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Status of Land Carrying Capacity for Agricultural and Environmental Sustainability in the Nusa Penida Tourism Area

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Abstract. Land resources are very important in supporting tourism activities. As a developing tourism area, Nusa Penida requires sufficient land resources. The increasing population and tourists have triggered new activities affecting land use patterns, negatively impacting land availability and agricultural sustainability. This study aims to calculate the availability, needs, and status of land-carrying capacity to support the sustainability of agriculture in the Nusa Penida Tourism Area until 2028. The research method uses a quantitative approach by collecting primary data obtained directly in the field, secondary data originating from previous research, and data originating from official sources. The result of the calculation of land requirements based on the ecological footprint is the number of inhabitants multiplied by the ecological footprint (gha/capita); the land requirement for 2020 is 49,849 people multiplied by 0.36958702, which is 17,724.283 hectares, while the availability of land in Nusa Penida is 9,894 hectares. This shows that the carrying capacity of land in Nusa Penida has exceeded the threshold or a deficit of 7,830.283 hectares. The area of land in Nusa Penida reaches 20,284 hectares. In contrast, the availability of land in Nusa Penida is based on calculations using the actual production of each type of commodity and the price of rice at the producer level, the unit price of each commodity at the producer level, and the productivity of rice in Nusa Penida is only 9,894 hectares. The projection of land needs until 2028 is 24,640 hectares, so the land carrying capacity in Nusa Penida is a deficit. The results of the calculation of land requirements based on the ecological footprint are 14,746.283 hectares, while the availability of land in Nusa Penida is 9,894 hectares. This shows that the land carrying capacity in Nusa Penida has a deficit of 12,374.283 hectares.

***Keywords*:** agriculture; carrying capacity; status of land; tourism

I. INTRODUCTION

Tourism development in the last three years in Nusa Penida has increased rapidly. In 2016, the number of tourists arriving in Nusa Penida was 350,000 people, and it is predicted that in 2025, it will reach 1,050,000 [1]. The growth of tourism accommodation is increasing rapidly. In 2016, the total number of accommodations was 189, and the number of rooms was 1,300; in 2017, the number of tourism accommodations increased to 301, and the number of rooms was 2,143. The rapid growth of tourism has put pressure on the environment, such as the waste problem [2]. It has affected the carrying capacity of the environment, especially the carrying capacity of land.

The increase in population triggers new activities that affect land use patterns and reduce water carrying capacity [3], which negatively impacts agricultural and environmental sustainability and can even cause an environmental disaster if the environmental support has been exceeded [4]. Tourism industry activities are inseparable from the need for land. In tourism industry activities. Land conservation must be carried out to reduce the degradation of agriculture and the environment and restore the function of land to support tourism and environmental sustainability [5]. Land use must be carried out effectively because land never increases [6].

Land carrying capacity is calculated by considering the availability and demand for land resources for residents and tourists in the study area. An inventory of natural resources is required to measure the magnitude of the decline in environmental quality. Measurement of the decline in environmental quality will show how much the environment can support human life [7]. Land carrying

capacity is systematic land use and population data [8]. The increased demand for land results in land conversion and disrupts the environmental balance [9]. The growth of tourism resulted in a decrease in the ecological function of the environment [10]. Analysis of the carrying capacity of agricultural land needs to be carried out to determine the ability of the land to provide food to meet the population's needs in a certain area and at a certain time. This research aims to determine land availability, land requirements, and land carrying capacity for residents and tourists in the Nusa Penida Tourism Area.

II. RESEARCH METHODS

This study uses a quantitative approach by collecting primary and secondary data, which are used to calculate the following:

Land Carrying Capacity

a. Calculation of Land Availability

Land availability is calculated by taking land availability into account. Analysis of land availability uses an equation that refers to the Minister of Environment Regulation No. 17 of 2009 as follows:

$$S_L = \frac{\Sigma(Pi \times Hi)}{Hb} x \frac{1}{Ptvb}$$

Note: SL is land availability; Pi is each commodity type's actual production (unit depends on the commodity type). Commodities that are taken into account include agriculture, plantations, forestry, livestock, and fisheries. Hi is the unit price of each type of commodity (Rp/unit) at the producer level, Hb is the unit price of rice (Rp/Kg) at the producer level, and Ptvb of rice productivity (Kg/Ha). In this calculation, price is the conversion factor that equates to non-rice products.

b. Calculation of Land Needs

To determine whether or not sufficient land supply can be achieved by comparing the available land with land requirements. The equation used refers to the Minister of Environment Regulation No. 17 of 2009:

$$D_L = N \times HKL_L$$

Note: DL is the total land requirement equivalent to rice (Ha); N is the number of residents (people); and KHLL is the area of land required for decent living needs per resident and tourist needs:

- The land area required for decent living needs per resident is the decent living needs per resident and tourist needs divided by local rice productivity.
- Decent living needs per resident and tourist are assumed to be 1 ton of rice equivalent/capita/year.
- Regions that do not have local rice productivity data can use the national average rice productivity data of 2400 kg/ha/year.

c. Determination of Land Carrying Capacity Status

The status of land carrying capacity is obtained from a comparison between land availability (SL) and land demand (DL) (Regulation of the Minister of Environment No. 17 of 2009):

- If SL > DL, the land's carrying capacity is declared a surplus.
- If SL < DL, the land's carrying capacity is declared a deficit or exceeded.

Land Carrying Capacity Based on Ecological Footprint

The ecological footprint calculation in this study adopts the ecological footprint calculation used by the Global Footprint Network (GFN) in 2003. The ecological footprint calculation considers six parts of basic needs products expressed: agricultural, livestock, forest, fishery, built-up area, and use products. energy. Calculating the ecological footprint requires consumption data or needs of each type of staple product, which can be either a primary staple product or a secondary staple product, where each staple product has an average global yield and equivalent factor [11].

The equation for calculating the ecological footprint for types of agricultural products, livestock, forests, fisheries, and built-up areas is:

$$JE = \sum\left(\frac{P/_{Y_W \; X \; FQF}}{N}\right)$$

Note: JE is ecological footprint (gha/capita); P is total consumption of each type of product (tons or m^3); Yw is global average yield factor (tonnes/ha); EQF is an equivalent factor (gha); and N is the total population.

The equation for calculating the ecological footprint of a product type in a built-up area is:

JE Area Built-up = Area XB x YW x EQF

Note: JE Area Built-up is ecological footprint (gha/capita); Area is built-up area (ha); XB is coefficient value (2.368 x 10-8); Yw is global average yield factor (tonnes/ha); and EQ is equivalent factor (gha).

The ecological footprint of energy use is calculated by the equation:

JE Energy Use = C x ((1-faOc)/Yc) x c

Note: JE Energy Use is Ecological footprint of energy use (gha/capita); C is consumption of fossil fuels and electricity (tons); FaOc is CO absorbed by the sea (0.27 CO2/gha); Yc is Sequestration rate (1.35 tons/gha); and c is coefficient value (1.18 x 10-8).

The equivalent is a conversion factor from the area dimension (ha) to the global area dimension (gha). The equivalent factor is the same for each country and does not change. The equivalent factor values can be seen in Table 1.

TABLE 1
EQUIVALENT FACTOR VALUES

Main Product	Equivalent Factor (gha)
Agriculture	2,64
Livestock	0,50
Forest	1,33
Fisheries	0,40
Built-up area	2.64
Energy used	1,00

The calculation of land requirements is based on the guidelines for determining the status of land carrying capacity (KLHK, 2008), which is at level 3. The calculation of land requirements at level 3 includes the influence of the JE value in the calculation. The equation for calculating land requirements at level 3 is:

$$D_L = N \times JE$$

Information:

DL = total land requirements
N = population (people)
JE = ecological footprint (gha/capita)

Population Projections

Population projections were calculated using the exponential method to determine the land needed for 10 years (2028) (KLHK, 2008). Exponential method projection calculations can be done using the equation:

$$P_n = P_o.er.n$$

Information:

Pn = Projected population in the desired year
Po = Population in the last available data
r = Population growth rate
n = Time period in years
e = Exponential number = 2.7182818

III. RESULT AND DISCUSSION

Result

According to land use, the land area in Nusa Penida is mostly non-rice fields, with an area of 14,366 ha. Most non-paddy fields are fields/gardens with an area of 4,970 ha and plantations of 3,572 ha. Planted trees covering an area of 5,361 ha. Nusa Penida has a forest area of 6,401 ha consisting of 824 ha of state forest, 244 ha of mangrove forest, and 5,333 ha of community forest. Land area according to use in Nusa Penida is presented in Table 2.

Nusa Penida is a dry land area with wavy to undulating topography dominated by limestone with shallow soil solums (<30 cm) and steep slopes (dominated by slopes >40%). Annual average rainfall in Nusa Penida during the last 10 years was 1428.40 mm, causing a very high erosion potential [12]. Soil types in Nusa Penida are generally Mediterranean brown, a type of soil whose parent material is limestone; this soil is spread throughout the karst area of Nusa Penida with an area of 86.54% of the Nusa Penida area. Another type of soil is gray-brown alluvial, whose parent material is river sediment, with an area of 10.43%. Gray-brown regosol soil with 3.03% area as the parent material.

TABLE II
LAND AREA BY USE IN NUSA PENIDA IN 2021 (HA)

No	Land Use	Land Area
I	Agricultural land	14.366
1.1	Paddy Field	
	a. Irrigation	
	b. Rainfed	-
	c. Tidal Swamp	-
	d. Lebak Swamp	-
1.2	Not Paddy Field	14.366
	a. Tegal/Garden	4.970
	b. Farm/Huma	-
	c. Plantation	3.572
	d. Planted Trees	5.361
	f. Shepherding Field	-
	g. Temporary uncultivated land	-
II	Non-Agricultural Land	6.381
	a. State Forest	824
	b. Mangroves	224
	c. People's Forest	5.333
III	Residential and Tourism Accommodation	762
	Amount	21.046

Source: Klungkung in Figures 2022

Land capability is a systematic assessment of land based on the potential characteristics and inhibiting its use sustainably. Land capability analysis includes soil properties (physical and chemical), topography, drainage, soil depth, and other environmental conditions. Based on the characteristics of the land, land capability classification is carried out with the depth of class, sub-class, and management unit levels. Land capability is closely related to the "level of damage hazard" and "obstacles in managing land." Based on the analysis of the land capability map for 2020 Klungkung Regency, which is presented in Figure 1.

Discussion

Availability of land

Land availability is calculated based on Minister of Environment Regulation No. 17 of 2009 concerning Guidelines for Determining the Carrying Capacity of the Environment in Regional Spatial Planning. Based on this,

the data needed in calculating land availability are the actual production of each type of commodity (Pi) and the price of rice at the producer level (Hb), the unit price of each commodity at the producer level (Hi), and the productivity of rice in Nusa Penida (Ptvb). The calculation of the total production value of each commodity in Nusa Penida is presented in Table 3. Based on data from the Central Bureau of Statistics, combined with survey results, the unit price of rice at the producer level is Rp. 9,400 per kilogram, and the average rice production per hectare is 7,000 kilograms. Using the equation SL (land availability), the availability of land in Nusa Penida is 9,894 hectares.

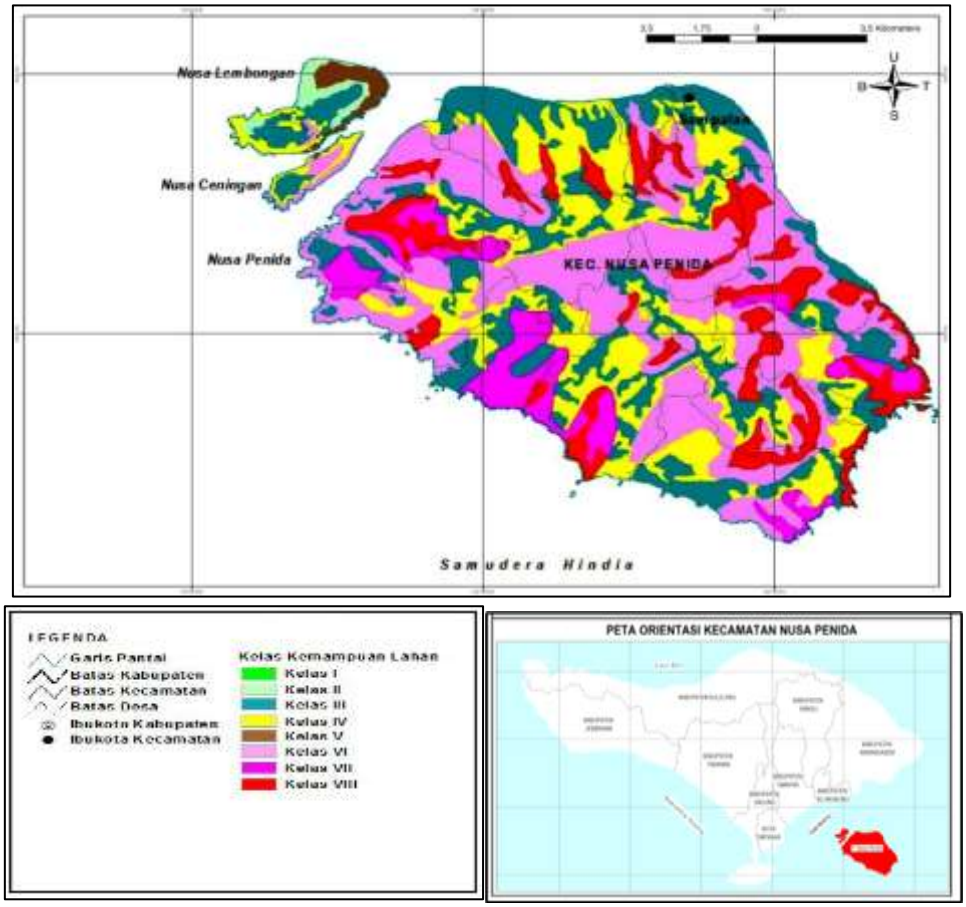

Figure 1. Land Capability Map of Nusa Penida

Land requirements

The need for land is the minimum requirement of life. Population pressure on the carrying capacity of land can be determined based on the comparative value between the total population and the percentage of farmers with a minimum land area for a decent life [13]. The area of land required for decent living needs per population is the decent living needs per population divided by the productivity of local rice. According to the Regulation of the Minister of Environment No. 17 of 2009, for decent living needs per resident, it is assumed to be 1000 kg of rice equivalent/per capita/year. As noted above, rice productivity in Nusa Penida District is 2,400 kg/ha/year; because Nusa Penida cannot produce rice with local rice productivity data, you can use national average rice productivity data of 2,400 kg/ha/year. So, the land area needed for decent living per resident in Nusa Penida is 0.417 hectares/person.

Calculation of the need for land in Nusa Penida uses the approach of the population in Nusa Penida and the number of tourists each year who travel to Nusa Penida. Based on data from the National Tourism Strategic Area study and data from the Klungkung Regency Tourism Office, the number of tourists who came to Nusa Penida in 2015 was 255,079 people; in 2016, there were 293,647 people, and in 2017, there were 338,046 people. Using basic data for 2016, the tourist growth rate is the number of tourist arrivals in 2017 (338,046 people) minus the number of tourists in 2016 (293,647 people) multiplied by 100, so the tourist growth rate is 15.12%. Projections of tourist arrivals can be seen in Table 4.

Based on data from the Klungkung Regency Tourism Office, the average length of stay for tourists in the Nusa Penida Tourism Area is 3 days. The number of tourists staying in Nusa Penida is obtained based on the number of tourists who come multiplied by the average length of stay

divided by 365 days (1 year). So, the projected number of tourists staying for 1 year in the Nusa Penida Tourism Area can be seen in Table 5.

From the projected number of tourists who stay for 1 year in Nusa Penida considered as residents, the total population in Nusa Penida will be the number of indigenous people of Nusa Penida plus the number of tourists who stay for 1 year in Nusa Penida, which is presented in Table 6.

Based on the projected population plus tourists in Nusa Penida and the area of land needed for decent living needs per resident in Nusa Penida, the land requirements in Nusa Penida are presented in Table 7.

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TABLE III
CALCULATION RESULTS OF TOTAL PRODUCTION VALUE IN NUSA PENIDA IN 2021

No	Commodity Type	Actual Production (Pi) (Kg)	Unit Price Commodity (Hi) (IDR/Kg)	Nilai Produksi (PixHi) (Rp)
1	Corn	10.500.000	5.000	52.500.000.000
2	Cassava	19.524.000	4.000	78.096.000.000
3	Peanuts	1.620.000	8.000	12.960.000.000
4	Mung beans	46.000	12.000	552.000.000
5	Red beans	67.000	15.000	1.005.000.000
6	vote	39.200	15.000	588.000.000
7	Mango	7.800.000	9.000	70.200.000.000
8	Orange	97.300	10.000	973.000.000
9	Water apple	3.600	8.500	30.600.000
10	Sawo	13.200	14.000	184.800.000
11	Pineapple	500	7.000	3.500.000
12	Silik	7200	10.000	72.000.000
13	Pawpaw	16.700	7.000	116.900.000
14	Banana	720.000	12.000	8.640.000.000
15	Guava	6.200	10.000	62.000.000
16	Jackfruit	38.200	7.500	286.500.000
17	Coconut	8.450.000	5.000	42.250.000.000
18	Cashew	79.800	28.000	2.234.400.000
19	Cow	26.800	10.000.000	268.000.000.000
20	Goat	536	3.500.000	1.876.000.000
21	Pig	18.461	2.500.000	46.152.500.000
22	Kampong chick	138.204	100.000	13.820.400.000
23	Seaweed	1.830.000	20.000	36.600.000.000
		Amount		637.203.600.000

Source: Nusa Penida in Figures 2022 and survey results

TABLE IV
PROJECTION OF TOURIST ARRIVALS IN NUSA PENIDA

No	Year	Projection of Tourist Arrivals
1	2018	389.159
2	2019	447.999
3	2020	515.737
4	2021	593.716
5	2022	683.486
6	2023	786.829
7	2024	905.798
8	2025	1.042.754
9	2026	1.200.419
10	2027	1.381.922
11	2028	1.590.869

TABLE V
PROJECTION OF THE NUMBER OF TOURISTS STAYING FOR ONE YEAR IN NUSA PENIDA

No	Year	Projection of the Number of Tourists Staying for 1 Years
1	2018	3.199
2	2019	3.682
3	2020	4.239
4	2021	4.880
5	2022	5.618
6	2023	6.467
7	2024	7.445
8	2025	8.571
9	2026	9.866
10	2027	11.358
11	2028	13.076

TABLE VI
PROJECTION OF POPULATION AND TOURISTS IN NUSA PENIDA

No	Year	Population Projection	Projection of the Number of Tourists	Amount
1	2018	45.510	3.199	48.709
2	2019	45.560	3.682	49.242
3	2020	45.610	4.239	49.849
4	2021	45.660	4.880	50.540
5	2022	45.711	5.618	51.328
6	2023	45.761	6.467	52.228
7	2024	45.811	7.445	53.256
8	2025	45.862	8.571	54.432
9	2026	45.912	9.866	55.778
10	2027	45.963	11.358	57.321
11	2028	46.013	13.076	59.089

TABLE VII
PROJECTED LAND NEEDS IN NUSA PENIDA

No	Year	Projection of Land Needs in Nusa Penida (ha)
1	2018	20.311
2	2019	20.534
3	2020	20.787
4	2021	21.075
5	2022	21.404
6	2023	21.779
7	2024	22.208
8	2025	22.698
9	2026	23.260
10	2027	23.903
11	2028	24.640

Source: Calculation Results and Projections

Status of land carrying capacity

Land carrying capacity status is obtained by comparing land availability (SL) and land demand (DL). Based on Table 7 regarding the projection of land requirements and land availability in Nusa Penida, namely 5,350 ha, the status of the carrying capacity of land in Nusa Penida can be seen in Table 8.

The assumption used in the Regulation of the Minister of Environment Number 17 of 2009, used as the basis for calculating decent living needs per population, equated with rice, is too small, namely 1000 kg per year. The price of rice at the consumer level is Rp. 11,000/kg, then the need for decent living per resident per year is Rp. 11,000,000 or Rp per month. 916,000. Based on the 2018 Klungkung Regency minimum wage, Rp, this figure is far below a decent life. 2,200,000. figure Rp. 916,000 is equivalent to the poverty line set by the World Bank at 2 dollars per capita per day. Another weakness is that the Regulation of the Minister of Environment Number 17 of 2009 does not include sources of consumption other than rice, of which there are 47 types in villages and 52 in cities [14].

Population growth because some of the population living in or living outside Nusa Penida have returned and settled in Nusa Penida due to tourism growth increasing the conversion of productive agricultural land to build homes or to build new business premises as research results by [15], revealed that the need for land continues to increase due to uncontrolled population growth, causing a lot of productive agricultural land to be used for residential purposes or as a supporting area for the processing economic sector as well as tourism supporting facilities. Thus, the land's carrying capacity can occur, and it is necessary to diversify consumption, which does not focus on rice alone but on other foods such as corn, cassava, porang, and other crops so that food sufficiency can be fulfilled. The government needs to revive rainfed land for upland rice plants by providing incentives and subsidies to farmers, providing assistance to excite farmers, making agriculture attractive, and creating millennial farmers and cultivators [16].

TABLE VIII
Status of Land Carrying Capacity in Nusa Penida

No	Year	Land Requirement Projection (ha)	Land Availability (ha)	Land Shortage (ha)	Comparison Land Availability and Need	Status of Land Supporting Capacity
1	2018	20.311	9.894	20.311	10.417	Deficit
2	2019	20.534	9.894	20.534	10.640	Deficit
3	2020	20.787	9.894	20.787	10.893	Deficit
4	2021	21.075	9.894	21.075	11.181	Deficit
5	2022	21.404	9.894	21.404	11.510	Deficit
6	2023	21.779	9.894	21.779	11.885	Deficit
7	2024	22.208	9.894	22.208	12.314	Deficit
8	2025	22.698	9.894	22.698	12.804	Deficit
9	2026	23.260	9.894	23.260	13.366	Deficit
10	2027	23.903	9.894	23.903	14.009	Deficit
11	2028	24.640	9.894	24.640	14.746	Deficit

Source: Calculation Results and Projections

The increase in land use in Nusa Penida caused by the construction of settlements and tourism accommodation has put pressure on land availability [17]. The efficiency of energy and water sources is an important step in supporting land availability and the sustainability of tourism [18]. Tourism growth will affect the land's carrying capacity and the people's social culture in Nusa Penida [19]. Land use change will cause pressure on land use and disrupt environmental ecology [20]. One of the efforts that has begun in Nusa Penida is the development of hydroponic plants, which in the short term are to meet the vegetable supply needs of hotels and restaurants in Nusa Penida. To support land sustainability in Nusa Penida, it is necessary to develop organic farming or environmentally friendly agriculture [21]. To reduce the land deficit in the Nusa Penida tourism area, it is necessary to change government policies that are pro-agricultural and involve technology [22]. Communities must diversify food, increase production, and not depend on tourism alone [23].

Land Carrying Capacity Based on Ecological Footprint

Calculating the ecological footprint requires data on the consumption or needs of each type of staple product, which can be either a primary or a secondary staple product. Consumption data or needs for each type of staple product, which can be either a primary or a secondary staple product in Nusa Penida, can be seen in Table 9.

The average per capita consumption of agricultural, livestock, and fishery products was calculated using statistical data from the Ministry of Agriculture for 2017. The average wood consumption uses the wood consumption approach adopted by Siagian in 1992. The built-up area data comes from digitizing maps of the Nusa Penida District. Energy consumption data uses data sources from each Bali Province Regional Apparatus Organization and PLN data. The ecological footprint calculation is based on six parts of basic needs products expressed in agricultural products, livestock, forests, fisheries, built-up areas, and energy use in Nusa Penida, which can be seen in Table 10.

The result of the calculation of land requirements based on the ecological footprint is the number of inhabitants multiplied by the ecological footprint (gha/capita); the land requirement for 2020 is 49,849 people multiplied by 0.36958702, which is 17,724.283 hectares, while the availability of land in Nusa Penida is 9,894 hectares. This shows that the carrying capacity of land in Nusa Penida has exceeded the threshold or a deficit of 7,830.283 hectares. The area of land in Nusa Penida reaches 20,284 hectares, while the availability of land in Nusa Penida is based on calculations using the actual production of each type of commodity and the price of rice at the producer level, the unit price of each commodity at the producer level and the productivity of rice in Nusa Penida is only 9,894 hectares. Innovative emission-absorbing objects can be carried out using sustainable greening and planting strong emission-absorbing plants such as palm, trembles, mahogany, and Angsana and Mother-in-law's tongue plants around homes and tourism accommodations [24].

There are several directions that the government can take to reduce the land deficit in Nusa Penida: (1) Vertical farming for areas with limited land. The need for a healthy environment is also one of the reasons for using vertical farming methods. Vertical farming is not vulnerable to local climate change. Aquaponics is a sustainable food production system that combines traditional cultivation (raising aquatic animals such as lobsters, fish or shrimp in tanks or ponds) with hydroponics (cultivating plants in water) in a symbiotic environment [25], (2) increasing green open space, for example using state lands as oases or oxygen factories by planting trees suitable for the conditions of Nusa Penida, fruit trees, ornamental plants both in the upper and coastal areas by adding pedestrians and tracking, especially in coastal areas. Under these conditions, it is necessary to take anticipatory steps so that the land's carrying capacity remains sustainable and the environment in Nusa Penida is sustainable. Tourism development must consider land and water availability to support sustainability [26]. The construction of settlement facilities should be carried out on less productive land to ensure the availability of land and food in Nusa Penida [27]. With the coronavirus outbreak in early 2020, tourism activity in Bali, including in Nusa Penida, has been sluggish. Agriculture and seaweed are the hope of the people of Nusa Penida, and activities as farmers and cultivators have risen again because there are no other options for survival. We recommend farmers and cultivators as the main job and tourism as a bonus.

Under these conditions, the government needs to take anticipatory steps so that the land's carrying capacity remains sustainable and the environment in Nusa Penida is sustainable by using land according to its designation [28]. To reduce the land deficit in Nusa Penida, it is necessary to intervene in food development patterns, such as using a touch of technology to reduce the food that enters Nusa Penida by creating food self-sufficiency in Nusa Penida. One of the efforts that has begun to be carried out in Nusa Penida is the development of hydroponic plants, which, in the short term, are to meet the vegetable supply needs of hotels and restaurants in Nusa Penida. Another breakthrough step is implementing drip farming for food commodities, developed in many other parts of the world, such as in Ethiopia, which was assisted by Israel. Fruit plants can become a new commodity using processing

technology, so Nusa Penida fruit products have a fairly high selling power

IV. CONCLUSION

a. The projected need for land and land availability in Nusa Penida is 9,894 hectares, so the status of the carrying capacity of land in Nusa Penida is deficit or exceeded because land availability is less than land requirements.
b. Calculating land requirements based on ecological footprint is 17,724.283 hectares, while land availability in Nusa Penida is 9,894 hectares. This shows that the carrying capacity of land in Nusa Penida is a deficit of 7,830.283 hectares.

REFERENCES

[1]. Bali Provincial Tourism Office, 2016. Nusa Penida National Tourism Strategic Area. Denpasar.
[2]. Armadi, M., Suarna, W., Sudarma, M., Mahendra, M. S., Sudipa, N. 2020. Greenhouse Gas Emissions from Household Waste in Denpasar City. Journal of Industrial Management and Tourism, XI (47):1750-1760.
[3]. Sudipa, N., Mahendra, M. S., Adnyana, W. S., Pujaastawa, I. B. 2020. Water Carrying Capacity in the Nusa Penida Tourism Area, Bali; Journal of Natural Resources and Environment: 7 (3): 117-123.
[4]. Admadhani, D., N., Haji, A., T., S., Susanawati, L., D. 2014. Analysis of Water Availability and Needs for Environmental Carrying Capacity (Case Study of Malang City). Journal of Natural Resources and Environment; 1(3): 13-20.
[5]. Pramesty, A., R., Nirmala, A., Aspan., A. 2014. Calculation of Environmental Carrying Capacity Based on Water Availability and Land Productivity in Seventeen Districts, Bengkayang Regency. Journal of Wetland Environmental Technology. 1(1): 1-10.
[6]. Moniaga, V., R., B. 2011. Analysis of the Carrying Capacity of Agricultural Land. ASE, 7(3): pp. 61-68.
[7]. Wijaya, H., Rusdiana., O., Tarigan, S., D. 2017. Environmental Carrying Capacity of the Ciliwung Hulu Watershed, Bogor Regency, Journal of Env. Engineering & Waste Management, 2(1): 25-32.
[8]. Riyadi, Supriyadi B. Deddy. 2004. Perencanaan Pembangunan Daerah: Strategi Menggali Potensi Dalam Mewujudkan Otonomi Daerah. Gramedia Pustaka Utama. Jakarta.
[9]. Sudipa$_a$, N., Mahendra, M. S., Adnyana, W. S., & Pujaastawa, I. B. 2020. Tourism Impact on the Environment in Nusa Penida Tourism Area. Journal of Industrial Management and Tourism, XI (41), 113-124
[10]. Limbong, F., Soetomo, S. 2014. The Impact of Tourism Development on the Karimunjawa National Park Environment; Space Journal: 22 (1): 351-354.
[11]. Adnyana, I. W. S., As-syakur, A. R. 2012. Application of a Geographic Information System (GIS) Based on Raster Data for Land Capability Classification in Bali Province using the Distinctive Pixel Value Method; Journal of Man and Environment: 19(1): 21-29.
[12]. Regional Regulation Number 1 of 2013 concerning Klungkung Regency Regional Spatial Planning
[13]. Soemarwoto, O. 2001. Ecology, Environment and Development. Djambatan: Jakarta. p 30-39
[14]. BPS. 2015. Nusa Penida District in Figures. Semarapura
[15]. Darma Putra, D. G. A., Utama. M. S., Murjana Yasa, G. W. 2016. Analysis of Carrying Capacity based on Total Agricultural Production Value in Gianyar Regency. Economics and Business E-Journal: 5 (3): 387-402
[16]. Cristie, Y., A., Sina, L., Erawati., R. 2013. Impact of Environmental Damage Due to House Building Activities (Case Study in Palaran City Housing by PT Kusuma Hady Property). Beraja Niti Journal: 2 (1): 1-4.
[17]. Arlius, F., Irsyad, F., Yanti, D. 2017. Analysis of Land Carrying Capacity for Rainfed Rice Fields in West Pasaman Regency; Rona Journal of Agricultural Engineering: 10 (1): 21-33.
[18]. Rasul, G. 2016. Managing the food, water, and energy nexus for achieving the Sustainable Development Goals in South Asia. Environmental Development: 18: 14-19.
[19]. Sudipa$_c$, N., Mahendra, M. S., Adnyana, W. S., Pujaastawa, I. B. 2020. Socio-Cultural Impacts in the Nusa Penida Tourism Area. Journal of Cultural Research, 5 (2): 60-66.
[20]. Pratama, N. A. Widiatmono, B. R., Wirosoedarmo, R. 2016. Evaluation of Environmental Carrying Capacity Based on Land Capability in Batu City. Journal of Natural Resources and Environment, 2 (1): 14-21.
[21]. Doyle, M., W, Windheim, J., P. 2015. Environmental Management Strategy: Four Forces Analysis. Environmental Management Journal, 55(1): 6–18.
[22]. Sauve, S., Bernard, S., Sloan, P. 2016. Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research. Environmental Development Journal, 17: 48-56.
[23]. As-Syakur, A. R., Adnyana I. W. S., Suarna. I W. 2011. Land Carrying Capacity of Bali Province based on Ecological Footprint. In: Adnyana I. W. S., Arthana, I. W., As-Syakur, A. R., editor. Environmental Research Center. Udayana University. Denpasar. p 77-85.

[24]. Marganingrum, D. 2019. Ecological Footprints of the Bandung Regional Area. Journal of Environmental Technology, 20 (2): 159-170.
[25]. Febrianto, Rahman, M., Satriani. 2017. Environmental Carrying Capacity Based on Ecological Footprint in Tamangapa Subdistrict, Makassar City; Indonesian Built Environment Research Association (IPLBI) Scientific Meeting: 6, C 053-060.
[26]. Sudipa$_b$, N., Mahendra, M. S., Adnyana, W. S., Pujaastawa, I. B. 2020. Environmental Management Model in the Nusa Penida Tourism Area, Bali. Ecotrophic Journal, 14 (1): 1-13.
[27]. Krisnamurti, Utami, H., Darmawan, R. 2016. The Impact of Tourism on the Environment on Tidung Island, Thousand Islands. Journal of Studies, 21 (3): 257-273.
[28]. Qian, Y., Tang, T., Qiu, Q., Xu, T., Liao, J. 2015. A Comparative Analysis on Assessment of Land Carrying Capacity with Ecological Footprint Analysis and Index System Method: Xiamen. Chinese Academy of Sciences, 10(6): 1-17.

TABLE IX
DATA ON CONSUMPTION OR NEEDS FOR EACH TYPE OF STAPLE PRODUCT IN NUSA PENIDA

No	Commodity	Consumption (kg/capita/year)	Amount Population	Total Consumption (Tons)
Agriculture				
1	Rice	100,57	47.957	4.823,035
2	Wheat	2,35	47.957	112,699
3	Soya bean	4,97	47.957	238,3463
4	Sugar	24,7	47.957	1184,538
5	Cooking oil	11,78	47.957	564,9335
6	Vegetables	52,33	47.957	2.509,59
Farm				
10	Beef	0,42	47.957	20,14194
11	Chicken meat	5,37	47.957	257,5291
12	Pork	0,26	47.957	12,46882
13	Egg	9,79	47.957	469,499
14	Milk	6,17	47.957	295,8947
Forest		Volume ($m^{3)}$		
15	Wood	0,19481	47.957	9.342,503
Fishery		31,17	47.957	1.494,82
Built Area		Wide (Hectares)		
16	Settlement and Industry	845,721		
17	Transformation	124,665		
Energy Use		Consumption Netto (10^3 t)		
18	Kerosene	0.000054108	47.957	2.5949
19	Solar	0.000043894	47.957	2.1050
20	Gas	0.000141600	47.957	6.7907
21	Gas	0.018396741	47.957	882,2525
22	Electricity	0.698210431	47.957	33.484,0777

Source: Agricultural Statistics and Survey (2021)

TABLE X
CALCULATION OF THE ECOLOGICAL FOOTPRINT IN NUSA PENIDA

Main Products	Total Consumption (Tons)	Global yield (t/ha)	Equivalence factor (gha/ha)	JE (gha/cap)
Agriculture				
Rice	4.823,04	2,80	2,64	0,094823133
Wheat	112,70	4,11	2,64	0,002215715
Soya bean	238,35	47,07	2,64	0,004686000
Sugar	1184,54	2,83	2,64	0,023288573
Cooking oil	564,93	2,38	2,64	0,011106858
Vegetables	2.509,59	16,92	2,64	0,049339718
Farm				
Beef	20,142	2,23	0,50	0,000075000
Chicken meat	257,53	2,23	0,50	0,000958929
Egg	12,47	2,23	0,50	0,000046429
Milk	469,499	2,23	0,50	0,001748214
Forest				
Wood	9.342,503	1,84	1,33	0,092534748
Fishery	1.494,82	19,15	0,40	0,004452858
Built Area	Wide (ha)			
Settlements and Industry	845,72	1,74	2,64	0,081008069
Transformation	124,665	1,74	2,64	0,002450972
Energy Use	Consumption Netto (10^3 t)			