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2016 IOP Conf. Ser.: Earth Environ. Sci. 37 012057

(http://iopscience.iop.org/1755-1315/37/1/012057)

IOP Conf. Series: Earth and Environmental Science **37** (2016) 012057 doi:10.1088/1755-1315/37/1/012057

Socio-economic impact of Trans-Siberian railway after the collapse of Soviet Union by integrated spatial data analysis

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Abstract: How Russian cities have stood up again after the collapse of Soviet Union will be discussed in this paper. In order to know how the cities has managed the difficult period after the change of social system, transition of urban area, population, and nighttime light is searched. Although Far East will not stop as one of the most important area with abundant resources, overpopulation in towns and depopulation in countryside is going on. By searching the present situation, this research also aims to predict the future of Far East and Russia. First of all, Landsat data from 1987 to 2015 is collected over Moscow, Vladivostok, Novosibirsk, Tynda, and Blagoveshchensk and urban area is calculated by land cover classification. Secondly, population and retail turnover data are collected from year books in Russia. Thirdly, gross regional product (GRP) is estimated by nighttime light images from DMSP-OLS and VIIRS DNB dataset. In addition, these data are compared and difference of development stage after the collapse of Soviet Union between the unstable era (1990s-2000) and development era (2000-) will be discussed. It is expected that these analysis will give us useful information about Russian strategy for the future.

1. Introduction

Trans-Siberian railway (TSR) is the longest railway in the world. It is constructed in 1916 and has been used for 100 years. TSR plays an important role not only for passenger transport, but also for cargo transport. Since its history is very long, there are so many researches about this railway. Mori, T. [1] studied about resent use of TSR and guessed future use. However, there are very few research which focused on the cities along the railway. Although Rishat, M. [2] mentioned about development of Novosibirsk, which is along TSR, its analysis is limited in that it does not based on enough quantitative analysis. We can say that this study is unique in that it aims to detect the changes of the cities along TSR by using statistical number and information extracted from satellite images.

This study aims to know how the cities along TSR has restored from the huge impact of collapse of Soviet Union. TSR has succeeded in improving Russian economy and developing cities along it. Cities along TSR has equally developed before the collapse of Soviet Union, but after that, the way to recover from the damage is different to city to city. This research also tried to know the difference of the cities.

2. Methodology

2.1 Flow chart of this study

Flow chart of this study is shown in Figure 1. Population was collected in the Year Books in library of Moscow State University. For calculating urban area, Landsat images were used over 1985 to 2015. Each city was masked according to its shapefile and supervised classification was conducted. For nighttime light, VIIRS monthly image of August 2014 was used. After collecting these data, these data were compared.

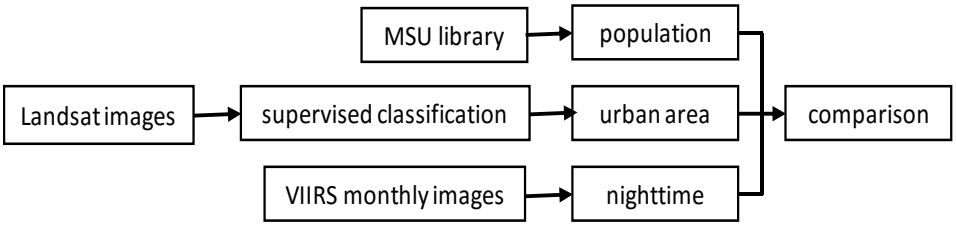

Figure 1. Flow chart of this study about data sources and analytical process.

2.2 Test site

Six cities shown in Figure 2 were selected. Tynda is not along TSR, but all of the other cities are along TSR. Moscow, Ekaterinburg, Novosibirsk, Blagoveshchensk, and Vladivostok were chosen because these were big, developed cities and were along TSR. Tynda was selected as a comparison target.

Figure 2. Test site of this study along TSR.

2.3 Data used in this study

Population data were collected by some books in the library of Moscow State University. Population of each six cities were collected for about 100 years. Urban area was calculated by Landsat images. Images were gained from 1990 to 2015. Urban area, water, vegetation, and follow land were chosen as region of interest and supervised classification was conducted. Since Tynda is a very small city and even inside administrative district of Tynda, there is forest, which produces more error in classification. That's why only urban area around the station is cut and classification was conducted only in the square region in the case of Tynda.

Nighttime light was gained by NPP-VIIRS (http://ngdc.noaa.gov/eog/viirs.html). Data of August in 2014 were used because in winter, reflects of snow increase the amount of light and it will decrease the research quality. GADM shapefile was used to cut the cities according to administrative definition. Total light amount was calculated for each city and it was divided by area of each city. However, in the case of Tynda, since the administrative area was too large and it was difficult to compare, the same area which was used when classification was chosen and nighttime light amount in the square area was calculated.

3. Results and discussion

3.1 Urban area changes by Landsat

Figure 3 and 4 shows the change of urban area. The area of the first year of observation is set one and rate is shown in this figure. Tynda is the only one city whose urban area is decreased since 1990. We can see that all the cities along TSR has expanded urban area. Especially in Ekaterinburg and Vladivostok, urban area did not change before 2010 so much, but after 2010 urban area started to increase greatly.

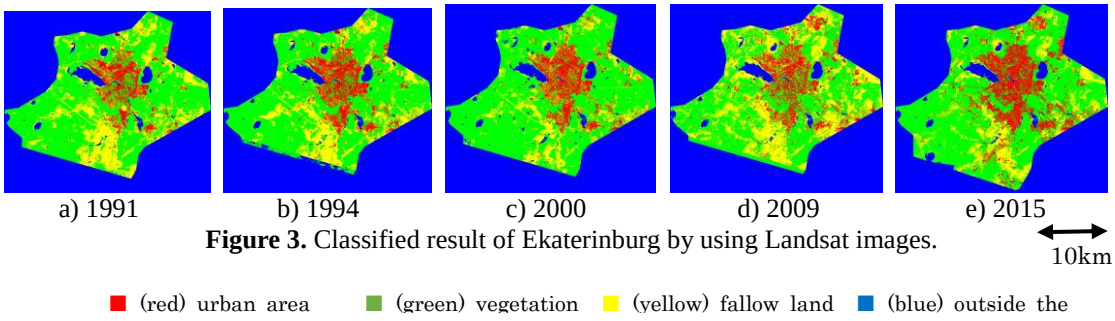

Figure 3. Classified result of Ekaterinburg by using Landsat images.

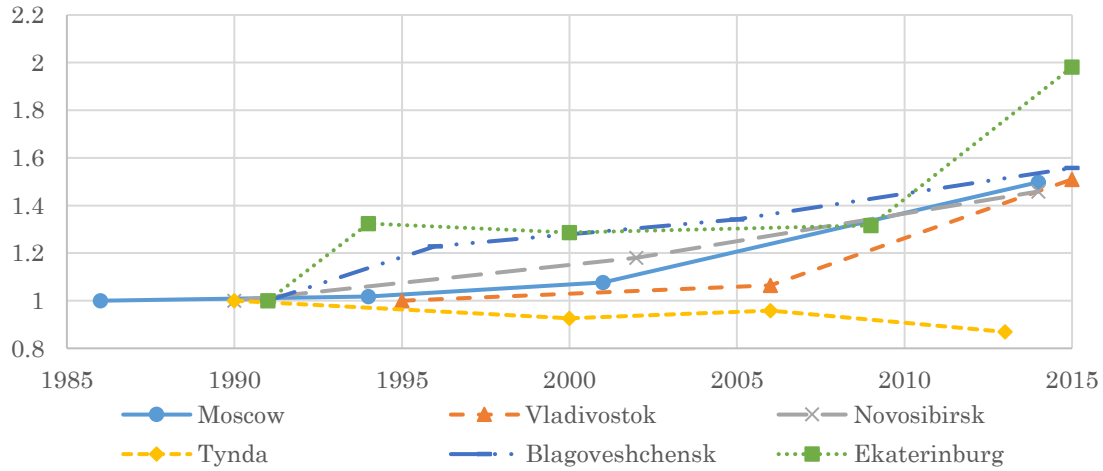

Figure 4. Urban area change of six target cities shown with the value of the first observation year set as one in each city.

3.2 Nighttime light at 2014

Table 1 shows that the total amount of light is much higher in Moscow than in other cities. According to Figure 5, nighttime light is concentrated especially at the cross point of railway. This area is the place where station is located, so we can assume that city has developed around railway station.

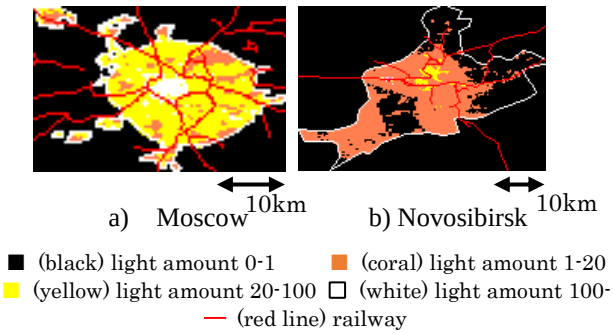

Figure 5. Nighttime image in August 2014 taken by VIIRS in (a) Moscow and (b) Novosibirsk.

Table 1. Sum of Nighttime light in August 2014 by VIIRS dataset. Unit is [nanoWatts/cm2/sr].

	Moscow	**Ekaterinburg**	**Novosibirsk**	**Tynda**	**Blagoveshchensk**	**Vladivostok**
Sum of nighttime light	101907	17550	22960	1795	3373	6739

3.3 Population changes

According to Figure 6, population of cities along TSR has increased greatly after construction of TSR. However, there was an unstable era after the collapse of Soviet Union, during which population has stopped increasing. Recently, from around 2010, population has started increasing again. However, in the case of Tynda, which is not along TSR, population has increased greatly only in 1970s and 1980s. It might be because government's policy to attract workers to Far East. Right after the collapse of Soviet Union, which means after this policy has over, Tynda population starts to decrease.

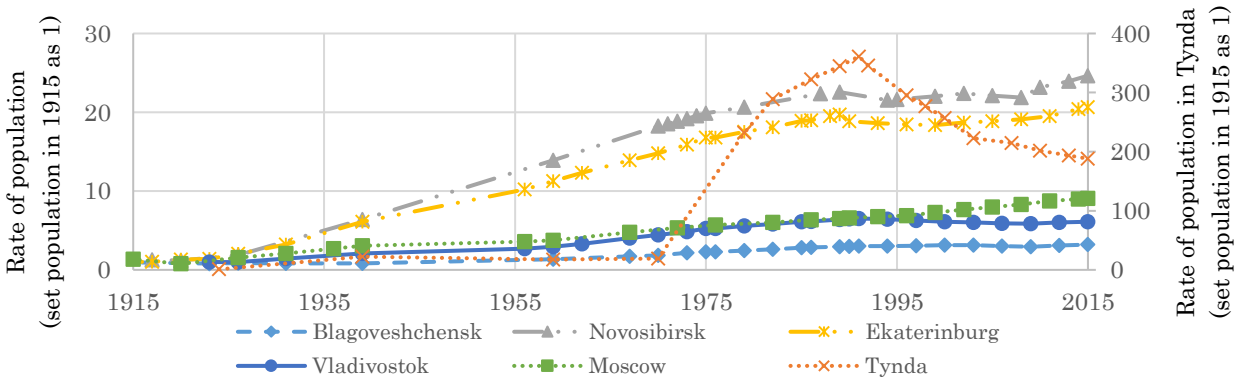

Figure 6. Population transition of six cities (set population in 1915 as one).

3.4 Discussions

Figure 7 shows population and nighttime light has strong relation. It can be a good reason for high value of nighttime light in Moscow in Table 1. Moscow is the most populated city in Russia, so its nighttime light is also very bright.

Figure 8 shows that in Moscow and Novosibirsk, nighttime light assumed by urban area is higher than other cities, and in Vladivostok and Ekaterinburg, nighttime light assumed by urban area is lower than other cities. This fact means that in Moscow and Novosibirsk, the city is more developed to vertical. Moscow is the largest, and Novosibirsk is the third largest city (second is Saint Petersburg) in Russia, and there might be many skyscraper in these cities.

Figure 8 also shows that the plot of Tynda is on the approximate curve. Figure 5 and 6 shows that although the population of Tynda has decreased greatly, urban area does not change so much. It might be because even though the number of people has decreased and there are some houses which are not used anymore, satellite image cannot tell them from houses which is still in use. From this fact, it can be said that what lit in Tynda does not houses but some factories or commercial buildings. These kind of buildings will not stop to light even if the number of people working there decreases.

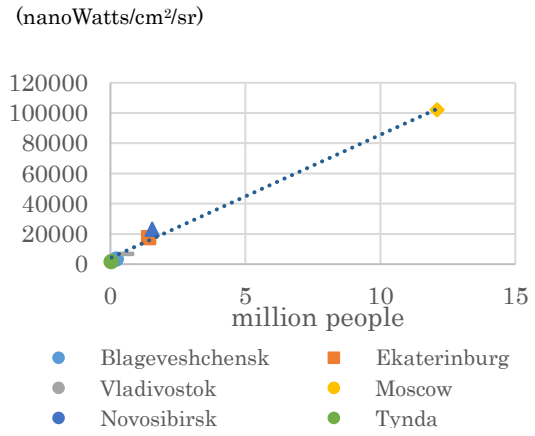

Figure 7. Population and nighttime light of each city.

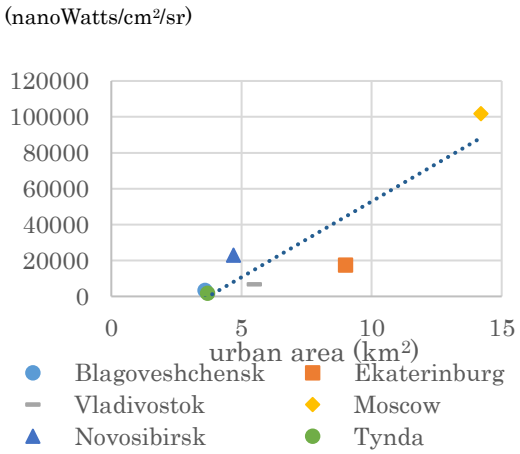

Figure 8. Urban area and nighttime light of each city.

Figure 5 shows that Ekaterinburg and Vladivostok has greatly increased its population after 2010. In the case of Vladivostok, there was APEC conference held in 2012, so Russian government made some policies to construct infrastructure and made some roads. We can guess that the same kind of thing have happened also in Ekaterinburg. That may be the reason why in these cities nighttime light amount is smaller than expected from urban area. Since the great development of these cities has happened just recently, there were not that much people living in the city. According to Figure 7, population and nighttime light amount has liner relation, which leads the result in Figure 8.

4. Conclusion and future works

In conclusion, we can say that TSR has played an important role in increasing the number of people in the cities along TSR. However, because of collapse of Soviet Union, population transition pattern after 1990 differs from city to city. But Russia has gradually stood up against this difficulty and after around 2010, each city along TSR has turned to increase its population. TSR has also effected urban area along it. Urban area of the cities along TSR has increased after 1990, but urban area of Tynda, which is not along TSR, has not increased. Although all the five

cities along TSR has increased its urban area after 1990, transition pattern differs from city to city. In those cities, Ekaterinburg and Vladivostok has greatly increased urban area after 2010. Seeing that other cities has increased gradually, it might be the result of some policy. In the case of Vladivostok, APEC conference was held in 2012, and government has invested a lot of money to construct infrastructure. The same kind of thing might have happened in Ekaterinburg. And this result might have affected the relation of urban area and nighttime light. And about Tynda, concerning population has decreased, urban area has not decreased so much, and nighttime light is not that small, people might be working in factories or commercial buildings. In order to know the effect of TSR more exactly, more cities which is not along TSR need to be searched.

Acknowledgements
I would like to thank JSPS for supporting the Russian and Japanese student exchange program managed by the cooperation of the natural science and civil engineering.

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