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Policy Design for Independent Integrated City Development Based on Environmental Carrying Capacity in Lunang Silaut Area, Indonesia

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ABSTRACT

This study aims to explain the development policy of Lunang Silaut Independent Integrated City (LSICC), Indonesia, from the perspective of environmental carrying capacity. The assessment of environmental carrying capacity is carried out through an indicative methodology based on the units of analysis, parameters, indicators, and benchmarks related to each unit of analysis. The results of the study indicate that the social carrying capacity of the LSICC is good, which indicates that has effectively carried out its role in community service. Through the analysis of the development scenario of the LSIIC, both in the short term (2030) and long term (2040), it can be seen that there are critical factors related to the sustainability of its development, namely population pressure. Given the importance of understanding environmental carrying capacity for the sustainability of regional development, the Pesisir Selatan Regency Government together with the West Sumatra Provincial Government is advised to conduct research on the environmental carrying capacity of LSIIC periodically every year as an effort to monitor regional development.

1. INTRODUCTION

Numerous scholarly investigations indicate that the concepts of carrying capacity and environmental capacity denote the environment's capability to sustain human existence alongside diverse biological species, as well as the equilibrium that is maintained between these two facets [1-9]. The principal challenge associated with the stewardship of natural resources and the governance of environmental systems resides in achieving a balance that addresses current human requirements while ensuring the sustainability of these resources for future developmental endeavors, all while taking into account social and economic welfare in conjunction with the conservation of environmental functions for succeeding generations [10-17]. Consequently, comprehending the environment's capacity to support human life and other organisms, in addition to the equilibrium between these entities (termed environmental carrying capacity), as well as the environment's capability to assimilate substances, energy, and various inputs, is crucial for informing the strategic planning of natural resource utilization, developmental initiatives, and spatial planning endeavors [18, 19]. Furthermore, to expedite the establishment of growth centers via the creation of Transmigration Development Areas and Transmigration Settlement Locations, a strategy focused on integrated autonomous urban development is employed. The framework of an Independent Integrated City consists of spatial planning geared towards the realization of an urban milieu, economic business planning that highlights multi-sectoral engagement, including participation from the private sector, and community development planning that prioritizes the involvement of transmigrants and the local populace. An independent integrated city is characterized as a transmigration area whose development and expansion are meticulously orchestrated to function as a growth center, thereby fulfilling urban roles through the sustainable governance of natural resources [20]. Urban functions encompass the transmigration framework, which includes (a) a center for agribusiness activities that involve the conversion of agricultural products into both production and consumer goods, a hub for specialized agro-industry services, and advanced plant breeding, as well as a venue for educational and training initiatives within the agricultural, industrial, and service sectors; and (b) a regional trade nexus distinguished by the presence of financial market institutions, wholesale markets, and warehousing facilities. The Lunang Silaut region is located in the southern part of Pesisir Selatan Regency, West Sumatra Province; administratively, prior to the revision of the Master Plan in 2015, it comprised three districts, namely Lunang Silaut District, Basa IV Balai Tapan District, and Pancung Soal District. In a broader regional framework, the Lunang Silaut Area possesses considerable strategic potential for development into a new growth zone due to its positioning at the intersection of West Sumatra Province and the adjacent provinces of Bengkulu and Jambi.

The inception of the LSIIC, located within the jurisdiction of the Pesisir Selatan Regency, encompasses the entirety of the Lunang Silaut District. Simultaneously, the aggregate number of villages integrated within the LSIIC is enumerated as 25, which includes 12 villages classified as Transmigration Settlement Units (TSU) and an additional 13 indigenous villages. The villages formerly identified as TSU within the Lunang Silaut Area have transitioned into permanent village status, with several advancing further to attain sub-district municipality classification. Tanjung Baringin Village (Lunang 1) functions as the administrative capital of the Lunang Silaut District. The erstwhile TSU villages within the Lunang Silaut Area have emerged as prominent hubs for palm oil production within the Pesisir Selatan Regency. At the levels of municipal and local governance, methodologies pertaining to urban development and comprehensive planning may highlight the distribution of financial resources and facilitate collaboration and engagement among various urban settings [21-26]. In residential areas, the meticulous planning and design of thoroughfares and communal areas can substantially improve urban quality, bolster social unity and inclusivity, and safeguard local resources [27-34].

In its scholarly treatise titled "Transmigration Area Development: A More Independent Integrated City," the author asserts that environmental carrying capacity refers to the capacity of the ecosystem to sustain human existence alongside various other biological entities [35]. The assessment of ecological carrying capacity is undertaken through the examination of the natural environment's potential and its resources to facilitate human or population activities that necessitate spatial allocation for survival purposes [36-39]. The prevailing conditions and characteristics of the locally available resources significantly affect the capacity of that particular region. The limitations imposed by environmental and resource capacity serve as critical factors in determining appropriate spatial utilization [40-46].

In its extensive report about the "Examination of the Master Plan for the LSIIC," the Department of Social Affairs, Manpower, and Transmigration of the Pesisir Selatan Regency Government has explicated that, at its core, the documentation for the Master Plan of the LSIIC was initially developed in 2008. Currently, not all components specified within the document have been realized. Consequently, by 2015, the data encapsulated within the document can be regarded as outdated, particularly in consideration of the shifting economic dynamics within Indonesia, thus prompting the need for a reassessment of the Master Plan. Through this Examination, it is anticipated that a thorough and accurate urban spatial planning framework, including technical specifications in designated areas, can be crafted, thereby instituting a prioritized schema for development and policy interventions. This master plan examination also incorporates evaluations related to environmental carrying capacity, particularly with respect to both production and non-production spatial planning, as well as the accessibility of potable water, drainage systems, waste management, soil characteristics, topographical features, groundwater levels, habitats, and climatic conditions. The review of the Master Plan for the LSIIC functions as a das solen, symbolizing a standard or objective for the progression of the LSIIC. Since its establishment from 2008 to 2019, the development of the Independent Integrated City Area has incurred total expenditures amounting to Rp. 216.81 billion, sourced from the State Budget totaling Rp. 106.25 billion, the West Sumatra Provincial Budget totaling Rp. 53.11 billion, and the Pesisir Selatan Regency Budget totaling Rp. 57.45 billion. In the fiscal year 2020, the allocation from the State Budget reached Rp. 3.82 billion, accompanied by a budget of Rp. 2.74 billion from the Pesisir Selatan Regency Budget. The effectiveness of the LSICC development initiative should not merely be evaluated through the prism of the significant financial resources allocated and the concrete development of urban infrastructure; it is essential to assess it from the standpoint of its environmental carrying capacity to guarantee that its roles and functions as an Independent Integrated City can be maintained over the long term. As a reality (das sein), this perspective is vital for understanding and ensuring the integration and autonomy of a center for sustainable economic growth as an aspiration (das solen), as articulated in the 2015 master plan review. In light of the operational tenure of the LSIIC exceeding a decade since the initiation of development in 2008, it is now propitious to transition into the evaluation and monitoring phase.

Some of the issues that arise in the implementation of the independent integrated city policy in Lunang Silaut are as follows: First, infrastructure and Finance, including: first, the urban facilities and infrastructure are not yet functioning; second, the intra- and inter-regional transportation facilities and infrastructure are not yet functioning; and third, spatial planning and the environment have not been optimally managed. Second, economy, including: first, the development of the agricultural subsystem is not yet optimal; second, the development of economic institutions is not yet optimal; third, the management institutions of the area are not yet functioning and the role of local governments in the development of independent integrated cities is still minimal; and fourth, the institutionalization of social services on a regional scale has not yet been established.

In this study, the financial indicators were not used [35]. Ultimately, the evaluation and monitoring activities of the function and development [35] of the Independent Integrated Cities will culminate in the ability of the environmental carrying capacity and the suitability of local land to support the dynamics of growth and services of the Independent Integrated Cities.

2. LITERATURE REVIEW

2.1 Environmental carrying capacity

The Guidelines for Determining Environmental Carrying Capacity and Accommodation Capacity (DECCA) assert that comprehensive studies of environmental aspects are imperative and that their findings must be incorporated into development planning [47]. Consequently, the execution of ecological aspect studies that account for environmental capacity limitations and living standards must be comprehended by policymakers, planners, programs, and stakeholders [48-50]. The determination of DECCA encompasses nine facets, precisely: (1) demographic carrying capacity, (2) population pressure, (3) settlements, (4) food balance, (5) agricultural land, (6) carrying capacity ratio, (7) protective function, (8) water carrying capacity, and (9) land suitability for oil palm [47].

The concepts of environmental carrying capacity and accommodation capacity in spatial planning are designed to ensure that spatial utilization, as guided by planning, does not surpass the environmental limits necessary to sustain and accommodate human activities without inflicting ecological harm [51-54]. These capabilities encompass the provision of space, the availability of natural resources, and the capacity to enhance environmental quality in response to impacts that may disrupt ecosystem equilibrium [55-59]. Neglecting ecological carrying capacity in spatial planning will inevitably lead to challenges and deterioration of environmental quality, manifesting as phenomena such as floods, landslides, droughts, and pollution [60].

Numerous definitions delineate the construct and methodologies pertinent to the quantification of environmental carrying capacity. Nonetheless, a shared characteristic persists in that carrying capacity invariably underscores the interrelationship and equilibrium between availability (supply) and demand, with all considerations congruent with the specified objectives [61, 62]. Environmental carrying capacity may be interpreted as the environment's potential to provide a thriving and sustainable existence for the organisms residing within a specific locale [3, 63].

The allocation of space must consider land capacity to ensure that spatial utilization within a region aligns with environmental and resource capacities [64, 65]. The outcomes from assessing environmental carrying capacity serve as a foundational reference in formulating regional spatial plans. Given that ecological carrying capacity transcends administrative boundaries, the implementation of spatial planning must integrate considerations of environmental linkages and the efficacy and efficiency of space utilization [66-68].

2.2 Independent integrated city

This study clarifies that autonomous transmigration is congruent with individual attributes, given that communities with unique characteristics tend to manifest diverse reactions to the motivating and attractive forces of migration and display varying capabilities to overcome obstacles [69]. An Independent Integrated City is defined as a locality or region that develops and progresses as a focal point for the aggregation and processing of goods, alongside the distribution and provision of services emanating from the Transmigrant Development Area (TDA), which is systematically devised as a structured developmental framework for transmigration settlement units and adjoining villages within a singular infrastructural network and regional economic unit [70].

The purpose of nurturing an Independent Integrated City is to improve the accessibility of fulfilling a variety of fundamental needs, thereby promoting the emergence of opportunities for socio-economic enhancement in transmigrant territories and establishing hubs for commercial activities that attract investors, as part of a strategic initiative to invigorate and expand the economic endeavors of transmigrants and the surrounding populace. The objective of developing an Independent Integrated City includes the provision of social, economic, and governmental services to address the essential living requirements of transmigrants and adjacent villages, the establishment of infrastructure and facilities to support the business operations of transmigrants and nearby urban areas, as well as the creation of business activity centers to stimulate economic activities within transmigration zones.

3. METHOD

The methodology involving analytical units and indicators within the environmental carrying capacity and capability framework is directed toward assessing ecological carrying capacity and capability. In this research endeavor, the methodological approach utilizing analytical units and indicators within the paradigm of ecological carrying capacity and capability is aimed at evaluating the LSIIC's environmental carrying capacity and capability.

3.1 Analysis method

The methodological approach for examining the analytical unit pertinent to the determination of environmental carrying capacity and its associated capabilities encompasses:

1. Stock is assessed by calculating the availability of extant natural resources; this approach is applicable for evaluating carrying capacity and potential at national and island/archipelago scales.
2. Evaluating supply and demand involves quantifying the requisite resources (as informed by the ecological footprint) necessary to satisfy human requirements within a specific locale, alongside assessing the environmental capacity to furnish these necessities (environmental carrying capacity).
3. Ecosystem services are categorized into four distinct types, which include:
    a. Functional services (provisioning services): the tangible products and services derived from ecosystems, encompassing genetic resources, food, water, and similar entities.
    b. Regulatory services: the advantages accrued from ecosystems' regulatory functions, which include mechanisms for flood mitigation, erosion control, and the management of climate change repercussions.
    c. Cultural services: the intangible and non-quantifiable benefits associated with ecosystems, which encompass spiritual enrichment, cultural traditions, aesthetic values, and knowledge systems.
    d. Supporting services: the essential ecosystem functions that sustain human life, including biomass production, oxygen generation, nutrient cycling, and water supply.

Economic valuation is conducted by evaluating the economic implications of a policy, plan, or program (PPP) within a designated area. This is juxtaposed with the costs of potential losses (impacts) that may arise from the PPP, which must be compensated to align with the optimal environmental carrying capacity.

3.2 Unit of analysis

In assessing carrying capacity, the analytical unit can be categorized into administrative divisions and ecoregional segments, each possessing distinct data requirements. The requisite data types encompass administrative records and spatial information. The environmental carrying capacity metric constitutes a fundamental element in evaluating ecological carrying capacity as informed by the analytical unit. Indicators represent analytical methodologies employed to quantify a region's capacity within the framework of environmental carrying capacity and overall capacity. Benchmarks serve as analytical units derived from the parameters associated with ecological carrying capacity.

In this study, the discussion of the evaluation and monitoring activities of LSIIC is limited to (1) the tasks and functions of KTM as a growth center that provides services and support for the development of businesses in a number of Development Area Units (DAU) consisting of several Settlement Units (SP) or Transmigration Settlement Units (TSU) or villages; and (2) measurement of the environmental carrying capacity of Independent Integrated City using indicators:

a) Based on function and purpose.
b) Based on media typology such as forest land and water and several national, regional, and ecoregion economic sectors.
   - Land carrying capacity
   - Water Carrying Capacity [71].

This problem limitation was carried out by considering that it has covered all important indicators of the success of an Independent Integrated City development program in an integrated transmigration area based on environmental carrying capacity, so it can be used as a guideline (model) for further Independent Integrated City development planning.

3.3 Determination of environmental carrying capacity

The methodology for calculating carrying capacity is generally contingent upon the specific function or purpose under consideration, whether it pertains to economic, demographic, or other dimensions. Each objective necessitates its formulation due to the disparate characteristics of units and scales [71]. About the theoretical foundation for assessing Environmental Carrying Capacity (ECA), a synthesis of the criteria for determining ECA can be delineated as follows (Table 1) [71]:

Table 1. Determination of carrying capacity based on function and purpose

No.	Concept / Purpose	Formulation	Information
1.	Demographic Capacity	A = L / P A = Land Carrying Capacity L = Land area (Ha) P = Population (people)	Need land according to amount population (Yeates) Population 10,000 (0.1 Ha/person); 25,000 (0.091); 50,000 (0.086); 100,000 (0.076); 250,000 (0.070); 500,000 (0.066); 1,000,000 (0.061); 2,000,000 (0.057)
2.	Economy	$EcoCC = \frac{GRDP\ tot}{PR \times C}$ Information: EcoCC=Economic Carrying Capacity GRDP total = Gross Regional Domestic Product (Rp) TP = Total Population C = Consumption resident per capita (Rp) Consumption value can used as NMP (Requirement), Minimum Physical) (Rp), or poverty line (Rp).	• EcoCC > 1, regional resources and economy can support residents' needs and consumption within minimum limits. • EcoCC < 1, capability regional economy has No capable support resident. • EcoCC = 1, which means there is a balance
3.	Food Balance	$K = \frac{As1.Ys1+As2.As3.Ys3+\cdots AsnYsn}{Cs1+Cs2+Cs3+\cdots.Csn}: R$ Bayliss Smith Concept Information: K = Carrying capacity land = Person/Ha As1... Asn = area planted land with type plant s1., sn in Ha land Ys1… Ysn = productivity net types plant food s1… sn in calories / Ha / year Cs1… Csn = level minimum consumption for each type of plant food in the population menu, in percent from total calories R = needs average calories per capita	
4.	Agricultural Land	$\sigma = \frac{SA/Pd}{NMP/Pr}$ Information: σ = Carrying capacity of agricultural area SA = Land area harvest (Ha) Pd = Total population (soul) NMP = Needs Minimum Physical (Kg/capita/year) Pr = Production average land per hectare (Kg / Ha)	With assumption if : • σ < 1, no capable self-sufficiency food • σ > 1, capable self-sufficiency food
		CCR = (A × r) / (H × h × F) Information: CCR = Ratio ability Power support (*carrying capacity ratio*) A = Total area that can be used for activity agriculture r = Frequency harvest per hectare per year H = Number of houses later) h = percentage of residents who live as a farmer F = Size land average farm-owned farmer	• CCR > 1, the region can support the needs of primary resident • CCR < 1, a region not capable of support needs the primary resident
5.	Settlement	$SCC = \frac{SA/TP}{\alpha}$ Information: SCC = Settlement Carrying Capacity TR = Total resident α = coefficient wide need space/capita (m^2 / capita)	• SCC > 1, capable of accommodating residents for residence. • SCC = 1, occurred balance between residents who live (build) homes) in the existing area.

		According to SNI 03-1733-2004, it is 26 m^2, while according to Ministerial Regulation of the State for Public Housing No. 11/2008, needs vary according to area. SA = Settlement Area (m^2), can use several limitations, including: 1. Eligible area for land settlement is the outside area protected and area vulnerable to disasters (floods and landslides) so that: SA = AR– (PAS + APD) AR = Area of the region PAS = Protected Area Size APD = Area of the area vulnerable to disaster 2. Use area class ability land, where we can assume class ability land I-IV is feasible and feasible for settlements.	• SCC < 1, no capable accommodating resident for settling (build) house) in the area
6.	Function Protect	$ECC = \frac{\sum(Lgl1.\alpha 1+Lgl2.\alpha 2+\cdots.+Lgln.\alpha n)}{LA}$ Information ECC = Carrying capacity function protect Lgl1 = Useful area land type 1 (Ha) LA = Area (Ha) α 1 = coefficient protect For land 1 Nature reserve (1.00); Sanctuary wildlife (1.00); Tourist park (1.00); Hunting park (0.82); Protected forest (1.00); Reserve forest (0.61); Production forest (0.68); Large plantation (0.54); Smallholder plantation (0.42); Rice fields (0.46); Fields/ dry fields (0.21); Grasslands (0.28); Lakes/ ponds (0.98); Plants wood (0.37); Settlement (0.18); Vacant land (0.01)	The carrying capacity environment (ECC) has a range mark between 0 (minimum) to 1 (maximum). Therefore, the more approach value 1, the better function and protection in the area will be
7.	Threshold	WB = (LA – Lm) Lm = (La – Lb – Li) Information: WB = Area can develop LA = Area (Km^2) Lm = Limitation or threshold, namely the area at risk for development (Km^2) La = Limitation nature, namely protected and vulnerable areas disaster as well as condition soil and hydrology are not according to (Km^2) Lb = Limitation development, namely using area land for non-agricultural cultivation (Km2) and fertile agriculture. Li = Limitation infrastructure and utilities, namely areas that have been used for development infrastructure and utilities area (Km^2)	
8.	Pressure Resident	$PR = (1 - \alpha t)\, Zt\, \frac{ft.P0(1+r)^t}{\beta Lt}$ Information PR = Pressure resident to land agriculture t = Period time calculation Zt = Area of land required for support life farmers at the level desired life (Ha/person) f = percentage of farmers inside the population P0 = Magnitude population at the time reference time t0 (person) r = Average level increase in resident annual L = area land agriculture in the area concerned. α = percentage non-agricultural income ($0 < \alpha < 1$) β = part benefit land enjoyed by farmers or cultivators ($0 < \beta < 1$) $Pt - P0\,(1 + r)^t$	• PR > 1; pressure population occurs, exceeding power support • PR < 1; no happen pressure population, still capable of supporting existing population
9.	Environment (Ecology)	ECC = BK / TE Information: ECC = Carrying capacity ecological BC = Biocapacity (Ha/person) BC = (0.88 × SALi × FPi)/TP $BC = \sum_1^t BC$ Information: BC = Biocapacity use land (Ha/capita) SALi = Area of use land 1 (Ha) 0.88 = constant (12% of it) used to ensure sustainability biodiversity FPi = Production factor-1 (Ferguson, 1998) TP = Total population (people) EC = Ecological footprint (Ha/person) ECi = TP × Ki × EFi $ECt = \sum_1^t JEi$ Information ECi = value footsteps ecological use land 1 (Ha) TP = Total resident Ki = Need value land I, for fulfill need consumption sit down per capita (Ha/ capita) with use results WWF, ZSL and GFN research, (2006) EF = Equivalence factor (result in WWF, ZSL and GFN research, (2006) ECi = Trace value total ecology	• ECC > 1 means a surplus condition where the ecosystem is capable of supporting the people living in it (*ecological debt*) • ECC < 1 means condition *overshoot*, where the ecosystem is not capable of supporting a living population (ecological *deficit*) • Ki × EFi Value has calculated and generated a mark coefficient that can be directly applied

Description:

a. Demographic capacity (A), calculated using the formula: A = Land area divided by population
b. Population pressure (PP) is calculated using the formula: PR = (land area needed by farmers multiplied by the percentage of farmers in the population multiplied by the population in 2021) divided by the area of agricultural land in 2021.
c. Settlement (SCC), calculated using the formula: SCC = (land area suitable for settlement divided by population) divided by the coefficient of space requirements per capita.
d. Food balance (K) is calculated using the formula K = (rice field area multiplied by annual rice productivity) divided by (rice consumption rate per capita per year).
e. Agricultural land (σ), calculated using the formula: σ = (Number of rices harvested land divided by population) divided by (minimum physical needs per capita divided by average rice production per hectare)
f. Carrying capacity ratio (CCR), calculated using the formula: CCR = (area of agricultural harvested land) divided by (number of heads of families multiplied by the percentage of farmers multiplied by the average size of land owned by farmers).
g. The protection function (ECC) is calculated using the formula ECC = Sum (land use area multiplied by land protection coefficient) divided by area.
h. Water carrying capacity is calculated using the formula SA = water availability = (conversion factor multiplied by weighted runoff coefficient multiplied by average annual rainfall multiplied by area). DA = population multiplied by water requirement for decent living per capita per year.

In this study, the formula for determining carrying capacity based on the functions and objectives used includes (1) demographic carrying capacity, (2) population pressure, (3) settlements, (4) food balance, (5) agricultural land, (6) carrying capacity ratio, and (7) protective function.

Table 2. Determination of land carrying capacity

Land Availability Side (*Supply Side*)	**Land Requirement Side (*Demand Side*)**
Total actual production throughout commodity local $AL = \frac{\sum Pi \times Hi}{Hb} \times \frac{1}{Ptvb}$ Information: AL = Availability Land (Ha) Pi = Actual production per month type commodity (unit) depends on type commodity). Commodities to be reckoned with cover agriculture, plantations, forestry, animal husbandry, and fisheries. Hi = Unit price each type commodity (Rp/ unit) at the level manufacturer Unit price rice (Rp/kg) at the level manufacturer Ptvb = Productivity rice (Kg/Ha) In the calculation, this factor conversion used to equalize non-rice products is the price.	1. Population resident 2. Need land per person assumed equivalent with vast land for produce 1-ton equivalent rice per year LE = N × LAR Information: LE = Total requirement land equivalent rice (Ha) N = Number population (people) LAR = Land area required for need life worthy per inhabitant a. Land area required for need life worthy per inhabitant is need life worthy per inhabitant shared productivity local rice b. Need life worthy per inhabitant assumed equal to 1-ton rice/capita/year c. Areas that do not have productivity data for local rice can use the average productivity data for rice national of 2400 kg/Ha/year.
Land Carrying Capacity If AL > LE, power support land declared surplus If AL < LE, power support land declared a deficit or exceeded	

The formula for determining land-carrying capacity was not used in this study (Table 2).

3.4 Determination of land suitability

Land suitability indicators in this study are specifically for land suitability indicators for oil palm plantations, which are the mainstay and most widely planted.

a. Oil Palm Smallholder Plantations in Lunang District (2020) covering an area of 6,378 Ha with a production of 81,157.83 Tons.
b. Oil Palm Smallholder Plantations in Silaut District (2020) covering an area of 8,587 Ha with a production of 70,205.07 Tons

The source of research data is the Central Bureau of Statistics. Data analysis refers to the formula for calculating environmental carrying capacity in the "Guidelines for Determining Environmental Carrying and Carrying Capacity (DECCA)" published by the Ministry of Environment. Data analysis was carried out by considering the availability of secondary data for LSIIC. The availability of secondary data can be seen in the Appendix. The limitations of secondary data have an impact on the scope of calculation and analysis of environmental carrying capacity for LSIIC covering eight aspects, namely: (1) demographic carrying capacity, (2) population pressure, (3) population settlements, (4) food balance, (5) agricultural land, (6) carrying capacity ratio (7) protection function, and (8) water carrying capacity. In addition, this study also conducted an analysis and discussion of the suitability of oil palm plantation land as the largest superior commodity planted in LSIIC.

4. RESULTS AND DISCUSSIONS

The source of research data is the Central Bureau of Statistics of the Pesisir Selatan Regency. Data analysis refers to the formula for calculating environmental carrying capacity in the "Guidelines for Determining Environmental Carrying and Carrying Capacity (DECCA)" published by the Ministry of Environment (2014). Data analysis was carried out by considering the availability of secondary data for LSIIC. The availability of secondary data can be seen in the Appendix. The limitations of secondary data have an impact on the scope of calculation and analysis of environmental carrying capacity for LSIIC covering eight aspects, namely: (1) demographic carrying capacity, (2) population pressure, (3) population settlements, (4) food balance, (5) agricultural land, (6) carrying capacity ratio (7) protection function, and (8) water carrying capacity. In addition, this study also conducted an analysis and discussion of the suitability of oil palm plantation land as the largest superior commodity planted in LSIIC.

Table 3. Summary of environmental carrying capacity analysis results

No.	DECCA Aspects	Results	Criteria	Conclusion
1.	Demographic Capacity	Amount population 38015 people A = 1,499 HA / Soul	Population 50,000 people required A = 0.086 HA / person	Capacity demographics LSIIC is still good (safe).
2.	Pressure Resident	PR = 0.65	PR < 1; no happen pressure population, still capable of supporting existing population.	There is no high-pressure population in the LSIIC, but it is still capable of supporting the existing population.
3.	Settlement	SCC = 137.3	SCC > 1, capable of accommodating resident to reside	LSIIC is capable of accommodating residents for residence.
4.	Food Balance	K = 62592 people/Ha	Population residents of LSIIC moment This is 38015 souls. This means power supports land. For balance, food can still accommodate 1.65 times the current population.	Carrying capacity land from perspective balanced food in the LSIIC is still good (safe).
5.	Agricultural Land	σ = 3	σ > 1, capable of self-sufficiency in food	From the perspective of power-supporting agricultural areas, LSIIC can achieve food sustainability.
6.	Ratio Ability Power Support (*carrying capacity ratio*)	CCR = 1.77	CCR > 1, the region can support the needs of the main resident	LSIIC Sea's ability to support the needs of its main population.
7.	Function Protect	ECC = 0.82	The carrying capacity environment (ECC) has a range mark between 0 (minimum) to 1 (maximum). Therefore, the more approach value 1, the better function and protection in the area will be	Carrying capacity, LSIIC environment Sea from perspective function protect is approach maximum (good)
8.	Water Carrying Capacity	SA = 4190421600 m^3 / year DA = 60824000 m3/ year or SA = 68.89 × DA	If SA > DA, power water support declared surplus	Carrying capacity in the LSIIC declared surplus

The results of the analysis of the environmental carrying capacity of KTM Lunang Silaut produced findings which are summarized in Table 3.

Based on Table 3, it can be explained in the section below:

a. Demographic Carrying Capacity

$$A = L / P = 56984 / 38015 = 1{,}499$$

The DECCA criteria state that A = 0.086 Ha/person is needed for a population of 50,000 people. The calculation results for LSIIC, with a population of 38,015 people, show that the land carrying capacity A = 1,499 Ha / Person is greater than 0.086 Ha/Person, so it can be said that the demographic carrying capacity of LSIIC is still good (safe).

Assuming that the LSIIC land remains the same and the current population growth rate is 2.2% per year, a population of 82,057 people will be achieved in the next 35 years.

b. Population Pressure

$$PR = (Ztft.P0\ [(1+r)]^{t})/Lt$$
$$PR = (1 \times 0.58 \times 38015)/34190 = 22048.7/34190 = 0.65$$

The DECCA criterion states that PR > 1, population pressure occurs, and carrying capacity is exceeded. PR < 1; there is no population pressure, and it can still support the existing population. The calculation results show that PR = 0.65, which is <1; so it is said that in LSIIC, there is no population pressure, still able to support the existing population. With a population growth rate of 2.2%, 58948 people will occur in the next 30 years.

c. Settlement

$$SCC = (SA/TP)/\alpha = (135700000/38015)/26 = 137.3$$

DECCA criteria state that SCC > 1 can accommodate residents to settle. SCC = 1, a balance exists between the population who settle (build houses) and the existing area. SCC < 1, unable to accommodate residents to settle (build houses) in the area.

The calculation results show that SCC = 137.3, which is > 1. Thus, LSIIC can accommodate residents who want to settle. The balance between the population who settle (build houses) with the existing area will occur if SCC = 1. If SCC = 1 and the land area requirement per person remains 26 m2, this condition occurs if the number of LSIIC residents becomes 135700000 / 26 = 5219230 people. The number of residents will occur over a long period, considering that the current population is only 38015 people while the current population growth rate is only 2.2% per year.

d. Food balance

$$K=(As1.Ys1+As2.As3.Ys3+\cdots AsnYsn)/(Cs1+Cs2+Cs3+\cdots.Csn)\text{: } R = (2608 \times 3120)/1\text{: } 130 = 62592 \text{ people/Ha}$$

Cs1…Csn = minimum consumption level for each type of food crop in the population's menu, in percent of total calories. In this study, the minimum consumption level is 100%

because the plant consumed is rice. R = average calorie requirement per capita in this study is equivalent to 130 Kg of rice / Year. The result, K = 62592 people / Ha, means that the land carrying capacity for food balance can meet the food needs of 62592 people. At the same time, the current population of LSIIC is 38015 people. Thus, the land carrying capacity for food balance can still accommodate 1.65 times the current population. This shows that the land carrying capacity from the perspective of food balance in LSIIC is still good (safe). Assuming food productivity remains constant and the population growth rate is 2.2% per year, the land-carrying capacity for food balance will meet the population's needs up to 1.7 times the current population in the next 25 years.

e. Agricultural Land

$$\sigma = (SA/Pd)/(NMP/Pr) = (4425.9/ 38015)/(130/3120) = 0.12/0.04 = 3$$

The calculation results show that σ = three, which is > 1, so it can be said that from the perspective of the carrying capacity of agricultural areas, LSIIC is capable of food self-sufficiency. With these assumptions and a population growth rate of 2.2% annually, food self-sufficiency will continue for 50 years.

f. Carrying capacity ratio

$$CCR = (A \times r) / (H \times h \times F) = (8096) / (7886 \times 0.58 \times 1) = 1.77$$

The DECCA criteria state that: CCR > 1, the area can support the population's basic needs; CCR < 1, the area cannot support the population's basic needs. The calculation results show that CCR = 1.77, which is > 1; thus, it can be said that LSIIC can support its population's basic needs. Assuming that the agricultural land remains the same and the population growth rate is 2.2% per year, the carrying capacity of the farmland will be sufficient for the next 25 years.

g. Protection Function

$$ECC = \frac{\sum(Lgl1.\alpha1+Lgl2.\alpha2+\cdots.+Lgln.\alpha n)}{LA}$$

$$ECC=(49720+2650.45+2688.15+8081.1+5517.54+1199.68+924.84+2095.24+130.34+2442.6+79.41) / 92318 = 75529.35 / 92318 = 0.82$$

The DECCA criteria state that the environmental carrying capacity (ECC) has a value range between 0 (minimum) and 1 (maximum). Therefore, the closer to 1, the better the protective function in the area. Based on the DECCA criteria, the ECC of LSIIC = 0.82 is close to 1, or in other words, the environmental carrying capacity of LSIIC from the perspective of the protective function is close to the maximum (good).

The carrying capacity of the calculated protective function is ECC = 0.82, which is close to 1, so it is said that the carrying capacity of the protective function of LSIIC is close to the maximum (good).

h. Water Carrying Capacity

Water availability side (SA)

$$C = \sum (ci \times Ai) / \sum Ai = (15508 + 2520.05 + 4 + 2619.05 + 2123.39) / (19385 + 3877+ 20 + 7483 + 11796.59) = 22774.49 / 42561.59 = 0.54$$

$$R = \sum Ri / m = 20$$

$$SA = 10 \times C \times R \times A = 10 \times 0.54 \times 20 \times 1940010 = 4190421600 \text{ m}^3\text{/year}$$

4.1 Environmental carrying capacity

The discourse regarding the analytical outcomes was undertaken by consulting the standards for environmental carrying capacity delineated in the "Guidelines for Determining Environmental Carrying Capacity and Accommodation Capacity (DECCA)" issued by the Ministry of Environment in 2014. The findings derived from the assessment of the environmental carrying capacity of the LSIIC are encapsulated in the summary.

4.2 Demographic capacity

The outcome of the demographic capacity assessment reveals A = 1,499 Ha/person, which translates to a population density of 0.7 individuals per Ha of land. Concurrently, the DECCA criterion is established at 0.86 Ha/person, indicating a population density of 1.2 individuals per Ha. During the 2021 analysis, the land area designated for the LSIIC amounted to 56,984 Ha. To attain a population density of 1.2 individuals per Ha, the population within the Independent Integrated City must reach 82,057 individuals. Presently, the population of the Independent Integrated City stands at 38,015 individuals. Assuming the land area of the Independent Integrated City remains unchanged, and factoring in the current annual population growth rate of 2.2%, a demographic total of 82,057 individuals will be realized within the subsequent 35 years. Consequently, from the perspective of demographic capacity, the LSIIC is projected to sustain its viability over the next 35 years.

4.3 Population pressure

The outcomes derived from the analysis of population pressure concerning agricultural land indicate a PR value of 0.65, which is less than 1. This finding implies that within the LSIIC, there exists an absence of population pressure on agricultural land, signifying that the farmland is currently capable of sustaining the existing population. Population pressure on agricultural land is anticipated to commence when PR equals 1. By employing the population pressure equation and operating under the premise that the extent of agricultural land, the proportion of the population engaged in farming, and the characteristics of land amenable to cultivation remain constant, it can be determined that PR will reach 1 when the population of the Independent Integrated City attains 34,190 divided by 0.58, resulting in 58,948 individuals. The population was recorded at 38,015 individuals at the time of the analysis. Assuming a population growth rate of 2.2%, the population figure of 58,948 individuals is projected to materialize within 30 years.

4.4 Settlement

The results of the calculations indicate that the settlement area's carrying capacity within the LSIIC is quantified as SCC

= 137.3, which exceeds the threshold of 1. This observation implies that the LSIIC can accommodate residents for permanent habitation. This scenario is inherently plausible, given that an Independent Integrated City represents an advancement of a transmigration zone characterized by its substantial land area. A state of equilibrium between the resident population (those constructing residences) and the available land area will be achieved when SCC equals 1. Should SCC equal one and the spatial requirement per individual is maintained at 26 m², this equilibrium would be realized if the population of an Independent Integrated City reaches 135700000 / 26 = 5219230 individuals. Such population growth is anticipated to occur over an extended duration, particularly in light of the current population of merely 38015 individuals and a prevailing population growth rate of only 2.2% annually.

4.5 Food balance

The computed outcome regarding the land's carrying capacity for food balance is quantified as K = 62592 individuals per hectare, indicating that this land capacity is sufficient to fulfill the nutritional requirements of 62592 individuals. Concurrently, the current demographic of the LSIIC stands at 38015 individuals. Presuming that food productivity remains constant and the annual population growth rate is 2.2%, the land's carrying capacity for food balance is projected to adequately address the needs of a population that is 1.7 times greater than the current figure within the forthcoming 25 years.

4.6 Agricultural land

The derived calculation about the carrying capacity of the agricultural sector yields $\sigma = 3$, signifying that the farmland within the LSIIC possesses the capability to satisfy food requirements up to threefold for its resident population (indicating food self-sufficiency) under the stipulation that any surplus food is not distributed beyond the regional confines. Given this premise and an annual population growth rate of 2.2%, the prospect of food self-sufficiency is projected to persist for an ensuing period of 50 years.

4.7 Carrying capacity ratio

The calculations reveal a carrying capacity ratio for agricultural land denoted as CCR = 1.77, suggesting that the LSIIC's agricultural terrain can adequately sustain the fundamental needs of its populace to an extent of 1.77 times the current demographic. Assuming the agricultural land remains unchanged and the annual population growth rate is maintained at 2.2%, the carrying capacity of this farmland will be deemed adequate for the subsequent 25 years.

4.8 Protection function

As derived from the calculations, the assessment of the carrying capacity concerning the protective function yields ECC = 0.82, which approaches the value of 1. Consequently, it is inferred that the carrying capacity for the protective function of the LSIIC is nearing its optimal threshold (indicative of favorable conditions).

4.9 Water carrying capacity

The findings from the analysis concerning the water carrying capacity reveal that the LSIIC possesses a surplus of water, as evidenced by the water availability (SA) significantly exceeding the water requirement (DA), specifically SA = 68.89 × DA. A state of equilibrium in water carrying capacity is achieved when SA equals DA. Under the assumption of consistent rainfall and uniform infrastructural conditions yielding similar water runoff, the condition where SA equals DA is projected to arise only when the population increases by a factor of 69, a scenario anticipated to unfold over an extensive temporal framework. The literature review presented in this study elucidates that the principal determinants influencing environmental carrying capacity include population dynamics, food availability, water resources, and adequate spatial resources (land and air). In this investigation, the ecological carrying capacity of the LSIIC is evaluated through eight dimensions: (1) demographic carrying capacity, (2) food balance, (3) food self-sufficiency, (4) the capacity to meet the fundamental needs of its inhabitants, (5) settlement patterns, (6) protective functions, (7) population pressure, and (8) water carrying capacity. A comprehensive analysis of the results derived from existing secondary data indicates that the environmental carrying capacity and overall carrying capacity of the LSIIC remain in a satisfactory state, and with the current assumptions, this condition is projected to be sustainable for a minimum of the next 25 years. Nevertheless, it is essential to acknowledge that the assumptions employed in this analysis will inevitably undergo alterations over time; for instance, changes in spatial conditions (land and air), seasonal variations, shifts in land use and functionality, modifications in air quality, fluctuations in population growth rates, transformations in demographic profiles, advancements in technology, variations in macro and microeconomic circumstances, evolutions in lifestyle, modifications in regulatory frameworks, and shifts in political, economic, social, and cultural contexts will all likely occur. Consequently, while the theoretical assessment of the environmental carrying capacity of the LSIIC suggests that it will remain adequate for at least the next 25 years, the anticipated myriads of changes indicates that the LSIIC is expected to continue functioning effectively over the ensuing decade. In this study, the formula for determining water-carrying capacity was used (Table 4).

The primary impediment encountered in this research resides in the accessibility of data, which, as articulated by the author, poses significant challenges in procurement due to the incompleteness of documentation, and this investigation represents the inaugural study to be executed in the context of the LSIIC. Consequently, it is recommended that the local government undertake annual assessments of the environmental carrying capacity within the LSIIC, thereby providing essential insights for subsequent regional development endeavors. Nonetheless, the master plan for the advancement of the LSIIC can be characterized as a commendable framework for regional development, as evidenced by the fact that since the initiation of construction in 2008, the LSIIC has continued to operate effectively, a condition anticipated to persist for an estimated decade hence, particularly concerning demographic growth, food resource availability, land access, and water supply, all of which do not compromise environmental integrity. The master plan for the developmental trajectory of the LSIIC serves as a potential paradigm for the strategic planning of future developments within Lunang Silaut and in analogous areas. Furthermore, the implementation of an analysis of the environmental carrying capacity of the LSIIC applies to the advancement of other regions, including urbanization, tourism initiatives, mining operations, agricultural enterprises, industrial pursuits, and more, facilitating the acquisition of feedback or alternative input regarding the environmental carrying capacity conditions. This enables stakeholders engaged in regional development to render decisions that ensure the sustainability of regional growth. The findings derived from this research and ensuing discourse align with the perspectives of scholars who, based on their investigative work, disclose the following: First, unregulated alterations in land use, in conjunction with the absence of soil and water conservation strategies, have the potential to induce erosion [72-74]. The resultant erosion may lead to land degradation, ultimately resulting in a decline in land productivity [75-77]. Conversely, erosion may also precipitate sedimentation and the consequent shallowing of aquatic ecosystems, including lakes, reservoirs, rivers, channels, and other bodies of water. Moreover, erosion and sedimentation can function as pollutants, diminishing the quality and quantity of land and water resources and adversely affecting these essential resources' productivity [78].

Second, environmental carrying capacity and capacity must be considered in spatial planning [14, 39, 42, 79] as stated in Law Number 26 of 2007 concerning Spatial Planning to ensure the sustainability of human life today and for future generations. As a detailed plan for a regional spatial plan, the Detailed Spatial Plan will be a crucial player in licensing the use of space to support the Online Single Submission (OSS). Therefore, environmental carrying capacity must be considered and strengthened through a Strategic Environmental Assessment (SEA) to prepare a detailed spatial plan.

Third, sustainable development, which constitutes the primary objective of Law Number 32 of 2009 about Environmental Protection and Management, should serve as a foundational principle for enhancing the environmental carrying capacity and capability. The inherent capacity of the natural world to sustain life, along with its tolerance for anthropogenic substances, must be governed by specific limitations; consequently, humanity, as a component of the ecological system, bears the responsibility of safeguarding the environment in which it resides. By embracing sustainable development that considers the availability of natural resources for forthcoming generations, it is feasible to augment the quality of environmental carrying capacity and capability [2, 19, 80-82]. Fourth, economic development is conceptualized as a continuous and dynamic advancement process [83-85]. Furthermore, structural characteristics define economic development as a transformative process [86-88]. These transformations emerge due to financial activities and the presence of factors that influence alterations in the economic sector's role in the endeavor to generate national income. Economic development is a cornerstone of a nation's prosperity. Nonetheless, it concurrently presents a formidable challenge that necessitates attention, particularly regarding the repercussions of the developmental process on environmental quality [89-92].

Table 4. Determination of water carrying capacity

Water Availability Side (*Supply Side*)	**Water Needs Side (*Demand Side*)**
1. Coefficient overflow for every type of land 2. The area of each type of land The coefficient method modified the runoff from the rational process. $C = \sum (ci \times Ai) / \sum Ai$ $R = \sum Ri / m$ $WA = 10 \times C \times R \times A$ Information : WA = Water availability (m^3 / year) C = Coefficient overflow weighed Ci = Coefficient overflow use land i Information Ai – wide use land i (Ha) Algebraic mean rainfall Rain annual area (mm/ year) Ri = Rainfall annual at the station i M = Total station observation rainfall Rain A = Area (Ha) 10 = factor conversion from mm Ha to m^3. Description (coefficient overflow according to use of land) 1. City, street asphalt, tile roof (0.7 – 0.9) 2. Industrial area (0.5 – 0.9) 3. Settlement multi-unit shops (0.6 – 0.7) 4. Complex housing (0.4 – 0.6) 5. Villa (0.3 – 0.5) 6. Cemetery Park (0.1 – 0.3) 7. Yard land heavy: a. > 7 % (0.25 – 0.35) b. 2 – 7% (0.18 – 0.22) c. < 2% (0.13 – 0.17) 8. Yard land light a. > 7% (0.15 – 0.2) b. 2 – 7% (0.10 – 0.15) c. < 2% (0.05 - 0.10) 9. Heavy land (0.40) 10. Grassland (0.35) 11. Cultivated land agriculture (0.30)	1. Population resident 2. Water requirements per person based on pattern consumption Calculation water needs $TWR = N \times WR$ Information : TWR = Total water requirement (m^3 / year) N = Number population (people) WR = Water requirement for life worthy = 1600 m^3 of water/capita/year = 2 × 800 m^3 water/capita/year where 800 m^3 water/capita/year is needed water for domestic needs and for produce food. See information for total water needs and about "virtual water" (water needs for producing One unit product) 2 = is factor correct for considering the need for life, which includes needing food, domestic things, etc. Note: WHO criteria for total water requirement of 1000 – 2000 m^3 / person/ year. Description (water requirements) Example For water needs 1. Rice 120 kg/ year equivalent with 324 m^3 / year 2. Drinking water and housing stairs 120 l/h = 43.2 m^3 / year 3. 1 kg of eggs contains 16 eggs, equivalent to 105.75 m^3 / year 4. Fruit 1 kg of oranges = 5 fruits; equivalent to 3.84 m^3 / year 5. Meat 1/10 kg/5 days equivalent with 20.16 m^3 / year 6. Salad = 5.40 m^3 / year 7. Soybeans 276.00 m^3 / year Total 778.35 m^3 / yr

12. Production forest (0.18)
Determining power status supports water.
If WA > TWR, power water support declared surplus
If WA < TWR, power water support is declared a deficit or exceeded.

4.10 Land suitability for oil palm

The findings of the analysis indicate that palm oil cultivation is appropriate for establishing Lunang Silaut as a self-sufficient, integrated urban area. This conclusion aligns with the preliminary regional planning objectives established during the formulation of the master plan for the LSIIC, which was designated as a site for transmigration initiatives. Nevertheless, concerning the Palm Oil commodity, it is imperative to evaluate its economic significance for the local populace, as it is indisputable that the geographical positioning of the LSIIC is considerably distant from the provincial capital. Consequently, it is plausible that the development of transport facilities and infrastructure has not yet reached an adequate level to facilitate the marketing of the superior Palm Oil commodity. It is widely acknowledged that the quality of the Palm Oil yield, commonly referred to as Fresh Fruit Bunches (FFB), will deteriorate if not promptly processed at the Palm Oil processing facility; therefore, the transport facilities and infrastructure linking to the Palm Oil processing factory are of paramount importance.

4.11 Social support capacity

According to empirical research findings [93], environmental carrying capacity refers to the capacity of the ecosystem to sustain human existence and other biological entities. The assessment of ecological carrying capacity is achieved by evaluating the potential of the natural environment and its resources to accommodate human or population activities that necessitate spatial utilization for survival. Social carrying capacity is the environment's capability to facilitate human social interactions. An investigation was undertaken to ascertain the social carrying capacity of LSICC and determine if the operational performance of Lunang Silaut as an independent integrated city aligns with the anticipations of its local populace [94]. Among the twelve attributes that have not fulfilled these expectations, as indicated by the IPA analysis, seven attributes require enhancement, specifically the primary market, cemetery, public library, job training center, auction building, warehouse, and supermarket. The study's findings reveal that the social carrying capacity of the LSIIC is robust; in other words, the LSIIC is effectively fulfilling its role in serving the community.

4.12 Independent integrated city development scenario

This research [92] articulates that the environmental carrying capacity refers to the capacity of the environment to sustain the existence of human beings and other forms of life. This perspective suggests that the ecological carrying capacity will be influenced by the demographic presence of humans and other life forms under a constant environmental capacity. The population growth rate plays a pivotal role in determining the demographic composition of a given area. This population growth rate is influenced not merely by the frequency of births but also by the economic allure of a particular region. The greater the financial appeal of a locale, the more individuals will migrate from the other areas to benefit from the economic advancements of that locality [95-97]. The LSIIC has thus far demonstrated the efficacy of its service provision to the transmigration community, which aligns with the Government's objectives as outlined in the Master Plan, specifically aimed at establishing the LSIIC as a hub of development within the transmigration sector. Consequently, numerous immigrants from outside the region may seek opportunities to partake in its economic growth.

In light of the aforementioned considerations, the subsequent development scenario for the LSIIC has been devised, encompassing a medium-term scenario spanning 10 years (culminating in 2030) and a long-term scenario extending over 20 years (culminating in 2040) from 2021. The equation represents the population model employed:

$$P0 (1 + r)t$$

where,

P0 = Population at the beginning of 2021 is 38,015 people
r = Population growth rate in 2021 is 2.2% per year
t = 10 years for the medium term, and 20 years for the long term.

The population is obtained with the formula

$$P0 (1 + r)td$$

a. In 2030 (10 years) medium term = 38,015 (1 + 0.022) 10 =38,015 (1.24) = 47,257 people.
b. In 2040 (20 years) long term = 38,015 (1 + 0.022) 20 = 38,015 (1.55) = 58,745 people.

The medium and long-term environmental carrying capacity scenarios are as Table 5.

This table shows that in the medium-term scenario (2030), where the population reaches 47,257 people, the eight environmental carrying capacity indicators of the LSICC are still good and can support the lives of the community. In the long-term scenario (2040), where the population reaches 58,745 people, population pressure begins to occur while the other 7 (seven) indicators remain safe.

4.13 Sustainability guidelines for independent integrated cities

Based on the analysis of the developmental trajectory of LSICC within the medium-term horizon (spanning a decade until 2030) and the long-term perspective (extending over two decades until 2040), it becomes apparent that within the context of sustainable development, a singularly pivotal aspect that necessitates meticulous scrutiny is the phenomenon of population pressure. Furthermore, it is imperative to acknowledge that this investigation omits the examination of the Strategic Environmental Assessment, a requirement delineated in Law Number 32 of 2009 about Environmental Protection and Management, enacted on October 3, 2009, as it was not incorporated into the LSIIC Master Plan established in 2008. Consequently, for subsequent inquiries pertinent to the sustainability of the Independent Integrated City, it is advised that the discourse surrounding the Strategic Environmental Assessment be integrated into the analysis.

Table 5. Medium and long-term environmental carrying capacity

Aspect	Criteria	Scenario Amount Resident Year 2030 47,257 souls	 Year 2040 58,745 souls	Information
Demographic Capacity	Population 50,000 people required A = 0.086 HA / person	A = L / P = 56984 / 47257 = 1.21 HA / person	A = L / P = 56984 / 58745 = 0.97 HA / person	In the term intermediate and also long Power capacity demographic Still Enough
Pressure Resident	PR < 1; no happen pressure population, still capable of supporting existing population	PR = 0.80	PR = 0.996	In the long term, start to happen pressure residents
Settlement	SCC > 1, capable of accommodating resident for reside	SCC = 110.44	SCC = 88.85	In the term, intermediate and long settlements can accommodate resident residences
Food Balance	Population residents of LSICC moment This is 38015 souls. This means power supports land. For balance, food can still accommodate 1.65 times the current population	K = 62592 souls	K = 62592 souls	In the term, intermediate and long power support land can accommodate balanced food
Land Agriculture	σ > 1, capable of self-sufficiency in food	σ = 2.34	σ = 1.88	In the term intermediate and also long capable self-sufficiency food
Ratio ability Power Support (*carrying capacity ratio*)	CCR > 1, the region can support the needs of the main resident	CCR = 1.42	CCR = 1.15	The primary resident is needed in terms of intermediate and length of capable area support
Function Protect	The carrying capacity environment (ECC) has a range mark between 0 (minimum) to 1 (maximum). Therefore, the more approach value 1, the better function and protection in the area will be	ECC = 0.82	ECC = 0.82	In terms of intermediate and extended functions, existing protection is still sufficient
Water Carrying Capacity	If SA > DA, power water support declared surplus	SA = 4190421600 m^3/ year DA = 75,611,200	SA = 4190421600 m^3/ year DA = 93,992,000	In the term, intermediate and also long water supply is still sufficient

5. CONCLUSION

Based on the findings derived from the analysis and discourse about the research employing data from the 2021 LSIIC, the following conclusions can be drawn: First, the demographic carrying capacity of the LSIIC remains satisfactory (safe). Second, there is an absence of population pressure within the LSIIC; it continues to possess the capability to support the current population adequately. Thirdly, the LSIIC retains the capacity to accommodate additional residents. Fourth, the land carrying capacity regarding food balance in the LSIIC is still deemed adequate (safe). Fifth, from the viewpoint of agricultural area carrying capacity, the LSIIC is still positioned to attain food self-sufficiency. Sixth, the LSIIC can fulfill its populace's fundamental needs. Seventh, the environmental carrying capacity of the LSIIC, when evaluated from the perspective of its protective function, is nearing its maximum threshold (sound). Eighth, the water carrying capacity within the LSIIC is classified as surplus. Ninth, the cultivation of Palm Oil is deemed appropriate within the LSIIC.

The investigation findings suggest that the social carrying capacity of the LSIIC is sound, indicating that the LSIIC has effectively performed its role in community service. Through an analysis of the developmental scenarios for the LSIIC in both the short term (2030) and long term (2040), it can be discerned that a critical factor pertinent to the sustainability of its development exists, specifically, population pressure. Given the significance of comprehending the environmental carrying capacity for the sustainability of regional advancement, it is advised that the Pesisir Selatan Regency Government, along with the West Sumatra Provincial Government, undertake periodic research concerning the environmental carrying capacity of the LSIIC on an annual basis, as a measure to monitor regional development. The implementation framework for the research on the ecological carrying capacity of the LSIIC, as per the Guidelines for Determining Environmental Carrying Capacity and Accommodation Capacity (DECCA) established by the Ministry of Environment (2014), is recommended for application not only in the prospective planning of the LSIIC but also for the development of other regions, including urban development, tourism initiatives, mining sectors, plantations, industry, and others within the jurisdiction of the West Sumatra Provincial Government.

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