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Sustainability Study Based on Ecological Footprint of Traditional Housing Kampung Naga

Doddy Anwar
*Department of Architecture, University of Catholic Parahyangan, P.O. BOX 40141, Bandung, Indonesia. *Corresponding Author*

Gagoek Hardiman
Professor of Architecture Faculty of Architectural Engineering, University of Diponegoro, P.O. BOX 1262, Semarang, Indonesia.

Rumiati R.Tobing
Lecture of Architecture Faculty of Architectural Engineering, University of Catholic Parahyangan, P.O. BOX 40141, Bandung, Indonesia.

ABSTRACT

Traditional housing is mostly considered environmentally friendly due to low-level consumption of the natural resources and has assumed having a minor impact on its surrounding environment. Sustainability can be achieved by reducing excessive consumption of natural resources. One way to measure sustainability is through the Ecological Footprint (EF) this method. EF is used to figure human demand on this ecosystem and natural resources annually. Accordingly, it's interesting to use the EF method on the house in order to figure the value of EF and comfort level of the houses. The purpose of this research is to determine the value of EF and impact on the traditional houses in Tasikmalaya district, West Java. The research also investigates the comfort level of physical space of the houses. Total EF of Kampung Naga is 0.3368 gha / cap with details of Ecological Footprint (EF) of food 0.1678 ha / cap, transportation 0.0153 ha / cap, building 0.1537 ha / cap. EF Kampung Naga is smaller than EF Indonesia which is 1.07 gha/cap. While the average EF population on earth is 2.2 gha. It means the level of sustainability Kampung Naga higher because of the pattern of consumption of natural resources is low and the local population makes good use of the resources in relation to the environment.

Keywords: Ecological footprint; Traditional housing; Kampung Naga

1. INTRODUCTION

Almost all modern human activities are related to energy and resources consumption. While the energy used by humans today largely comes from fossil fuel, it means in the process generating the energy releases CO2 in large quantities and will impact the future sustainability. For a sustainable future, it is important to understand what sustainability means and how it can be measured [1]. Human consumption for resources tend to impact the environment such as food production and may be expanded by converting forest into cropland [2]. To see human consumption and how much are needed natural resources to support this, a method needed to measure the ecological impact on the natural resources which is the demand for finite resources will cease to increase [3]. One of the methods is Ecological Footprint (EF). Measuring the level of sustainability is not only seen from the release of carbon emissions, but also can be seen from the value of Ecological Footprint (EF) every individual, buildings area, or even a country. The calculation of Ecological Footprint (EF) still has some advantages and disadvantages [12]. By using the Ecological Footprint approach (EF), it is conceivable that traditional housings have a small EF value which means they in return has a small impact on the surrounding environment. But the problem what exactly is the value of the EF? This study investigates the EF value of the Kampung Naga houses and compares them to the average EF value of Indonesia and developed countries. It is necessary to see how far the life of Kampung Naga community can effect on the sustainability of the earth. Furthermore, this research departs from a hypothesis that Kampung Naga people have Ecological Footprint (EF) per capita value under Ecological Footprint (EF) per capita of Indonesia.

2. MATERIAL AND METHOD

This study conducts a Quantitative Method which has measured the Ecological Footprint (EF) in Kampung Naga village, West Java. The research begins by collecting data on the amount of natural resource consumption per person per year. Natural resources studied include food, house, and transportation. The basic formula for calculating Ecological Footprint (EF) per person [4].

$$\text{Land needs per capita (ha)} = \frac{\textit{consumption per capita } (kg\ year^{-1})}{\textit{production per hectare } (kg\ ha^{-1}\ year^{-1})} \tag{1}$$

Land needs per capita (Percapita land requirement) unit ha. Consumption per capita (per capita consumption) unit kg.year-1. Production per hectare (Resources of consumption of local arable land) unit kg.ha-1year-1. Total Ecological Footprint (EF) is total EF of all people in a certain population [5].

3. RESULT AND DISCUSSION

Before the survey, initial data have was for occupancy positions in Kampung Naga based on direct field data. The data is listed below:

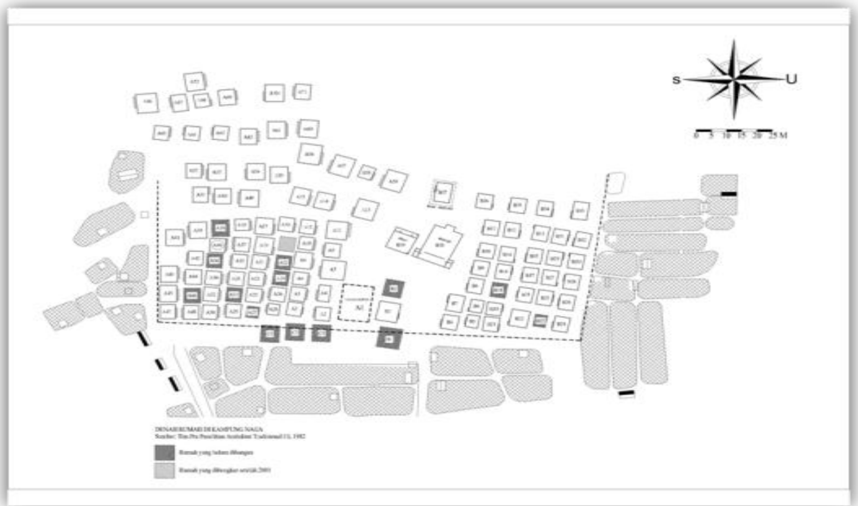

Fig.1. Residential Position of Kampung Naga

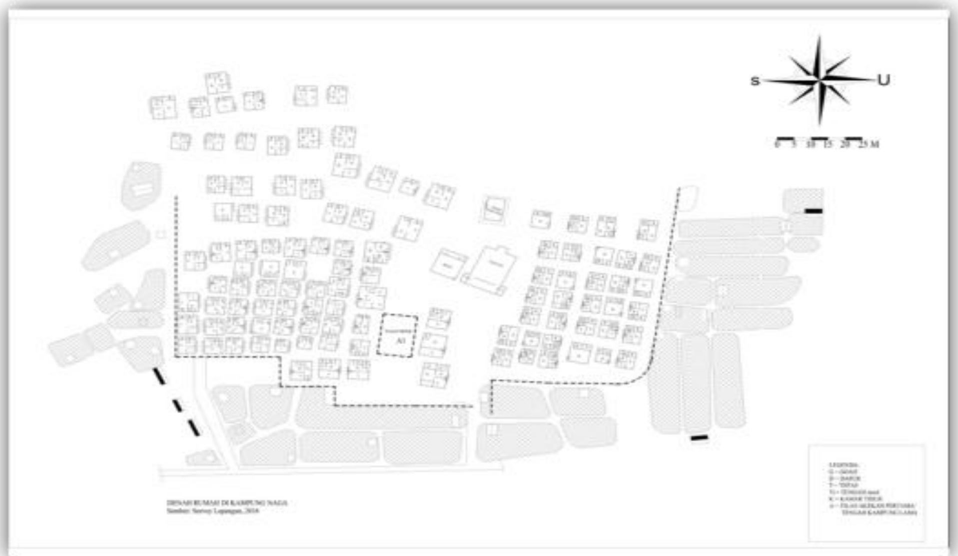

Fig.2. The Residential Site Plan of Kampung Naga

From the picture above the entire buildings have been measured and identified. Every house generally has tepas, middle *imah*, kitchen, bedroom, and *goah*. The size of each house tends to vary.

3.1 ECOLOGICAL FOOTPRINT (EF) FOOD

3.1.1 RICE

The Ecological Footprint (EF) of rice consumption in Kampung Naga area based on survey results is 0.0189 ha/cap. This value is obtained by dividing the average per capita consumption of 94,526 kg/cap to crop yield per year (kg/ha). This crop yield For Indonesia is 5414 kg/ha taken from FAOSTAT "Food Balance Sheets" [6]. As for the value of EF rice on Kampung Naga area as a whole is 1.0587 ha/cap.

Moth Flame Optimization is the recent population-based algorithm which was developed in 2015 by Seyedali Mirjalili [12], in this algorithm, the month navigation is based on transverse (spiral movement) around the best solution which is the flame position.

Table 1: EF Rice, Kampung Naga

NO	Value	Cap Consumption (kg/cap) in a year	Crop yield per year (kg/ha) of FAO data for Indonesia	EF (ha/cap)
1	Amount	5293.438	5414	0.978
2	Average	94.526	5414	0.0175

In 2013, Tran [7].shows that for the overall crops, Vietnam has smaller EF than New Zealand and Finland. As viewed from a geographic position, Vietnam has a natural resemblance to Indonesia from New Zealand and Finland. In addition, the general climate and diet of the people are also similar to Indonesia, especially Kampung Naga with Vietnam. The rice yield in Vietnam is 5.581 kg/ ha/year [5]. With three times the cropping season, same as the planting and harvesting period in Kampung Naga.

3.1.2 CHICKEN EGGS

Ecological Footprint (EF) for the consumption of chicken eggs Kampung Naga area based on survey results amounted to 0.00085 ha/cap. This value is obtained from the multiplication of the average per capita consumption of 5.33 kg/cap on the area required to obtain 1 kg of chicken eggs by 0.00016 ha/kg [7]. The value is obtained from the area of land needed to feed 1 chicken by 0.0008 ha/chicken divided egg production from a chicken per year of 5 kg eggs/year. The value of 0.0008 is the area of land needed to raise 1 poultry (chicken) species obtained from Vietnamese data. The value of EF chicken eggs Kampung Naga area as a whole is 0.0477 ha/cap.

Table 2: EF Chicken eggs, Kampung Naga

NO	Value	Cap Consumption (kg/cap) in a year	Area of land to grow 1kg of chicken meat (ha/kg)	EF (ha/cap)
1	Amount	456	0.0004	0.1824
2	Average	10.86	0.0004	0.0043

3.1.3 CHICKEN MEAT

Ecological Footprint (EF) for the consumption of chicken meat Kampung Naga area based on survey results amounts to 0.0043 ha/cap. This value is obtained from the multiplication of average consumption per capita 10.86 kg/cap to the land needed to raise 1 kg of chicken by 0.0004 ha/kg. The value of 0.0004 ha/kg is the average of the land needed to feed 1 kg of livestock in Vietnam (0.0002 ha/kg) with the global average (0.0005 ha/kg). As for the value of EF chicken meat, Kampung Naga as a whole is 0.1824 ha/cap.

Table 3: EF Chicken meat, Kampung Naga

NO	Value	Cap Consumption (kg/cap) in a year	Area of land to grow 1kg of chicken meat (ha/kg)	EF (ha/cap)
1	Amount	456	0.0004	0.1824
2	Average	10.86	0.0004	0.0043

Referring to the Tran in 2013 [7], the average age for slaughtering animals in New Zealand and Finland is found similar. While the age of chicken livestock growth in Vietnam is longer because farms are still mostly done traditionally and just rely on the home yard only. This is also similar the case for chicken livestock in Kampung Naga.

FRESHWATER FISH

Ecological Footprint (EF) for the needs of freshwater fish consumption Kampung Naga area based on survey results is 0.10 ha/cap. This value is obtained from dividing the average consumption per capita 15.80 kg/cap to crop yield per year of 152 kg/ha based on Hengrasmee [8]. The value of crop yield is taken from Hengrasmee's research because the study was conducted in Thailand which has similar natural conditions to Indonesia. As for the value of EF freshwater fish, Kampung Naga area as a whole is 5.82 ha/cap. The total value of EF fisheries for Indonesia is 0.18 gha/cap.

Table 4: EF Freshwater Fish, Kampung Naga

NO	Value	Cap Consumption (kg/cap) in a year	Crop yield per year (kg/ha) of FAO data for Indonesia	EF (ha/cap)
1	Amount	885.00	152	5.82
2	Average	15.80	152	0.10

3.1.4 VEGETABLES

Ecological Footprint (EF) for the needs of vegetable consumption of Kampung Naga village based on survey results is 0.0041 ha/cap. This value is derived by dividing the average per capita consumption of 36.781 kg/cap to crop yield per year of FAO [6] data for Indonesia is10.231 kg/ha. So, the value of EF vegetables of Kampung Naga area as a whole is 0.1716 ha/cap.

Table 5: EF Vegetables, Kampung Naga

NO	Value	Cap Consumption (kg/cap) in a year	Crop yield per year (kg/ha) of FAO data for Indonesia	EF (ha/cap)
1	Amount	1544.80	10.231	0.151
2	Average	36.7810	10.231	0.0036

Table 6: EF Crop yields, Kampung Naga

Variety	Crop yield per year (kg/ha) of FAO Indonesia data	EF (ha/cap) of FAO Indonesia data
Rice	5414	0.978
Vegetables	10.231	0.0036
Total Cropland (gha/cap)		0.0225

The total value of EF for the cropland Kampung Naga agricultural area is 0.0225 gha/cap. The total value of EF crops for Indonesia is 0.57 gha/cap. This shows that the EF of Kampung Naga is lower than the EF of Indonesian crops. The total EF for basic foods includes crops, livestock, and fish.

3.1.5 INSTANT NOODLE (NON-BASIC FOOD)

Ecological Footprint (EF) for the needs of instant noodle consumption Kampung Naga area based on survey results amounted to 0.0133 ha/cap. This value is obtained from the average consumption per capita consumption of 5.1 kg/cap on the land area to produce 1 kg of instant noodles of 0.0026 ha/kg [9]. As for the value of EF instant noodles, Kampung Naga area as a whole is 0.7426 ha/cap.

Table 7: EF Instant noodle, Kampung Naga

NO	Value	Cap Consumption (kg/cap) in a year	Land area to produce 1kg of product (ha/kg)	EF (ha/cap)
1	Amount	285.6	0.0026	0.7426
2	Average	5.1	0.0026	0.0133

3.1.6 INSTANT COFFEE (NON-BASIC FOOD)

Ecological Footprint (EF) for the needs of instant coffee consumption Kampung Naga area based on survey results amounted to 0.0282 ha/cap. This value results from the average consumption per capita consumption of 4.7829 kg/cap on the land area to produce 1 kg of instant coffee by 0.0059 ha/kg [9]. As for the value of EF instant coffee, Kampung Naga area as a whole is 1.5803 ha/cap.

Table 8: EF Instant coffee, Kampung Naga

NO	Value	CapConsumption (kg/cap) in a year	Land area to produce 1kg of product (ha/kg)	EF (ha/cap)
1	Amount	267.8400	0.0059	1.5803
2	Average	4.7829	0.0059	0.0282

Based on survey data of Ecological Footprint field study for food needs of Kampung Naga can be recapitulated as below table:

Table 9: Recapitulation of EF food

NO	VARIETY	EF Average (ha/cap)
1	Rice	0.0175
2	Chicken eggs	0.00085
3	Chicken Meat	0.0043
4	Freshwater fish	0.10
5	Vegetables	0.0036
6	Instant noodles	0.0133
7	Instant coffee	0.0282
	Total	0.1678

Based on Ecological Footprint Recapitulation (EF) data for food needs of Kampung Naga area based on survey result is 0.1678.

3.2 ECOLOGICAL FOOTPRINT (EF) TRANSPORTATION

For transportation, EF quantities are measured by users walking, bicycles, motorcycles, cars, buses, trains, and *angkot*. The calculation of EF for transportation is to find the distance from each mode of transportation including walking (km/year). The distance is multiplied by the EE transportation coefficient (Vehicle Embedded Energy GJ/km [7]) to obtain the energy value used per capita (Energy Used per Cap GJ/cap).

3.2.1 WALKING IN FOOT

The average EF value for pedestrians is 0.0038 ha/cap. While the average energy used per capita per year is 0.3833 GJ/cap with the average distance per capita per year is 1533.4 km/year. The coefficient for Embodied Energy used for walking is 0.00025[7].

3.2.2 BICYCLE

For cycling, all respondents had no bicycles. This is due to the contoured nature of Kampung Naga that is located in the valley and has main access to the stairs, causing it is difficult to use bicycles on the up and down on the stairs.

3.2.3 MOTORCYCLE

The average EF value for motorcycle use is 0.0032 ha/cap. While the average energy used per capita per year is 0.3153 GJ/cap with the average distance per capita per year is 3087.2 km/year. The coefficient for Embodied Energy used for motorcycles is 0.00026[7].

3.2.4 CAR

The average EF value for using a car is 0.0006 ha/cap. While the average energy used per capita per year is 0.0632 GJ/cap with the average mileage per capita per year is 1011.1 km/year. The coefficient for Embodied Energy used for car use is 0.0005 [7].

3.2.5 TRAIN

The average EF value for using a train is 0.0004 ha/cap. While the average energy used per capita per year is 0.0371 GJ/cap with the average distance per capita per year is 1733.1 km/year. The coefficient for Embodied Energy used for train use is 0.0002 [7].

3.2.6 ANGKOT

The average EF value for using an *angkot* is 0.0063 ha/cap. While the average energy used per capita per year is 0.6272 GJ/cap that the average distance per capita per year is 2926.8 km/year. The coefficient for Embodied Energy used for public transport (*angkot*) is 0.0005 [7].

Table 10: Recapitulation of EF transportation

Type of Transportations	**Vehicle EE (GJ/km)**	**EF (ha/cap)**
Walking on foot	0.00025	0.0038
Using bicycle	0	0
Using a motorcycle	0.00026	0.0032
Using a car	0.0005	0.0006
Using bus	0.00025	0.0010
Using train	0.0002	0.0004
Using *angkot*	0.0005	0.0063
Total		0.0153

From the above data, it can be seen that the lowest EF Kampung Naga residents regarding transportation are using the train. Using a train is rarely done by Kampung

Naga residents except when visiting relatives outside the city at certain times such as religious holidays. While the highest EF is using a*ngkot*. This indicates that the population of Kampung Naga more often use public transportation as daily transportation. The total value of EF for transportation in Kampung Naga area is 0.0153 ha/ cap/year. In comparison, the total EF of transport for Hanoi, Vietnam is 0.1869 ha / cap / year, for Wellington (New Zealand) 0.3874 ha / cap / year, and Oulu (Finland) 0.4521 ha / cap / year. This shows that Vietnam's transport EF has lower than New Zealand and Finland. [7]

3.3 ECOLOGICAL FOOTPRINT (EF) BUILDING

The Ecological Footprint (EF) of Kampung Naga consists of 2 matters related to building materials and building operations. The building materials studied are in the form of wood and bamboo as it is the most widely used material. As for building operations, people use kerosene.

3.3.1 BAMBOO AND WOOD

The main material used in the existing buildings in Kampung Naga are bamboo and wood taken from around the neighborhood using human labor in mutual assistance. In the calculation of bamboo and wood, distinguished at the growing speed of bamboo is faster than wood. While the same mileage when taking is assumed to be the same. Forests on the surface of the earth can grow sustainably as much as 10 m3 / year and will produce 70 GJ/ha [9]. This means 1m3 of wood will produce 7 GJ (almost 2000 kWh). Meanwhile, according to Wackernagel and

Monfreda [10], the average forest is capable of producing 40GJ of wood fuel/ ha/year. Vale and Vale estimate that forests are capable of delivering 50GJ / ha/year. In this study, the value of wood used is 40GJ / ha/year because it is the average value of forest production. As for the value of bamboo using 60GJ / ha/year, value bamboo can grow faster than wood in general. The calculation of EF Building as follows:

Table 11: EF Per Home

Materials	**Consumption (M3 / Home)**	**Convert to GJ (1 M3 = 7 GJ)**	**EE Forest (GJ / Ha)**	**EF Forest (Ha / Year)**
Wood	3.61	25.26	40	0.03
Bamboo	0.33	2.34	60	0.43
TOTAL				0.45

Table 12: EF Per Capita

TOTAL EF	TOTAL HOUSE	TOTAL POPULATION	EF BUILDING (ha / year)
0,45	109	326	0,15

3.3.2 KEROSENE

Kampung Naga community relies heavily on kerosene especially for night lighting and cooking. They reject the entry of electricity supply and do not use LPG for cooking. Stove for cooking in the kitchen still use a stove (*hawu*) that still uses firewood. The average community spends 0.64 liters of kerosene per day. The following is an Ecological Footprint (EF) calculation of kerosene.

Table 13: EF Per Capita

Fuel	Consumption in GJ	Yield Factor (GJ/ha/year)	EF (Ha/person)
Kerosene	0.37	100	0.0037

The first assumption is converted to Gyga Joule (GJ) units in gallon units using the American standard (US). As for the yield factor using non-renewable categories of 100 GJ/ ha/year [7].

Table 14: EF Total Building

Building	EF (Ha/person)
Building material(wood and bamboo)	0.15
Kerosene	0.0037
TOTAL	0.1537

6. CONCLUSION

Total Ecological Footprint of Kampung Naga is 0.3368 gha/cap with details of Ecological Footprint (EF) of food 0.1697 ha/cap, Transportation 0.0153 ha/cap, building 0.1537 ha/cap. The smallest Ecological Footprint (EF) value is transportation. This is generally because Naga Village people rarely have private vehicles. In case of a long journey, they tend to use public transportation such as *angkot* and bus. And in short distance traveling, people prefer to walk. Compared to the total value of

Ecological Footprint (EF) of Kampung Naga of 0.3368 gha / cap and compared with West Java province of 0.42 gha / cap or even Indonesia of 1.07 gha / cap [11], then the level of sustainability Kampung Naga is higher because of the pattern of consumption of natural resources is low and has good local wisdom, especially related to the environment. EF Kampung Naga has a smaller EF than Indonesia. The average EF population on earth is 2.2 gha. Highest EF per capita population are the United States 9.5 gha, UK 5.45 gha, Switzerland 4 gha. The lowest EF is Bangladesh, with an average of 0.5 gha. This approach shows that the more developed a country is, the greater their ecological footprint from of natural resources. Thus, the capacity required with the lifestyles of developed countries is more consumptive.

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