PARALLEL STUDY ON MATERIAL FLOW AND STOCK OF ROADS LOOKING FORWARDS TO A SUSTAINABLE SOCIETY- CASE STUDY IN JAPAN

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INTRODUCTION

Resources that used for development are never endless. Material flow society does have a variety of benefits. However, too much movement of materials and correlated energy consumption has also caused giant influences on the nature. Therefore, it is necessary for us to transfer our society from a material flow based to a stock based one by utilizing the infrastructures in an efficient and effective way. There is no direct and concrete solutions for a country to measure the effectiveness and efficiency of material usages in infrastructure and so, it needs some possible findings for relations and dependencies of material stock and flows to convey ways for a country to go to a sustainable society. This research tries to a make a parallel study of material flow and stock of roads and also uses some indicators. For the first point, we evaluated total road stock, and material flows of roads, which are gross additions to stock (GAS) and net additions to stock (NAS). For the second point, gross domestic product (GDP) and population are taken account into consideration. The detail evaluation and analysis is discussed in this paper.

DATA AND METHODOLOGY

Gross additions to stock (GAS) and net additions to stock (NAS) are very important indicators in economic wide material flows accounts to trace the entire stock consumption conditions. The authors of this research have already evaluated material stock of roads, road-bridges and road-tunnels in their previous research (Lwin, C. M., et. al, 2011). In this research, although we showed the condition of total stock and found its correlation with GDP and population, in evaluating GAS and NAS, we will focus only on roads excluding high ways, road-bridges and road-tunnels.

By using direct method calculation of NAS and by making strictly keeping a system boundary only on road stock, determining of NAS could be done for the specific study year by using Eq.1 where *Avg. Annual* NAS_A means average annual net additions to stock at year A, MS_A stands for total material stock at year A, and MS_{A+5} is total material stock at year A + 5. To get average annual result of NAS, 5-year NAS value has to be divided by 5.

$$Avg.\ Annual\ NAS_A = (MS_{A+5} - MS_A)/5 \qquad (1)$$

Since materials are added to the economy's stock every year denotes to GAS, in this research, GAS of roads was directly evaluated by calculation of material consumption for all new construction part and maintenance part of roads and pavements by using the following Eq. 2 where $MI_{ia}(t)$ is the amount of material i which is input to infrastructure type a in year t, $C_a(t)$ is the amount of infrastructure type a in year t and $\partial_{ia}(t)$ is the input rate of material i per construction infrastructure type a in year t.

$$MI_{ia}(t) = C_a(t) \times \partial_{ia}(t) \qquad (2)$$

As the second part, evaluating correlation of the road stock with GDP and population was done. GDP published by the Cabinet Office was used and in this research, and the same base year 1990 (68SNA) was used to calculate every five-year of GDP (1980- 2005) by adjusting the deflator to trace the real trends of the correlation between the GDP and material road stock in Japan and we also tried to correlate stock and population as shown in figure 2.
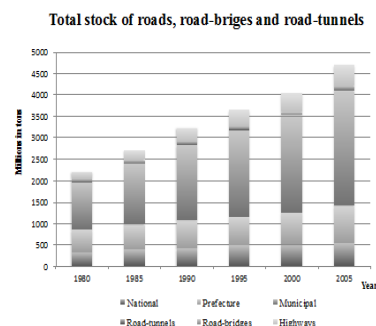
RESULTS AND DISCUSSIONS

Fig.1 Cumulative road stocks

Although Lwin, C. M., et al has already estimated the total stock, we again more categorized the result of previous research's results as shown in figure 1. By observing figure 1, it could say that although total material stock for the study period (from 1980 to 2005) has been increasing, by capturing the national overall trend, variation of the growth rate of the infrastructure stock for the whole country contracted gradually. These conditions are very attractive conditions for going forwards to a low material society. Figure 2 shows the correlations of total stock that was shown in figure 1, with GDP and population. As stock/person was increasing while total stock is also increasing, it could conclude that stock may be affected by changes in number of population (decreasing or increasing). GDP/stock shows decreasing stock productivity: in general, the trend of less and less effective and efficient use of road stock. Figure 3 depicts GAS and annual average NAS. The shown NAS and GAS value are only for roads excluding high ways, road-tunnels, road-bridges. The values of NAS indicate that the disposal of waste will show a rising or falling tendency in the study period and also that the pressures exerted on land (or, broadly, speaking, space) are growing or decreasing. This is most evident in the study period at 2005 and the least in the case at 2000. It is observed that both GAS and NAS become less while total stock has been increasing. Construction activities in Japan are decreasing and so reasonably, GAS of roads in Japan becomes less and less. If the less GAS and NAS could result the more economic outcomes, it could lead a sustainable society.
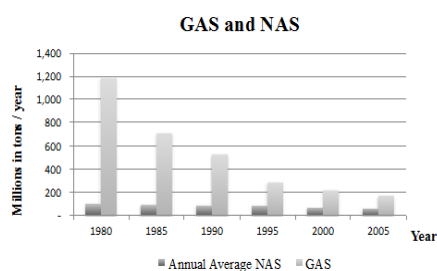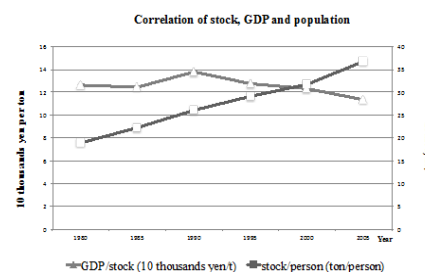

Fig. 2 Correlation of stock, GDP and population

Fig. 3 GAS and NAS (millions in ton/year)

CONCLUSIONS

This research could prove that calculation for GAS and NAS by direct method is feasible in Japan due to data availability. In addition, this research tries to capture material stock and flow together to convey some points to ponder to go to a sustainable society because as examples, stock and flows are look like rocks and water. In nature, the rocks shape the water in the short term, but in the long-term, it is the water that shapes the rocks. So, this research focuses on both of them to anticipate not only for short term but also for long term. The pending objective is elaboration and application of the same methodology applied in this research for developing countries not only in roads but also for other types of infrastructure.

REFERENCES

1) Cherry Myo Lwin, Ji, H., Shirakawa, H., Tanikawa, H., Study on the Correlation between Material Stock of Roadways and Industrial Structure Change in Japan, Proceedings of the Thirteenth International Summer Symposium, JSCE, Vol.13, 305-308, 2011