Urban Sustainability Indicator Systems for the Canton of La Libertad

Sistemas de indicadores de Sostenibilidad Urbana del cantón La Libertad

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Abstract

The objective of the research is to design a model of urban sustainability indicators to strengthen the local development of the canton of La Libertad; urban sustainability indicators have been seen as signals that mark the progress of the achievement of the objectives and goals set in the urban planning process, and allow making relevant and timely decisions. The types of research used are descriptive and analytical, by measuring variables through the deductive and inductive methods; a population of 48671 was considered, corresponding to the number of inhabitants of the canton of La Libertad between the ages of 20 and 64, from which a sample of 356 people was selected. The proposed model MSUCLL - 2021, is a model determined in relation to the criteria determined in the research, thus allowing the improvement of critical factors that affect urban sustainability; it includes 4 axes: compactness and functionality, urban complexity, efficiency, and social cohesion. **Keywords:** compactness, urban complexity, local development, unsustainability, urban sustainability.

Resumen

El objetivo de la investigación es diseñar un modelo de indicadores de sostenibilidad urbana que permita fortalecer el desarrollo local del cantón La Libertad; los indicadores de sostenibilidad urbana han sido vistos como señales que marcan el avance de la consecución de los objetivos y metas planteados

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en el proceso de planeamiento urbano, y permiten tomar decisiones relevantes y oportunas. Los tipos de investigación empleada son descriptiva y analítica, mediante la medición de variables a través de los métodos: deductivo, e inductivo; se consideró una población 48671 que corresponden al número de habitantes del cantón de La Libertad entre edades de 20 a 64 años, en los que se selección una muestra de 356 personas. El modelo propuesto MSUCLL – 2021, es un modelo determinado en relación a los criterios determinados en la investigación, permitiendo así mejorar factores críticos que afectan a la sostenibilidad urbana; incluye 4 ejes: compacidad y funcionalidad, complejidad urbana, eficiencia, y cohesión social.

Palabras clave: compacidad, complejidad urbana, desarrollo local, insostenibilidad, sostenibilidad urbana.

Introduction

According to Gambarota, (2019) Sustainability is focused within the interaction of environmental, economic and social objectives, its principles are required to be specified through indicators and indexes that allow evaluating the strengths or resources that a city has to be sustainable, the restrictions of various kinds, especially the natural physical ones, the vulnerability of the population, of the built structure and of the ecosystem, and its behavior over time.

It is currently accepted that the degradation of the urban environment is the main factor limiting the capacity for social, economic and physical development of cities around the world, especially in developing country settlements. In recent decades, the question of the capacity of cities to improve and maintain adequate conditions for the habitability of their present and future citizens has been highlighted.

Sustainable development is conceived as a process that can define the path towards a rational model that emphasizes the importance of satisfying the essential needs of those who have the least, without compromising the balance of natural resources. Under this approach,

the economic and environmental variables must be complemented by an equity variable that emphasizes quality of life indicators.

The instruments of the strong sustainability approach are the most demanded in the urban sphere, specifically, the analysis of the urban ecological footprint, carrying capacity and ecosystem indicators. However, this preference does not avoid the obstacle it faces: it is necessary to collect a type of information, usually through the use of physical indicators, to which the institutions that handle statistics are not accustomed or experienced, specifically, data on the interaction between natural and urban ecosystems.

Unsustainability is an obligatory topic of reflection at the present time on the planet, where the great challenges to be faced are marked by climate change, population growth and accelerated urbanization, the consequences of which go hand in hand with irrational consumption of resources, pollution, inequality and poverty. In Latin America, this situation is reflected in discontinuous urban growth, poor peripheries, low densities, deficits in infrastructure and services, among other factors that have been considered triggers of socio-environmental and health problems for its population; facts that demand to be addressed through more comprehensive planning processes that include sustainability criteria and measurement mechanisms such as sustainability indicators and indexes, to help forge more sustainable cities and territories.

According to Mariani, (2018) urban sustainability is underpinned by five pillars: compactness, complexity, energy efficiency, social cohesion and governance. It refers to the Mediterranean compact and sustainable city that fits the sustainable city model. A model in which the systemic approach to the relationship between city, environment and its components: territory, environment, population and economy prevails; however, this model proposes its actions at a smaller scale level such as the neighborhood. The latter being the preferred sphere of action because it is considered the basic territorial unit in the city, where sustainable proposals will have a greater chance of being applied and appropriated by its inhabitants, generating a greater impact on the city.

The implementation of these public policies in the canton of La Libertad requires instruments, methodologies, tools and instances of coordination, information and strategies for their adequate execution, as indicated in the reference guiding document. It is evident then to

highlight, that among the national development objectives Semplades, (2021) emphasizes in the second axis, referred to the Economy at the service of society, the need to consolidate the sustainability of the economic, social and solidarity system, boost productivity and competitiveness for sustainable economic growth, develop productive capacities and the environment, to achieve food sovereignty and Good Living, aspects to consider in the proposal of a methodology for the implementation of Local Agenda 21 in rural and urban communities of Ecuador.

For Quiroga, (2019) urban sustainability is supported by five pillars: compactness, complexity, energy efficiency, social cohesion and governance; it refers to the Mediterranean compact and sustainable city that fits the sustainable city model. Model in which the systemic approach of the relationship between city and environment prevails, as well as its components: territory, environment, population and economy; however, this model proposes its actions at a smaller scale level such as the neighborhood.

According to Borja, (2019) states that urbanism must be balanced and integrating, urban planning and management must be developed in such a way that cities guarantee a balance between urban development and the protection of historical, cultural and natural heritage, generating social cohesion; thus avoiding a dispersed, fragmented and segregating urbanism, which allows the city to become a non-city, as happens with the peripheries.

According to Monfort, (2020) urban sustainability indicators have been seen as signals that mark the progress in achieving the objectives and goals set out in the urban planning process, and allow relevant and timely decisions to be made. Therefore, their role is important because they become magnitudes that can be measured and interpreted in order to identify the behavior of society in relation to the surrounding natural system.

According to Marquez, (2019) Indicators are considered as effective tools for communicating complex processes in both social, political and economic spheres; they are defined as identifiable and measurable characteristics of cities that evaluate progress or setbacks in the sustainability process, whose selection constitutes a technical and political choice of important consequences, because these parameters serve as a guide for setting objectives and these, in turn, become physical limits defined in measurable terms.

According to Urbano & Sánchez, (2018) sustainability requires solvent indicators that allow detecting changes in natural dynamics or variations in socioeconomic activity; it is necessary to establish general criteria that allow choosing the most suitable indicators to be used. In this sense, there are six general and necessary criteria that will serve as references for the selection of the final set of indicators:

Relevance and pertinence: Determines whether the indicator is appropriate and relevant in the context of sustainable mobility; this criterion should be used to assess the indicator's connection to the issues addressed by the study.

2. Clarity of focus and meaning: The indicator must be clear and simple so that it is easy to understand and interpret; its meaning must be unambiguous and reflect the object of the assessment accurately.

3. Measurable and verifiable: An indicator must be measurable in quantitative or qualitative terms, since the greatest usefulness of an indicator is to be able to compare it between the measured situation and the expected situation. Its calculation must be adequately supported and documented for follow-up and evaluation.

4. Data availability and quality: Refers to the degree to which data are accessible for use as part of the study; this criterion requires the identification of possible primary and secondary data sources, which must be reliable, valid, and complete.

5. Universal and comparable: Despite the disparity of territorial realities, the starting point should always be the attempt to conceive the indicators as universally as possible, ensuring that they can be valid for the maximum number of territories and, thus, to be able to compare them.

Sensitive: Indicators must be adapted to the level of aggregation of the analysis of the system under study; for this reason, it is essential that these indicators be sensitive to changes so that they can be transferred to multiple ecosystems.

The selection process of sustainable indicators is carried out through a matrix formed by the initial set of indicators obtained through the bibliographic review and the general criteria mentioned above, in which those that do not meet the requirements will be discarded.

For Alarcón Pérez & González Becerra, (2018) local development is a set of economic, social, cultural, political and territorial processes through which a community, based on its own potential and the

opportunities provided by the environment, accesses well-being, without exclusions or discrimination, and guarantees the conditions so that future generations can also do so.

Local development appears to provide solutions to the problems that exist in the locality, for this it is necessary to take into account the specific characteristics of the territory that are essential and must be considered to focus the development towards the community; therefore, it is a factor of democracy and sustainable development, which does not arise by chance, but as a result of the previous state of affairs, as a different and alternative route of national and regional development (Pérez & Hernández, 2015).

Local and community development is an important link in the sociocultural development of society. The United Nations Organization (UNO) has made an emphatic and profound statement in this regard, considering that the feeling of identity with the community, with its purposes and objectives, is a precondition for generating and sustaining community development. It is a process aimed at creating conditions of economic and social progress for the entire community, with the real participation of its stakeholders in improving their standard of living.

(Sotelo , 2017) associates local development as a process of multiple objectives, which are: efficiency in the allocation of resources for territorial competition; equity in the distribution of income and balance of the environmental setting for the conservation of the territorial productive system. Therefore, participation is considered as a process in which the community commits itself to the transformation of its own reality and assumes the tasks that correspond to it. Local development as a process is of great importance in the organizational and educational sense: organizational, because it requires the reorientation of existing institutions or the creation of new types of institutions, and educational because it implies the change of attitudes and practices that hinder socioeconomic improvements.

According to Tortajada Martínez, (2018) Local development is one of the most significant factors in the creation of networks that favor the quality of life of the inhabitants and the care and protection of resources, being its axis of transformation, the local space, that is, the space in which each person can act. Therefore, it has the necessary elements to carry out this improvement of space and society of which

it has been made protagonist, with the need to involve global actors as well as local agents and population.

Methodology

This research was carried out in the canton of La Libertad, with the purpose of evaluating urban sustainability and determining indicators that contribute to local development; therefore, it is considered necessary to establish a sustainability model to strengthen the critical factors associated with the topic of study.

To develop the research, the descriptive type was used to learn about the topic of study through the theoretical disaggregation of the variables, and a situational analysis of the urban sustainability of the canton of La Libertad was also carried out; in order to identify the problem of study, and thus raise the proposal.

The project also used analytical research, through indicators that allowed the analysis of the study variables, in addition to knowing the factors that influence urban sustainability; therefore, an analysis of the results obtained in the data collection was carried out, in order to identify the critical factors that should be improved, in order to strengthen local development in the canton of La Libertad.

To obtain the results of this research, qualitative research was used to learn about factors related to urban sustainability and local development, through a literature review on the variables of studies; on the other hand, quantitative research was used to determine the level of urban sustainability of the canton La Libertad; likewise, in this research different methods of practical and experimental nature were used to learn about the current situation of urban sustainability in the canton La Libertad, which is detailed below:

This method made it possible to learn about the object of study, design tools and strategic actions according to the environment, through direct observation of the object of study and interviews with those involved.

This method made it possible to draw a conclusion from the study variables in order to identify the critical factors related to sustainable development, and to develop the urban sustainability metamodel.

This method made it possible to analyze data obtained in the field research, starting from an exhaustive analysis of the study variables by measuring urban sustainability indicators to be carried out on those involved in the study, through the determination of factors related to local development.

In the present study, a population of 48,671 was considered, which corresponds to the number of inhabitants of the canton of La Libertad between the ages of 20 and 64 years, which is 50.73% of a total of 95,942 data obtained in the Inec 2010.

The sample size is 356 people to survey in order to know in depth about the object of study, with a confidence level of 95%, a margin of error of 5%, and with a 50% probability of being fulfilled, and a population is 48671 corresponding to the number of inhabitants of the canton of La Libertad between the ages of 20 to 64 years which is 50.73% of a total of 95,942 data obtained in the Inec year 2010.

Probabilistic sampling was used, through systematic sampling, in which a database was used to obtain the people to be surveyed, using an Excel function to determine the person to be surveyed, and then a pattern was used to continue the selection process.

For the development of the research topic, several sources were used to obtain the necessary information for the design of the urban sustainability model for the canton of La Libertad, which are detailed below:

Field information was obtained through the application of data collection techniques to learn about the topic of the research study. This technique was used to learn about the situational reality of Urban Sustainability in the canton of La Libertad, through a questionnaire addressed to experts in the topic of study, in order to identify the critical factors oriented to the topic of study.

Indirect observation was carried out to identify the factors associated with urban sustainability and local development in the canton of La Libertad, in order to establish the model of sustainability indicators that is part of the study proposal.

The inhabitants of the canton of La Libertad were surveyed in order to evaluate the factors involved in urban sustainability; therefore, 4 identification questions and 10 research questions were asked to validate the proposal.

Secondary source information was used in order to have the theoretical and reference argumentation related to the topic of study and the proposal designed, for this purpose a documentary and virtual review will be used, which will allow access to books, scientific articles, theses and documents related to the research topic.

Results

Through the analysis of the compactness axis, it was possible to evaluate the indicators related to the dimensions: urban morphology, public space, mobility and services; in order to determine the proximity between urban uses and functions. Based on this group of indicators, a building density and an adequate degree of compactness are proposed to allow a rapprochement between urban uses and functions, which configures an adequate public space and generates an idea of the city.

Table 1 *Urban morphology indicators*

Axis 1	Indicator	Parameters/conditioning	Scope of measurement	Area
Dimension 1: Urban morphology	Housing density	Minimum housing density of 60 dwellings/Ha.	100 x 100 m2	Urbanism
	Absolute compactness	Absolute compactness values higher than 5 meters (Indicative index of net buildability: > 1.2 m2c/m2s).	200 x 200 m2	Urbanism
	Corrected compactness	Corrected compactness values between 10 - 50 meters (living space per inhabitant: 10-20 m2/inhabitant).	200 x 200 m2	Urbanism
	Corrected and weighted compactness	Weighted corrected compactness values between 10 and 50 meters.	200 x 200 m2	Urbanism

Source: Own elaboration with data from the Gad of La Libertad canton.

It is important that the canton of La Libertad does not encourage the growth of private urbanization, because it fragments the urban fabric, produces insularization of public space and green areas, departing from the regulations set by municipal ordinances; it also configures a false idea of security by creating separation barriers with the adjacent urban fabric. This situation determines the distancing of human relations, coexistence, and control of the street, which is the basis of urban complexity. With this, a balance is sought between function and urban organization, and the spaces destined to the citizen such as: leisure, tranquility and contact with the green; in this area, the corrected compactness becomes a fundamental indicator to determine the balance between urban compression and decompression.

Table 2. *Indicators of public space and control of environmental variables*

Axis 1	Indicator	Parameters conditioning	Scope of measurement	Area
Dimension 2: Public space and control of environmental variables	Public road space.	Public roads for pedestrians and other uses of public space (resident vehicles, loading and unloading, emergency vehicles, cab service) greater than 75%. Public roads used for transit vehicles and public transport	400 x 400 m2	Urban Planning / Mobility

	with a surface area of less than 25%.		
Accessibility of pedestrian transit space.	Fully accessible pedestrian transit space: sidewalks with a minimum width of 2.5 meters, and a longitudinal slope of less than 6%:	Surface area of development sector	Urban Planning / Mobility
Thermal comfort	Minimum obstruction of 30% of solar radiation in the public space (shadows cast by trees).	Surface area of development sector	Urbanism
Acoustic comfort	Percentage of population exposed according to noise level. - Daytime noise level: < 65 dBA (15% of the population);	Surface area of development sector	Urban Planning / Mobility

	>70 dBA (25% of the population)

Source: Own elaboration with data from the Gad of La Libertad canton.

Based on the results of the research, it is proposed to reduce the allocation of motorized roads to 25% and increase to 75% the remaining roads for urban uses and functions. The non-motorized public spaces will make it possible to configure a network of interconnected pedestrian routes within the superblock. This action potentially frees up new surface areas for unrestricted use of public space, thus generating accessibility for all groups, including those with reduced mobility.

Table 3. *Mobility and services indicators*

Axis 1	Indicator	Parameters/conditioning	Scope of measurement	Area
Dimension 3: Mobility and services	Proximity to surface public transportation stops.	Access to public transportation stops at a distance of less than 300 meters.	400 x 400 m2	Urban Planning / Mobility
	Proximity and provision of bicycle parking spaces.	Access to a bicycle network at a distance of 5 kilometers, so that it can become a means of transportation.	Surface area of development sector	Urban Planning / Mobility
	Proximity and provision of parking spaces for private vehicles.	Minimum reserve of paid zone parking spaces every 3k. in regenerated sites.	Surface area of development sector	Urban Planning / Mobility

Source: Own elaboration with data from the Gad of La Libertad canton.

With regard to public transport, it is recommended that stops be located at a distance of no more than 300 meters from any point in the urban fabric and from the network of bicycle lanes. As for bicycles, it is recommended that their parking should be located in different parts of the city to ensure their safety. For this purpose, the creation of a network of basic roads connecting the entire urban fabric is conditioned; these roads will be distributed into: roads for transit vehicles and roads for public transport.

By analyzing the urban complexity of the canton of La Libertad to know the level of multifunctionality of a territory, this way there is a better approach and proximity man/activity. First floor activities are fundamental for attracting people to public space, generating greater concurrence and strengthening the perception of safety. Measuring the degree of knowledge of an urban system is fundamental for the generation of new activities that are considered as the basis of the competitiveness strategy of the new city.

Table 4 *Urban complexity indicators*

Axis 2	Indicator	Parameters conditioning	Scope of measurement	Area
Dimension 1: Urban complexity	Urban complexity.	Urban diversity values higher than 4 bits of information per individual. Values higher than 6 bits in areas of new centrality (areas of commercial attraction, offices, advanced services, transportation centers).	200 x 200 m2	Urbanism

	Proximity commercial activities.	Minimum reserve of 10% of non-residential lucrative use for proximity commercial use (daily activities).	200 x 200 m2	Urbanism
	Dimensions of commercial premises on the first floor.	Division of the first floor destined to commercial premises in useful surface from 50 m2 and up to a maximum of 200m2. Application for 80% of the premises located in plots of land with main residential use.	200 x 200 m2	Urbanism
	Spatial and functional continuity of the corridor street.	Percentage of street sections (linear meters) with high or very high spatial sequence interaction, higher than 25% (ratio between the density of activities and the percentage of public road for pedestrians per street section).	Surface area of development sector	Urbanism

Source: Own elaboration with data from the Gad of La Libertad canton.

On the other hand, the dimension of green spaces and biodiversity that allows the articulation of a network of green spaces easily accessible on a daily basis in the city was evaluated. To this end, the conformation of an urban green network is conditioned by the formation of a green urban network generated both by land assigned by urbanization and by land previously planned for this use.

Regarding soil impermeability and its impact on life, the promotion of permeable soils and green roofs is recommended.

Table 5. *Urban complexity indicators*

Axis 2	Indicator	Parameters conditioning	Scope of measurement	Area
Dimension 2: Urban complexity	Proximity to spaces green.	Simultaneous access to green spaces according to surface and walking distance: a) green space > 1000 m2 less than 200 meters; b) green space > 5000 m2 less than 750 meters; c) green space > 1 ha. At less than 2000 meters; green space > 10 Ha., at less than 4000 meters.	200 x 200 m2	Urban planning / Biodiversity
	Soil permeability	Percentage of permeable soil higher than	200 x 200 m2	Urban planning / Biodiversity

		30% (soil biotic index). Compensation of sealing in waterproofing of the soil.		
	Provision of trees in public spaces according to surface area occupied.	Provision of 1 tree for every 20 m2 of built-up area.	Surface area of development sector	Urban planning / Biodiversity
	Proximity to urban green corridors.	Access to an urban green corridor at a distance of less than 600 meters.	Surface area of development sector	Urban planning / Biodiversity

Source: Own elaboration with data from the Gad of La Libertad canton.

Through the analysis of urban metabolism indicators, energy self-sufficiency was evaluated based on: strengthening the use of solar and geothermal energy, the generation of energy flows and storage (from organic matter), the incorporation of passive systems in construction, and energy savings with high-efficiency lighting fixtures. It is important to promote the reduction of water use from the network, the combination of rainwater harvesting measures, the use of reclaimed water for irrigation and vehicle washing, and the promotion of the use of efficient household appliances and toilets, are fundamental actions for achieving the objectives of this new urban model.

The proposed model MSUCLL - 2021, is a metamodel that has the name by its acronym identified as: Model of urban sustainability of the canton La Libertad developed in 2021, aims to strengthen local development. The determined model is designed in relation to the criteria determined in the research, thus allowing the improvement of

critical factors that affect urban sustainability; it includes 4 axes: compactness and functionality, urban complexity, efficiency, and social cohesion.

Compactness is the axis that takes into account the physical reality of the territory and, therefore, the formal solutions adopted: the density of buildings, the distribution of spatial uses, the percentage of green space or roads. It determines the proximity between urban uses and functions. This axis is accompanied by the mobility and public space model and the derived spatial planning model.

Public space is the structural element of a more sustainable city model; it is the space for citizen coexistence and forms, together with the network of facilities and green and recreational spaces, the main axes of social life and relationships. The quality of space is not only an indicator related to the concept of compactness, but is also an indicator of stability.

Complexity refers to urban organization, to the degree of mixticity of uses and functions implemented in a given territory. Urban complexity is a reflection of the interactions established in the city between organized entities, also called legal entities: economic activities, associations, facilities and institutions. Complexity is linked to a certain mixture of order and disorder, an intimate mixture that, in urban systems, can be analyzed in part by making use of the concept of diversity.

Efficiency is the axis related to urban metabolism, that is, to the flows of materials, water and energy, which constitute the support of any urban system to maintain its organization and prevent it from being polluted. The management of natural resources must achieve maximum efficiency of use with minimum disturbance to ecosystems. In the field of energy, a minimum level of renewable energy generation and a certain degree of energy self-sufficiency must be planned, combining generation and saving and efficiency measures.

Social cohesion is concerned with people and social relations in the urban system. The social mix (of cultures, ages, incomes, professions) has a stabilizing effect on the urban system, as it implies a balance between the different actors in the city. The analysis of diversity shows us who occupies the space and the probability of exchanges and

relationships between the components with information within the city. On the other hand, the social segregation that occurs in certain areas of cities creates problems of instability such as insecurity or marginalization.

According to Monfort, (2020) urban sustainability indicators have been seen as signals that mark the progress of the achievement of the objectives and goals set out in the urban planning process, and allow relevant and timely decisions to be made. Therefore, their role is important, because they become magnitudes that can be measured and interpreted in order to identify the behaviors of society in relation to the surrounding natural system; the research agrees with the author because it was determined that indicators are effective tools for communicating complex processes in the social, political and economic spheres; they are defined as identifiable and measurable characteristics of cities that evaluate progress or setbacks in the sustainability process, whose selection constitutes a technical and political choice of important consequences, because these parameters serve as a guide for setting objectives and these, in turn, become physical limits defined in measurable terms.

According to Alberti & Bettini, (2018) New urban planning policies play a particularly relevant role in achieving sustainable local development, given that urbanism and the act of creating cities is the most powerful source of global environmental impact. It does not go unnoticed that global urbanization is an ever-increasing process and that cities consume most of the world's natural resources, despite the fact that they occupy only 2% of the earth's surface. However, through research it was determined that the development of urban areas in recent decades without proper planning has introduced an extreme separation of functions by neighborhoods, discontinuous urbanization and extensive occupation of the territory. These changes are creating new and serious problems of habitability and sustainability, together with the waste of land and infrastructure and the rising costs of supplying services: electricity, water, public transport.

Conclusions

The Sustainable Development indicators are tools that constitute a system of signals that make it possible to evaluate the progress of our countries towards sustainable development; it is still a field in the

process of conceptual, methodological and instrumental development. In relation to the research, urban sustainability is based on four axes: compactness, complexity, energy efficiency, and cohesion; a model in which the systemic approach to the relationship between city and environment prevails, as well as its components: territory, environment, population and economy; however, this model proposes its actions at a smaller scale level such as the neighborhood.

Local development is a process of multiple objectives, which are: efficiency in the allocation of resources for territorial competition; equity in the distribution of income and balance of the environment for the conservation of the territorial productive system. Therefore, participation is considered as a process in which the community commits itself to the transformation of its own reality and assumes the tasks that correspond to it.

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