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## ENVIRONMENTAL MANAGEMENT

**FOR SUSTAINABLE DEVELOPMENT IN ECUADOR. INTERNSHIP IN PROVINCE, EL ORO**

**GESTIÓN AMBIENTAL PARA EL DESARROLLO SOSTENIBLE EN ECUADOR. PRÁCTICAS EN LA PROVINCIA, EL ORO**

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## ABSTRACT

The current patterns of production and consumption are causing a staggered degradation of the environment and social marginalization. Strengthening policies to improve waste management and reverse part of the environmental degradation is an elementary step towards sustainable development. The present work proposes to systematize experiences on environmental management for sustainable development, with emphasis on the behavior of indicators of waste management in Ecuador. The object of practical study is focused on the El Oro province, Machala canton. A descriptive statistical study was carried out to compare indicators of organic waste management in the urban and rural regions of Ecuador, according to the available information, as well as the total organic waste treated and recovered, during the period 2018-2021. From the El Oro province, the types of solid waste were analyzed and finally a forecast model of the resident population in Machala was obtained for the five-year period 2021-2025, showing a sustained growth, whose density must be directly related to the generation of waste, for which policies are required to facilitate it. The variability in the available information could limit the validation of procedures and statistical models at an international level.

### Keywords:

Sustainable development, environmental management, solid waste.

## RESUMEN

Los actuales patrones de producción y consumo están causando una escalonada degradación del medio ambiente y una marginación social. Fortalecer las políticas para mejorar la gestión de residuos y revertir parte de la degradación ambiental es un paso elemental hacia el desarrollo sostenible. El presente trabajo propone sistematizar experiencias sobre la gestión ambiental para el desarrollo sostenible, con énfasis en el comportamiento de indicadores propios de la gestión de residuos en Ecuador. El objeto de estudio práctico se centra en la provincia El Oro, cantón Machala. Se realizó un estudio estadístico descriptivo para comparar indicadores propios de la gestión de residuos orgánicos en las regiones urbana y rural de Ecuador, según la información disponible, así como del total de residuos orgánicos tratados y recuperados, durante el período 2018-2021. De la provincia El Oro, fueron analizados los tipos de residuos sólidos y finalmente se obtuvo un modelo de pronóstico de la población residente en Machala para el quinquenio 2021-2025, mostrando un crecimiento sostenido, cuya densidad debe estar relacionada directamente con la generación de residuos, por lo que se requieren políticas que lo faciliten. La variabilidad en la información disponible, pudiera limitar la validación de procedimientos y modelos estadísticos a nivel internacional.

### Palabras clave:

Desarrollo sostenible, gestión ambiental, residuos sólidos.

## INTRODUCTION

The current global and multidimensional crisis is especially reflected in environmental problems (global warming, deforestation, soil degradation, pollution, increase in natural disasters, etc.); such problems are reflected in social inequalities as the growth of poverty, hunger, unhealthiness, etc. and have an impact in the historical construction of the concept of development (Quevedo et al., 2021).

For these researchers, the conceptualization of development can be perceived in international published documents in the 40s of the 20th century and for almost 30 years it was related to economic growth and social well-being; generally evaluated based on a quantitative indicator: the Gross Domestic Product (GDP). Since the United Nations Conference on Environment and Human Development held in 1972, new development concepts and qualitative indicators related to health, education, equity, inclusion, and other spheres of social life arise.

The sustainable development model is projected as a conciliatory alternative between economic growth, the exploitation of natural resources and the quality of life of society; in contrast to the current extractive and consumerist economic development model, based on the overexploitation of natural resources and the huge generation of waste, which still persists and rise considerable challenges to present and future generations (Sosa et al., 2020).

From the research of Quevedo et al. (2021); it is inferred that the idea of severe damage caused to the environment and that it constitutes the basic source of sustenance for the survival of species and the development of any country, has gained the widest consensus.

From there the general acceptance that sustainable development is based on the idea that development must satisfy current needs, without compromising the livelihood of future generations, places human beings at the center of the development model (Sosa et al., 2020); whose sustainability is expressed in fundamental dimensions: economic, technological, social, cultural and environmental (Quevedo et al., 2021).

The economic development, based on the rational use of natural resources, efficiency and competitiveness; technological development, supported by the introduction of environmentally friendly technologies, cleaner production and the use of renewable energy sources; social development, based on fair and equitable access to such resources, the reduction of poverty and social inequalities, democracy and participation in public decision-making; cultural development, based on the preservation of values, practices and identity symbols and respect for cultural diversity and environmental conservation, which means the care and conservation of natural ecosystems and biodiversity (Quevedo et al., 2021).

Nevertheless, there is still a long way to go in the radical transformation of paradigms embedded by the extractive and consumerist economic development model and which are reflected in “*public policies, business management systems, investments, regulation of polluting waste, public finances, financing systems and, in general, the adaptation capacities of Latin American economies*”. (Van Hoof et al., 2022, p.17).

Seemingly, this criterion agrees with that of Garabiza et al. (2021), who attribute the slowness in the transformation process to the limited participation of government agencies in the formulation and development of public policies aimed at forming links between public and private organizations, for the purposes of establishing commercial, financial and innovative relations. In this regard, Salinas et al. (2023), highlight the existence of weaknesses in respect of financing sources and add that knowledge socialization about sustainable development is still insufficient.

These conceptual development were received by the United Nations (UN), which in 2015 launched the 2030 Agenda for Sustainable Development and its Sustainable Development Goals (SDGs), an occasion in which the majority of countries were committed to the implementation of actions for its socio-economic development, maximizing the opportunities for endogenous development and the efficient management of available resources to ensure its sustainable economic development and productive diversification, with a social approach and respect for the environment.

The objective of this research is to systematize experiences on environmental management for sustainable development, forcefully on the behavior of performance indicators of waste management in Ecuador. In particular, emphasizing on the province of El Oro and its canton Machala.

## DEVELOPMENT

The environmental approach from the 2030 Agenda mainstreams the 17 Sustainable Development Goals (SDGs). In Figure 1 can it be graphically observed the SDGs that accompany the 2030 Agenda for Sustainable Development.



Figure 1. Sustainable Development Goals (SDG).

Source: Da Costa (2022).

According to the conceptualization of sustainable development, various investigations with an environmental focus have emerged, some of them are mentioned below:

- Related to environmental management as a distinctive feature of the competitiveness of organizations (González Ordoñez, 2019; González Ordoñez, et al., 2020).
- On the tactical and strategic planning of development that articulates various actors, territories and scales in the National Development Plan, the National Territorial Strategy and the Development and Territorial Planning Plans (Burgo Bencomo, 2022ab).
- Referring to the management of products, materials, productive processes, urban planning, sustainable development, etc. (Sosa et al., 2020; Quevedo et al., 2021; Coronel Pomá & Sánchez Cuenca, 2022)
- About the circular economy as "an inherent element of sustainable development and it is closely linked to the SDGs (Da Costa, 2022, p. 15); through four fundamental pillars: a) Sustainable production; b) Responsible consumption, c) Comprehensive solid waste management (GIRS) and; Policies and Financing (Da Costa, 2022; Herrera Guanoquiza & Carvajal Romero, 2022; Van Hoof et al., 2022; Salinas et al., 2023).

The preceding mention is not exhaustive since there are other investigations related to the aforementioned topics and others such as the use of biomass and other renewable energy sources, as well as communication, which indispensable to increase citizen culture on the benefits of the contribution of the new paradigm of development on a social, economic and environmental scale.

The general guidelines outlined in international documents such as the 2030 Agenda for Sustainable Development and its Sustainable Development Goals (SDGs) are reflected internally in the country where environmental management is protected by a robust legal framework that is reflected in the Political Constitution of the Republic, especially in its Article 14, referring to the right of citizens to live in a healthy and ecologically balanced environment that guarantees sustainability and good living (*sumak kawsay*); in addition to Article 71, on the right of nature to have its existence respected, the maintenance and regeneration of its life cycles, structures, functions and evolutionary processes.

Within the current legal framework must be implemented through the National Decentralized Participatory Planning System (SNDPP), through planning instruments such as: the National Development Plan, the National Territorial Strategy and the Development Plans and Territorial Planning that are formulated at the provincial, cantonal and parish levels, whose specific actions respond to the implementation of the five dimensions of sustainable

development in the medium and long terms (Burgo Bencomo, 2022ab).

Other planning instruments are sectorial and institutional plans, zonal coordination agendas and equality agendas, special plans for strategic projects, differentiated territorial plans and border plans (Burgo Bencomo, 2022a); routed to articulating the national planning instruments with the institutional planning instruments, adapting the objectives, guidelines, policies and strategies between the economic sectors and at the same time horizontally linking the set of public entities and institutions directly involved with the implementation of the national planning (Ecuador. National Institute of Statistics and Censuses, 2017).

To monitoring the implementation of planned goals and objectives, official statistical information is processed through the National Statistics Program, which has identified four fundamental sources of information: first, those related to national planning; secondly, the national sectorial agendas; thirdly, those related to the necessary basic statistics for the preparation of national, annual, quarterly accounts and other statistical operations; fourthly, the goals and indicators of the Sustainable Development Goals, aligned with the 2030 Agenda for Sustainable Development (Ecuador. National Institute of Statistics and Censuses, 2017).

Meanwhile, the National Municipal Information System (SNIM) has been established for more official statistical information from the 221 cantons in the 24 provinces on topics such as drinking water, sewerage and solid waste (Solíz Torres et al., 2020).

In the inventory of statistical operations by thematic areas, it can be inferred the persistence of an imbalance in the social, economic and environmental dimensions, typical of the sustainable development paradigm, since economic operations and those of a social and demographic nature are the majority (44% respectively). ); instead, statistical operations on environmental issues only cover 12% (Ecuador. National Institute of Statistics and Censuses, 2017).

(Figure 2).

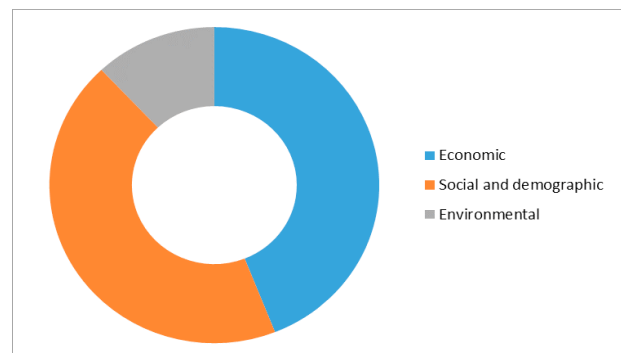


Figure 2. Inventory of statistical operations by subject areas.

Source: Ecuador. Instituto Nacional de Estadísticas y Censos (2017).

The city of Machala gives its name to the canton of the El Oro province, which is part of the Ecuadorian Costa region, this city constitutes the provincial political-administrative capital and socio-economic epicenter; it is characterized by its productive dynamics (especially in agricultural, industrial, port, commercial and stock market activities) that distinguish it as an important economic pole in the south of Ecuador (Ecuador. Municipal Decentralized Autonomous Government, 2020); but at the same time, they generate significant amounts of waste (Solíz Torres et al., 2020).

Machala shares with other localities in the province a significant biodiversity and natural ecosystems characteristic of the Coast region, as well as important landscape, historical and cultural values (Burgo Bencomo, 2022a).

According to the Territorial Development and Planning Plan of the Machala canton for the 2019-2030 period (Ecuador. Municipal Decentralized Autonomous Government, 2020); in the Machala canton there are two types of climate: tropical megathermal semi-arid (TMSA) and tropical megathermal dry (TMS), with the latter predominating; therefore, two seasons are noticeable, the dry season when the temperature fluctuates between 23 °C and 25 °C, during the months from June to December and; the rainy season, when the temperature reaches average values ranging between 26 °C and 28 °C, during the months of January to May. Annual precipitation values fluctuate between 500 mm and 750 mm and relative humidity ranges between 64% and 87% (Ecuador. Municipal Decentralized Autonomous Government, 2020).

The geological formation of the canton parallels to estuarine marine clays, rich in nutrients that favor the growth of hygrophilous plants and mangrove plant formations, in addition to the development of agroindustrial activities (essentially banana and cocoa production) and aquaculture activities (mainly shrimp farming), which have gradually replaced native vegetation and influenced biodiversity (Ecuador. Ecuador. Municipal Decentralized Autonomous Government,

The very same development and territorial planning instrument (Ecuador. Municipal Autonomous Decentralized Government, 2020); states that the land is used primarily to carry out agro-industrial activities, mainly banana cultivation (occupying 43.9% of the cantonal territory) and aquaculture, essentially shrimp ponds (occupying 23.8% of the cantonal territory). The rest of the land is used for the residential sector and to develop industrial, commercial and social activities.

In the aforementioned plan it is recognized that the intensive use of land in these activities has influenced its degradation, the reduction of mangrove areas and the

increase in conflicts due to the irregular settlement of homes in high-risk areas and/or incompatible with this use. This last phenomenon generates incompatible conditions with good living (unsafe and unhealthy construction typologies, overcrowding, absence of basic services, legal uncertainty in land ownership, etc.), which impact in the quality of life of the population.

The cantonal territory consists of three hydrographic basins; to the north, the Jubones River basin; to the center, the Motuche River basin and; to the south the Buenavista River basin. These basins transport the water used to carry out domestic, commercial, agricultural and industrial activities, in addition to being the natural sources of water supply to the coastal ecosystems, identified with the El Macho estuary, to the north; the Pilo estuary, to the south; the Huaylá estuary, to the southwest and the Santa Rosa estuary, where Puerto Bolívar is located (Ecuador. Municipal Decentralized Autonomous Government, 2020).

For this matter, Coronel Pomá & Sánchez Cuenca (2022); highlight the high sensitivity of coastal ecosystems to environmental transformations due to human activities and the need to conserve these areas and protect them from negative consequences attributable to such activities, including: the dumping of solid waste, the generation of bad odors, water color changes, the deposit of sediments, the cutting of the native vegetation to open new spaces for agriculture, livestock or aquaculture.

Both researchers regret that, despite there is an environmental legal framework, this is not enough, ***“to protect the environment; thousands of mangroves, estuaries and biodiversity, in general, of flora and fauna have been invaded by the growth of the city”***. (Coronel Pomá & Sánchez Cuenca, 2022, p. 78).

Solíz Torres et al. appear to agree with this criterion. (2020), who sustain that communities, individual recyclers, social organizations, the academy and the environmental movement in general, have warned that Ecuador is going through a crisis characterized by the increase in waste generation, the lack of express policies for its reduction, extending the responsibility to the producer, classifying waste at its source and improving final waste disposal methods. They add that, as consequences, negative impacts are generated on a social, ecological and human health scale, which demand from the State structural changes in waste management models as an urgent priority in the implementation of the country's environmental policy.

The development of economic-productive activities (agricultural, industrial, commercial, etc.) in Machala, are linked to others (port activity, transportation, silos, collection centers, markets, etc.) and associated services (private banking, banking public, forwarding agents, exporters-importers, etc.), which cope with informal commercial activities (restaurants, vehicles retail sales, appliances,

clothing and other items, community tourism, crafts, etc.), many of them with their corresponding equipment and infrastructure (Burgo Bencomo, 2022b); that in the opinion of Solíz Torres et al. (2020), constitute a metabolic relationship between society and nature.

Solíz Torres et al. (2020), adhere to the social metabolism theory, whose fifth process is excretion. They sustain that every metabolic relationship (regardless of its extension and/or complexity) generates waste, a part of it is reincorporated into the metabolic cycle and another part (not used or usable) is discarded, circulates from waste to waste.

In this regard, they express their concern about differentiating various denominations of garbage, waste and urban solid waste, which are commonly used as synonyms, but, they are not. The concept of urban solid waste (MSW for short) is a name used by local governments to refer to the waste produced by the population, which is differentiated from bio hazardous waste (generated by medical and/or hospital activities) and industrial ones.

In the statistical records of environmental and economic information of the municipal decentralized autonomous governments, it is possible to perceive the contrast between urban and rural areas in relation to the treatment of organic waste during the 2018 to 2021 period, where it is lower in the rural area. A visual summary of both statistics is shown in Figure 3.

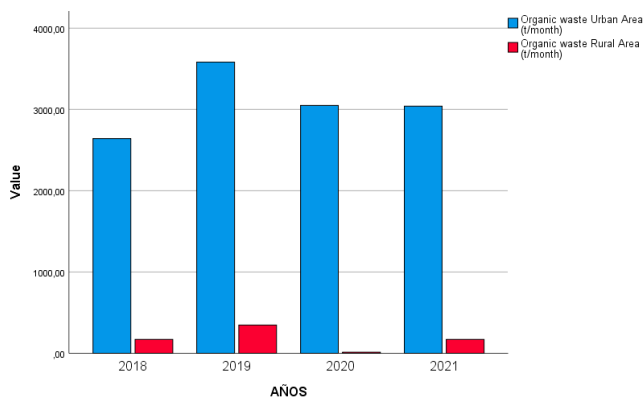


Figure 3. Performance the organic waste treatment according to the area of analysis.

Source: Ecuador. Instituto Nacional de Estadísticas y Censos (2021).

The volumes of organic waste generated in the Ecuadorian national context are significant, mainly in the urban area. However, municipal governments' concern is appreciated on the treatment and recovery of such wastes on the part of the waste management process.

From a simple descriptive statistical analysis in the period 2018-2021, the main descriptive summary statistics are

distinguished that allow the situation in the analysis period to be characterized (table 1).

Table 1. Statistical summary on waste treatment (2018-2021) in tons/month.

	ORGANIC WASTE URBAN AREA	ORGANIC WASTE RURAL AREA
Counting	4	4
Average	3078.38	175.77
Standard Deviation	385.879	136.19
Coefficient of Variation	12.54%	77.48%
Minimum	2641.3	14.1
Maximum	3581.8	347.4
Standardized Bias	0.416961	0.178636
Standardized Kurtosis	0.670872	0.623129

Source: Ecuador. Instituto Nacional de Estadísticas y Censos (2021).

In the descriptive statistics interpretation, central tendency and dispersion statistics are of great importance as well. Even though in the urban area the average treated waste exceeds the rural area by 2902.6 tons per month, the high relative variability of the latter regarding the urban area during the period, displays a high coefficient of variation of approximately 77.5%. Such deed shows that the volumes of organic waste preserved in such area on a monthly basis are highly variable.

Table 2 displays the results of an inferential study as of the sample under analysis.

ZONE	CONFIDENCE INTERVAL FOR THE AVERAGES	CONFIDENCE INTERVAL FOR THE DIFFERENCE BETWEEN AVERAGES
URBAN	3078.38 +/- 614.02 [2464.35; 3692.4]	2902.6 +/- 500.648 [2401.95; 3403.25]
RURAL	175.775 +/- 216.71 [-40.94; 392.5]	

\*The requirement of equality of variances has been proven.

Consequently, it can be summarized that with 95% reliability in the urban area they were treated between [2464.35; 3692.4] tons of monthly waste on average, while in the rural area this average revealed a maximum level of 392.5 t/month, for a difference between the averages of treated waste in both areas that ranged between 2401.95; 3403.25 tons.

#### Treated organic and recovered inorganic waste during 2018-2021 at country level

De manera general, se lograron recuperar en este período, aproximadamente entre el 12% y 21%, para un valor

promedio de 16,3% de residuales inorgánicos, en relación al total de residuales orgánicos tratados (figura 4).

In general, approximately between 12% and 21% were recovered in this period, for an average value of 16.3% of inorganic residuals, in relation to the whole treated organic residuals (figure 4).

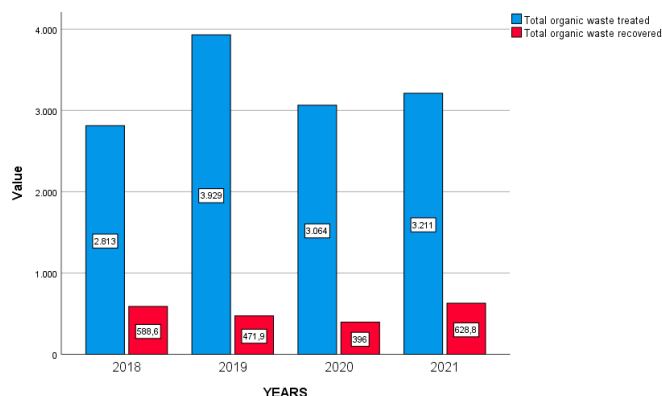


Figure 4. Treated and recovered residuals.

Source: Ecuador. Instituto Nacional de Estadísticas y Censos (2021).

The El Oro province has a waste management system, structured according to its classification (table 3).

Table 3. Composition of the urban solid waste in El Oro province.

Type of solid waste	Relative percent
Organic	61.98
Cardboard	3.08
Paper	8.19
Flexible plastic	6.03
Rigid plastic	4.60
Glass	1.35
Wood	0.43
Metal	0.84
Rubber	0.69
Textiles	1.83
Disposable lamps	2.00
Batteries	0.12
Disposable diapers, towels, toilet paper, etc.	5.19
Unclassified	1.77

Added to the economic-productive and social activities is the phenomenon of rapid and uncontrolled urbanization,

which as a whole imposes significant concerns on cities regarding waste management (wastewater, household waste, waste from industrial, extractive, construction waste, cyber waste, bio-hazardous waste and others that are counted by tons and that are generally disposed of in water paths, streams or landfills, a practice that causes environmental problems such as contamination of water and/or soil by leachate; of the air due to bad odors, gases or biogas released directly into the atmosphere (Soliz Torres et al., 2020).

Within the El Oro province, the Machala canton is not exempt to the rapid population growth, so the concern and occupation of the municipal government for the management of waste generated that must also grow proportionally to the population.

In this respect, population projections are crucial to assume a precise and timely management process so that its dynamics are controlled and concrete actions can be taken to manage changes in their activities (figure 5).

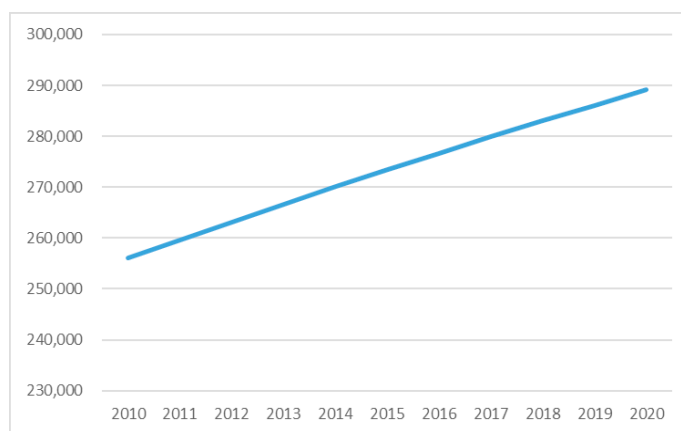


Figure 5. Population projection of the Machala canton 2010-2020.

Although appraisals from various sources display a slight decrease in the resident population of Machala, as of 2020, in official sources of the national government, according to cantons, population projections are established that distinguish the Machala canton with sustained population growth.

In the search for a model that allows establishing a discrete projection from the recorded retrospective values, it was obtained from the Random Walk Model for the next five years (figure 6).

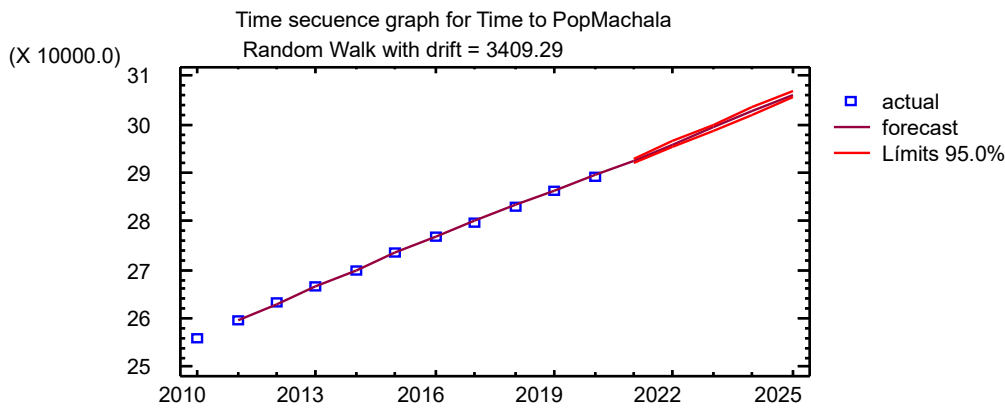


Figure 6. Estimated forecast on the population of Machala.

If the trend in the number of resident population continues, the estimated values assume a population limit in Machala for 2025 of 306,947 inhabitants (table 4).

Table 4. Estimate table (2021-2025).

		Limit at 95.0%	Limit at 95.0%
Period	Forecast	Lower	Upper
2021	292550	292211	292890
2022	295960	295479	296440
2023	299369	298781	299957
2024	302778	302099	303457
2025	306187	305428	306947

Sustained growth in the population requires forms of waste management that are capable of recovering higher percentages. Territorial Planning plans must consider updates based on population dynamics and the raise of public policies and strategies, focused on reducing waste generation, increasing environmental education and cleaner production, with cycle closures from the model of circular economy.

## CONCLUSIONS

Taking into account the unequal population density in the canton of Machala, especially in the cantonal capital city and the rural parishes, as well as the corroborated sustained growth of the population, policies must be implemented that ensure a direct relationship with the sustainable management of waste generation.

In urban areas, the waste generated is mostly organic (generally domestic food waste, vegetable peelings, processed food leftovers, garden waste, etc.), but inorganic waste is also generated (cardboard, paper, plastics,

disposable diapers), towels, toilet paper, electronic components, etc.); while in rural areas waste is characterized by being predominantly agricultural.

Territorial planning must promote public policies and strategies focused on reducing waste generation, promoting cleaner production, the circular economy, differentiated citizen responsibility, responsibility extended to the producer and other mechanisms that limit the dispersion of solid waste, improve final disposal methods, facilitate recycling and use of waste, promote the regeneration of natural ecosystems, facilitate access to technological innovations, among others that promote sustainable development and the reduction of socio-environmental impacts.

Limitations are observed in obtaining and processing updated statistical data and information from reliable sources that may affect its validation, in contrast to international statistical procedures and models.

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