Quito Implementation Plan in helping to operationalize the concept of resilience.

1 Operationalizing Urban Resilience

Despite a large number of contributions concerning the meaning of urban resilience (Meerow et al. 2015), there is still a lack of consensus regarding its empirical application. The identification of resilience involves practical difficulties (Carpenter et al. 2005) such as determining which variables to measure, developing standard metrics (Cutter et al. 2008), making resilience observable (Nyström et al. 2008), locating and finding measures for thresholds (Eakin and Luers 2006), acquiring sufficient data (Malone and Brenkert 2008) as well as measuring resilience in a context of multiple fast and slow-moving drivers of change (Nelson et al. 2007).

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Findings of a bibliometric analysis by Schiappacasse and Müller (2017), show that existing tools and methods to analyze resilience are highly diverse, in terms of their characteristics, targets and application solutions. Consequently, no comprehensive methodologies are currently available to assess cities' reactions to shocks or to indicate how resilient capacity can be enhanced. This may be a reaction to the complex and open character of urban systems, although this constraint is supposed to be one of the concept's strength (Berkes et al. 2008). Defining urban resilience, for instance, as the ability to *transform*, the capacity to *prepare, respond and recover* (Table 1) is too vague if the related terms are not explained in a clear and measurable way. Meerow et al. (2015: 38) agree that resilience has not yet been sufficiently well explained, pointing out that definitions are "*underdeveloped with respect to incorporation of crucial concepts*" such as urban, system equilibrium, adaptation and the time scale of action. This lack of conceptual clarity in the terms involved, may be attributed to the fact that definitions have been borrowed from ecological resilience under the assumption that there are no essential differences in behaviour and structure between urban and ecological systems. Yet there are indeed some basic differences. On the one hand, we know that urban areas evolve over time and space as a result of constant interactions between social, economic, political and environmental processes operating over multiple scales (region-city-neighbourhood). On the other hand, individuals, communities, institutions and businesses have the capacity to learn and innovate based on past experiences. Consequently, the degree and the capacity to which cities might be able to "*tolerate alteration and…. reorganized*" is influenced by multiple spatial and temporal interactions between the city domain(s) and the type of shock(s) (Figs. 1 and 2).

Table 1 Definitions of urban resilience

Author, year	Understanding of resilience
The Rockefeller Foundation and Arup (2014: 3)	"…the capacity of cities to function, so that the people living around and working in cities—particularly the poor and vulnerable—survive and thrive no matter what stresses or shock they encounter"
Wagner and Breil (2013: 114)	"…the capacity and ability of a community to withstand stress, survive, adapt and bounce back from a crisis or disaster and rapidly move on"
Ultramari and Rezende (2007: 51)	"…the ability to transform and retransform urban spaces"
Colten et al. (2008: 38)	"…the capability to prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to public safety and health, the economy and security"
Campanella (2006: 141)	"…the capacity of a city to rebound from destruction"
Alberti et al. (2003: 1170)	"…the degree to which cities are able to tolerate alteration before reorganising around a new set of structures and processes"
Comfort (1999: 21)	"…the capacity to adapt existing resources and skills to new situations and operating conditions"

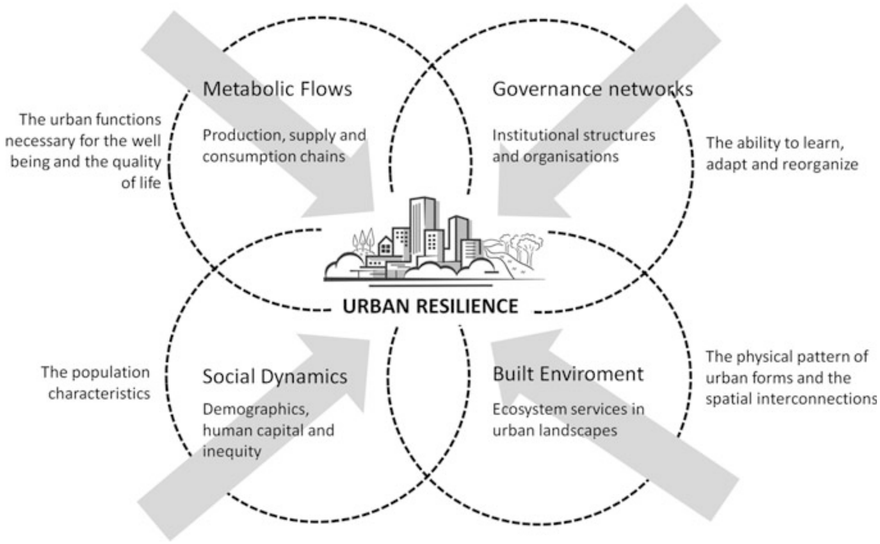

Fig. 1 Themes/domains to prioritize and focus research on urban resilience. *Source* Resilience Alliance (2007). Drawing by Sarah Strugale

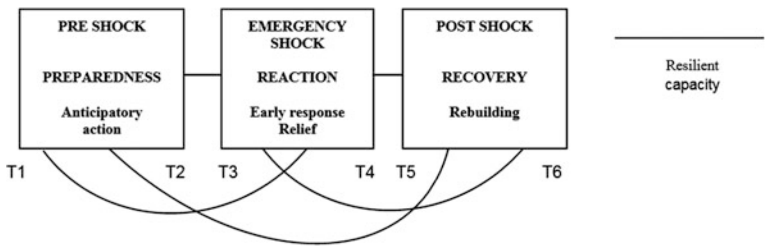

Fig. 2 Temporal contexts for understanding resilient capacity

As a starting point to scrutinize how the notion of resilience can be applied to cities, a four-step methodological framework is proposed:

(a) *Specify the object of study*. This constraint, proposed by Carpenter et al. (2001), addresses the need to clarify the object of study by distinguishing the resilience *of what to what.* Regarding *resilience of what*, there are four general features of cities that can be affected by shocks (Resilience Alliance 2007): (a) metabolic flows with regard to urban functions (production, supply and consumption chains) necessary to sustain citizens' well-being and quality of life; (b) governance networks concerning institutional structures and organizations and their ability to learn, adapt and reorganize to deal with urban challenges; (c) the social dynamic of people as citizens, consumers and users; and finally, (d) the built environment, which defines the physical pattern of the city (Fig. 1).

Concerning *resilience to what*, it is vital to clarify which type of shocks can push the city over the threshold of some controlling variable. Shocks can arise in diverse ways. Their origins can be natural (earthquakes, floods, etc.), economic (market shocks, trade prohibitions, etc.), biological (mainly diseases), social (demographic shrinkage, riots, etc.), technological (generally large-scale industrial accidents) and/or political (change of government, terrorism, wars, etc.) (Table 2).

(b) *Consider the spatial and temporal contexts*. Researchers have to clearly specify the limits of the system, defining the time period and the spatial scale adopted for the analysis of resilience capacity. Shocks can vary in their impact, affecting specific areas of the city to varying degrees, the city as a whole, or indeed a group of cities and/or countries. As Cumming et al. (2006) argue, many of the problems encountered by societies in crisis management arise from a mismatch between the scale of institutional management and the scale of the processes being managed. Additionally, it is important to define whether the research is oriented towards the derivation of lessons from the pre-shock situation (preparedness), from the emergency itself (reaction), the post-shock situation (recovery) or all three phases (Fig. 2). From a methodological perspective, how long we will give to recover and what can we expect?

(c) *Connect the understanding of resilience with the variables to be measured*. Resilience can be measured by pinpointing suitable indicators and metrics that reflect key attributes of the specific understanding of resilience (Table 1). This process allows researchers to reflect on the fact that resilience is a means and not an end (Quinlay 2014). As Reghezza-Zitt et al. (2012: 2) argue: "*resilience*

Table 2 Threats and risks considered in the German National Strategy for Critical Infrastructure

Natural events	Technical failure/ human error	Terrorism, crime, war
Extreme weather events storms, heavy precipitation, drops in temperature, floods, heat waves, droughts	System failure insufficient or excessive complexity of planning, defective hardware and/or software bugs	Terrorism
Forest and heathland fires	Negligence	Sabotage
Seismic events	Accidents and emergencies	Other forms of crime
Epidemics and pandemics in man, animals and plants	Failures in organization shortcomings in risk and crisis management, inadequate coordination and co-operation	Civil wars and wars
Cosmic events energy storms, meteorites and comets		

Source Federal Ministry of the Interior (2009) *pre-exists the impact, it is a potential revealed through the impact*". Some scholars, for instance, are interested in a city's capacity to "recover" from economic or natural shocks (recessions, floods, etc.) that derail specific indicators from the previous development pathway of growth (Hill et al. 2011: 4). In this case, the pre-shock situation (Fig. 2) is assumed to be the equilibrium state (engineering resilience) while the "capacity to return" or the "speed of return" is measured by indicators such as employment, poverty, social assistance or environmental quality. In this cities can either rebound from disaster or they can face long-term decline (Vigdor 2008). When a city does not experience a downturn, it can be classified as "shock-resistant". If it is adversely affected by the shock before returning to its prior growth path within a relatively short period of time, it is considered "resilient"; if not, it is seen as "non-resilient" (Hill et al. 2011). Pendall et al. (2010) suggest that it is more precise to call a region resilient when it responds in ways that maintain or even increase the production of goods and services at an equal or higher rate. Although the single-equilibrium perspective is rather reductionist and sectoral, i.e. "a resilient society is one where local economies are stronger", this approach offers one important and "legitimate metaphor" for understanding the evolution of regions (Pendall et al. 2010: 3).

Other researchers define resilience as the ability of a city to withstand, adapt or change while undergoing some shock (Table 1). Under this "socio-ecological" perspective, urban complexity is determined by the existence of infinite equilibriums in continuous adjustment, with shocks operating at different temporal and spatial scales. Here, being resilient or non-resilient is a process (of economic transformation, institutional reorganization, reconstruction or the injection of public funds) measured by narratives or variables that are more qualitative than quantitative. The transformation process of the industrial Ruhr region (*Ruhrgebiet*) into a centre of culture and tourism is a good illustration of this way of understanding resilience.

(d) *Identification of sources of resilience*. A city's capacity to prepare, withstand and recover from shocks seems to be connected with specific characteristics that enable or hinder reactions to impacts. These characteristics (as proposed by The Rockefeller Foundation and Arup 2014; Tierney 2014; Zimmerman 2001; Comfort 1999) include:

- *Diversity*, which empowers the city by ensuring a range of knowledge (e.g. consultation processes) and spatial patterns (e.g. land use, culture).
- *Collaboration and communication* regarding all levels of decision-making. This is a cross-sectoral and trans-boundary issue that requires comprehensive integrated approaches. It is crucial for successful reaction to changes as well their forecasting.
- *Memory*, generally defined as the ability of a city to preserve knowledge and information. This allows future plans and actions to be based on previous experiences.

- *Flexibility*, referring to the ability to adopt alternative strategies in response to changes or crises.
- *Adaptive capacity*, which is based on concepts such as governance and a city's robustness in response to events according to the set of available resources (economic capital, technology, infrastructure, information, knowledge and social capital).
- *Leadership and coordination*, understood as a committed city government taking decisions based on evidence, engaging with stakeholders, and in sectoral alignment with the national and regional levels.

By analysing the sources of resilience (those that have been successful and those that have not), we can buttress some properties or promote new ones to ensure future development.

In the following sections, we discuss how the methodological framework for the study of urban resilience described above can be operationalized in practice using the city of Dresden as a laboratory. First, urban resilience is analyzed from a single equilibrium perspective (capacity to bounce back). Second, we describe how one city domain, i.e. the built environment, has been affected over previous decades by various shocks such as wartime bombing, political upheaval and flooding (adaptation). Third, we look at how one particular shock, the severe flooding of 2002, affected various interconnected city domains and how the city reacted to a similar event in 2013.

2 Case 1—Resilient Capacity of Dresden's Domains to Bounce Back

During the 19th and the beginning of the 20th century, Dresden was an industrial centre with a large number of small- and medium-sized companies. The diverse industries to be found included electronics (Radio H. Mende, Seidel and Naumann, Richard Gäbel & Co.), food processing (Jordan & Timaeus), banking (Dresdner Bank), photography (Zeiss-Ikon Ag) and cigarette production (Bernsdorf & Co.). In 1929 ten major companies with more than 1,000 employees had settled in the city.[1] However, many of the industries that made the city prosperous closed down or were transformed (armament production) during World War II (WWII) or later disappeared under communist rule.

From a single equilibrium perspective (capacity to return/recover), Dresden was not resilient to the dramatic shocks experienced during the 20th century (Fig. 3). For example, if a specific indicator such as population is analyzed, the city has not bounced back to its pre-war state. In May 1939 Dresden had a population of

[1] www.dresden.de: Website of the City of Dresden (retrieved April 26, 2017).

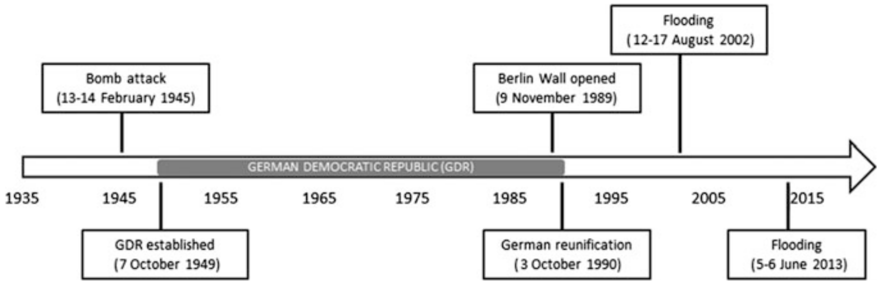

Fig. 3 Dresden—Main shocks affecting the city since 1945

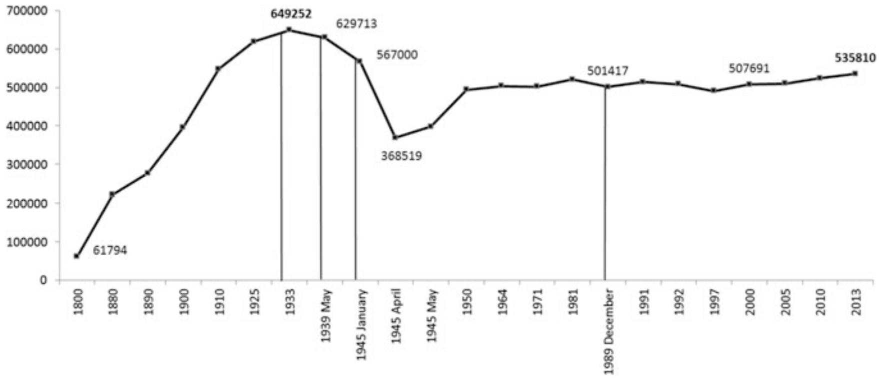

Fig. 4 Dresden population development. *Source* Elaborated from data of the Landeshauptstadt Dresden 2013

629,713, making it the seventh largest German city after Berlin, Hamburg, Munich, Cologne, Leipzig and Essen (Fig. 4).

Since German reunification, demographic and economic development has been rather unsteady. The city and indeed the state of Saxony are still afflicted by many social and economic problems stemming from the collapse of the former socialist system, including high unemployment.[2] According to the Deutscher Städtetag (Association of German Cities),[3] in 2015 Dresden was Germany's twelfth largest city with a population of 543,825. Certainly, Dresden has failed to achieve a rebound to its pre-war indicators. But how does the image change if the 40 years of East German government are considered to be a kind of slow-burn shock (Fig. 3)? Comparing data on GDP from 1989 and 2009, we see that Dresden has undoubtedly been resilient

[2]In 2017 unemployment in the former East German states is about 8.5%, while in former West Germany it has risen to 5.6%. In the City of Dresden the rate is 7.3% (Bundesagentür für Arbeit, 2017, Arbeitsmarkt in Zahlen – Arbeitslose nach Kreisen).

[3]www.staedtetag.de: Website of the Association of German Cities (retrieved April 26, 2017).

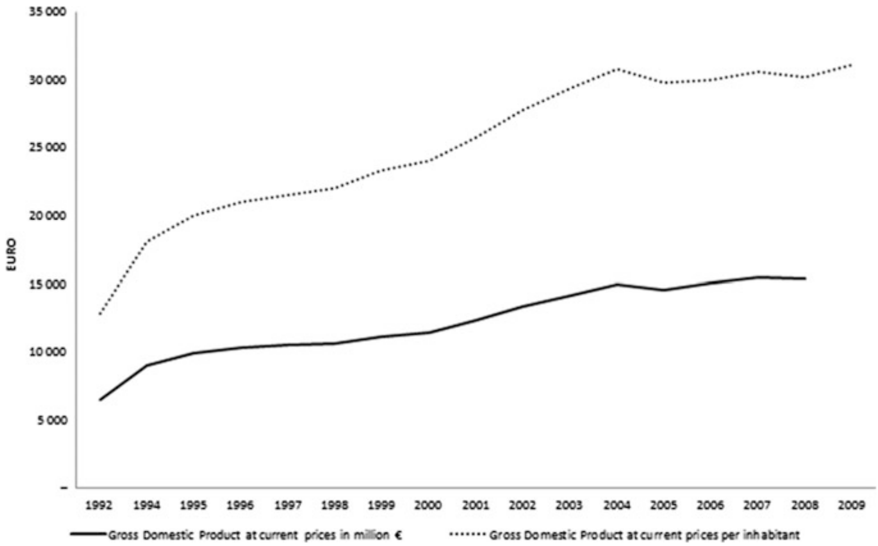

Fig. 5 Dresden's economic development (1992–2009). Per capita Gross Domestic Product at current prices. *Source* Elaborated from data of the Statistisches Landesamt Sachsen (2009)

(Fig. 5). However, it is important to remember that the economic conditions after reunification have undergone significant fluctuation. The first phase of reunification was characterized by the collapse of former East German industries and large-scale emigration to the west. Jobs were lost, and despite extensive measures to encourage early retirement, retraining and employment through special programmes, the unemployment rate increased to about 15% in the former East German states between 1989 and 1995 (Hauser 1997). The process of economic integration was fast: the East German Mark was replaced by the Deutsche Mark on a basis of parity, while wages and incomes were simply translated at face value into the new currency.

Many of the jobs that were created required new qualifications. Employment quickly fell to about 65% of the level in the GDR (Weber 2003). The new regions (Länder) received strong federal support for infrastructure, housing, business and education through the "Aufbau Ost" (a national programme to build up the eastern states). Subsidies ranging from 15 to 50% were offered for new business investment (Weber 2003). Around 300 microelectronics companies including Siemens (since 1996), and the American semiconductor AMD (since 2005, now GlobalFoundries) transformed Dresden into a "Saxon Silicon Valley". Former East German companies such as Rotkäppchen (a producer of sparkling wine), Florena (cosmetics) and Fit (detergent) are examples of successful privatizations (Wiedemann 2003). New firms also settled, such as Volkswagen, which produced the luxury Phaeton model in the heart of the city. Furthermore, the "Aufbau Ost" campaign has enabled the Max Planck Society and other research institutions to inject money and talent to create institutes of international standing. After analyzing the macroeconomics of the German unification process in 2005, Wiesenthal concluded that "*comparing East Germany's present situation with the state of the late GDR, one can easily see that the eastern economy has made tremendous progress*" (Wiesenthal 2005: 43). These economic transformations cannot be solely attributed to massive public funding; other local factors such as the high educational and training standards, the presence of research institutions, few bureaucratic barriers and the quality of life have played a crucial role in attracting investors (Weber 2003). In recent years, the Saxony semiconductor industry has been squeezed by financial crisis. In 2009 the second largest chip producer, Qimonda, faced insolvency, leading to around 3,000 job losses (Wink et al. 2016). While the economy has subsequently recovered, the growth rates of the semiconductor industry in Dresden are greatly reduced (Kluge et al. 2012). Although Saxony's economy is one of the most successful in the former East German states, it is still unable to raise the level of employment. Thus, when the current economic and fiscal conditions of the city of Dresden are compared with cities in parts of western Germany, the picture of resilience once changes one again.

3 Case 2—Resilient Capacity of Dresden's Built Environment to Multiple Shocks

From the multi-equilibrium perspective, Dresden's built environment domain (Fig. 1) qualifies as a surprisingly dynamic and resilient sector. In February 1945 the historic centre of Dresden was destroyed by Allied bombing along with most of the inner suburbs (Fig. 3). Public utilities and facilities were crippled and, according to British assessments, 23% of the city's industrial buildings and 56% of dwellings were seriously damaged (Angell 1953). The old city was reduced to a mass of rubble. Due to a severe lack of manpower from wartime casualties, all women aged between 15 and 50 were required to clear away the rubble as part of the National Reconstruction Works (*Nationales Aufbauwerk*). These women became known as the "rubble ladies" (*Trümmerfrauen*). The remaining debris was then removed by a well-organized rubble railway (*Trümmerbahn*). Due to these efforts, the city centre was cleared of the enormous mounds of rubble in the first year after the war. Shortly thereafter, the GDR authorities faced the challenge of a housing shortage. The existing, largely pre-war, housing stock was rundown, often with wartime damage still visible. As a first step, Soviet-inspired buildings and squares emerged from the debris during the 1950s. Later, as the economy slowed, the Soviet-style building boom went into decline, ushering in the era of low-cost building. Instead of the former single-family buildings under private ownership, large pre-fabricated blocks dedicated to social housing were constructed (*Plattenbauten*). The traditional Baroque design of central Dresden was reverted obliterated in many areas.

In the post-reunification 1990s, the city was afflicted by out-migration and population shrinkage (Fig. 4). Economic growth was dominated by the construction sector, highly subsidized through fiscal incentives. New infrastructure, housing and industrial parks were built to attract investors. The resulting housing glut served to depress rents and made it unprofitable to renovate old houses. Pre-fabricated blocks were no longer viewed as attractive places to live so that the number of vacant dwellings shot up (Weber 2003). In response to population contraction and high levels of vacancy, thousands of *Plattenbauten* apartments were renovated to a high standard, thereby reducing housing density and creating a more varied and individualised landscape. The Stadtumbau Ost program offered subsidies to housing associations and developers to demolish many apartment buildings. Simultaneously, Dresden has confirmed its obsession with the past in its revival of the old historic centre, the Neumarkt, where numerous buildings have been reconstructed with their pre-WWII facades.

Considering only its built structure domain (Fig. 1), we can summarize by saying that Dresden has been one of the biggest post-reunification "winners" (regarding resilience), as in recent years the average price for apartments has been the fourth highest in eastern Germany after Berlin, Potsdam and Rostock (data for 2014–2016, TAG Immobilien 2016). Of course, one side effect has been to make the city more expensive and socially exclusive. Regarding the evolution of the physical pattern of Dresden, new questions arise: Are we actually talking about city resilience? Was Dresden's built environment resilient due to the contribution of the *Trümmerfrauen*, the decision to construct *Plattenbauten* and their further scaling down by means of large public subsidies? Are we simply addressing the capacity of people to adapt to stresses in the built environment? Is merely the built environment domain resilient or the city as a whole?

First, notions of path dependency (how the past shapes the future) are seen to either enable or constrain Dresden's capacity to react to stresses. The processes of reaction/adaption need to be contextualized as embedded within the structural process of change: the accumulation of rubble from wartime destruction and the housing shortage within the local economic circumstances of the time as well as the high level of housing vacancies within the stage of demographic shrinkage. Second, Dresden's resilience capacity is understood here as the collective or individual capacity to evolve with and adapt to disturbances affecting the built environment. The examples discussed above show three different adaptation pathways: the capacity of the city of Dresden to incorporate the *Trümmerfrauen* and the *Trümmerbahn* in the post-war reconstruction (reactive), the ability to choose *Plattenbauten* as an alternative to deal with housing shortages (proactive) and the choice to downscale building structures to cope with demographic change (proactive). Hence, adaptive capacity to structural shifts is the key source of resilience in the case of Dresden. In other words, we highlight the city's historical robustness and political capacity to respond to events affecting the built environment according to the set of resources available at the time, namely knowledge and innovation as well as human and financial resources.

4 Case 3—Resilience Capacity of Various Domains in Dresden to Floods

Before August 2002, the inner city of Dresden was never seriously flooded, and so there was little experience and preparedness regarding comprehensive flood risk management. Flood management in Dresden "*relied more on retention areas than on technical flood protection*" (Kreibich and Thieken 2009: 51) as the Elbe flood plain had the status of a protected area for reasons of landscape conservation. Concerning emergency planning, managers were uncertain of their responsibilities and powers (Keys 2005), and the city did not possess an early warning system.

A rapid and unexpected succession of floods events in August 2002, during which the Elbe reached its highest recorded level, inundated the inner city and central residential districts of Dresden (Fig. 3). Media articles testify to the selfless action by inhabitants and volunteers, in stark contrast to the lack of coordination on the part of officials at all levels of government. Thousands of volunteers were involved in the disaster relief operation led by the German Armed Forces, the Federal and Regional Police, the Fire Department, the German Red Cross and various non-governmental organizations (Richter et al. 2009). Despite efforts to put up barriers, water advanced through the historic old town, forcing the city's art galleries and museums to evacuate their collections in "*one of the swiftest salvage operations ever mounted to save priceless works of art*" (Taboroff 2003). In the affected residential districts, the local inhabitants were largely left to their own devices during the worst of the flooding. In most cases, the evacuation of about 35,000 people (according to DKKV 2003) was initiated by local residents, with parts of the city completely abandoned after their departure. Summing up, the majority of the flood responses were crisis-driven (Keys 2005) and all city-domains (Fig. 1) showed a lack of resilience in terms of preparedness and reactions to floods.

After the event, basic services and functions were patchily restored. A week after the worst of the flooding, the main tourist area had largely been cleaned up, whereas only a few hundred meters from the centre some streets remained covered by a thick layer of mud for several weeks. Media and charitable organizations made an emotional call for assistance and donations (Krauß and Rulfs 2003). The reaction was considerable. For instance, three months after the flood, several artists raised money by auctioning famous items. The German government established the Reconstruction Support Fund to finance rebuilding and to compensate public and private entities (Socher and Böhme-Korn 2008). Furthermore, the flood event precipitated a consideration of and orientation towards flood protection and management disaster in Germany. What began as a catastrophe subsequently became an opportunity for change at all administrative levels.

The **Federal Government** responded by transferring responsibilities for disaster management to the local and regional levels (Länder) and by introducing new legislation to increase the variety and scope of individual assistance (Mechler and Weichselgartner 2003). The government adopted a 5-point programme to prevent flooding: Interstate action plans for river areas, European cooperation on flood prevention, assessments of riverbank reinforcement, short-term measures for flood protection as well as improved coordination and crisis management. This programme formed the basis for the “Act to Improve Preventive Flood Control 2005”.[4] Under the new law, states are obliged to designate additional areas as flood plains, to inform the general public about decisions and to ensure that soil erosion and pollution of water bodies are prevented or reduced (Federal Law Gazette 2005).

The State of Saxony reviewed its Protection Strategy, which today is based on three pillars: sustainable reconstruction, flood protection and flood prevention. Technical measures such as the redesign of water infrastructure or the construction of new reservoirs were introduced in parallel with the elaboration of flood protection concepts for the entire catchment area of the Elbe as well as the re-organization of the Saxon Flood Alert System (Saxon State Ministry of the Interior 2006).

The Dresden City Council ordered the repair of the flood damage, and commissioned the Environment Office to design a modern flood control system. This resulted in the creation of a detailed Flood Prevention Plan (Landeshauptstadt Dresden 2008). Two additional trenches about 50 m wide have been dug to keep the inner city safe by diverting floodwater downstream. In addition, the flood regulation system (retention basins and water reservoirs) located outside the city area has been re-evaluated. After the flood, precautionary measures were undertaken by 42% of households (Kreibich et al. 2005). Moreover, the local government and civic society, strongly supported by the media, participated in lengthy formal and informal discussions on the need to overcome failure and implement new actions to protect all city domains (Fig. 1).

Remarkably, Dresden suffered another “once in a century” flood in June 2013. This time round, however, there were no major impacts to the various domains (Fig. 1). The city thus provides a good example of the importance of learning from the past (memory as a source of resilience) and of being proactive in creating responses that prepare cities and communities for unexpected events. Governance networks, including the media, played a crucial role in fostering society’s capacity to learn, adapt and reorganize ways of coping with urban challenges. The 2002 flooding of Dresden can be considered a “window of opportunity” to make the city more resilient to sudden shocks.

5 Conclusions

Table 3 provides a methodological framework to scrutinize how the notion of resilience can be analysed in urban areas. The assessments of past reactions to events can assist city managers and politicians prepare and plan for the future. Over the years Dresden has been systematically affected by dramatic events and

[4]Gesetz zur Verbesserung des vorbeugenden Hochwasserschutzes.

Table 3 Methodological approach to analyze the notion of resilience

Step/cases	Case 1	Case 2	Case 3
Object of study	Resilience of governance networks and metabolic flows (economic sector) to multiple shocks	Resilience of the built environment to multiple shocks	Resilience of governance networks, metabolic flows, built environment and social dynamics to floods
Spatial and temporal context	City within the regional and national context	City within the regional and national context	City centre with the city, regional and national context
	Pre-1939 to post-1990s	First year after WWII	Pre-2002 to post-2013
	Pre- and post-1990s	1950s 1990s 2000s	
Understanding of resilience	Single equilibrium	Multiple equilibrium	No equilibrium, constant movement
	Capacity to bounce back	Ability to transform and retransform urban spaces	Capacity to prepare for, respond to and recover from hazards with minimum damage
Variables	Population, GDP. Industrial development and unemployment	Implemented policies, actions and programmes	Flooded areas, population and basic services affected with economic losses Implemented policies, actions and programmes
Sources of resilience	1939–1990: non-resilient (decline)	Adaptive capacity according to the resources available, leadership and coordination	Memory, collaboration and communication
	Pre- and post-1990s: collaboration and communication, flexibility		

subsequent periods of transformation (socialist rule, reunification), and thus is a suitable laboratory to understand the methodological hardships mentioned in the literature.

Firstly, results confirm the possibility of operationalizing resilience while acknowledging sources of resilience identified in the literature (Table 3). Only few variables were available to analyze past reactions in the case at hand. Adequate quantitative (unemployment rates, and the number of industries) and qualitative (policies, actions or programmes) indicators necessary to understand a city's capacity to rebound or transform are not always available and/or incomplete for the space and timeframes under examination. A major challenge for cities is the development of tools and inventories to assess resilience. Accordingly, it is recommended that further research be conducted to investigate the association between resilience metrics and the potential sources of resilience.

Secondly, the issue of resilience is closely related to context and perspective (Bourbeau 2013). Thus, a stronger understanding of the social, political and economic situations that determine local adaptive capacity or transformation could potentially support the necessary contextualization that metrics alone cannot capture. Thirdly, it should be recognized that resilience to one shock does not guarantee resilience to others, and the resilient capacity of one city domain (the built environment) does not guarantee the resilience of another domain (governance networks). Hence, it is crucial to distinguish and clarify the object of study according to specific spatial and temporal parameters. Finally, the proposed framework step approach to analyze urban resilience could prove helpful in supporting the Quito Implementation Plan, as we now must move forward from the discourse on resilience to its operationalization.

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Chapter 18
Reconsidering Urban Planning through Community-based Initiatives

Akito Murayama

Abstract This chapter emphasizes the need to reconsider Japanese urban planning through community-based initiatives. The country's changing urban environment as well as the increasing level of planning uncertainty in its cities are introduced through some examples: Unexpected population decline in Toyota City, an increase in (surface) parking lots in urban center and inner-city neighborhoods, demographic and spatial trends in Yokosuka City and the gradual relocation of urban areas in Owase City. After reviewing the evolution of planning theories and the introduction of a new tentative framework of urban planning, three pioneer cases are introduced in support of this new framework. These case studies are Fujimakicho's urban park issue, Nishiki 2 District's low carbon projects and disaster mitigation planning for the Greater Nagoya Region, all of which challenge Japan's current urban planning framework. While these case studies are basically community-based, they outline a potential pathway to the transformation of formal urban planning processes.

1 The Changing Environment and Increased Uncertainty

Many of Japan's cities are facing a raft of problems such as the decline of the working-age population, a hyper-aging society, economic stagnation, widening income disparity, strained budgets, an intensification of environmental problems in the wake of climate change (in particular, repercussions on energy, food, water supplies) as well as the frequent occurrence of natural disasters such as earthquakes, tsunamis, typhoons, severe rainfall, and volcanic eruptions. Urban development plans must take account of these issues, providing appropriate responses to a changing environment. In the following we will explore the issue of uncertainty under a changing urban environment through four examples.

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The first example is Toyota City, which is dealing with an unexpected decline in population. Previously, a growing city with a strong automobile industry, the population forecasts as laid out in the city's current 7th Urban Development Comprehensive Plan showed steady population growth from 412,141 residents in 2005 to 422,000 in 2010 and 430,000 in 2017. However, the actual population trends have been rather different: An unexpectedly high rate of growth to 423,200 residents was recorded in 2008, just before the bankruptcy of Lehman Brothers and the ensuing financial meltdown. After the so-called 'Lehman Shock', population growth suddenly lost momentum, growing slightly to 423,822 in 2010 but thereafter declining to 422,181 in 2014. At the same time, neighboring suburban cities have continued to grow. This continuing process of suburbanization combined with a decline in population has been one factor preventing further growth in the central city of Toyota. Residents prefer to live in more affordable suburban single-family homes in the west of the city toward the larger Nagoya City. In an attempt to remedy this relative decline, the local authorities in Toyota City decided to update the city's Urban Development Comprehensive Plan in 2015, a year earlier than originally scheduled. It was determined that the old policies and implementation measures, drawn up in the expectation of population growth, had to be revised in the light of falling population levels.

The second example is an increase in the number of surface parking lots in urban centers and inner-city neighborhoods. Economic stagnation and processes of industrial transformation have led to high rates of bankruptcy amongst small- and medium-sized companies. If old and unsuited to other uses, many company properties are likely to be demolished. Subsequently, these parcels of land are turned into surface parking lots, the most stable temporary land use for tax-paying landowners under low development pressure. In Nagoya City, the rise in the number of surface parking lots can be observed in commercial zones in the periphery of urban centers, as large-scale redevelopment projects are feasible only in particular areas within the urban center such as Nagoya Station area and Sake area. The spatial pattern of surface parking lots is unpredictable and unstable: They appear and disappear with high frequency.

The third example considers the demographic and spatial trends of Yokosuka City in Kanagawa Prefecture, one of the cities in the suburb of Tokyo Metropolitan Region most severely affected by falling population levels. In fact, in 2013 Yokosuka City saw the greatest population drop of any Japanese city. This trend is continuing. According to calculations, it will be possible to house the population of 2034 in the much smaller historic urban area of 1974. Yet urban growth is irreversible; we cannot expect the urban area to shrink like a balloon. What, then, will be the emergent urban form in the age of depopulation? Currently, many vacant houses and lots can be observed in less attractive valley areas in Yokosuka City. Such areas feature narrow, steeply inclined roads and stepped pathways. Many homes are not accessible by car. A New York Times article from August 23, 2015 described the situation in Yokosuka City as follows, '… these ghost homes are the most visible sign of human retreat in a country where the population peaked a half-decade ago and is forecast to fall by a third over the next 50 years.' (Soble

2015). On the other hand, new residential areas are still being developed outside the existing urban area. Here population is growing, in contrast to the overall depopulation of the city. Over the next several decades, it is highly likely that even those residential areas featuring high quality infrastructure developed for baby-boomers in the 1970s and 1980s will lose residents as the young generation moves away. Although the city is currently updating its urban master plan, uncertainties about the emerging urban form in an age of depopulation make it very difficult to plan for the next decades.

The fourth example is the gradual relocation of the urban area in Owase City, Mie Prefecture. The center of the city is located near the bay, which is forecast to be hit by a massive tsunami when the expected Nankai Trough Major Earthquake finally arrives. Local residents have already been informed of this potential disaster. The city authorities are developing evacuation routes and facilities as well as conducting evacuation drills in the central part of the city. Many young families have moved out of the center in order to build homes in the newly developed highland residential area called Hikarigaoka, far from the bay. Clear urban planning policies are required to stop this kind of gradual relocation of the urban area. While residents in Hikarigaoka will avoid the impact of a tsunami, they face the risk of mountain landslides. Furthermore, the new residential area lies outside the existing urban area and possesses no public transport infrastructure, no public facilities and no commercial services. The fact that possession of private cars is imperative for residents may lead to additional problems in the future.

2 The Evolution of Urban Planning Theories

Many urban planning theories were developed in Japan in the 1960s and after. This began as a response to the apparent limitations of rational comprehensive planning. Here I use the framework of four planning models, namely the Technical Bureaucratic Model, the Political Influence Model, the Social Movement Model and the Collaborative Model. These are effective in different circumstances according to the level of 'diversity' and 'interdependency' of actors. Each model can also be characterized by the 'place' and 'activities' of planning. The 'place' of planning is either centralized (top-down) or decentralized (bottom-up). The 'activities' of planning are specified in terms of rational activities or various irrational activities, based on the premise that irrational activities are impossible or unrealistic. Nine planning theories can be classified according to these four planning models, visualized in Fig. 1.

Figure 2 shows the evolution of nine planning theories, based on a review of relevant literature. First, Rational Comprehensive Planning appeared in the 1950s. This planning theory believed that elite bureaucrats and scientists could plan an optimized city based on computer simulations. However, such as a top-down and holistic approach to urban planning was severely criticized. Two planning theories then appeared as a response to Rational Comprehensive Planning: Incrementalism,

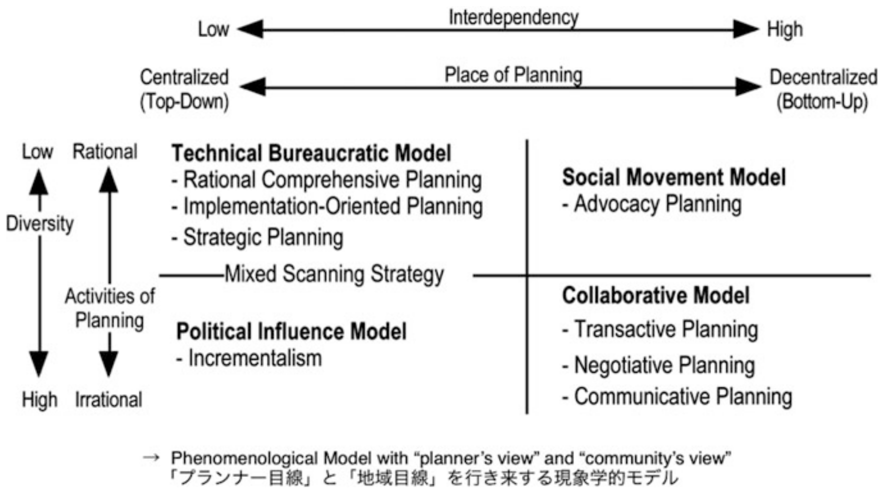

Fig. 1 Four planning models (based on Murayama 2009)

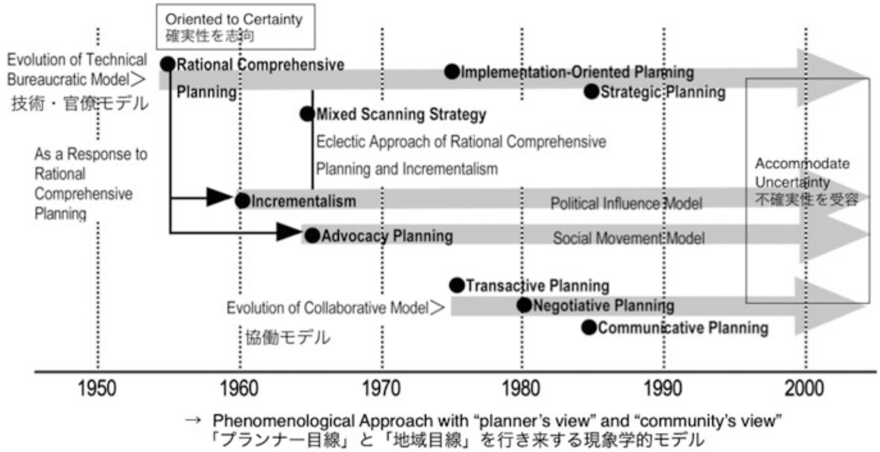

Fig. 2 Evolution of planning theories (based on Murayama 2009)

popular from the end of 1950s to the beginning of the 1960s, and Advocacy Planning, which arose in the mid-1960s. Incrementalism was established as a Political Influence Model while Advocacy Planning led to a Social Movement Model. The former emphasized the consideration of smaller decision-making elements while the latter focused on the ignored sections of the top-down approach. The Mixed Scanning Strategy, which appeared in the mid-1960s, was an eclectic blend of Rational Comprehensive Planning and Incrementalism. The Technical Bureaucratic Model, with its roots in Rational Comprehensive Planning, was developed as an Implementation-Oriented Planning Model in the mid-1970s and as Strategic Planning in the mid-1980s. These were top-down approaches that attempted to take account of future uncertainties. On the other hand, the Collaborative Model was developed through Transactive Planning in the mid-1970s, Negotiative Planning in the 1980s and Communicative Planning since the mid-1980s. These theories believed in finding solutions through the interaction of related actors of society. Uncertainties could be dealt with by involving various stakeholders in the planning process. The development process of planning theories can be understood as the process of four planning models evolving to co-exist with the appearance of new planning theories. More recently, the planner's perspective and the community perspective have become alternative planning approaches. This is what we call the phenomenological approach.

Planning theories have evolved under recognition of the conceptual limitations of the Rational Comprehensive Planning, which makes specific assumptions about current and future urban conditions. Subsequently, planning theories were developed to cope with varying levels of uncertainty.

3 Limitations of the Current City Planning System in Japan

The current urban planning system in Japan has its foundation in the City Planning Act of 1968, which focused on developing new urban areas and new infrastructure under the pressure of population growth. This rather static system is based on the approach of Rational Comprehensive Planning of the Technical Bureaucratic Model. The City Planning Act provides for:

- The designation of City Planning Areas and Quasi-City Planning Areas;
- The establishment of Master Plans for City Planning Areas (by prefectural governments) and Municipal Master Plans (by local governments);
- Land use regulations that include the division of the City Planning Area into Urbanization Promotion or Control Areas, the designation of zones and districts (12 categories of basic and overlay zones as well as districts) and the development of district plans that provide for detailed regulations and projects;
- The development of urban facilities including transport facilities (roads, railways, terminals, etc.), public spaces (parks and green space, etc.) and water supply/treatment facilities (water works, sewerage, waste management facilities, etc.) and others;
- The implementation of Urban Development Projects including Land Readjustment Projects and Urban Redevelopment Projects.

This sophisticated system has a number of shortcomings, such as the inability to control urban sprawl. For example, Nagakute City is a still-growing city located to the east of Nagoya City and to the west of Toyota City. The city's urban master plan calls for a planned urban expansion near linear-motor public transit stations, implemented through the expansion of Urbanization Promotion Areas and the land readjustment projects. However, a large-scale private residential development has been approved in the Urbanization Control Area, as long as the development meets certain technical and location standards. This illustrates the gap between the concept of the urban planning system, the aim of the urban master plan and the implementation measures.

4 Toward a New Framework of Urban Planning

Figure 3 shows a proposed new framework for urban planning (derived from the work of Japanese planning researchers) currently being discussed by the Urban Planning Committee of the Architectural Institute of Japan. The potential new framework tries to address a new planning approach for a sustainable and resilient future that takes sufficient account of uncertain factors.

The vertical axis indicates the location of the various planning initiatives. Towards the top of the figure at one extreme we find 'formal planning', characterized by keywords such as citywide, mid to long range, government-led, planning restrictions, incentives, projects based on system. The opposite extreme towards the bottom of the figure is 'informal planning' or 'alternative planning' characterized

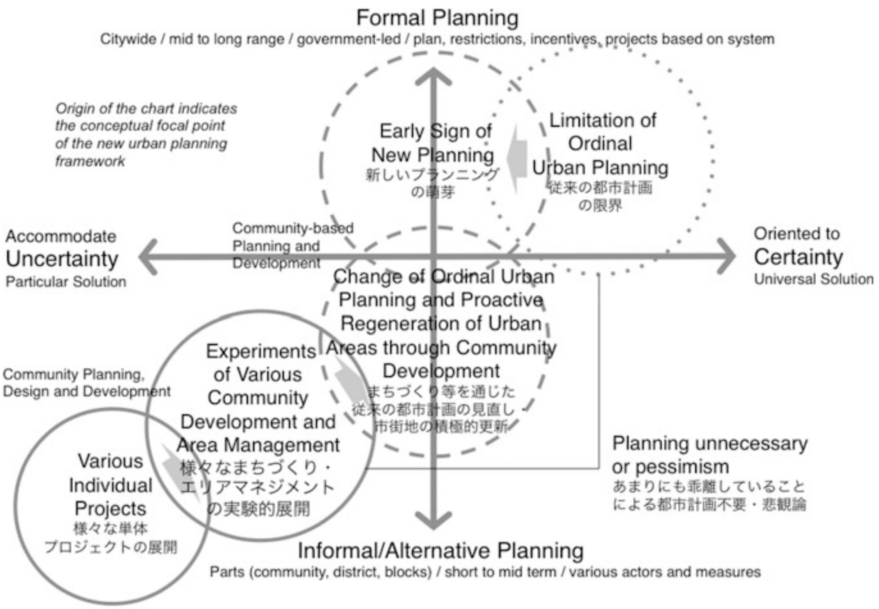

Fig. 3 Proposed new framework of urban planning (Murayama 2015)

by keywords such as parts (community, district, blocks), short to mid-term as well as various actors and measures. The horizontal axis shows how planning initiatives deal with certainty and uncertainty. One extreme is the orientation toward certainty, where plans strive to provide a universal solution. The opposite extreme is the accommodation of uncertainty, where particular solutions are sought.

The apparent limitations of ordinal urban planning are located in the top-right corner accompanied by early signs of a new planning approach that tries to shift to the left in order to accommodate uncertainty. On the other hand, in the bottom-left corner we find various individual projects focused on a single building or open space as well as experiments of various community development and area management initiatives. This is the field of community planning, design and development that tries to accommodate uncertainty in an informal or alternative manner. While a considerable gap still exists between formal planning and community planning, design and development, there is a move to formalize some of the experimental initiatives. This is a challenge to change ordinal urban planning and to promote the proactive regeneration of urban areas through community-based approaches.

5 Learning from the Pioneer Cases

Three pioneer cases in which the author has been involved are now introduced in order to provide some evidence of the emerging new framework of urban planning introduced above.

5.1 Fujimakicho: Creative Solutions for the Residential Community in the Undeveloped Urban Park

Fujimakicho is a low-density residential community of nearly 200 households. It is part of Higashiyama Park, designated by Nagoya City under the City Planning Act, but not fully developed due to budgetary constraints. Under the current urban park development program, the city will purchase land from all property owners in the future with the aim of extending the Higashiyama Park. In the meanwhile, residents can continue to live there; even some new constructions are allowed with certain restrictions. However, since the intention is to make Fujimakicho a park, the city does not invest in infrastructure such as roads and sewerage networks. The city authorities have already purchased some parts of Fujimakicho to be maintained as forest. However, in the face of a tight budget, the city is unable to maintain the forest without the help of volunteer work from Fujimakicho's residents. In turn, the residents would like to continue to live in Fujimakicho until the city purchases their properties. Of course, they have requested that improvements be made to the basic infrastructure. According to a rough calculation, it will be impossible for Nagoya City to purchase all properties within the next 100 years. This is an example of outdated ordinal urban planning.

Is it possible to devise a creative and realistic win-win solution to this problem? The author and a group of students decided to initiate some advocacy planning activities for Fujimakicho residents with the aim of voicing their concerns to Nagoya City and thereby launching a careful discussion of the issue. As it was clear that the city would not talk to the residents unless they had a common vision and concrete ideas, the author's research unit (with the help of an urban planning consultant funded by the city) implemented a process to develop a community vision. Through a number of residents' meetings, the Fujimakicho Community Vision was developed and passed by the residents' association. This included an idea to reconsider the designation of the park, and to encourage residents in a grassroots initiative to manage the existing forest. The residents' volunteer work to manage the forest is already underway.

Nagoya City officials have been monitoring the advocacy planning activities in Fujimakicho. Now the Greenification and Public Works Bureau, in cooperation with the Housing and City Planning Bureau, is taking this issue up in their Green Council, a policy-making body consisting of experts and stakeholders. This is the challenge to shift ordinal urban planning to a new planning approach that accommodates uncertainty.

In Fig. 3, this case can be placed within the circle of 'Change of Ordinal Urban Planning and Proactive Regeneration of Urban Areas through Community Development'.

5.2 Nishiki 2 District: Community-Led Low Carbon Projects

Nishiki 2 District is an inner-city neighborhood located between Nagoya Station Area and Sakae Area, two commercial centers in Nagoya's urban center. It is composed of 16,100 m-by-100 m grid-pattern blocks. Located in Nishiki 2 District, Chojamachi was well-known as one of the three major fabric wholesale districts in Japan. Initially, prospering as a fabric wholesale district after World War II, from the year 2000 on Chojamachi started to decline due to ongoing economic stagnation and the structural change in logistics. Property owners and business owners formed the Nishiki 2 District Machizukuri Council in March 2004 with the aim of regenerating this neighborhood, easing the transition from a fabric wholesale district to an attractive mixed-use urban neighborhood where people live, work, gather, play, and recreate.

Many artistic and cultural events were launched, some of the old buildings were transformed into restaurants, shops and offices, and a number of environmental activities were initiated. At the same time, the Machizukuri Council formed a Master Plan Committee to develop a comprehensive, action-oriented master plan for the neighborhood. In April 2011 the council adopted the 'Nishiki 2 District

Chojamachi Machizukuri Vision (Master Plan) (2011–2030)' composed of policies concerning a vibrant economy, cultural activities, secure living as well as of physical zoning, a structural plan and various community-based actions.

After the adoption of the vision, some of the community-based actions were strategically organized under the umbrella of 'low carbon'. Behind this movement were the Nagoya City's 'Low Carbon City Nagoya 2050 Strategy' as well as the research projects of the Graduate School of Environmental Studies, Nagoya University. The Low Carbon District Conference was established within Nishiki 2 District Machizukuri Council, and a road map introduced to reduce carbon dioxide emission from the district up to 2030 based on ongoing and future actions such as the eco-renovation of buildings, the fostering of shared housing as well as the social experiment of expanding a segment of the sidewalk using local timber. Nishiki 2 District is now one of only two Low Carbon Model Districts approved by Nagoya City.

Currently, a project funded by the Ministry of the Environment is underway to implement and evaluate several community-based low carbon projects. It is being run by the local NPO, a private consultant, and the author's research unit. The social experiment of expanding a segment of the sidewalk using local timber in order to encourage people to walk and to use the additional public space has reduced the speed of cars as well as cars going the wrong direction along one-way streets as well as lowering emissions of carbon dioxide by using local raw timber instead of asphalt. Placing heat-shielding insulating film on the windows of old buildings has resulted in more favorable indoor environments in the hot summer months while also reducing the need for air conditioning (thereby reducing carbon dioxide emissions even further as well as saving expenditures). Green walls have also been introduced beside parking lots.

In Fig. 3, this case can be placed within the circle of 'Experiments of Various Community Development and Area Management'.

5.3 Web-Based Geographical Information System for Disaster Mitigation Planning in the Greater Nagoya Region

Japan's cities are facing both progressive and sporadic risks that should be considered in long-term land use and infrastructure planning. Various sustainable urban forms such as the 'networked compact city' have been considered in response to ongoing risks including the decline of the working-age population, hyper-aging, economic stagnation, widening income disparity, governmental budgetary constraints and the intensification of environmental problems in the wake of climate change as well as safeguarding supplies of energy, food and water. Recently, more proactive planning measures have been called for to provide better security against sudden risks, whether in the form of major earthquakes, tsunamis, typhoons, severe rainstorms or volcanic eruptions. One inevitable long-term planning measure is to implement the de-intensification or even the abandonment of existing high-risk urban areas in certain Japanese cities. Here the main challenge will be to achieve consensus in the decision-making process.

One important tool in assessing urban resilience and understanding the planning issues related to progressive and sudden risk is the web-based Disaster Mitigation Planning System (Hiroi et al. 2015). This makes use of various geographical information of the urban region including existing conditions and plans related to land use and infrastructure as well as disaster projections regarding earthquakes, landslides, land liquefaction, tsunamis and flooding. Trials of collaborative workshops using the system in the Greater Nagoya Region and sub-areas within the region have allowed researchers, planners and decision-makers to come up with some new ideas for the long-term planning of land use as well as infrastructures. This has highlighted the importance of adopting a multi-level approach ranging from neighborhoods, sub-areas of cities, to cities as well as to the regional level, along with the strong need for cooperation among cities within the region.

In Fig. 3, this case can be placed within the circle of 'Early Sign of New Planning'.

6 Concluding Remarks

Against a backdrop of our changing global environment and increasing uncertainty, urban planning for Japanese cities has reached a turning point. Many people are disconcerted by this incursion of uncertainty into planning simply because we have not experienced such an environment before and are not sure how best to deal with it. Yet this fear of uncertainty can be conquered if urban planners are able to answer basic questions such as 'What is happening to the physical environment of cities and communities?' and 'What is happening to our forms of urban living?'.

It goes without saying that we need to consider the optimal approach to planning our communities and cities. In particular, we have to develop new planning theories in order to transform our system of urban planning. Currently, this system is largely founded on the approach of Rational Comprehensive Planning of the Technical Bureaucratic Model.

The three pioneer cases introduced here constitute challenges to the framework of urban planning in Japan. While these cases are basically community-based, they provide useful suggestions on how best to revise the formal urban planning system. Contemporary community-based initiatives in Japan can help to bring change not only at the scale of communities or neighborhoods but also to entire cities and regions. Therefore, it is time to reconsider Japanese urban planning from the perspective of the various community-based initiatives that have sprung up in recent years.

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Chapter 19
Planning of Public Facilities in Japanese Communities Facing Demographic Decline and Super-Aging

Hisashi Komatsu

Abstract Under the impact of demographic decline and super-aging, many of Japan's public facilities (including housing and schools) which were constructed from the 1960s to 1970s during a period of economic growth, currently require physical and functional upgrading. Previously, these facilities were built using standardized design methods to meet the rapid growth of cities. However, with the aim of making sprawling urban areas spatially and functionally compact and sustainable, today's demands for public facilities are not the same as those implemented forty years ago. Instead, the country requires facilities that meet the current needs of local communities. In this chapter I intend to discuss various approaches to establishing sustainable local communities, exemplified through a case study of four key areas around Nagoya that display a range of characteristics and prospective approaches. In particular, the problems and challenges surrounding public housing from the 1960s onwards in suburban areas of Nagoya will be reported and studied in detail. Finally, I argue that to build up a sustainable society, Japan's public facilities should not be upgraded in piecemeal fashion. Instead such reorganization must be undertaken comprehensively and in harmonization with the current demands of local communities by pursuing urban planning policies.

1 Introduction

Today, Japan is suffering under the twin demographic pressures of a falling population as well as a rapidly ageing society. These trends have a clear impact on public services. Lower tax revenues undermine the overall quality of services while also affecting negatively the number of public facilities. While services and facilities for the elderly are lacking, there is an overabundance of children's facilities. Due to the falling population, there will inevitably be a wide-ranging quantitative and quali-

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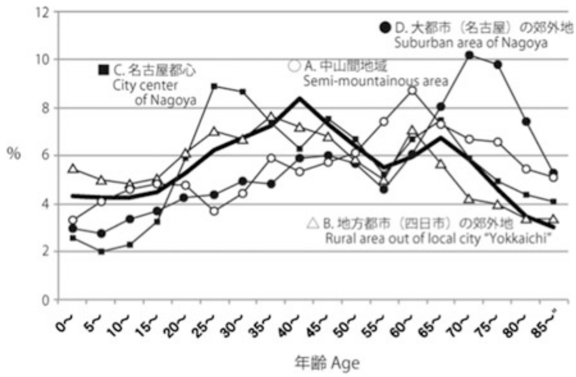


Fig. 1 Demographic breakdown of the four study areas in five-year intervals

tative restructuring of public facilities. At the same time, evolving demographic structures will also affect the quantity, quality, and range of public services.

Against this background, I have selected four typical areas for discussion. The first study area is a semi-mountainous region; the second is a rural area just outside of Yokkaichi City; the third area is located in the center of Nagoya City; and the fourth is a residential community located in the suburbs of Nagoya.

Figure 1 shows a population breakdown based on age for each of these four areas. The black bold line represents the total population of Nagoya City, while the other four lines show the demographic breakdowns of the four communities. Line D is an interesting case: It represents the suburban area within Nagoya, but rather closely follows the line representing the semi-mountainous area.

2 Current Conditions of the Communities Under Demographic Change

Why are the population breakdowns so different? To attempt to answer this question, it is first necessary to describe the current states of these four communities. Table 1 shows the characteristics, current population, and estimation of future population trends. The arrows represent the ten-year trends, which can be increasing (upward), decreasing (downward), or static (horizontal). Regarding the ratio of over 65-year old in the four study areas, this figure widely fluctuates from the national average of 25%. For example, in the suburb of Nagoya City the proportion is more than 40% (Nagoya City 2015).

Another important indicator is the ratio of children under 15 years. Table 1 provides further details on the conditions of the public elementary schools. The number of children in a community generally has a strong impact on the educational conditions as most families with infants and children show great interest in the quality of education in the area where they live or may live soon. In the current case, the affected residents in the four communities are all concerned about the

Table 1 Profile of the four study areas

No.	地域特性 Character of area	人口(増減傾向) Population (Change trend)	高齢化率 Ratio of over 65 years old	こどもの人口率 Ratio of under 15 years old	小学校の状況 Public elementary school's situation
A	中山間地域 Semi-mountainous area	6,000(↘)	31.1	12.0	小学校の統廃合の可能性 Potentiality of consolidation
B	地方都市外の農業地域 Rural area out of local city "Yokkaichi"	5,200(→)	20.5	15.2	コミュニティ・スクールとして運営(生徒数300名) Rebuilt and managed as "Community School"
C	大都市の都心 City center of Metropolis "Nagoya"	3,700(↘)	26.7	6.7	2015年に小学校が統廃合 Elementary school was closed by consolidation in March, 2015
D	大都市の郊外地 Suburban area of metropolis "Nagoya"	3,900 (↘)	40.7	9.1	小学校の統廃合が予定 Under the planning of consolidation

current and future conditions of the schools that their children will attend. The fate of the elementary school in a town or community is one of the most common and serious concerns of residents. Depending on the local government, schools can be managed and handled in various ways. Schools in some of the discussed communities have been closed (or closure is planned) due to falling school enrolment figures. After a school has shut, the buildings can be redeveloped to meet current needs in a town, or the property can be purchased and developed by a private owner.

3 Community-Based Development of Communities

Another common issue of bottom-up initiatives is not rooted in the regular top-down planning system. Nevertheless, community-based initiatives are currently being promoted in the four study areas discussed here. In fact, I am involved in these initiatives in each of the four communities as an expert for community-based development. During Japan's period of economic growth from the 1960s to the 1980s, a top-down approach to urban development was common, whether in the field of urban or regional planning. This also applied to the planning of public facilities. However, since the 1990s, the concept and methodology of community-based development has gradually spread throughout the country. This chapter explains in detail what its impact has been in four different types of communities, exemplifying the experience all over Japan.

4 The Japanese Government's Vision to 2050

First, it is necessary to comprehend the national government's current policy of urban and regional planning under demographic change and the hyper-aged society. In 2014, the Ministry of Land, Infrastructure, Transportation and Tourism (MLIT) published 'The Grand Design of 2050' as a vision for the future (MILT 2014). This vision portrays an ideal state for the country, its land use, and its planning of public facilities in 2050. Spatially, the plan intends to restructure the entire country in three dimensions to create three metropolitan areas, approximately 70 local cities of about 300,000 people, and 5,000 so-called 'small stations'. Public schools are included within these 'small stations' as well as other public facilities such as town halls. In Japan, the historical function of local public schools is not only to educate children but also to symbolize community activity. Further, the school district is also the district unit of neighborhood organizations. Hence, public schools, and in particular elementary schools, have traditionally existed as a center for Japan's local communities. In order to realize the vision for 2050 at the local level, it will be necessary to restructure existing paradigms for the planning and management of public facilities, especially regarding institutional and operational dimensions.

5 Case Studies

5.1 Sustainability of Semi-mountainous Area

This area, referred to as Kamiishizu, is comprised of four districts located in the semi-mountainous area of Ogaki City. Currently, around 6,000 people live in the four districts, the population has been fallen by about 1,000 over the past 15 years (Ogaki City 2015). Comparing the four districts, some districts have seen a slightly more stable population in recent years due to new housing developments. However, the overall trend for all four districts is a falling population.

Against this backdrop, discussions are currently being held on whether one large public facility should continue to operate or be closed down. This facility was built in 1982 with the aim of boosting economic development in a rural area that lacked jobs and sources of revenue. Initially, the local government hoped to persuade a company to settle there. However, the company found the location less than ideal and instead a recreational facility was created at the site. When this was completed, the number of visitors increased as expected. However, this occurred during the peak of Japan's period of economic growth. Reflecting the economic decline of the 1990s, the population of Kamiishizu also began to fall, as did the number of visitors to this facility.

Why, specifically, did the number of visitors fall? Firstly, a more attractive recreational facility was constructed around Kamiishizu. Secondly, the original building started to show its age and the recreational programs offered there became less and less popular. More significant, however, was the fact that people started to organize their holidays differently. Demand for such an old-fashioned recreational facility quickly dropped. Given this unpopularity, the local government is no longer eager to continue investing in such a facility. Therefore, it is left to the community to consider not only how to upgrade the facility, but also what action must be taken. This could also be the decision to close the facility. As a preliminary step, I suggested holding several meetings with stakeholders in each of the four districts. The meetings revealed the great frustration of local residents that such a large public investment had been made by the municipality in this old-fashioned facility while other community needs were seemingly disregarded. In fact, the residents felt that they had more urgent needs that could have been met by public funds.

On the other hand, some demographic forecasts show that the local population will fall to zero by 2100 under current trends (Fig. 2). In order to avoid this, the birth rate must increase to 1.8. Alternatively, the falling population can be arrested or reversed by encouraging the immigration of families. Although such forecasts do not represent hard facts, this data was discussed at the meetings with local residents in four districts. By focusing on these forecasts, citizens could start thinking in more specific, clear terms. For example, topics discussed were the immigration of residents living in cities, services for the elderly, and ways in which locals could utilize their own forest resources. By incorporating these forecast in the debate, locals were encouraged to attempt to create a revitalization plan for Kamiishizu.

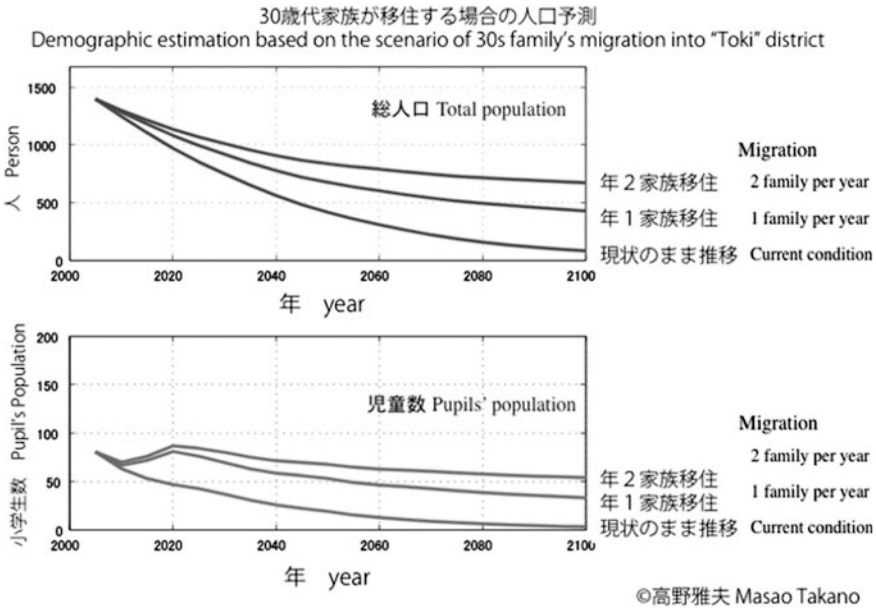


Fig. 2 Demographic estimates for Toki District in Kamiishizu

The most significant concern of residents proved to be the problem of consolidating the public elementary school. However, discussions involving the local government as well as the stakeholders in Kamiishizu have yet to take place. This issue must also be addressed directly to the local government. Generally speaking, the future of a public school is one of the major factors affecting the sustainability of a local community. In Japan, around 400–500 public elementary schools are closed every year due to a lack of demand. This means that few young families with children can expect to live in an area with a public school (especially a public elementary school) within walking distance of their home. This confirms once again that maintaining public schools is a key to ensuring the sustainability of local communities.

5.2 *Different Approaches to the Reorganization of Public Elementary Schools*

Several ideas present themselves to secure the future of schools and thereby safeguard existing local communities. Among these, one prospective option is the development of a ‘community school,’ an approach also promoted by the Japanese Ministry of Education. Figure 3 illustrates an example of such a school in Inabe City (the suburban area of Yokkaichi City) that has been jointly rebuilt and managed by the local community and the school authorities.

For over fifteen years, the Ishigure elementary school and the local community have successfully collaborated in the school’s management and running. I have also been involved in this project for more than ten years. Regarding its design, this does not look like the average Japanese elementary school building. The educational and communication programs offered here are all devised and organized through a partnership of local residents and the school authorities (Ushimaru and Komatsu 2013). A school café was opened two years ago in order to enhance communication further. Due to the close collaboration between the school authorities and various organizations comprised of local residents, the public school functions to improve the level of communication between local residents.

A further case is the public elementary school located in the center of Nagoya, just 5 min from Nagoya Station. Unfortunately, it was closed in March 2015 due to a steep drop in the number of pupils. However, this is not an average community, but rather one with many historical and urban resources located in the city center. It also has a considerable potential to attract a great number of new residents and visitors. Reflecting these positive aspects, a committee for community-based development (‘Machizukuri’ in Japanese), made up of public, private, and civil societies, was established in October 2012 in order to discuss and realize several common goals. One of these is how best to utilize the site of the closed elementary school. This is another example of how greatly a community can be affected by this particular topic.

Fig. 3 Example of a 'community school'

After the closure of the school, Nagoya City now has the option to sell the land to the private sector in line with its standard approach to property management in order to create much needed extra tax revenue. Land prices near Nagoya Station are also rather high. If the sale goes through, it is likely that a high-rise residential building will be constructed. Such a building would not be rooted in the existing community as local people would not generally choose to live in such a high-rise residence. Hence, this venture would be rejected by the local community. In fact, there are already two high-rise buildings located just across the street from the school, on land originally owned by Nagoya City until it was sold to the private sector. This led to the construction of the high-rise buildings, a major source of frustration for the community. To avoid repeating this situation, many workshops and meetings have been held to discuss various surveys and studies on this area. These deliberations have resulted in one overarching goal: To make this property the social center of the local community, the center for disaster prevention and mitigation, and a center to promote the community development.

This development is still in the process of negotiation. If a commercial business is created in this area by utilizing the closed school building, then it is likely that some revenue will be generated (Nonogaki 2015). However, since this building is owned by Nagoya City, all the revenue will accrue to the city under its standard financial set-up. However, attempts are being made to ensure that at least some part of the new business's revenue is returned to the community, so that it will become a source of investment and support for local development.

5.3 Suburban Residential Area with Public Housing

The last case study is the Takasaka School District (hereafter, T District) located in the suburbs of metropolitan Nagoya. The three districts of Takasaka, Aioi, Shimada underwent considerable development from the 1960s with the erection of many semi high-rise residential buildings and detached houses. Once vibrant with many young families, the local population has considerably aged. In fact, the population of T District is the oldest of all the approximately 260 school districts in Nagoya City. On the other hand, a recently opened subway station is only a 10-min walk from T District. However, the elderly residents of T District rarely use this subway because of the hilly topography of this part of the city. The 750 public housing units built since the 1960s are currently home to 1,350 residents, 49% of whom are aged over 65 (Nagoya City 2015). This is due to the public housing authority giving preference to low-income residents when filling vacant public housing. In today's Japan, elderly people generally belong to the low-income group, explaining the high ratio of senior citizens in T District.

Another factor is the low average number of persons per household at less than two. However, this situation is not unique to this area but in fact is becoming widespread throughout Japan.

The nuclear family of parents and several children may once have been the standard model, but this is certainly no longer the case. Rather, the elderly (including singles and couples) make up the most common household type according to recent statistics. This is driving the slow decrease in population in T District, even when the total population of Nagoya City is leveling out and that of Tempaku Ward (to which T District belongs) is even increasing.

Another important factor in this case are the relative proportions of the various age brackets. Figure 4 shows the population of Japan, Nagoya City, Tempaku Ward, and T District broken down according to age. T District clearly has the highest proportion of elderly people. At the same time it is important to note that public housing as well as areas of detached housing in the neighborhood also show a high proportion of older people. The origin of this situation can be found in the typical residential developments in the suburbs (largely during the 1960s). Hence, a comprehensive approach is required, one that focuses on detached housing as well as public housing in order to achieve the general sustainability of T District.

Figure 5 shows an example of the aforementioned public housing, in this case a multiple-dwelling house referred to as 'Dan-chi' in Japanese. It was not easy to develop this site due to the steep inclination of the land. Surrounding this public

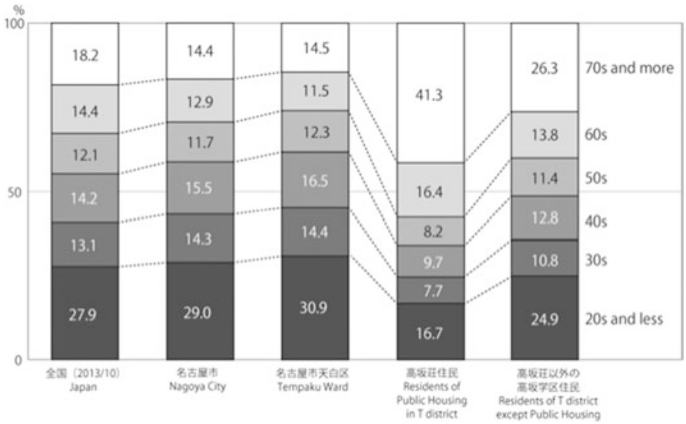


Fig. 4 Demographic breakdown for T District

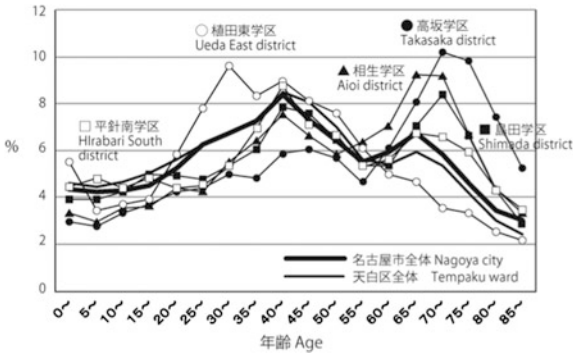
Fig. 5 Public housing in T District

multiple-dwelling house are many detached houses. Figure 6 shows a typical vacant house. One can easily imagine how, after being vacated by an elderly family or couple, the building was left unoccupied and uncared for. Such vacant detached houses are a significant problem in addition to the proportion of elderly people.

However, this is not only a difficulty faced by T District. Figure 7 shows, that the neighboring districts of Aioi and Shimada face a similar problems as T District in regard to demographic composition. This suggests that the problems experienced by T District will sooner or later afflict these two adjacent districts, which also have public housing.

Fig. 6 Vacant detached house in T District

Fig. 7 Demographic breakdown by age comparing different areas



How should we approach such issues? Firstly, at this stage we must clarify the short-term challenges. Specifically we must consider how to care for the increasing elderly population. In addition, we must deal with the long-term challenge of finding ways to positively influence the district's demographic composition.

The former is the main issue of interest for many of T District's residents (especially the aged), who demand that Nagoya City meets this important challenge. This issue is compounded by the fact that many elderly people in need of outside care are, in fact, receiving this care from another more active senior citizen living in T District. However, these voluntary support systems have already reached their maximum capacity and are likely to fail in the near future. Consequently, the local residents support will soon be needed from a different sector such as a non-profit organization organized by T District and Nagoya City. In fact, some cities have already introduced a similar system to support the community living in public housing (Yamada and Komatsu 2011).

The wider problems are certainly rooted in the development of new public housing in the suburban area in the 1960s. When this area was first constructed, most residents were young families. However, over the course of four decades, the parents grew old together and their children moved away. Currently, high rates of dependent people live here, especially in public housing. Nagoya City currently maintains approximately 60,000 public housing dwelling units. However, the number of elderly residents will continue to increase under the current tenant selection procedure of Nagoya City for vacant public housing. In addition, the budget to physically maintain or improve buildings is insufficient and requires further refinement. These factors serve to transform a district (and its public housing) into an old-fashioned residential area with many elderly inhabitants, of which T District is a typical example. Therefore, improvements in these two factors are required to make T District a sustainable community.

There is another viewpoint that should not be dismissed. This is the strategy of encouraging young families to move into a hyper-aged community such as T District. To successfully implement this strategy, one key point is to determine how to deal with the public elementary school in T District. As previously mentioned, the role of the school is essential to an area. However, the focus of local government and administration is currently on the number of children needed to run a school efficiently, whereas the social impact or the repercussions on the wider community are likely to be neglected. Yet young families are not attracted to a district in which the local school has closed. Hence, a comprehensive approach is needed to rebalance the demographic composition of a local community and to realize its potential for sustainability.

In my opinion, one possible solution is to reduce the total number of public housing units. Another, perhaps better, option would be to utilize vacant private residences, in particular to house the remaining elderly population living in public housing. This solution is referred to as the ‘American community’. In 1970s, when many public housing schemes in the USA were facing dilapidation, a voucher system was introduced to encourage the relocation of low-income or elderly people into dwellings of slightly better quality. It is unclear whether such an approach could work in Japan; until now no similar scheme has been implemented by the national government or local authorities. However, in view of the large number of vacant private houses located near low-income public housing, perhaps a similar proposal should be considered for the whole of Nagoya City, with the aim of establishing a city-wide socially-mixed community rather than in just one particular residential area.

However, various problems in using vacant houses for this goal have already become clear. First of all, private housing is run as a business rather than a social service. Hence, real estate developers will only accept elderly people if this proves profitable. At the same time, public authorities are unwilling to pay the high rents demanded by property developers. Therefore, unless more innovative public service schemes are proposed and backed up with public investment, they will not be accepted by the market. This underlines the importance of reviewing the general policy on public housing.

6 Conclusions

The demographic decline and super-aging of Japanese society is affecting lifestyles in urban, suburban, and rural areas, with some areas already facing a crisis of social sustainability. To maintain the high quality of life that has been established in the described areas, local communities and experts in architecture and urban planning must now decide how best to reorganize public facilities. However, as previously mentioned, a key approach to resolving this issue is not the piecemeal reconstruction of public facilities, but rather the comprehensive reorganization of these facilities as public service hubs that can meet current local demands. In particular, we must recognize the ever-increasing role of public schools in anchoring young families to a local area. Public schools should, therefore, not be reconstructed as single-service facilities, but be redeveloped as centers for diverse public services as well as to foster a community's social cohesion. Another important factor serving cohesion is the availability of public housing. To realize this change, the paradigm of public facility planning must be shifted from the pursuance of efficiency, encapsulated in the slogan 'one building, one function'. To this end, various trials have already been implemented in many of Japan's local areas. Now we need to verify intensive practices based on a new paradigm in order to develop an appropriate planning theory, both in terms of concepts and methodology.

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Chapter 20
Developments in Urban Planning by Public Facilities Management Based on Regional Characteristics

Kazuhisa Tsunekawa and Koji Saito

Abstract In the presented case study of Aichi Prefecture, the goal was to examine the challenges that local authorities must overcome in reorganizing public facilities based on an urban planning perspective and using information on location, floor space and current use. Differences in population trends, population density, regional characteristics, as well as the history of management policies, have resulted in wide variations in the provision and condition of public facilities in each municipality. Yet by viewing facilities in a complementary and integrated manner, we believe that public services can be performed more efficiently and effectively. We discuss differences in facility development based on density and population coverage as well as walking distance. An over-reliance on cars and public transportation to access public facilities is observed. Furthermore, differences can be discerned between municipalities and facility type. By making use of databases on public facilities and applying GIS techniques, we are able to illuminate the management of public facilities, thereby encouraging a multifaceted view of urban development.

1 Introduction

1.1 General Conditions of Public Facility Management

In recent years, Japan's local authorities have shown increased activity and interest in public facilities. The three main issues related to public facilities can be summarized as follows:

(1) The Rapid Aging of Facilities: A large number of public facilities such as schools, hospitals, libraries and city halls were built in the period of high

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economic growth from the 1960s to the 1970s. Fifty years later, these aging facilities have become a serious problem. Provoked by events such as the Great East Japan Earthquake of 2011 and the collapsed roof of the Sasago highway tunnel in 2012, critical voices have been raised across the country regarding poor infrastructural maintenance.

(2) Population decrease, an aging society, and falling birthrates: As a result of Japan's decreasing population, many local governments currently have surplus stock of public facilities that were built during a period of population growth. This problem has been exacerbated by changes in the structure of the population, specifically a declining birthrate and an aging society, which have undermined demand for these facilities. At the same time, it is proving difficult to accommodate these changes within the existing framework.

(3) The financial burdens of local governments: Every local authority is facing the financial burden of increased costs for social security at the same time as tax revenues are declining. This has led to budget shortfalls for the proper maintenance or renewal of public facilities. Hence, it has become difficult to keep the facilities in a usable condition. For example, in the case of Nagoya city, even if the lifespan of existing facilities can be extended to 80 years, the local government only has the funds to cover half of the annual bill for repairs and reconstruction.

Reacting to these problems, in April 2014 the Ministry of Internal Affairs requested all local governments to develop a 'Comprehensive Plan for the Management of Public Facilities'. This requires the restructuring of public facilities with the goal of introducing the idea of Facility Management (FM).

An ever-increasing number of local governments are starting to tackle these issues. However, these activities have just got underway, and the total number of local governments producing real results is still extremely small. Furthermore, the biggest problem facing all local governments is a limited budget. Therefore, the two core elements of the FM strategy are (1) a reduction in the number of public facilities and (2) an increase in the lifespan of facilities through planned conservation (Fig. 1).

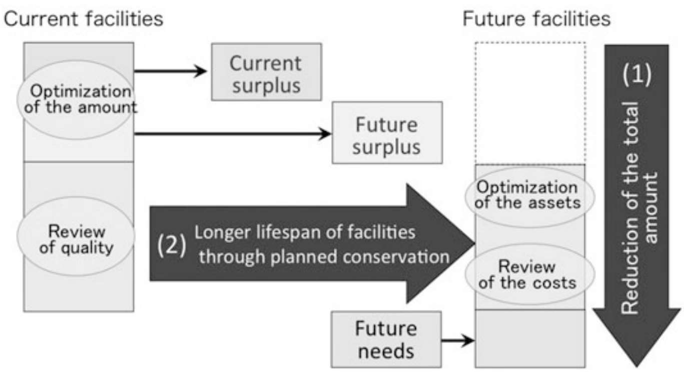

Fig. 1 Two strategies for the restructuring of public facilities

In these efforts, public authorities face some basic challenges. Specifically, these are: (1) how best to plan for the future way of life and the future form of regional areas; (2) how best to select the public facilities which are necessary resources to safeguard a community; (3) how best to determine which services to offer and how to manage the facilities. Clearly, this range of planning problems requires the active management of local government in cooperative ventures over a wide area as well as the drawing up of urban master plans. However, these measures are hampered by various obstacles within local government as well as red tape imposed by government ministries and departments. In addition, the number of local governments currently involved in the kind of coordinated activity described above is practically zero.

1.2 Research Goals

In the presented case study of Aichi Prefecture's local governments, the goal is to examine the challenge of reorganizing public facilities based on an urban planning perspective and using information on location, floor area, and current use.

There exists very little cross-sectional research on the large number of local government public facilities. A Report on the State of Public Facilities issued by the Ministry of Internal Affairs and Communications (MIC 2014) provided data on the number of facilities as well as their total floor areas but did not allow for any further detailed comparisons between local governments. To remedy this lack of comparative data, this chapter presents a method to classify the different types of facility, allowing the creation of a database of public facilities across local governments. Using topographical information and facility location information from each municipality such as walking distance and population distribution (which cannot be derived from other data sources), we tried to understand the characteristics and challenges of each region with regards to urban planning and FM.

1.3 Investigation Method and Targets

Investigations were carried out regarding the current conditions of public facilities in all 54 municipalities of Aichi Prefecture. Requests were submitted for information relating to the names, locations and floor areas, etc. of each facility. From the 39 municipalities that replied, analysis was carried out on public facilities in 36 municipalities deemed suitable (covering around 87% of the population). The following analyses were undertaken:

(1) Public facilities were classified in each target municipality, the correlation between population and the floor area of each facility was investigated and the current situation was analyzed from derived data.

(2) Areas within Aichi Prefecture which showed disparate results were then selected for further comparison using GIS to examine the current conditions of each type of facility.

2 The Current Condition of Public Facilities in Each Municipality in Aichi Prefecture

2.1 Classification of Use of Public Facilities

The classification method used by each local authority was noted. These official forms of classification are shown in Table 1. Based on these classificatory systems, a standard classification was devised to permit analysis of the public facilities in the 36 target municipalities and thus allow for comparison between the local governments.

Table 1 Floor space of each class of public facility in the target municipalities

Large classification	Small classification	Floor space (m^2)
Government office etc.	Government office	865,903
	Office	130,569
	Fire fighting facilities	279,383
Medical and welfare facilities	Welfare facilities	443,796
	Medical facilities	188,005
Parenting support facilities	Child welfare facilities	199,069
	Kindergarten and nursery	754,731
Social education facilities	Public hall	472,629
	Lifelong study facilities	390,832
Library	Library	183,863
Exhibition facilities	Exhibition facilities	359,818
Cultural facilities	Cultural facilities	585,920
Sport and tourist facilities	Sport facilities	981,423
	Tourist facilities	168,887
School facilities	School facilities	8,176,902
Public housing	Public housing	6,210,042
Industrial development	Industrial development	535,242
The others	Sanitary facilities	783,332
	Parking	321,419
	Park	187,864
	The others	260,698
Total		22,504,967

2.2 *Overview of Public Facilities Within Towns and Cities in Aichi Prefecture*

This investigation dealt with about 11,800 public facilities with a total floor space of about 22,500,000 m^2 (Table 1).

Figure 2 gives an overview of the total floor space per person of each class of facility for the investigated municipalities.

While the average value of floor space per person is around 3.6 m^2, this figure varies widely. When the population density is lower, the value tends to increase.

School facilities and public housing make up the largest proportions of total floor space of public facilities at 36 and 27% respectively. Furthermore, by looking at the floor space of each facility according to type, the disparity between local authorities becomes even more striking. For government buildings, floor area can vary by a factor of five between municipalities, for libraries and gyms by a factor of ten, and for welfare facilities, social education facilities and cultural facilities, the disparity can be even greater. These figures confirm the huge variation in the total floor space of classes of public facility across municipalities.

2.3 *Correlations Between Population and Floor Space*

Now we will analyze quantitatively the variations in the floor space of facilities and derive various correlations for each type of facility based on the indicators: population, age group distribution, age group distribution ratios, population density, population density of inhabitable area, population growth rate, target area size, and financial capability index.

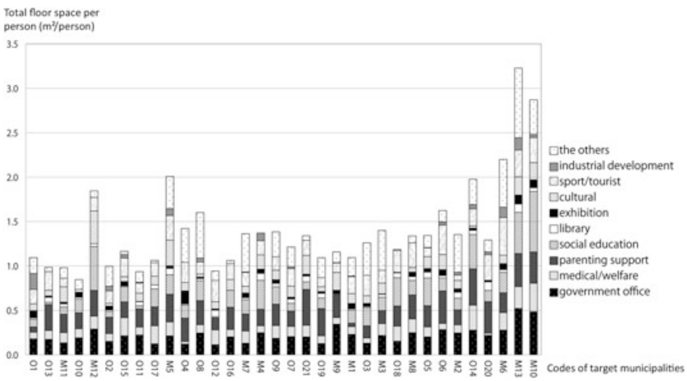

Fig. 2 Total floor space per person of public facilities in the target municipalities (excluding public housing and schools)

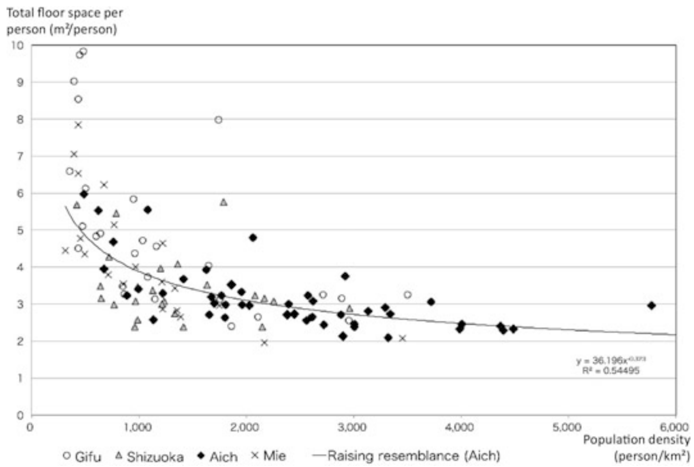

Fig. 3 The population density of inhabitable land and the total floor space of public facilities per person

Through this analysis, the strong correlation between population and area size became evident. Furthermore, various correlations were found for each type of facility. The most characteristic correlations are as follows:

i. A strong correlation with population size: school, government buildings;
ii. A strong correlation with target area size: adult learning facilities, community centers, etc.;
iii. A comparatively weak correlation with target area size but a strong correlation with the ratio of working-age population: libraries, cultural facilities.

Furthermore, a correlation can be seen between the population density of inhabitable land and the total floor space per person (Fig. 3).

However, several public facilities do not display any of these correlations. Two examples are tourist and cultural facilities, for which development greatly depends on regional and municipal policy and measures.

2.4 Discussion

While each municipality classifies, compares, and analyzes its public facilities by type, different forms of classification are applied in each case. Thus, facilities with similar functions may be classified differently, preventing any easy comparison between local governments. Furthermore, the name of the facility does not clearly reflect its purpose and use. Another problem is that the classification of facilities can depend on the specific departments given responsibility for their operation by the government ministries and offices.

For example, facilities used for public meetings, such as community halls and life-long learning facilities, can be designated as social education system facilities. Alternatively, similar facilities such as community centers and meeting places for the elderly can be designated as welfare facilities. Therefore, when considering the reorganization of facilities, we need to grasp their specific functions and likely capacities, trying to adapt these to the activities and needs of citizens.

Another important point is that differences in population trends and population density between municipalities as well as the specific characteristics of the region and the history of municipal policies all impact the state of public facilities under each local authority. Very few municipalities take a broader view of the situation by considering the range of private facilities that can be incorporated in their plans. Yet we believe that only such an integrated approach that makes use of complementary facilities will allow civil services to perform efficiently and effectively.

3 Analysis of the Provision of Facilities in the Four Areas in Aichi Prefecture

In the previous section we analyzed the relationship between the floor space of public facilities and population while ignoring topographical information. In the following, we consider residents' accessibility and the density of public facilities, investigated using methods of GIS.

3.1 Selection of Areas Targeted for Analysis

The scope of analysis was determined by the following criteria:

(i) Areas with different populations, population densities and/or area sizes,
(ii) The scope of analysis covers an area that exceeds municipal boundaries.

Based on these criteria, we selected Nagoya Area, which is an officially designated city, Chiryu Area, which is a suburban inhabited area, Toyohashi Area, which is a core city, and Shinshiro Area, which is a sparsely populated area (Fig. 4). We studied these areas within a 6 km radius from Nagoya Tempaku Ward Office, Chiryu City Hall, Toyohashi City Hall, and Shinshiro City Hall, respectively.

3.2 Distribution of Facilities Based on Intended Use

Nine classes of facilities were chosen (excluding industrial development facilities, public housing and some other facilities) for analysis using GIS in order to grasp the

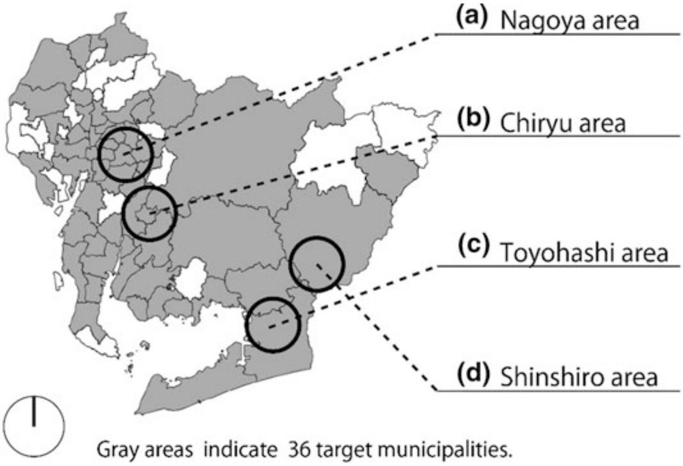

Fig. 4 Target areas for analysis

current distribution in the four target areas (Fig. 5). There is a wide variation in population density in the four areas from about 7,000 people/km^2 in Nagoya, to 3,000 people/km^2 in Chiryu and Toyohashi, to only 300 people/km^2 in Shinshiro.

As for the density of public facilities, differences can be seen depending on population. Whereas in Nagoya facilities are uniformly distributed, in Chiryu, Toyohashi and neighboring cities there is non-uniform distribution of facilities. In Shinshiro area, where the facility floor space per person is largest, the public facilities are mainly located in populated areas.

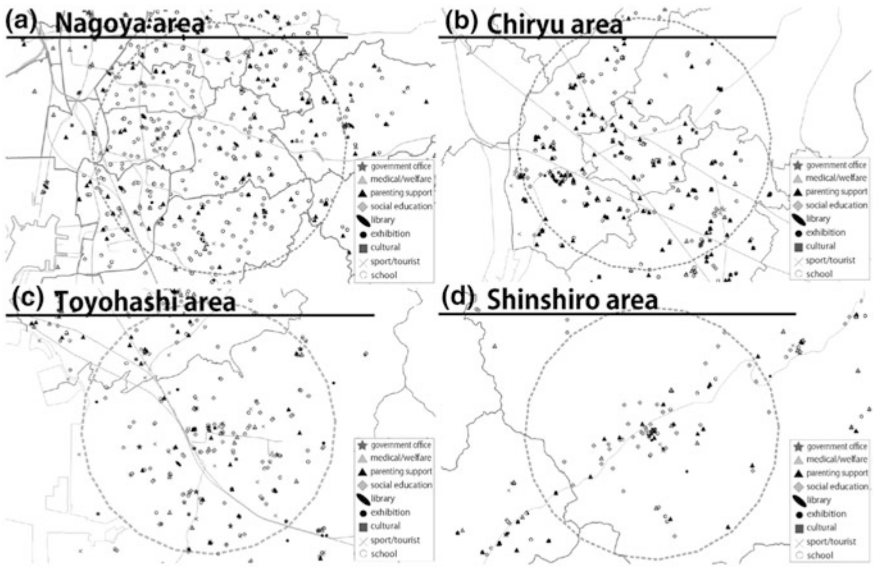

Fig. 5 Location of the public facilities in the four target areas

3.3 Arrangement Analysis Based on Walking Distance

Although the transport infrastructure is different in each of the four areas, this factor is irrelevant here. Our chosen perspective is the walking distance, allowing for a comparison between the target areas. We specified an acceptable walking distance of 800 m as the cut-off value (Fig. 6). Hence, people living within 800 m of the facilities are regarded as being within walking distance. From this we can determine the coverage rate (population within walking distance/population in the area), giving results shown in Fig. 7. These numbers indicate the percentage of the population within walking distance of the selected class of facility in the target area. Five classes, namely welfare facilities for the elderly, child welfare facilities, kindergartens and nursery schools, community centers, and schools were determined as the target facilities for this analysis.

Schools and community centers in all areas have high population coverage. Public facilities have the highest coverage rate in the Shinshiro area, where it can be stated that local residents have the most immediate access.

The community centers in the Chiryu area have the lowest coverage rate in the four areas. Therefore, it is likely that local people depend on cars or public transportation to make use of these facilities. On the other hand, the coverage rate of

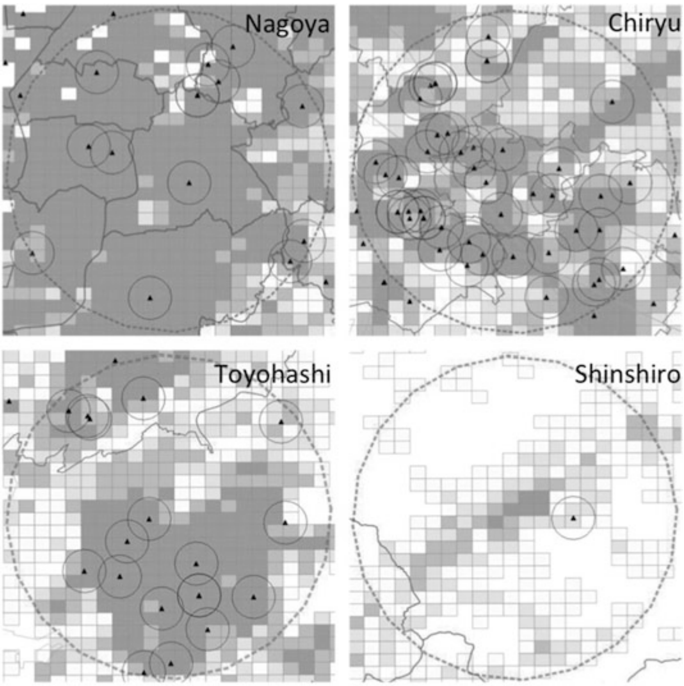

Fig. 6 The location of child welfare facilities in the four target areas

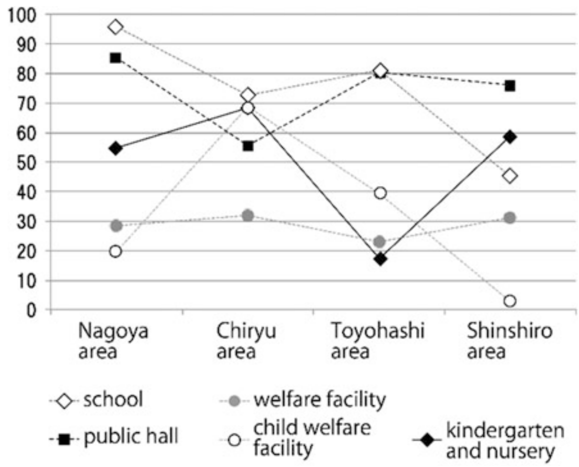

Fig. 7 The walking area population coverage rate in the four areas

kindergartens, nursery schools, and child welfare facilities is higher than in other areas. From this we can say that child-rearing facilities are within walking distances.

In the Toyohashi area, the facilities can be divided into two types: those with high population coverage and those with low population coverage. Alternatively, we can say that there are facilities which can be reached on foot and facilities which are reached by car.

In the Nagoya area, the construction of child welfare facilities and elderly welfare facilities follows the rule 'one facility in one district'. Consequently, the population coverage is low, meaning that such facilities are not within walking distance by children and elderly people.

3.4 *Discussion*

We have illustrated the differences in facility development in terms of area-based distribution, density and walking distance. Clearly, there is an over-reliance on cars and public transportation to utilize public facilities. We have also noted a range of differences across municipalities and facility types. It can be inferred that the situation regarding location and usage in disparate areas, even those in neighboring municipalities with relatively similar densities, differs more than the variation in public facility area per person (discussed in the previous chapter). This also applies to the municipal policies regarding facility placement.

Moreover, we have determined that depending on their needs, users not only make use of nearby facilities but also facilities located beyond the municipal borders. Therefore, it is necessary to consider complementary relationships with surrounding municipalities.

4 Conclusion and Future Challenges

Our analysis has been limited to the floor space of facilities per person and the location of facilities within walking distance of the local population. By comparing facilities with similar classifications in different municipalities beyond the city precincts, we were able to objectively specify the characteristics of regions that can capitalize on FM and urban planning.

Regarding the restructuring of public facilities, tight municipal budgets and the constraints of aging facilities encourage an intensification of use and consolidation of current facilities. We were able to get a general idea of the way in which objections concerning specific facilities have arisen. In many cases, such objections hinder the implementation of new developments. Hence, it is imperative that citizens, the national parliament, and all administrative departments develop a common notion of restructuring and urban planning in order to move towards building communities. We must transform the negative image of restructuring into a positive image of building new towns. Without this philosophy, it will be difficult to find agreement on reducing the number of facilities in order to make much needed financial savings.

White papers for public facilities have been drawn up in many municipalities. Other importance questions such as performance, usage, and expenditure of the public facilities have already been settled. However, essential data is still lacking in order to solve various regional problems related to public facilities such as disaster prevention, environmental issues, and how the community will be affected as a whole.

On the other hand, urban planning departments are responsible for optimizing the siting of new facilities. Here the favored urban design is the networked compact city. To this end, development plans will be drawn up to regulate the siting of facilities in the base areas (including private facilities). Here it is important to paint an accurate picture of intended activities, the kind of services and facilities that will be needed for said activities, and whether the services/facilities can be offered while keeping to a tight budget.

Additionally, in order to manage public facilities and to make the shift to compact cities, local governments are themselves undertaking their own investigations. However, isolated small- to medium-scale cities cannot provide all the requisite city functions; instead, it is necessary to investigate the wider metropolitan area outside the city limits. In the present study, we have made use of databases on public facilities and GIS techniques to illuminate one aspect of public facility management and thus to encourage a multifaceted view of urban development.

In further research, we intend to evaluate the accessibility of facilities that are outside easy walking distance, and will continue to perform deep comparative analyses between municipalities, taking into consideration differences in time distance as well as actual use.

In addition, we aim to capture the scale and performance of each facility as well as the capacity based on location, and will look at the range of activities for which said facilities are used. With such investigations, we aim to construct techniques for the management of public facility restructuring that takes a broader view, extending beyond municipal borders and departmental borders, as well as the border between the public and private sectors.

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Chapter 21
Identifying Gaps and Opportunities for Research on Urban and Regional Resilience—Highlighting the Advantages of Research Cooperation

Paulina Schiappacasse and Bernhard Müller

Abstract Resilience in urban and regional planning means preparing for the unforeseen, being able to withstand disturbance, dealing with risks in a coordinated way and recovering from destruction and decline. This requires the development of flexible, adaptive and resistant city structures (social, physical and institutional) that can both reactively and proactively adjust or transform to changing conditions. Influential nodes of international discussion on resilience have evolved, with strong guidance provided by a group of research centers and universities which dedicate much of their work to the topic of resilience. However, thus far the city-region discussion has been dominated by research on the effects of natural events (mainly 'disasters'), and climate change (as a slow burn) (Schiappacasse and Müller 2016). One of the challenges facing city planning researchers and practitioners is to build urban resilience. This can best be achieved by focusing on common research interests and promoting academic cooperation in various contexts and frameworks. The article focuses on answering the following two questions: (a) What do we know about resilience? This section includes a discussion on the conceptual understanding of resilience and the major areas of investigation. (b) Which research topics on resilience could become common research interests? This section of the article focuses on potential topics for joint research and academic cooperation between Japan and Germany.

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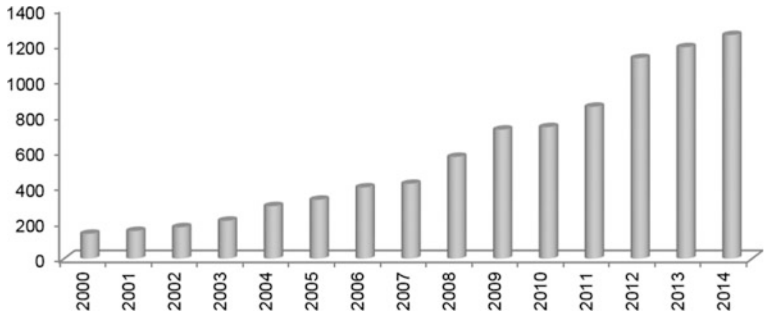

Fig. 1 Number of scientific articles containing the term ‘resilience’ (2000–2014). *Source* Elaborated from the web of sciences

1 Introduction

Resilience has attracted a flurry of interest in academic circles in recent years. This popularity can be illustrated by three key facts: First, the number of scientific articles on this topic has increased significantly during the last decade (Fig. 1). In particular, some journals have published special issues on resilience (*The Journal of Global Environmental Change* in 2006 and 2010, the *Journal of Disaster Research* and the *Cambridge Journal of Regions, Economy and Society* in 2010, and *The Journal of Planning Practice and Research* in 2013). Two journals dedicated to resilience were launched in 2013: *Resilience: International Policies, Practices and Discourse* edited by the Centre for the Study of Democracy at the University of Westminster, and *Resilience: A Journal of the Environmental Humanities* published by the University of Nebraska Press. Additionally, there has been a steady flow of white papers and policy statements on this topic (FSIN 2014).

Second, the number of research institutions focusing on resilience has substantially increased. The Resilience Alliance (RA)[1] was created in 1999. Many other research institutions have been subsequently founded, primarily in the English-speaking (Anglo-Saxon) world and Scandinavia (Table 1).

The third and final argument is the growing number of international conferences on resilience. In the early 1990s, the Beijar Institute for Ecological Economics organized several international closed workshops on biodiversity and resilience.[2] However, it was not until 2005 that resilience was officially addressed at an

[1]R.A is a multidisciplinary international research consortium exploring the dynamics of social-ecological systems.

[2]The workshops involved individuals who would become members of the Resilience Network (later Resilience Alliance) and of international coalitions focused on resilience research (Folke 2006; Parker and Hackett 2012).

Table 1 List of selected research institutions and journals on resilience by year of launch (1999–2013)

Before 2000	Resilience alliance
2000–2005	Journal Ecology and Society, Resilience Alliance; Centre for Resilience, The Ohio State University
2006–2009	Research Network: 'Building Resilience Regions', University of California Berkeley; Stockholm Resilience Centre; Centre for Disaster Resilience, School of the Built Environment, University of Salford; Centre for Urban Sustainability and Resilience, University College London; Centre for Environmental Change and Human Resilience, University of Dundee and The James Hutton Institute; Torrens Resilience Institute, International University Precinct, Adelaide; Resilience Institute, Western Washington University's Huxley College of Environment; Centre for Ecosystem Resilience and Adaptation, University of Waterloo; South American Institute for Resilience and Sustainability Studies (SARAS); Institute of Hazard Risk and Resilience, The Durham University, UK
2010–2012	The Centre for International Security and Resilience (CISR), Cranfield University; International Journal of Disaster Resilience in the Built Environment, University of Salford; The New York State Resilience Institute for Storms and Emergencies (NYC RISE); Institute for Security & Resilience Studies, (ISRC) University College London; Centre for Agro Ecology, Water and Resilience (CAWR), Coventry University; Resilience.org.; Erasmus Academic Disaster Resilience Network (Android)
2013	Centre for Resilience and Critical Infrastructure, University of Toronto; Centre for Risk, Resilience & Renewal, The University of Canterbury; Centre for Resilience Studies, North-eastern University; Science and Resilience Institute @ Jamaica Bay, Brooklyn College, New York; Centre for Societal Resilience, Lund University; Westminster Centre for Resilience, University of Westminster; Resilience Journal. International Policies, Practices and Discourse, University of Westminster; Resilience: A Journal of the Environmental Humanities, University of Nebraska
2014	The University of Oklahoma International Resilience Institute; Global Disaster Resilience Centre, University of Huddersfield; Centre for Disaster Resilience, A. James Clark School of Engineering, University of Maryland; The Centre for Resilience of Critical Infrastructure (CRCI), University of Toronto; Centre for Urban Resilience and Energy (CURE), University of Manchester

Source Schiappacasse (2014)

international event, namely the WCDR[3] in Kobe. And it was only in 2008 that the first international conferences were organized on the specific topic of resilience.[4]

[3]One main result of the Second World Conference on Disaster Reduction was the adoption of the Hyogo Framework for Action (HFA). The HFA is the first comprehensive plan detailing the work required of different sectors and actors to mitigate the impact of disasters by building resilience (United Nation 2007).

[4]The International Conference on Building Resilience (lead by the Salford Centre for Education and Built Environment); and Resilience 2008 (organized by the Stockholm Resilience Centre in collaboration with the International Commission on Climate Change and Development).

Yet by 2014, 11 international conferences were held on resilience, confirming the remarkable growth of interest in this subject.[5]

The increased adoption of resilience by practitioners and politicians may be related, according to Bahadur et al. (2010), to the concept's 'semantic ability' to represent an easily understandable and transferable idea: the ability to return quickly to a previous condition. Though there is some evidence this may be a transient fashion (Schiappacasse and Müller 2016), ideas of resilience have become powerful enough to cross traditional academic boundaries. Alexander argues that this increased popularity may be a sign that the concept 'has acquired a degree of common orthodoxy' in environmental sciences (Alexander 2013: 2714). In the following sections we review and discuss various recognized interpretations of resilience, considering how they have influenced diverse research approaches for promoting sustainable urban and regional development.

2 Knowledge of Resilience

2.1 Origins and Interpretations

The concept of resilience has a long and diverse history. Alexander (2013) argues that resilience was applied in a scientific context for the first time in the mid-19th century to denote the ability of a material to resist the application of a force by absorbing it without permanent deformation. From the mechanical sciences, the concept migrated into psychology in the 1950s (the capacity to recover after stress), to ecology in the 1970s (the amount of disturbance a system can absorb before change) and then to social studies in the 1990s (the capacity and necessity to learn to manage change by adaptation rather than passive reaction).

Early perspectives framed the concept of resilience as a return to normalcy, assuming a stable, controlled and self-repairing environment (single equilibrium). More recent understandings of resilience have emphasized non-linear dynamics, thresholds, uncertainty and change (multiple equilibria). It is in these different configurations of equilibrium that we can locate the bases for the available interpretations of the concept, namely engineering, ecological and socio-ecological (Folke 2006; Seeliger and Turok 2013).

[5]2nd International Conference on Urban Sustainability and Resilience, London; 4th Conference on Building Resilience, Salford; 3rd Annual Meeting of the ANDROID Disaster Resilience Network, Salford; 5th Global Forum on Urban Resilience and Adaptation, Bonn; 5th Conference on Community Resiliency, Arlington; Resilience 2014: Resilient and Development: Mobilizing for Transformation, Montpellier; IFRI Conference: Building Resilience for Food and Nutrition, Addis Ababa; Coastal Resilience Conference, Galveston; Regional Studies Association European Conference: Diverse regions building resilient communities and territories, Izmir; DLGS Conference: Resilience in Urban and Regional Development: from concept to implementation, Berlin; Urban Regions under Change: towards social and ecological resilience, Hamburg.

(a) *Engineering resilience* (a term coined by Holling 1996) or *the return time*: the time required for a system to return to an equilibrium point following a disturbance. In this perspective, systems are presumed to have single equilibrium. Resilience is explained in terms of elasticity, emphasizing resistance to disruption and the speed of return. This understanding excludes any normative dimension whereby resilience is considered a desirable or undesirable state. Although Manyena (2006) argues that this engineering perspective is more appropriate for objects capable of regaining their original shape after compression, over the years the interpretation has been adopted in many fields besides material sciences such as psychology, economics, disaster risk management and other environmental sciences. In the city-region discussion, the engineering vision has been applied using terms such as 'return to normal' or 'bounce back' within the shortest possible time and with emphasis on resisting disturbance, recovering quickly and conserving that which exists (Vale and Campanella 2005; Goldschalk 2003).

(b) *Ecological resilience* or *absorbing disturbance*: defined as the degree of disturbance a system can absorb before transforming into another regime controlled by a different set of variables and characterized by a different structure (Brand and Jax 2007). This understanding is based on the empirical evidence (Holling 1978; Walker and Meyers 2004) that most ecosystems types (lakes, coral reefs, deserts, forests, etc.) have multiple equilibria, i.e. they can exist in alternative stable regimes. Thresholds are used to describe 'breakpoints' between two regimes or alternate stable states in a system. In theory, when a threshold level is passed, a regime shift occurs and thus also the nature and extent of feedback in the system (Walker and Meyers 2004). These findings have provided a deeper understanding of the role of biological diversity in ecosystem dynamics. At the same time, research has shown that shifts between states in ecosystems are increasingly a consequence of human actions that erode resilience (Gunderson 2000). In the ecological view, resilience merely represents a quantitative and measurable concept; there is no 'value' judgment in determining whether ecosystems can or cannot withstand shocks. Thus, resilience functions again as a descriptor. The ecological perspective has influenced other scientific fields such as anthropology, ecological economics, environmental psychology and human geography (Zimmerer 1994; Pickett et al. 2004).

(c) *Socio-ecological resilience* or *continuous adaptation*: socio-ecological resilience or 'resilience thinking' (Walker and Salt 2006) have emerged from literature addressing and considering 'people and nature as interdependent systems' (Folke et al. 2010). It is defined as the capacity of a social-ecological system to absorb disturbance and re-organize while undergoing change, so as to still retain essentially the same function, structure, identity and feedbacks (Walker et al. 2004). Despite the similarity in meaning, ecological resilience emphasizes the fact that instabilities can flip a system into another regime (multiple equilibrium), while socio-ecological resilience considers a system in continual adjustment and evolution (adaptive cycle[6]) operating at different times and scales (panarchy[7]). Socio-ecological resilience recognizes constant uncertainty as well as people's ability to anticipate and manage change. These abilities are shaped, among other factors, by the political, economic and cultural context, the institutional rules, and the level of exposure to shocks (Adger 2000; Nelson et al. 2007). In this way, the socio-ecological understanding of resilience has expanded the ecological definition to encompass the capacity to learn, to experience and to innovate. Although the capacity to adapt is displayed by ecological systems, learning is essentially a human capacity. Following socio-ecological ideas, three 'dimensions' (Keck and Sakdapolrak 2013) have been introduced to explain future trajectories (e.g. probable reactions to shocks and uncertainties): absorption, adaptation and transformation (Walker et al. 2004; Maguire and Hagan 2007).

2.2 Particular Areas of Research

Uncertainties can arise at various spatial scales (within or between cities) and can impact interrelated dimensions of the city-region (economic, environmental, and political dimensions). Given such complexity, the study of resilience is oriented around such fundamental questions as 'resilience of what, to what' (Carpenter et al. 2001) and 'for whom?' (Lebel et al. 2006). As regards the specification of which part of the system to consider, the foremost objects of study are ecosystems (Schiappacasse 2014). Research is largely focused on understanding the extent to which ecosystems can withstand and rebound from disturbance. Community resilience (i.e. the resilience of human communities such as ancient civilizations, the elderly, households, migrants, livelihoods, etc.) has only recently emerged as an object of study. The response of economic systems (the wine industry, dairy farming, and organic farming) and the institutional view on disasters (Nicholas and Durham 2012; Frazier et al. 2010) is also attracting the attention of scholars. Results by Schiappacasse (2014) reflect a novel approach by analyzing normative and indicative frameworks including climate change strategies and environmental policy acts (Manyena et al. 2013; Benson and Garmestani 2011; Roberts 2010).

Resilience 'to what' refers to the type of uncertainties being studied. Uncertainties can be classified by the timeframe (months or decades), by frequency (regular flooding or rarer events such as tsunamis), by predictability (high risk of

[6]The adaptive cycle (Holling 1986) describes how an ecosystem self-organizes and responds to a changing world. It consists of four phases: rapid growth (exploitation, r phase), conservation (K phase), release (creative destruction, Ω phase) and reorganization (renewal, α phase).

[7]See Footnote 6.

occurrence) or scale of impact (exogenous/endogenous; from individual households to cross-scale and even global scale). In regard to the timeframe, Foster (2006) distinguishes between ‘sudden shocks’ and ‘slow burns’ (long-distance snowball effect), which are typical of regions undergoing economic, social or political transformation such as a heavy industrialized region shifting its economic base to services or biotechnology. The most common classification of uncertainties is by origin, for instance natural events and climate change, social, economic and political events, and biological, anthropogenic or security threats. Among scholars, research on climate change attracts most attention. The unprecedented frequency and cost of natural disasters and the projected increase in their severity due to climate change create significant challenges in regard to our understanding of and safeguarding against these events.

2.3 Methodological Approaches

In environmental sciences, ideas on resilience have evolved out of observation, using models as a tool to understand and involve stakeholders in adaptive management as well as to learn about ecosystem dynamics (Gunderson and Folke 2005). All intended management activities have to be considered, as these are derived from hypotheses about how a system will respond (Anderies et al. 2006). Some authors regard this methodological advance as constituting a paradigm shift in environmental management (White and O’Hare 2014). The perspective has shifted from controlling a well-understood system to one that maximizes various characteristics or maintaining the system in a particular state. In the social sciences, some scholars have attempted to understand actors’ responses to uncertainties such as social capital (trust) and networks, social memory (experience in dealing with change), mental models, and leadership. Yet our understanding of the social processes involve in resilience trajectories has progressed slower than expected. Concerning the specific methods used in resilience studies, no straightforward methodological application exists due to the multi-dimensional nature of the concept. Studies have incorporated quantitative and qualitative methods, including mathematical models, network analysis, literature analysis, experiments, surveys, interviews, questionnaires and archaeological techniques among others (Schiappacasse 2014).

The rapid uptake of the concept of resilience by development cooperation agencies and foundations has forced the issue of implementation, challenging the research community to make the leap from theory to practice to metrics. This has led to the framework step method becoming a popular approach to the analysis and management of the resilient capacity of systems (Schiappacasse and Müller 2016). Available frameworks (Walker et al. 2002; Anderies et al. 2006) incorporate different steps for analyzing/evaluating resilience, e.g. identification of the system, framing key issues, and identifying critical thresholds and scenarios, while the Resilience Alliance (2010) proposes a step-wise approach for resilience management as a necessary component to achieve sustainable futures. The framework includes a description of system boundaries, the framing of key issues, and the identification of critical thresholds and scenarios.

3 Opportunities for Joint Research and Cooperation on Urban and Regional Resilience

3.1 The Potentials for Joint Research Between Germany and Japan

Although Japan and Germany have vast experience in preparing, reacting to and recovering from 'sudden shocks' and 'slow burns' (Foster 2006), the discussion of resilience is rather new in both countries and largely confined to the management of natural disasters (National Resilience Promotion Headquarters 2014; Japanese Cabinet Secretariat 2013; Maki 2013; Takewaki et al. 2013) as well as adaptation to climate change (Greiving and Fleischauer 2009, and Birkmann 2008 in Müller 2010).

Japan has suffered a variety of damage due to repeated large-scale natural and human-made disasters, including a cascading disaster in 2011 (earthquake, tsunami and nuclear accident, Maki 2013). The country's policies and regulations have evolved through experiment and experience. The resulting 'robust catastrophic planning'[8] (a series of preventive measures and countermeasures against disasters) has contributed to social resilience. Although many fundamental policy changes in land use, disaster risk mitigation and infrastructure resilience were introduced after the 2011 disaster, many challenges extending beyond the engineering-infrastructural perspective have yet to be resolved. For instance, Maki (2013) mentions the necessity of incorporating and coordinating the vision of local communities within strategic planning. In Germany, risk management and disaster prevention strategies have long been topics of discussion in the national and regional agendas. Moreover, the intensive recent debate on climate change effects and related mitigation and adaptation strategies has fostered widespread recognition of the need for cities to accept and anticipate both change and uncertainty (Müller 2010).

The two countries' long experience in dealing with change and uncertainty is not sufficiently reflected in international debate (in terms of scientific publications), which has accepted English as the dominant language for pragmatic reasons. Furthermore, the concept of resilience has its origins in the Latin verb 'resilire', meaning to bounce back or to return, for which there is no exactly equivalent in

[8]Interview with Akihiro Ohta, Minister of Land, Infrastructure and Tourism, Japan. In PwC (2013) Rebuilding for resilience. Fortifying infrastructure to withstand disaster. Lessons from Japan: Setting the standards of resiliency.

German or Japanese. Thus, the terms adopted into German and Japanese (*Resilienz* and レジリエンス) can be considered specialist words not commonly used in colloquial language.

Within this context, the Japanese-German Cooperation programme between the IOER, the University of Nagoya (Graduate School of Environmental Studies) and the Technische Universität Dresden (Chair of Spatial Development) intends to conduct a research project on 'The resilient urban region'. In order to shed light on the state of discussion and the integration of concepts of resilience into urban planning and development in both countries, we propose the following guiding hypotheses:

Hypothesis 1:
The understanding of urban socio-ecological resilience common to the English-speaking (Anglo-Saxon) world dominates the local discussion in Germany and Japan.

Hypothesis 2:
In both countries resilience to sudden shocks (e.g. floods, earthquakes, and heatwaves) receives far more attention than resilience to 'slow burns' (e.g. depopulation, aging, and financial crises).

Hypothesis 3:
Uncertainty and risk are acknowledged through local adaptation using local planning instruments.

3.2 Demographic and Climate Change: Shared Challenges as a Basis for Cooperation

A key task for city planning researchers and practitioners is to build urban resilience. To this purpose, it is a worthwhile endeavor to establish common research interests and to promote academic cooperation in various context and frameworks. Two such common research interests are demographic and climate change, both major issues of urban and regional development in Germany and Japan.

Germany and Japan are facing unprecedented demographic changes that will have a major impact on the whole of society: The forces of depopulation and aging have ushered in a new phase of radical change, reflecting and contributing to new developments in social, economic and spatial organisation as well as in medical and technological knowledge. Our interest in this issue focuses on new challenges for regional development and local authorities such as falling demand for housing and ancillary infrastructure, the intelligent utilization and adaptation of public services and the constraints imposed by tight budgets.

At the same time, climate change is a particular challenge for local governments, who must deal with more frequent or intense extreme events such as heat waves, storms and floods. Impacts affect every local government service including health, infrastructure, natural resource management, recreation services, water and sewerage services as well as planning and development. Although local authorities in both countries have several instruments to foster adaptation, their role in the generation and implementation of responses has received inadequate attention. No clear answers have been given on how climate change will impact cities. Aside from regional climate variations, the built environment and communities will be affected to varying degrees. For instance, the demographic composition (e.g. high proportions of older people or low income groups) might increase vulnerability in terms of risk to health. In this context, joint research will focus on the role of local governments—specifically their potentials and limitations—as the frontline in building resilience to climate change.

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