B. Energy unit

According to the statistic report by Japanese government [5], the energy unit of each composite good, car trip and mass transit trip is set as values in Table 2.

TABLE 2 ENERGY UNIT OF GOODS IN KUMAMOTO

Composite good (kal/person.day)	*Car trip (kal/person.min)*	*Mass tranit trip (kal/person.min)*
2.46	142.74	17.68

C. Estimated energy consumption

More than 37200 kcal of energy is estimated for each person in one day in Kumamoto. Among them, more than 73% of energy is used for composite goods consumption. 26% of energy is for car trips. Only less than 0.5% of energy is used for mass transit trips (Table 3). Based on the estimation results, large part of energy is spending on composite goods consumption, which is mainly for household residential and recreation uses. Energy of car trips accounts for big share compared to mass transit trips, indicating car travels is very popular and energy intensive.

TABLE 3 ESTIMATED ENERGY CONSUMPTION FOR ONE PERSON PER DAY

Total energy consumption	3.72×10^4
Energy consumption for composite goods	2.72×10^4(73.12%)
Energy consumption for car trips	9.87×10^3(26.48%)
Energy consumption for mass transit trips	1.52×10^2(0.41%)

(): Energy share of goods

D. Energy efficiency

We introduce the energy efficiency index to compare energy consumption on different utility levels of zones in Kumamoto. This index is analyzed at two levels: region and zone level, respectively. The regional energy efficiency index is the ratio of average utility and energy consumption for one resident in Kumamoto region. Table 4 lists the averaged utility, energy consumption, and energy efficiency in Kumamoto.

TABLE 4 AVERAGED UTILITY, ENERGY CONSUMPTION AND ENERGY EFFICIENCY IN KUMAMOTO

Utility	6966
Energy consumption	37276
Energy efficiency	0.187

We also analyze the energy efficiency at zone level. Figure 2.a shows the estimated value of energy efficiency in each zone. While Fig. 2.b presents the main traffic network and population density in Kumamoto region. Although a few zones with higher energy efficiency are found in suburban and rural area, the energy efficiency decreases with the distance to the city center. Zones along the mass transit lines are higher energy efficient.

a. b.

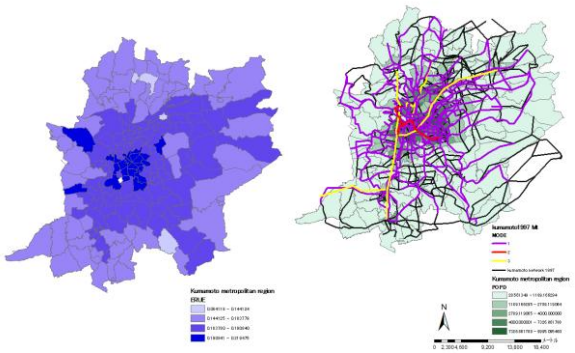

Fig.2.a Energy efficiency of zones in Kumamoto
Fig.2.b Population density and traffic network in Kumamoto

IV. CONCLUSION

V. This paper developed a model to estimate the energy consumption and utility based on individual consumption behaviors. An energy efficiency indicator was proposed to evaluate energy consumption efficiency of residents in different zones who are on several utility levels. By applying the method into Kumamoto, we found there is close relationship between the urban infrastructure configuration and energy efficiency. High energy efficiency zones mainly locate in dense area or along transport lines, especially mass transit lines. High population density and mass transit transport accessibility attribute to high energy efficiency. This founding gives meaningful suggestions for urban sustainable development.

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