

Revitalization of a mid-sized city in Japan through public transit and land use policies: Case of Toyama

Noriko Kono¹

Abstract

Beginning with the latter half of the 20th century, the excessive motorisation of cities has been one of the most controversial issues in urban planning. The impact of the automobile was far more wide-reaching compared to that of the earlier streetcar, which was more linear in movement and confined to discrete areas. The invention of the automobile allowed cities to spread in all different directions, and to sprawl into greenfields and undeveloped countryside. While it is true to say that motorisation raised the level of freedom and mobility for all, a high price has been paid in terms of both environment and minorities' lifestyles.

The City of Toyama, a mid-sized city in Japan, has succeeded to shift from a car dependent city into a transit-oriented, environment-friendly city. Presently the city, one of the 6 the Eco-Model Cities by the government, plays a leading role of the environmental conscious city planning. Innovative policies such as renewal of public transit into new model of Light Rail Transit (LRT), subsidy for development along public transit stations, and revitalization of CBD with introduction of new public transit/community rental cycle/construction of new facilities.

This study analyses the city's success in terms of modern urban planning paradigms such as Transit Oriented Development (TOD) and multi-core development. This paper first explains the outline of the City. Then it introduces policies of Toyama related to GHG emissions from the transport sector. Finally it calibrates environmental impact of the city's attempt by GHG emissions reduction and NOx reduction. For mid-sized cities, this case is one of the most successful examples of land use planning and development of public transit, which could avoid the degradation of CBD and environmental condition. In addition, the case potentially has a high relevance for developing countries.

¹ PADECO Co., Ltd. Shin-Onarimon Bldg. 6-17-19 Shinbashi, Minato-ku, Tokyo 105-0004 Japan nkono@padeco.co.jp

1. Introduction

The capital of Toyama prefecture, Toyama city, has a population of about 420,000, making it a mid-sized city in Japan. The city is located on the coast of the Sea of Japan in the middle of Honshū island, about 200 km north of the city of Nagoya and 300 km northwest of Tokyo. The city was once prospered as the castle town by several feudal shoguns. The city's major industry is manufacturing using their ample water resources and medicine from the long tradition of medieval era.

For a few decades, the city has suffered from problematic aspects of the population structure that the cities remote from major megalopolis area of Japan could have. The population has been declining, and it is estimated that in 2045, 23% of population will be decreased compared to the 2010 level. Young population and labour population are to be decreased, while the old will increase up to 30 % of the total population in 2020.

Toyama prefecture also has its own problems which make the city to suffer from excessive sprawl. The prefecture is flatter than the other ones and has the 2nd most inhabitable areas among all prefectures. The prefecture's road preparation rate is the highest than the others. People in Toyama prefer to purchase their own houses (No.2 rate in housing owners in 2008) and one of the highest income per household in Japan (No.4 in net income in 2009). Also, the land prices in the suburb areas are much lower than in the city centre, so the prices of collective housing in the city centre are relatively expensive than single detached houses in the suburbs.

Presently the city has the lowest densities of all prefectural capitals (40.3 person/ha in 2011), second highest car ownership rate in Japan (1.72 cars/household in 2010). These has resulted in many administrative problems. First, citizens without cars were exposed to many inconveniences in mobility. Second, greenfield development in suburban areas and weakening of the Central Business District (CBD) reduced the attractiveness of the city as a whole. Third, sprawl due to motorisation increased the cost of infrastructure expansion and administrative services.

In the 2000s, the city tried to solve these issues through urban planning and transportation planning policies. The city's attempts in these efforts are well-known among policymakers and researchers, but yet it does not have quantified their impact over global environmental challenges. This report reanalyses the city's success in terms of modern urban planning paradigms such as Transit Oriented Development (TOD) and multi-core development and calibrates the actual effects in GHG emissions reduction.

2. Policies of Toyama

2.1 Tables and Figures

The city of Toyama has engaged in the following policies for urban renewal since the beginning of the 2000s:

- 1) Public transit promotion via introduction of LRT and subsidies for city buses;
- 2) Multi-core development with Transit-Oriented Development to accumulate residential and commercial businesses and cultural services in CBD area;

2.2 Public transit promotion by introducing LRT

This public transit planning was primarily intended for the short term. During mid-2000, when the city was involved with designing a new master plan, city officials realised that they needed to consider the declining population. One of the chief aims was to reconstruct the abandoned streetcar lines within the CBD and remodel poorly operated Japan Railway (JR) lines. These policies were soon realised in the late 2000s owing to the strong political will of the present City Mayor, Masashi Mori, who serves for the city since 2002.

The Toyama Lightrail, Portram is basically a renovation of the old JR Toyamako line originally opened in 1924. During and after WWII, this 8 km line ran from JR Toyama station to Toyama Port along the Tomiwa Canal, a key transport route for cargo from the port. However, it had become ill-favoured due to its age, poorly-maintained cars, infrequent service, and lack of sufficient stops. In 2006, it was re-introduced as the nation's first modern Light Rail Transit System with fully air-conditioned, low-floor cars. It now serves 13 stations, four more stations than before, and cars run every 15 minutes from 5 am to 11 pm, an increase in the frequency and service hours of operation. These are the typical measures to increase ridership in fixed rail transit projects.

Table 1. Outline of the Toyama light rail (Portram)

Opening	2006.4.29
Length	7.6km
Stations	13 stations
Cars	7 cars
Duration	25 minutes

Figure 1 shows the stylish and futuristic cars of Toyama Portram. The system technique is imported from Germany Adtranz (ABB Daimler Benz Transportation, now merged to Bombardier Transportation) and it is the first fully

modern LRT system in Japan. The stations and cars are all equipped for handicapped people. Passengers need to purchase their own IC cards when boarding. The rail is earthquake proof and some tracks are planted with lawn. The LRT is full of new attempts that the present public transit systems can get.



Figure 1: Toyama Light Rail

Left - Modern, stylish design of the remodelled line, Middle - Lawn planted tracks, Right - Barrier-free floor, accessible for the aged and physically challenged. Note: Pictures taken by the author

Simultaneously, the city has tried the pilot study for transport on JR Takayama-Honsen. The study was held using a national subsidy for community planning (Machidukuri-kofukin) and attempted to work on transit oriented development in the areas of regional train, from 2006 to 2008, and, from 2008 to 2011, by increasing the frequency and making a new station to decrease the distance among stations. It also set "park and ride" policies and the city provided the free parking lots near these designated stations.

2.2 Multi-core development with TOD

Multi-core development with transit oriented development was to accumulate the residential commercial businesses and cultural services in CBD area. This policy is aimed to be achieved through theories on compact cities. Specifically, the theory employed was "dumplings-connected-by-skewers," or connecting the cities (dumplings) with skewers (transport lines). Figure 2 shows a comparison of a conventional compact city and Toyama example to show the contrast in future development. Moreover, the compact city attempts also include the meaning of infill development in that it targeted to create a lively CBD area.

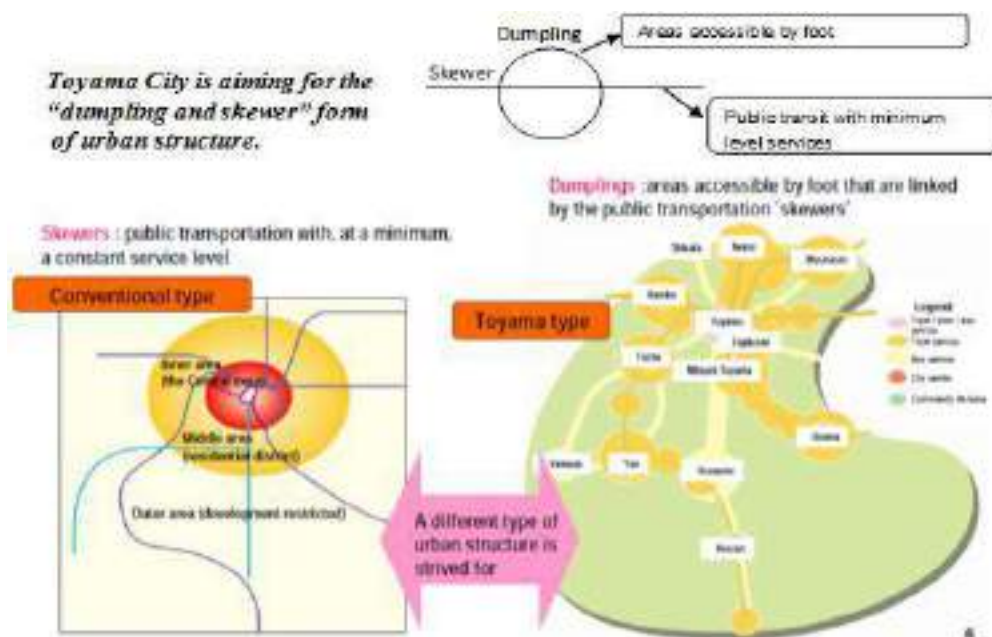


Figure 2: Toyama Multi-core Compact City Development Source: Made from Mori 2011.

3. Analysis

3.1 Changes made by the policies

The public transit renewal in Toyama has offered choice to its citizens in regard to mobility. The LRT conversion of the Toyamako-line has also shown an increase in ridership. It also tried the pilot study of the present JR lines, which represents a feasible option in terms of the total cost.

Table 1 illustrates the difference in number of users before and after the line remodelling. The city measured the ridership of LRT, both before and after the making of LRT line. Before the construction, the daily ridership of the LRT was about 2,200 in weekdays and 1,000 in holidays. After the LRT construction, each ridership became more than doubled and five times higher, around 5,000 for weekdays and 5,500 for holidays.

Table 2. LRT impact on ridership (Unit: persons)

	Before (2005 10)	After (2006 10)	Changes	Increase
Weekday daily average	2,226	4,988	224%	2,762
Holiday daily average	1,045	5,576	533%	4,531
Annual Weekdays (261 days)	580,986	1,301,868	--	720,882
Annual holidays (104 days)	108,680	579,904	--	471,224

Source: City of Toyama 2006

Figure 3 shows the LRT users previous modes measured from the questionnaire survey. Though half of the people are the former users of the same line before the renovation, the significant change can be seen that 11.5 % of people switch from driving their own cars.

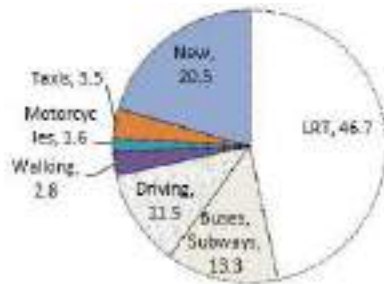


Figure 3. Modal shifts: Previous modes which transit users use (2006)

Note: Made from Mori 2011

Based on Figure 2, Table 3 calculates the estimated modal shifts of the riders in the year 2006. Though most of the users are former line users (556, 714 persons), 137,092 persons who drive, which are the most GHG emitting, switched to use LRT.

Table 3. Arrival of Toyama Portram and Mode Change of People (Unit: persons)

Switching from:	Percentage	Weekdays	Holidays	Total
Rail (former line)	46.7	336,652	220,062	556,714
Buses	13.3	95,877	62,673	158,550
Driving	11.5	82,901	54,191	137,092
Walking	2.8	20,185	13,194	33,379
Motorcycles	1.6	11,534	7,540	19,074
Taxis	3.5	25,231	16,493	41,724
New Users	20.6	148,502	97,072	245,574

	100.0	720,882	471,224	1,192,106
--	-------	---------	---------	-----------

Source: City of Toyama 2006

Similarly, the city used a national subsidy for community planning (Machidukuri-kofukin) and attempted to work on transit oriented development in the areas of regional train in 2006 and 2008 by increasing the frequency by 42 % and making a new station to decrease the distance among stations. It also set "park and ride" policies in 5 stations, where the city provided the free parking lots near the designated stations.

Table 4. Outline of the Takayama Honsen (TH) line Pilot Project -City region

Opening	2008.3.15-2011.3.11
Length	36.6km (total 225.8 km)
Stations	10 stations
Cars	7 cars
Duration	51 minutes (Express: 36 minutes)

Source: City of Toyama 2006

Table 5 shows the change of the ridership in TH line before and after the pilot study. The increase of the ridership shows 113.5% increase, from 890,000 to 1,011,000. The increase is about 12 thousand.

Table 5. TH line impact on ridership (Unit: persons)

	Before LRT	After LRT	Changes	Increase
Daily average	2,440	2,770	113.5%	330
Annual average	890,475	1,011,000	113.5%	120,525

Source: City of Toyama 2006

Table 6. Innovation of TH line and Mode Change of People (Unit: persons)

Switching from:	Percentage	Holidays & Weekdays
Rail (former line)	46.7	472,160
Buses	13.3	134,470
Driving	11.5	116,271
Walking	2.8	28,309
Motorcycles	1.6	16,177
Taxis	3.5	35,387
New Users	20.6	208,276
	100.0	1,011,050

Source: City of Toyama 2006

The city also experienced the changes of new housing development in the TOD area. The area where the transit stations exist had much higher new housing development during 2004-2009. Several studies show that neighborhoods in TOD clearly emit less GHGs from the transport sector (Winkelman 2000, Belzer and Autle 2002, Sotone et al 2007). Though the calculation for GHG emissions reductions needs more data, this certainly shows one aspects of the success of the land use policies in Toyama.

Table 7. New Housing Development in Toyama City

	2004	2009	Changes
TOD area	90	119	132%
Old City Area	2238	1455	65%

3.2 GHG Emissions Reduction

3.2.1 Toyama Portram

Previously the estimate of the people switched from cars to LRT was shown. Here the Person Trip Survey for the Toyama -Takaoka Regional Urban Area conducted in 1999 is used as the newest available person trip survey of this region. According to the survey, car users use cars average 22.4 minutes a day and average speed of car trips in this area (Hokuriku region) is calibrated as 33.5 km/h (2009). Using the calculation of MOE and MLIT, the emissions from a car per km are calibrated as 0.175kg-CO₂/person-km. Also, GHG emissions from person who uses a fixed rail is calculated through GHG emissions per one car (0.574kg-CO₂/car) divided by average number of passengers in one car. As there are 7 cars and 128 runs run in weekdays and 124 runs in holidays (Toyama Portram homepage 2012), weighted average passengers per car is:

$$\begin{aligned} & \text{Weighted average passengers per} \\ & = 2,770 / (128 \times 5 + 124 \times 2) / 7 \text{ -- (1)} \\ & = 5.80 \text{ (person/ car)} \end{aligned}$$

Therefore GHG emissions per person who takes LRT is:

$$\begin{aligned} & \text{GHG emissions from people who take LRT} \\ & = 0.574 / 5.80 = 0.0988\text{-CO}_2\text{/person-km -- (2)} \end{aligned}$$

In this calibration, we estimate people do not share the ride and only pursue drive-alone. The calculation used the most recent population from notional census in 2005.

Annual CO₂ reduction by transport
planning in Toyama city

$$\begin{aligned}
 &= (0.175 - 0.099) \text{ (kg-CO}_2\text{/ km)} \times 22.4/60 \text{ (hr)} \times 33.5 \text{ (km/hr)} \times 137,092 \text{ (People)} \\
 &\quad \text{-- (3)} \\
 &= 0.76 \text{ kg} \times 0.373 \text{ (hr)} \times 33.5 \times 137,092 \\
 &= 130,190.5 \text{ (kg-CO}_2\text{/year)} \\
 &= 130.2 \text{ (t-CO}_2\text{/year)}
 \end{aligned}$$

According to Ministry of Environment, NO_x emissions for a vehicle per km is 0.22 g/vehicle km. The LRT emits about 1/3 of the emissions and if its divided by the average number of passengers, it could be ignored as it is out of the range of significant figures.

Annual NO_x reduction by transport
planning in Toyama city

$$\begin{aligned}
 &= (0.0022 \text{ kg} - 0) \times 22.4 \text{ (hr)} / 60 \times 33.5 \text{ km/hr} \times 137,092 \text{ --- (4)} \\
 &\text{(kg-NO}_x\text{/km)} \\
 &= 3768.67 \text{ (kg-NO}_x\text{/year)} \\
 &= 3.77 \text{ (t- NO}_x\text{ /year)}
 \end{aligned}$$

3.2.2 Takayama Honsen

Previously the estimate of the people switched from cars to LRT was shown. The LRT is confined to the CBD area of Toyama, which occupies 43ha, about 0.3 % of the city. The study expands its scope to regional train. Car users use cars average 26.4 minutes a day and average speed of car trips in this area (Hokuriku region) is calibrated as 33.5 km/h (2009). Using the calculation of MOE and MLIT, the emissions from a car per km are calibrated as 0.175kg-CO₂/person-km. Also, GHG emissions from person who uses a fixed rail is calculated through GHG emissions per one car (and the approximate number of people in one car (0.574kg-CO₂/car). As there are 4 cars and 106 runs in weekdays and 49 runs in holidays (Toyama Portram homepage 2012). Weighted average passengers per car is:

Weighted average passengers per car

$$= (4988 \times 5 + 5576 \times 2) / (106 \times 5 \times 4 + 49 \times 2 \times 4) \quad \text{--- (5)}$$

$$= 21.83 \text{ (person/ car)}$$

Therefore, GHG emissions from the people who take TH line is:

GHG emissions from the people who take TH line

$$= 0.574 / 21.83$$

$$= 0.026\text{-CO}_2\text{/person-km}$$

In this calibration, we estimate people do not share the ride and only pursue drive-alone. The calculation used the most recent population from notional census in 2005.

Annual CO₂ reduction by LTR modal shift in Toyama city

$$= (0.175 - 0.026) \text{ kg-CO}_2\text{/ km} \times 22.4/60 \text{ (hr)} \times 33.5 \text{ (km/hr)} \times 116,271 \text{ (People)} \quad \text{-- (5)}$$

$$= 0.149 \text{ kg} \times 0.373 \text{ (hr)} \times 33.5 \times 116,271 \text{ (People)}$$

$$= 216,476.78 \text{ (kg-CO}_2\text{/year)}$$

$$= 216.48 \text{ (t-CO}_2\text{/year)}$$

According to Ministry of Environment, NO_x emissions for a vehicle per km is 0.22 g/vehicle km. The LRT emits about 1/3 of the emissions. 3×10^{-6} and this could be ignored as it is out of the range of significant figures.

Annual NO_x reduction by transport planning in Toyama city

$$= 0.0022 \text{ kg (kg-NO}_x\text{/km)} \times 22.4 \text{ (hr)} / 60 \times 33.5 \text{ km/hr} \times 116,271 \text{ (People)} \quad \text{---(6)}$$

$$= 0.0022 \text{ kg} \times 0.373 \text{ (hr)} \times 33.5 \times 116,271$$

$$= 3196.30 \text{ (kg- NO}_x\text{ /year)}$$

$$= 3.20 \text{ (t- NO}_x\text{ /year)}$$

3.2.3 Summary

Total emissions reduction by the policies is 346.67t-CO₂/year in GHG and 6.97 t-NO_x/year in NO_x. The reduction undoubtedly benefits the global environmental challenges. In addition, considering the people who decide to choose to live in CBD instead of suburbs, GHG emissions reductions will be additional. The policies of Toyama certainly contribute to mitigate GHG and local air pollution.

4. Other Policies

Previous section has shown the core policies of the city, light rail and compact city, and Toyama also came up with supporting policies for variation in modal choices and CBD's attractions. Toyama's Cyclocity is a service by which one can rent a bicycle in the inner-city area and return it at any of the 15 stations scattered around the CBD. This service first became available in March 2010, and over the subsequent five months, the service was used around 24,000 times and registered 850 people as members (as of October 2010).

Cyclocity uses the same system as the Paris Velib system, in which those intending to rent a bike first register online and then use an IC card or enter a registration number at their desired station. Registered users pay 700 yen a month as a membership fee and rental is free for the first 30 minutes, 200 yen for the following 30 minutes, then 500 yen per 30 minutes thereafter. The pricing reflects that the organiser of the system expects people to use bikes for short rides over short periods of time.

The system is useful for supporting the compact city idea as it supplements the public transit system and gives the residents more choices for modes of transportation. City officials have commented that this system was being widely used in less than a year from its introduction, which is a very short period of time. The reasons why introduction of Cyclocity was a strong political will by the City Mayor Mori, 100 % covered initial cost subsidy by MOEJ, the relatively wide roads in the inner city area of Toyama, and the mutual understanding of the city's compact city initiative within city hall departments, such as the police department, which is in charge of roads' usage and safety.



Figure 2. The Cyclocity System in the Centre of Toyama

Note: Left - A Cyclocity station in front of Toyama castle. Middle - Users pass their registration card over the IC reactive port next to a bicycle when renting. This is exactly same system as Velib in Paris. Bicycles are also imported from France. Right - One of Cyclocity's stations at night; all stations operate 24 hours.

5. Challenges

There are three major challenges that the City of Toyama faced: the financial burden, the coordination between the prefectural and national government, and the cooperation between local businesses and citizens.

LRT (Light Rail Transit) system is the city's biggest investment. Generally, in Japan, except for the biggest cities like Tokyo, Osaka, and their adjacent cities, it is difficult to make a profit with fixed-rail systems. Governments mostly invest in construction and maintenance of fixed rail networks. The profitability of the lines in mid-sized or smaller cities depends heavily on the reduction of operation costs. For the case of Toyama, the initial cost of its light rail transit system was subsidised considerably, as was its maintenance. In terms of actual operations, it is realising a profit and the positive externalities to urban planning and mobility benefits for citizens are significant. Therefore in Toyama as well, the total cost and benefit is not profitable. However, considering the negative externalities of using single occupant vehicles causing to both local and global environment, the investment in this LRT is commendable.

Coordination between the prefectural and national government, the prefectural government and the city government is actively facilitated partly because these entities are situated next to each other in front of Toyama Castle. This geographic proximity that has led to the strong partnership in creating Toyama's compact city. Initial investment for the Toyamako line from the prefectural government amounted to 16% and that from the city government was 33%. The national government also subsidised the line significantly as it is considered a project of MLIT. The Ministry has had a policy of subsidising the introduction of LRT systems since early 2000s. The partnerships here and the resultant outcomes of their combined efforts demonstrate that it is essential to be on good terms with other governmental bodies in making drastic changes in urban planning.

With regards to cooperation between local businesses and citizens, the city has realised successful partnerships between the private sector and its citizens. Because all Toyama's private transport businesses operate under one big company, Toyama Regional Railway, which is in charge of both fixed rail and buses (except for those belonging to JR), obtaining a consensus for use of public transit system was easier than in other cities. Furthermore, many local business owners wanted to invest in public-private joint venture companies in the operation of the LRT. In addition, nearly 80% of citizens stated that they are highly satisfied

with the new LRT lines . Thus the compact city initiatives and LRT development have been favourably welcomed by both local businesses and citizens alike.

6. Conclusions

The city of Toyama provides a good example to fast growing cities in the Asia-Pacific region as the city is promoting multi-core development, which is a useful concept for cities undergoing rapid growth. As it could reduce both GHG and NOx, it is a good policy measure for co-benefit of GHG mitigation in urban areas. The overall messages for mid-sized cities are the following: 1) Importance of multi-stakeholder initiatives, 2) Importance of a top down political will, and 3) Leapfrog in the development of a multi-core compact city;

First, the importance of multi-stakeholder initiatives reinforces the importance of building partnerships among the different levels of government, private sector, and citizens in urban planning policies. Aomori compact city was a stereotypical representation of Japanese government-led regional development projects prominent in the past: excessive investment in building and infrastructure and little interest in conceptual framework and management to run the new investment (Kono 2011). Toyama has created an original plan by creating many partnerships among stakeholders, such as railway companies, small business owners, and through a constant dialogue with the citizens.

Second, a top-down political will is important to pursue the big projects like Toyama. Toyama has been headed by Mayor Masashi Mori since 2002, who has a strong aim to make the city attractive and sustainable. His sense of crisis was blossomed as changing the city into Transit Oriented Development and the city official and citizens well cooperated to his idea. In a way, he is like a former Curitiba mayor, Jaime Lerner or Bogota mayor Enrique Peñalosa, who were succeeded to make both cities transit oriented development in a short period.

Lastly, considering leapfrogging to a multi-core compact city, it is important to plan ahead to determine smaller city boundaries. City officials say that even cities that are currently experiencing rapid urban expansion like China, it is important to work on the compact city idea. After all, it is very hard to compress a city once it has broadened. Especially in this age of scarce energy sources and global warming, cities should not just expand—they should leapfrog toward a multi-core compact, transit-oriented style city depicted by Toyama.

Acknowledgement:

This paper is based on: Kono, Noriko. 2011. "Chapter 1: Urban planning and land use management." In *Local Level Innovations towards an Environmentally Sustainable City: Case studies from Japanese cities*. Hayama: Institute for Global Environmental Studies (IGES). I thank the Institute for Global Environmental Strategies for funding the study during 2010-2011.

6. References

Belzer, Dena and Autler, Gerald. 2002. Countering sprawl with transit-oriented development. *Issues in Science and Technology* 19 (1).

Person Trip Survey for the Toyama -Takaoka Regional Urban Area. 1998. Toyama Prefecture, Civil Engineering Department, Urban Planning Division.

Susan Hanson and Genevieve Giuliano (eds.). 2004. *The Geography of Urban Transportation*. New York: Guilford. Third edition

STREAM: Sustainable Transport for East Asian Mega cities.
<http://www.jterc.or.jp/~reserch/stream/> accessed 15 January 2011

City of Toyama. 2010. Personal communications. October 2010.

City of Toyama. 2010. Email communications with city officers, February 2010.

Kono, Noriko. 2011. "Urban planning and land use management." In *Local Level Innovations towards an Environmentally Sustainable City: Case studies from Japanese cities*. Hayama: Institute for Global Environmental Studies (IGES).

Mori, Masashi. 2011. *Compact City Using Public Transit*. Presented on Smart City Week 2011 held on September 2011.

Toyama Prefecture. 2012. Email communications with prefectural officers, May 2012.

Winkelman, Steve, Hargrave, Tim, and Vanderlan, Christine. 2000. *Transportation and domestic greenhouse gas emissions trading*. Center for Clean Air Policy

Stone, Brian, Adam C. Mednick, Tracey Holloway & Scott N. Sp. 2007. Is Compact Growth Good for Air Quality? *Journal of the American Planning Association* 73 (4)