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Sustainability and resilience in smart city planning: a review

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Abstract: Urban planning is recognized as an interaction between the state and society, which aims to articulate public policies in the territory, facilitating their administration in favor of greater development and well-being of society. However, this interaction becomes complex because consumption demands increase, and the needs of the community exceed the capacity of the urban ecosystem to supply them, hindering its sustainable functionality. With this panorama, it becomes relevant to study urban planning from a sustainable environmental planning perspective, based on four topics: urban planning, sustainability, resilience and smart cities. The methodology used is based on a bibliometric study through a PRISMA adjustment to 87 articles, supported by VOSviewer® to construct and visualize the co-occurrence networks of important terms extracted from a body of scientific literature. The main result is to consider cities with a complex systems approach that works like a gear, that is, there is a connective element between inter- and intra-urban processes. This relationship is the key factor that allows understanding their synchronization, stating that the deepening of each of these topics is crucial to the ideal of a territorial administration through time scales, by means of adaptive cycles, allowing to provide new tools to concepts such as carrying capacity and the measurement of the environmental footprint.

Keywords: keyword 1. Planning; keyword 2. resilience, keyword 3. territory; keyword 4. Smart City; keyword 5. Sustainability

1. Introduction

Planning a territory becomes complex to the extent that the needs of its community exceed its capacity to supply them. One of the great challenges of the 21st century is to guarantee the functionality of urban ecosystems in a sustainable way, overcoming challenges such as increasing urban densification, the few natural resources to supply the basic elements like infrastructure, sanitation, transport, energy, decent housing, security, employment, health, recreation and education. The above factors are addressed from a sustainable environmental planning perspective, based on four topics: urban planning, sustainability, resilience and smart cities.

i. Urban Planning

Urban planning is understood as a process of interaction between the government and society, this relationship aims to articulate public policies and their implementation in the territory with local, regional and country priorities in general, facilitating the administration in favor of a greater development and well-being of society [1].

In Colombia, an example of the traditional urban planning instruments such as Development Plans and Territorial Planning Programs - TPP, have been deficient, managed under a totalizing approach, these promote the destruction of valuable natural resources in the peripheries, as well as the urban expansion [2]. The latter with a rapid and disorderly trend, drastically reducing rural areas with potential for agricultural use [3,4].

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On the other hand, well-thought-out cities are decisive in the solution of sustainable urban planning, because they are the most efficient way of living, tending to the optimization of resources and a lower environmental impact per area [5,6]; Thus, the current urban planning must consider environmental and socioeconomic variables associated with population densification in a combined and symbiotic way [7]; allowing to build a model of territory that favors decision-making and that is applicable to other environments, such as complex systems [8].

Nevertheless, urban planning has faced the imbalances caused by urban expansion, overexploitation, and the Western consumer society; between 1900 and 2000 the number of inhabitants increased by approximately 220 million [9]. This is how the importance of deepening urban flows that include the cost of economic agents and the rate of depletion of natural resources, guaranteeing an inventory of the latter so as not to use them beyond their regeneration capacity, takes shape [10,11]; managing to generate indicators for the analysis of ecosystem urban planning that allows us to capture an approximate panorama of the territory [3,12].

This leads to the need to change obsolete urban and regional planning models for innovative smart and sustainable models, where an analysis of the transformation of the peripheries in tune with environmental variables that minimize environmental deterioration, as well as the elements of risk generated on an ecosystem, forcing the recognition and understanding of natural systems under sustainability and resilience criteria that lead to smart city planning criteria.

II. Sustainability

The concept of sustainability is perceived from the understanding of urban ecological systems and depends on environmental management in favor of improving the quality of life of its beneficiaries [13]; being the environmental footprint an instrument to analyze consumption and lifestyles, however, the results of this do not guarantee a decision-making oriented towards sustainability [14,15]. In addition to this, the concept is perfected under the criteria that correspond to the principle of habitability, from its environmental dimension, the criterion of physical well-being that guarantees safety and comfort; and from its social dimension, the criterion of social welfare that pursues the formation of senses of appropriation and belonging, and universal access to urban services [16]; where it is clearly specified that this should not revolve around a principle of economic growth and territorial expansion, but rather a sustainable development approach in search of the balance of ecosystems [17] However, ISO 37101: 2016 proposes sustainability under an economic, social and environmental context, supporting and evaluating its performance in this area, limiting the analysis to the territory, promoting the development of a multi-stakeholder process [18,19].

To carry out a transformation process that allows obtaining levels of production and sustainability, urban ecology focuses on the interaction between urban and ecological systems, that is, coupled human-environmental systems [20], under the premise that systems must remain in balance and need a permanent flow of energy, matter and information, manifested through a complex and systemic holistic character [21]; thus creating an interest in developing urban interventions from a comprehensive perspective, which takes into account the sustainable provision of ecosystem services [22].

iii. Resilience

The concept of resilience in sustainable land planning for some academics' demands clarification from both theoretical and practical analysis of implementation in urban public policies. Thus, ISO 37123: 2019 takes the concept of "resilient city, which is capable of handling all the challenges of a changing world, counting on a level of preparation for extreme events, as well as its capacity to respond and rebuild in the face of they are creating innovative initiatives" [11,23,24].

In the same way, a concept approach towards adaptation to climate change also emphasizes the new design and planning challenges, which must generate paradigm breaks including a resilient vision [25]; Nonetheless, another analysis from the perspective of an urban ecosystem as a complex system that is composed of three stages, change, adaptation and transformation, suggests how the

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transformations can be expected or unexpected and that they return to their essential functions [26,27].

It is necessary to consider that this adaptive cycle does not occur in a short-term period, because although initially the environment enters a moment of catharsis, its response capacity occurs in the long term [28]. More recently, the elements of resurgence and internal transformation that help to situate the debate in the most current terms of evolutionary resilience are highlighted [29]; For this reason, it is necessary to take advantage of the networking of this complex system to reorganize the structures and available resources [30,31], and also integrate environmental services into the assessment [32,33,34].

The resilience analysis lacks assessment tools that allow landing the adaptation capacity of a complex system that evolves over time and is based on the relationship between the components of the internal system, addressing it as the analysis of a process. In addition, it states that increasing a city's resilience makes it more sustainable, but increasing a city's sustainability does not necessarily make it more resilient, and this is where we can see how a process is given by stages that link the effectiveness of its responses to the hand of intelligent cities. [21, 35].

iv. Smart Cities

The smart city concept is established as those "cities with an intelligent economic, institutional, social and physical infrastructure, which ensure the centralization of their citizens in a sustainable environment", this being a great challenge to be achieved [36,37].

Thus, ISO 37122:2019 "Sustainable Cities and Communities - Indicators for smart cities" establishes a series of integrated and interconnected strategies and systems to provide better services and increase the quality of life [38-40]; ensuring equal opportunities for all and protecting the environment and including some development factors [41-43]; generating a great capacity for learning, innovation and creativity alongside with institutionally, leading it towards an inclusive model [38, 44]. This means placing the citizen at the center, giving him/her a role that supports technological development and efficiency, which is achieved through a sustainable and participatory system, strengthening the Collective Intelligence to information and communication technologies - ICT [38, 45], and using governance to project a vision of the future with an intelligent combination of endowments and activities of independent and conscientious citizen [46].

On the other hand, other considerations of a smart city in the measure of the integrated use of ICT, among the most outstanding are internet networks -IP, mobile, in the cloud, Big Data and Internet of Things -IoT, this last one promotes the transition towards the Intelligent City in a practical way, because it is applicable in small sectors of a population and enhances the areas of development of these [47].

2. Materials and Methods

To delve into the topics raised above, a systemic review of literature available in multidisciplinary scientific journals was carried out. The objective of the review focuses on the availability of information related to the conceptualization and the different approaches used. Subsequently, we evaluate the progress made by different researchers around the world, classifying and studying peer-reviewed journal articles accordingly as shown in Figure 1 whose evaluation process is done in four phases:

a. For the compilation of the information, different search engines of scientific bases were used (such as Scopus, Web of Science and Google Scholar), the above through the use of Boolean operators "AND" and "OR", documents were included from 2010 to 2020 whose titles or abstracts contain:
   (TITLE-ABS-KEY ("Urban* Planning*") OR
   TITLE-ABS-KEY ("urban ecosystems") AND
   TITLE-ABS-KEY ("sustainability") OR
   TITLE-ABS-KEY ("urban resilience") O

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TITLE-ABS-KEY ("smart cities"))
The inclusion criteria used were: such as being an open data investigation and limited to areas of interest such as social sciences, Engineering, Computer Science, Urbanism and Agricultural Sciences, were considered; in addition, articles in the following languages were considered: English, Portuguese and Spanish.

b. Identification of duplicates was required, as some articles appeared in more than one database.
c. For the quality evaluation, the PRISMA tool was used for each article, providing an objective comparison between the articles and their classification.
d. Finally, grouping is applied through the use of VOSviewer®, applying in the latter a viewer of keywords where they are correlated, giving each word a weight according to the number of times it is mentioned in the selected information.

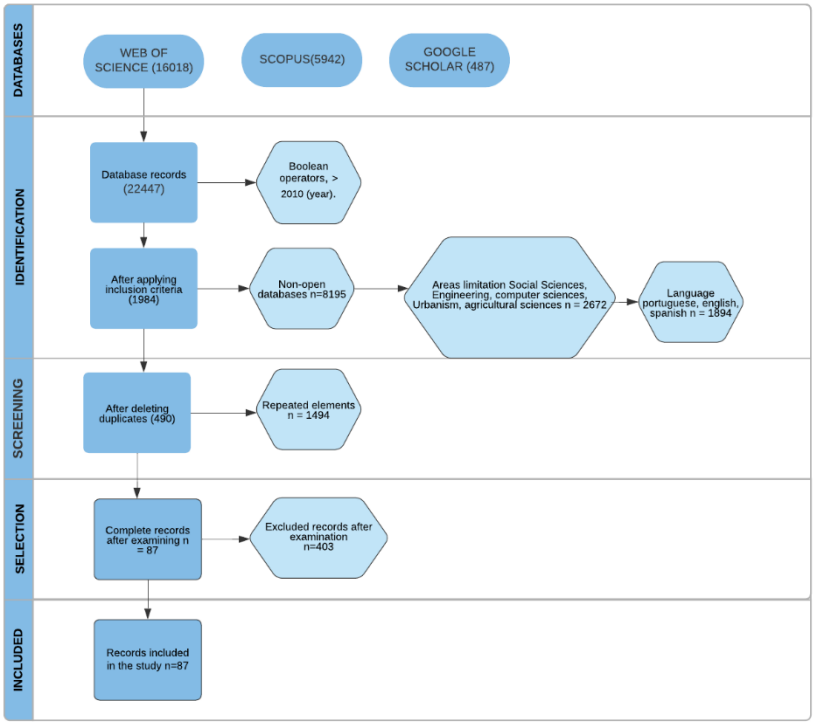

Figure 1. Methodology of analysis

With this approach, the common points and the differences between Urban Planning, Sustainability, Resilience, Smart Cities were determined, to identify key elements that can be used for their conceptualization.

2.1 Co-occurrence analysis

To better understand the approach of the four topics, we used the method stated above (in 103 articles from 1970 to 2020 that included the Boolean formulation), building networks of co-occurrence of keywords. Figure 2 shows the dominant position using the VOSviewer® tool: more than 22 terms out of 122 in total linked in these studied topics (Urban Planning, Sustainability, Resilience and Smart Cities).

Only seven terms represent the approach domain of the formulation: city, smart city, sustainable development, resilience, urban planning, urban planning and sustainability.

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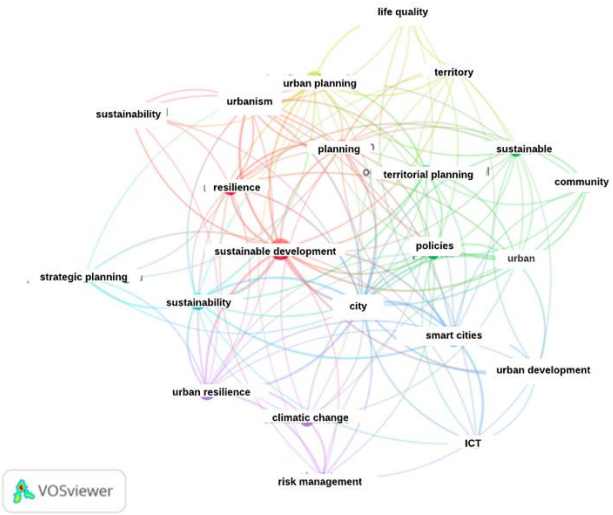

Figure 2. Co-occurrence analysis of terms

In the discourse of urban planning, those words that obtained higher weight were: urbanism, sustainable development, city and smart city, perceiving the need of academics for articulate the three classic dimensions: environmental, economic and social supported by technology, with a behavior very similar to the cluster linked to sustainability, urban resilience, and smart city.

Additionally, it could be determined that the ideal path for the construction of territory will be carried out only through sustainable development without giving sufficient importance to the variables of resilience, urban resilience and risk management, which could not guarantee the improvement of the quality of life that is ultimately one of the goals of land planning.

That is, in the construction of territory under these four topics, a city is considered as something static that is not perceived as a complex system, leaving aside internal processes or macro and micro, as adaptive cycles, moving away from the implementation of a strategic planning of territory.

3. SUSTAINABILITY AND RESILIENCE IN SMART CITIES PLANNING

3.1. Temporary study of Urban Planning -UP

In some countries the delimitation of the territory is established by states or departments, cities, provinces, municipalities and sidewalks. The municipalities are understood as a fundamental territorial unit of the political-administrative organization of the state; where the population inhabits and makes up the territories, giving the responsibility to urban planning of harmonize economic growth, care environmental and social equity [48].

In Colombia, it is reported the case of the Municipal Development Plan –MDP, which it defines as the navigation chart in the pursuit of objectives in favour of improving the quality of life of its beneficiaries, while the Territorial Planning Program - TPP is a tool for the spatial expression of development policies to be pursued, that is, it delimits land uses and occupations of space according to the aptitudes and ecological and social limits, minimizing the conflicts of the use of the territory, as well as the environmental impacts [49,50].

In this process it is essential to visualize the territory in a comprehensive manner, with a consonant link between urban and rural areas [51], allowing to assertively propose the design of strategies that guide the growth and potential of the region that enables the acceptance and articulation between the political and governance levels [52,53]. Consequently, cities become a common, dynamic space with the obligation to adapt to common needs, leading to continuous evolution [54].

The conceptual evolution and perception from its origin to the present, goes through four phases: Natural Planning, Empirical Planning, Functional Planning and Modern Planning.

 doi:10.20944/preprints202011.0487.v1

a. **Natural Urban Planning**: Leaving behind their nomadic nature, human beings begin their sedentary lifestyle by forming cities and building spaces for their group activities, where the basic organizing element around water sources. It means, if there was a water well within the area to be built, the growth of the settlement was distributed centrally, but if it was a river, it extended parallel to its shore [54,55].
A clear example of the first sedentary groups occurred in Uruk (Mesopotamia, 4500 BC) where temples of a length of 68 meters were built that being the first ceremonial centers, they convert a structure of political and religious control, giving the beginnings and later development of agriculture and livestock activities constituting as the first agricultural villages [56].

b. **Empirical Urban Planning:** Over time, man begins to accumulate experiences in the construction of cities, generating the first environmental impacts when rethinking the spaces with the particular characteristics and that supply the specific needs of the human population, what ended up categorizing the land, it could be thought that it would be the beginning of the figure of land uses [54].
Following the example given above, for the year 2500 - 1700 a. C in lower Mesopotamia, with the emergence of a stratified society, with armies and an increasingly complex institutionalized religion that demanded a greater effort from the worker in order to feed the growing population and the demands of the high elites monopolizing urban and agricultural tasks. The overexploitation of soil resources was such that the first salinization occurred as a result of intensified agriculture, resulting in irreversible decline of agriculture by 900 BC. and as a consequence generating the first forced displacements [56,57].
In the Middle Ages (476 to 1492 AD), the basis of the economy continued to depend on agriculture and the clergy, this had become an administrative authority of the empire in the main towns, giving way to feudalism, and later becoming centers of interregional commerce. However, this era was characterized by the displacement of the urban population to the countryside, dispersing it even more as a result of the change in the base of political power [58, 59].
In order to strengthen, the cities offered not only security and work, but also freedom from the injustices of the countryside, creating a new category of common people who not only worked as intermediaries or traders, but also provided a series of strictly urban services that make a city, such as plumbing and carpentry, among others [58,60].
In the modern era between 1493 - 1789, the Catholic kings promoted ordinance policies, even leaving aside the medieval privileges, which mainly sought the protection of public spaces, classification of land use for agricultural and livestock exploitation and irrigation districts, in turn, the beautification of the city took on special importance, promoting large construction projects [60,61].
Thus, a connection is beginning to be woven between the phenomena of urbanization, social stratification, demand for natural resources and ecological degradation for territory planning.

c. **Functional Urban Planning**: The arrival of the industrial revolution was the impetus for change in agriculture, transport, communication, economy and society, as well as in territorial planning from a purely utilitarian perspective. At this moment, the concept of functionalism is born, leaving empiricism aside and visualizing territorial planning as an integrated whole that should function effectively for the benefit of the territory's economic bases
From 1902 to 1930, the constant in the cities was the precariousness of public services, therefore, even the urban expansion continued being around the water sources as in its natural stage. in addition to this, the construction of houses emerges with force to supply the high offer of the traditional families, creating in general terms the first formalizations of land use from basic norms supported by instruments to grant construction licenses [62].
Between 1931 and 1960, the need to widen the roads was proposed in order to distribute traffic less homogeneously, emphasizing the differences between streets with dominant vehicle or pedestrian use. The concern for the provision of equipment such as schools, hospitals, more

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modest housing and parks on a local scale with some meadow, satisfying mainly the needs of the high-income sectors, acquiring special importance for professionals in the areas of engineering and architecture [62-64].
Although by this time there was a legal framework to regulate the physical expansion of the city, which was already disorderly, this policy still did not involve a citizen participation approach. By the early 1960s, the levels of regional and urban political-administrative division were evident, making poverty belts more noticeable by categorizing areas as good or bad [62,65].
It is not surprising that at this point this approach does not yet build a real plan of the city to which it is desired to reach, it emphasizes on setting guidelines to guide the daily actions of the city, that is, the city planned on immediacy.

d. **Modern Urban Planning**: At the beginning of the 1970s, the economic growth registered in the industrialized countries as a result of the post-war period produced the industrial reconversion to mass production, mainly to the war industry. At the same time, in another part of the world they faced acute crises food, serious deterioration of agricultural systems coupled with population growth, with a common denominator: the depletion of resources, the excessive increase in population and per capita consumption [66].
In 1972, at the Stockholm, Earth Summit, the United Nations Organization - UN laid the foundations for interaction between the environment and socio-economic aspects, which allowed to influence in the change of economic growth, since it was clear that the externalities produced resulted in unwanted consequences in a process of environmental degradation, a fact that was increasingly evident in the deterioration of air, water, soil and biodiversity quality. At this stage, the rise of legal instruments for environmental monitoring called "end-of-pipe" or "end-of-stack", so-called because it seeks to control pollution at the end of the process to treat for example, the liquid effluents and gaseous emissions, but it did not contribute to the prevention of environmental damage nor did it change the nature of the productive processes towards some cleaner and more efficient ones, in terms of the use of material and energy resources [67].
However, in order to make the responsibility of the human being in the environmental deterioration more evident, the idea of sustainable development was born in 1980 during the declaration of the World Conservation Strategy elaborated by the International Union for the Conservation of Nature -IUCN with the advice and financial support of the World Wildlife Fund -WWF and the United Nations Environment Program -UNEP, supported by three main objectives: to maintain essential ecological processes and vital systems, to preserve genetic diversity and to ensure the sustainable use of species and ecosystems [68]. Years later, this opened the way to the European Regional/Spatial Planning Charter (1983), where Spatial Planning -SP is presented as a geographical expression of the economic, social, cultural and ecological policies of every society (point 8), the balanced development of the territory (point 9), taking into account the human being and his well-being, in his interaction with the environment (point 10), under an interdisciplinary approach (point 9), constituting a prevailing instrument in the evolution of Territorial Planning [69].
In 1988, the concept of "sustainable development" was coined, as one that meets the needs of present generations, without compromising the opportunities of future generations to meet their own needs, as stated in the World Commission on the Environment and Development, Brundtland Report [70]. This concept articulates three classic dimensions: environmental, economic and social, which must be economically livable, economically viable and socially equitable [71].
Later at the Rio Summit, during the UN Conference on Environment and Development (1992), a world declaration regulating the relationship between environment and development was created. The key topics of this declaration were framed under the environmental principles of cooperation between states, consumption and overpopulation, environmental control and participation, the goal of this action plan proposed by the UN to achieve more sustainable development in the 21st century. The document was approved and signed by 173 heads of state,

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calling on local governments to assume the commitment to implement the agreements contained in this initiative from their context. Figure 3 shows the evolution of the perspective of UP from a natural vision that, as a result of the lessons learned, matured into a modern UP, in which they are still proposed under an approach of biophysical analysis without transcending the improvement of the ecosystem understood from biocentrism.

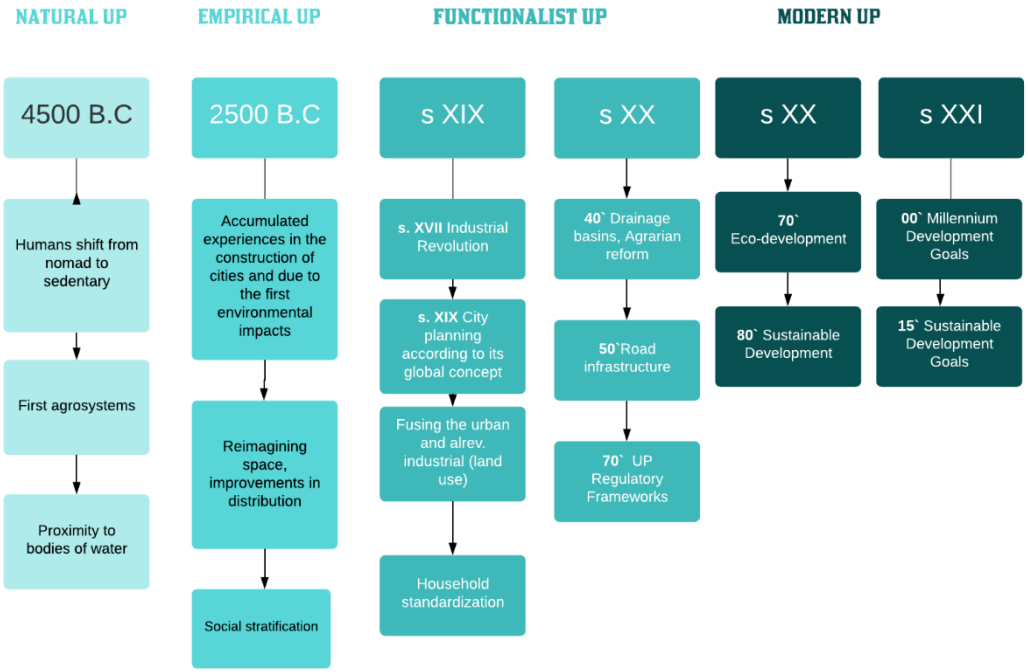

Figure 3. Milestones of Urban Planning Evolution

3.2. Approaches to Urban Planning in the 21st century

The 21st century begins with a constant left by previous century: the co-dependence of natural resources, whose poor administration has resulted in crucial problems that would frame the new needs of this century, for example the occupation and disparity of urban -rural areas, degradation of natural resources and loss of biodiversity, high rates of poverty and marginalization and vulnerability to natural phenomena. In 2000, this situation forced a new meeting called the Millennium Conference, in which the member countries signed this agreement before the UN under 8 objectives that had as a goal the year 2015, as shown in Figure 4.

Figure 4. Sustainable Development Goals

This strengthens environmental demands in different parts of the world, calling for responsible consumption, the exaggerated generation of waste and social inequality. Thus, in September 2015,

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the great world representatives approved the 2030 sustainable development agenda, which created 17 sustainable development goals - SDG as shown in Figure 2, which are universally applicable but not legally binding, in the hope that the different member governments will make them their own in their national policies [73].

In addition to prioritizing poverty reduction, it suggests as a pressing and urgent need to place sustainability at the core of public policy design with Goal 11 "Make cities and human settlements inclusive, safe, resilient and sustainable". According to the 2018 UN report, related to urban population growth indicators, it was determined that by 2050 at least two-thirds of the world's population will live in cities (Figure 5). This assumption is based on the variation in the percentage of people who moved from rural to urban areas, from 29% in 1950 to 51% in 2010.

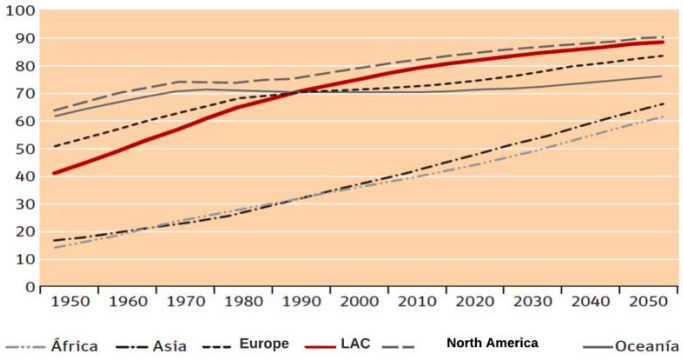

Figure 5. Evolution of urban population by regions

Throughout this study it has been agreed that the configuration of the territory depends on the transformations given such as economic crises, depletion of resources originated from inadequate management, causing economic, social and environmental collapses, which are repetitive over the history and that in each new version generates a much greater impact that makes it difficult to recover.

First, the UP must tend to include the perception of the actors involved that make up a territory to what has been called social cohesion, which focuses on the integrated search for the development of the territory, so that its inhabitants can take full advantage of its inherent characteristics, through the possibilities of spaces of identification and citizen belonging, with territorial intelligence and taking advantage of the diversity of factors existing in a region; as well as through the degree of cooperation between territories that guarantees the sustainability of exchanges between them, avoiding that the development of one is done at the expense of others, aimed at mitigating inequalities or territorial polarization in terms of economy, employment opportunities, among others [71,74].

Given that one of the objectives of the UP is to meet the needs of the population and improve their standard of living by increasing employment and reducing poverty, it is necessary to promote endogenous development by incorporating networks of businesses in the economic assessment of the territory, promoting innovation as part of the evolutionary and strategic process, that is, promoting capital accumulation and economic progress, based on local production systems, support for technological change and innovation, and self-sustained development [71].

Involve the bioregional approach where a territory of water and soils is perceived, whose limits are defined by geographical boundaries of ecological systems, which allows to sustain essential environmental processes, satisfy territory requirements for key species; and include human communities in the management, use and understanding of biological resources [71,75].

These new directions must be accompanied by strategic perspectives for the UP, since inherited conflicts become susceptibility factors that are a great threat to guarantee the basic needs of the communities and threaten the objective of sustainable development.

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3.3. Environmental Sustainability and UP

Just as urban planning underwent a conceptual and practical evolution marked by key moments in history, so did sustainability. The growing concern in the 1970s about global warming and its devastating consequences was expressed at the first world climate conference in Geneva in 1979.

Years later, the report Brundtland, this report was prepared by different nations in 1987 for the UN, originally called "Our Common Future," faces the position of current economic development in contrast to environmental sustainability, which exposed the phenomenon of climate change, recommending that CO2 emissions be reduced by 20% by the year 2005. This is demonstrated by the scientific evidence identified by the Intergovernmental Panel on Climate Change - IPCC in 1988 [78].

Nevertheless, the response to this evidence lasted until 1992, when in Rio de Janeiro, Brazil, the Framework Convention on Climate Change was adopted, in which the member countries committed to attempting to reduce greenhouse gas (GHG) emissions by the year 2000, establishing guidelines and strategies for the sustainable regulation of strategic ecosystems in the world, in order to preserve their richness and extension [79].

At this time, the so-called "end-of-pipe" or "end-of-stack" technologies, which allowed the treatment of liquid effluents and polluting gaseous emissions, became more popular. However, the solution proposed to the problem was insufficient because this type of mitigation technology is characterized by solving the problems once they are caused, but does not address the root cause from the generation of the problem; this did not contribute to the prevention of environmental damage nor did it change the nature of the productive processes to others that are cleaner and more efficient, in terms of the use of material and energy resources [80].

In addition, it is important to develop individuals who are concerned about the environment, as stated in the 1977 Declaration of Tbilisi in the USSR, where five objectives of Environmental Moral Education were established [81-84]: "Awareness and sensitivity to the environment ; Knowledge and understanding; Attitudes of interest; Techniques for identifying environmental challenges and contributing to their solution; and Participation in activities to solve environmental challenges "[71, 80, 91].

This declaration promotes a comprehensive and proactive training regarding environmental issues. Young university students have awareness, attitude and interest in caring for the environment, therefore, spaces are required that allow them to discuss and propose alternatives, from their area of study to provide solutions to problems that arouse their interest.

Later, in the year 2000, the eight-millennium goals were determined, which establish a clear commitment to improve the situation of the citizens of the signatory countries before 2015, described in figure 4. Two years later, the Johannesburg summit sought to reaffirm the previously established commitment to the millennium goals and, in addition, to manage financial funds for sustainable development projects in third world countries. This opened the door to the UN Conference on Environment and Development Rio + 20, where special emphasis is placed on green economy issues, the objectives of sustainable development and, through the document "The future we want", the aims of Rio 1992 are retaken [84, 86].

Such is the empathy with the environment in this awakening of green consciousness, that the concept of carrying capacity, understood as "the limit to which the population can extend, which can be supported indefinitely by a given ecosystem, maintaining its productivity, adaptability and capacity for renewal "[84], is deepened in academia. Therefore, it is urgent to implement environmental footprint assessment models that allow giving a quantitative value to the services provided by the environment for living beings, which allow them to improve their quality of life, which is defined as environmental services. These services are adopted in the 2011-2020 Strategic Plan for Biological Diversity and the Aichi Goals, and are defined in the 2005 UN Millennium Ecosystem Assessment [86]. Figure 6 presents the millennium goals.

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Figure 6. Millennium Goals.

In 2015, it was necessary to adopt new, more drastic measures to ensure compliance with the sustainable development approach, so the SDG Agenda 2030, also known as the Global Goals, was launched, which are a universal call for action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity [86].

In the timeline shown in Figure 7, it is evident that there are countless efforts of different global organizations, to make more evident what is already impossible to hide, that we are a large number of inhabitants on a planet that is becoming more limited to meet our demands.

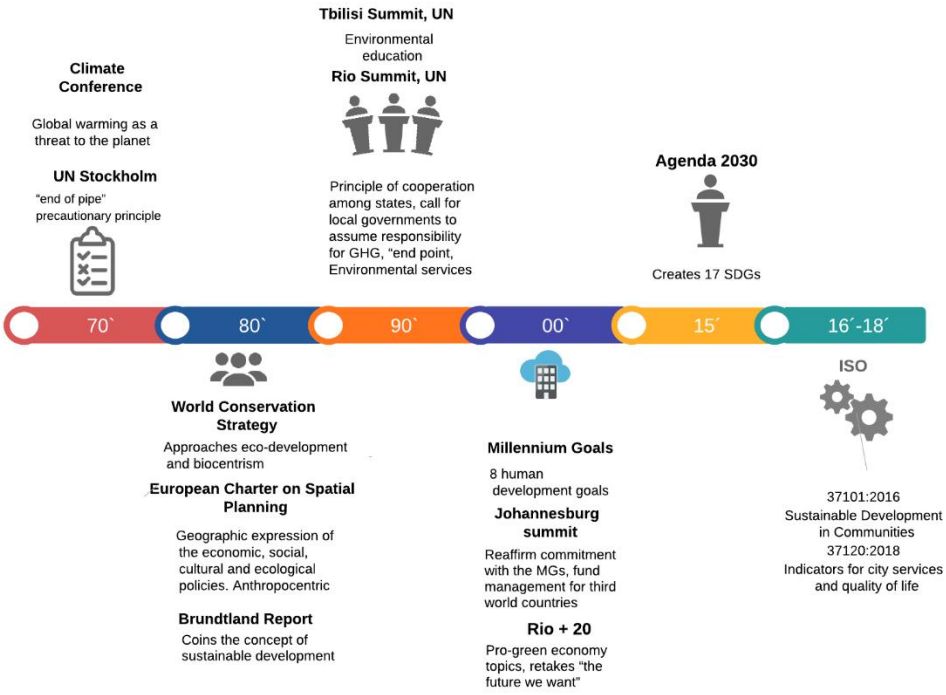

Figure 7. Sustainability timeline.

However, to understand the approaches that have been given to the concept of sustainability, it is worth noting that the Brundtland Summit, at the request of the UN, established the concept of Sustainable Development that frames two particular premises, the first is "satisfying the needs of the generations ", and the second element is implicit:" present and future generations", where the idea of time is introduced: the temporal variable as a fundamental element of the concept of sustainability, which explicitly shows us that the model of development must be considered in the short, medium and long term [86, 87].

It is important to clarify the difference between sustainable development and sustainability: sustainability could be called the goal to be achieved, the ideal state to be reached while sustainable development is the path we must travel from the three dimensions: social, environmental and economic, as presented in Figure 8.

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The approach of sustainable development is difficult to engage and even more complicated to fulfill its two premises. then is how the model of "green economy" or "sustainable economy" is reborn. The UN Program called UNEP, launched in 2008 the “Green Economy Initiative -GEI”. From one of its documents I take a literal phrase "The concept of green economy is not a substitute for sustainable development, but there is growing recognition as "one that leads to improved human welfare and social equity, while significantly reducing environmental risks and ecological scarcity". [85].

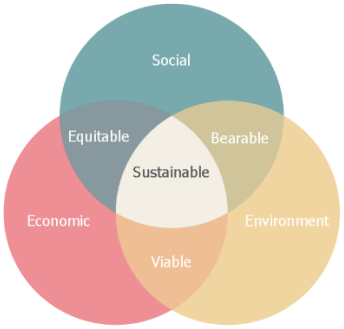

Figure 8. Venn diagram sustainable development

Sustainability is a concept that we could intuitively identify, however, the ISO 37101: 2016 standard called “Sustainable development in communities” is created under the precepts of the 2030 Agenda of the sustainable development goals for SDG 11. Where "Sustainable Cities and Communities", promotes the responsible use of resources, environment and the improvement of the well-being of citizens that are the final goal

The above, supported by the ISO 37120:2018 standard called "Sustainable cities and communities: indicators of urban services and quality of life" which provides indicators for services and quality of cities that establish the indicators of quality and well-being of life. Within the general principles of this standard, governance, empowerment, education, health and mobility are identified, which will help to define the objectives and strategies of sustainable development; it is noteworthy how it is gradually being associated with the territory. Figure 9 shows how ISO establishes standards for each of the SDG.

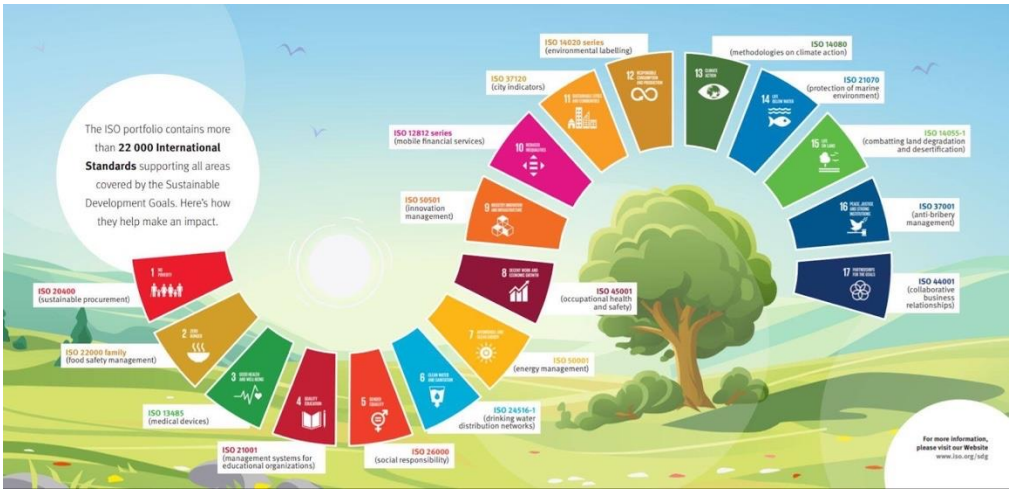

Figure 9. ISO standards for SDG [22].

3.4. Resilience in Smart Cities Planning

As mentioned above, one of the great challenges facing cities is their exponential growth, which is estimated that by 2050 more than 70% of the population will be concentrated in the main cities, consuming large volumes of natural resources in their path and making their administration even more complex. Another important challenge is to guarantee the minimum quality of life conditions for their inhabitants, forcing decision-makers to seek new alternatives that provide proactive responses to these dilemmas, allowing cities to evaluate, plan and act in order to prepare for and respond to the new obstacles [37]. This is where the concept of resilience comes into play in urban planning and how it must be adapted to the demands of sustainability.

This concept was born in 1973 with the Ecologist CS Holling, who establishes resilience as "a measure of the persistence of systems and their ability to absorb changes and disturbances and maintain the same relationships between populations or state variables", supported by two variables fundamentals such as stability and regeneration [30]. C.S. Holling's theory was to move from the laboratory as an experimental and analytical model of ecological interactions, to implementation in an ecosystem as a population model. By studying the amount of disturbance a system can sustain before its controls change to another set of variables, Holling then evaluated variability rather than stability.

The first applications of these findings were made at Columbia University in 1978, with the dynamics and management of grasslands and freshwater combining inductive science and field experience, which in 1996 CS Holling himself designed models ecosystem-scale [89,90].

By 1998, Simon Levin at Cambridge University considered that the concept ceases to be merely for ecological systems and argued that it is a "property of any complex, non-linear system, whether ecological or socioeconomic, that does not lend itself to management protocols based on assumptions of linear, globally stable, uniquely balanced systems ", evolving into a multidisciplinary concept, linking it to different uses with very different meanings from the urban perspective [81,91].

Again in 2002, CS Holling reappears introducing a new vision of resilience from the conception of the "panarchy", where the key element is the interactions between different adaptive cycles, that is, it must be seen as an evolutionary nature of complex adaptive systems, where their functioning and sustainability is given by the communication that exists between them, which they trigger in stages of accumulation, restructuring and renewal [81].

By 2005, the consequences of climate change, sea-level rise, climate extremes, led to increased disease, a long list of endangered species and the destruction of ecosystems, which were difficult to hide, and forced world leaders to meet in the same year in Kobe, Hyogo, Japan at the World Conference on Disaster Reduction, giving special emphasis on risk management and the development of responses through adaptation and mitigation, generating the action framework for 2005 - 2015 called "Increasing the resilience of nations and communities to natural disasters, leading to a reduction in losses in human lives, social, economic and environmental assets" [11,84].

In 2015 together with the SDG, the UN-Habitat report is published defining urban resilience as "the capacity of urban systems to recover rapidly from any event caused by disruptive phenomena of natural or human origin. Its purpose is to prevent an event from evolving into a disaster", again under two variables of stability and regeneration, at this point, it is still not very clear whether the disturbances are merely given by factors external to the complex systems or how much influence the internal variables have [37].

As a result of the challenges generated for the fulfillment of the SDG, the UN guide to urban resilience was created in 2016 for the member countries, which gives special importance to a new concept of risk which shows the definition of risk from additional variables [37].

The terms hazard, exposure, and vulnerability are constantly used in risk management, particularly the latter understood as a characteristic of the community that makes it susceptible to harm from a hazard [71]. Risk assessment involves the analysis of the disruptive agents that can cause damage to a system to the extent that it results in a disaster [84].

For this reason, the guide to resilient cities shows the classification of phenomena to which the territory may be exposed and which significantly affect it, as shown below in Table 1, where each

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phenomenon is categorized by a type of disturbance that may be of natural, anthropic or astronomical order, listing 37 phenomena.

Table 1. Classification of phenomena [37]

TYPE	PHENOMENA
Geological	1. Volcanism 2. Earthquakes 3. Tsunamis 4. Instability of slopes 5. Flows 6. Falls or collapses 7. Sinking 8. Subsidy
Hydro-meteorological	9. Cracking 10. Warm and cold waves 11. Droughts 12. Frost 13. Hail storms 14. Snowstorms 15. Tropical Cyclones 16. Tornadoes 17. Dust storms 18. Electrical storms 19. Extreme rains
Sanitary-ecological	25. Epidemics 26. Pests 27. Air pollution 28. Water Pollution 29. Soil contamination 30. Massive movements (marches, pilgrimages)
Socio-organizational	31. Large concentrations (sit-ins, political, social, cultural events) 32. Terrorism 33. Sabotage 34. Vandalism 35. Air accidents 36. Maritime accidents 37. Land accidents

Likewise, not only multiple edges are created from which resilience can be interpreted, but also a new approach for governments to respond to their commitments in urban planning by moving towards sustainability commitments as can be seen in Figure 11 showing its conceptual evolution.

More recently, research is focusing on finding proactive models that can be implemented to measure a city's resilience. The International Organization for standardization -ISO and the UN created the ISO 37123:2018 document "Communities of sustainable development: indicators for resilient cities" where disturbances are defined only as natural or a man-made event that causes a disaster, namely, floods, earthquakes, hurricanes, wildfires, chemical spills, power outages and a resilient economy [30].

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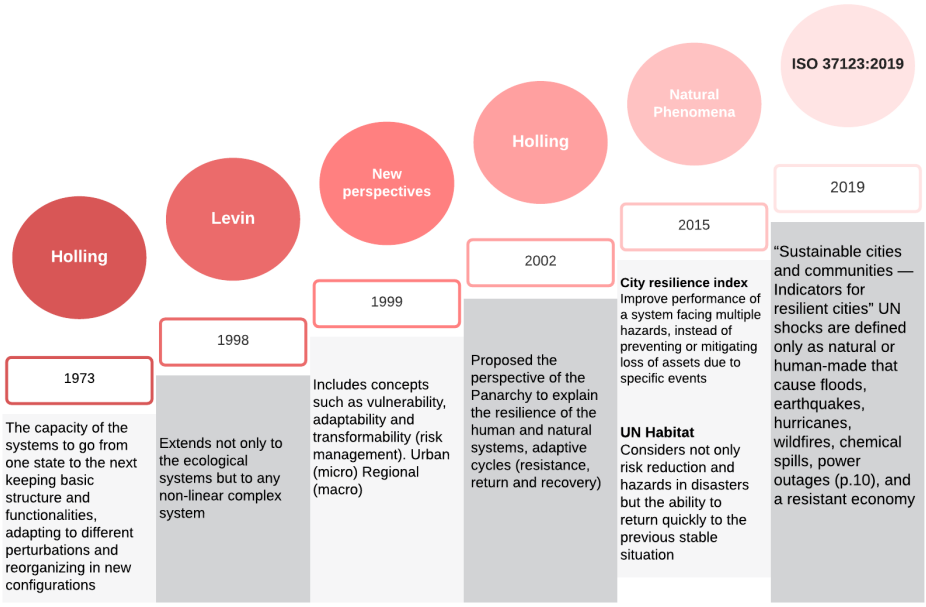

Figure 11. Evolution of resilience

Currently, multiple organizations of great global influence such as Resilience Alliance, Community & Regional Resilience Institute or Resilient City, Network on Building Resilient Regions, City Resilience Index, play an important role in building and spreading resilience, which, although it is a widely used concept, is rarely well defined [86, 93,95].

For the City Resilience Index, in the context of cities, "resilience is focused on improving the performance of a system in the face of multiple hazards, rather than preventing or mitigating the loss of assets due to specific events" [25].

3.5 Smart city planning strategies

At the beginning of the 21st century, the excessive growth of the urban population surpassed the rural population for the first time in 2011, multiplying the number of mega-cities, which are understood to be those with more than 10 million inhabitants, increasing from 3 in 1975 to 31 cities by 2016. In this context, the development of smart cities becomes a priority, where technology is put at the service of citizens to manage the urban environment intelligently in order to improve their quality of life [91].

The concept of the digital city, which was born in the 1990s as its precursor, was related to the massive use of Information and Communication Technologies -ICT- taking advantage of the existing infrastructure with the domain of the Internet, providing governmental, private and civil entities with a set of information-type services that allowed them to break down barriers to share data from one end of the world to the other [94].

By the end of the 1990s, it was evident that the new challenge was not to collect routine data but rather to make it operable for the benefit of the community and the city, so it became necessary to create technology centers to optimize planning, taking on a role as universal machines [94].

With the arrival of the 21st century, the concept was updated to smart cities based on three fundamental pillars: Instrumentation, Interconnection and intelligence in data processing [95]. The first one refers to the need for strengthening the sensors capable of collecting the maximum information. The second pillar refers to support the maximum traffic of all information and that these data can be transmitted to information centers. And the last and most important pillar, it is not only about collecting and transmitting data but how these will be processed and analyzed [86].

In response to these needs, it was necessary to integrate the infrastructure associated with ICTs with the policies of government agencies, in order to contribute to sustainability issues that were mainly focused on energy efficiency and the reduction of greenhouse gas emissions. –GHG [96].

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However, it is particularly important to create open data platforms that allow for citizen participation [97].

Nevertheless, the concept lacks precise definitions, it is used with different synonyms: smart, creative, digital, connected, cultural, all of them essentially empty since it requires definitions that complement it [40]. In this sense, the researchers agree that a smart city contains the following six dimensions, as shown in Figure 12.

Figure 12. Dimensions of smart cities [40].

- **Smart economy**: Cities must have a high level of productivity, supported by innovation and flexibility in the labor market, characterized by innovative solutions and flexible adaptation to changing conditions. The concept of smart industries, linked to Information and Communication Technology -ICT, as well as business parks and technology parks, is applied [98].
- **Smart mobility**: The infrastructure that supports ICT allows for high-speed connection networks in a city, uniting all the resources, thus letting the use of existing infrastructure to be rationalized [40].
- **Smart environment:** Energy consumption is optimized, using renewable energy sources, reducing harmful emissions to ecosystems. Based on the concept of sustainable development [40].
- **Smart people:** It establishes a society that is open to continuous learning promoted by its inhabitants who, with the appropriate technical support, undertake actions that prevent excessive energy consumption and environmental pollution, contributing to the improvement of the quality of life [40].
- **Smart living:** Guarantees access to public services, technical and social infrastructure, security, cultural and leisure offerings, as well as green spaces [40].
- **Smart governance:** In addition to optimal management and administration of the territory, this supports shared management between government agencies, private entities and citizens, taking advantage of technologies in the operation of the city, an intelligent public administration, capacity to create knowledge and its use in practice [99].

These six dimensions are based on the theory of competitiveness of cities and regions, taking the use of technologies as a differentiating element, also covering urban life and the functioning of public administration. Thus, an intelligent city is a territory with a capacity for learning and innovation, creativity, with the presence of institutions dedicated to research and development, higher education, digital infrastructure and communication technologies, as well as high performance in management and administration [41].

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Thus, from this new dimension, indexes and indicators emerge with the purpose of developing maturity models that allow monitoring and integrating operational conditions of a complex system, which uses ICT to innovate in administrative management. Among the existing models is the ISO 37122 standard for smart cities, being a starting point to relate the main characteristics of the perspective of the main domains of a smart city [100,101,102].

Therefore, one of the objectives that consists in the universalization of services for the development of smart cities, is based on the "construction enabled by emerging technologies such as the Internet of Things - IoT and machine-to-machine (M2M), social media, mobility and big data " [100, 103]. The development of IoT allows to speed up and streamline the control of various processes of daily life, from the control of areas of transport, health, energy, logistics, environment and others [48].

On the other hand, it also becomes relevant to open public data, which allows processing by citizens and requires constant renewal based on the data already obtained; this concept is ideal for an open government that considers maintaining credibility in its citizens and exercising good governance [41].

4. Discussion

4.1 Planning

As it has been stated throughout the document, planning is as old as man's presence on earth, that is, it is almost in the human being's DNA and it was evidenced when, through common sense, the need to reorganize its territory for a common good; with the passing of time, this became a discipline of knowledge and political instruments as a mechanism in favour of an economic system.

It is evident that urban planning has an exponential dependence on existing natural resources, especially water resources, because the guarantee of the well-being of human settlements is focused on the environmental services that this resource provides [8], coupled with historical urban expansion, socio-economic conditions of territory leading to increased demand for natural resources with negative impacts on the ecosystem.

On the other hand, the creation of political structures and organizations were important for the initiation of territorial planning instruments such as stratifications, categorization and land use; the latter two gave the guidelines for the emergence of equipment, influencing, in turn, cadastral valuations [3-15]. For this reason, these investments in development were initially exclusive to the upper elites, highlighting the territorial imbalance, framing the poverty belts and reinforcing the phenomena of disorderly growth in the peripheries.

Although eco-development aims to revolutionize urban planning, under its vision of sustainable development, in which it seeks to change the view of territory from anthropocentrism to bioregion [20,25], it seems that its implementation is becoming even more complex due to the growing demand of a consumer society, which expects to reach a representative level of development, even at the cost of the evident environmental sacrifice that we carry on our backs and which has been a protagonist in the construction of corrective measures.

It is important to recover the focus of environmental principles such as cooperation, precaution, prevention, biodiversity and sustainable development discussed at the Rio Summit in 1992 [31], which marked a real legal obligation in the instruments of territorial planning, providing important support for the implementation of public policies aimed at sustainability.

Questions arise such as what is the difference between ancient cities, that is, BC to those of today? Today the world is very different from that of the industrial revolution, with new economic realities, geopolitical tensions, technological advances, new actors involved, and innovative ways of waging wars that globalization has led us to.

In other words, one of the main causes of transformation in the cities is due to population growth, that is, while today we have more than 50 megacities with approximately 10 million inhabitants, in ancient times only 7 reached a million. Mesoamerican cities have shown growth

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patterns very similar to those of today, according to the urban scaling model, that is, as they grow, the community tends to inhabit smaller and more concentrated spaces [102].

On the other hand, for ancient cities the walls and fortifications that could be seen from a distance were synonymous with power and authority, something that is not far away today where modern skyscrapers equipped with the latest technology reflect the fashion for sustainability [102]. However, it can be said that cities governed with a view to equitable distribution showed greater long-term prosperity and competitiveness compared to those governed in an authoritarian manner [103].

4.2 Sustainability

The Brundtland Summit established the concept of sustainable development as "development that meets *the needs of the present without compromising the ability of future generations to meet their own needs*" [88], identifying two notions, the first framed in the environmental footprint and the second in the carrying capacity by assigning a time variable.

Sustainable development is based on a territorial approach aimed at the bioregion, in which the maintenance of essential ecological processes and life support systems, the preservation of genetics, and the sustainable use of species in accordance with their carrying capacity are seen as vitally important [22,27]. In other words, it pursues a bio-centric vision where the human being is no longer the centre and forces Urban Planning to reevaluate the ordinance of the territory as an instrument that harmonizes with the dynamics of an ecosystem and allows evaluating its carrying capacity and thus guaranteeing long-term planning.

Thus, the declaration of Tbilisi becomes important, establishing the five objectives of environmental moral education [33-34]; This is because it is useless to establish public policies of a police order in the pursuit of compliance with environmental duties if the community is not educated with a vision of roots in its territory.

The millennium goals allowed the establishment of 8 objectives strengthening the environmentalist demands and opening the doors so that in the UN Conference - Environment and Development -Rio +20, special emphasis was made on green economy issues [89], strengthening as a determining evaluation tool for sustainability, the measurement of the footprint and the economic valuation of environmental services, which allow establishing a consumption quantification. However, the implementation does not guarantee sustainability, because, in addition to a diagnosis, the Conference does not have a robust legal framework that requires corrective measures.

4.3 Resilience

Territorial planners relate urban resilience to intra-urban processes that are mainly associated with natural disasters [72], perceiving it as an isolated unit and therefore focusing mainly on internal interactions, without giving importance to the fact that the dynamics of these interactions must also be associated at a macro level, which are the relations with other cities.

This allows us to consider cities with a complex systems approach that functions as a network of relationships composed between their internal components and external networks [88]. This works like a gear, that is, each component of its extension fulfills a function and, to the extent that it harmonizes with this internal and external network, it is magnified with a common objective to make this complex system work effectively; these interactions at the local and regional level allow the city to develop further in a multilevel approach.

Hence, a city is seen as a connective element between inter- and intra-urban processes that allows resilience to be raised as a result of their interactions [30]. In these multi-level interactions "*new properties emerge and characterize the city as a collective entity*" [89]; it is clear that relationships are the key factor in understanding resilience, but how can each level be measured? Can an analysis of interactions between them be carried out? This will only be possible when the point of interconnection and synchronization is understood.

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The concept of "*panarchy*" is postulated as one of the tools to explain the multilevel synchronization of complex systems, as proposed by Hollings in his most recent speech [82]. Thus, urban resilience could be analyzed in its long-term interactions from its key formation factors (exploitation, conservation, liberation or reorganization), the analysis of these interactions will allow to contribute new tools to concepts such as carrying capacity and the measurement of the environmental footprint.

It is important to emphasize that the adoption of measures aimed at implementing resilience was related to risk management from a natural disaster perspective in order to improve the quality of life of citizens [84]. Nevertheless, it would seem that resilience is a magic formula for reducing the vulnerability to which cities are exposed, without considering that this is a concept that is still under construction and is still in search of its key training factors.

Sustainability and resilience are two concepts that will allow a strategic functionality in urban planning, because while the first one prioritizes results, the second one analyzes processes, demonstrating that a partnership between these two concepts will allow to widen the focus to anticipate the anthropocentric and natural uncertainties.

4.4. The Smart Cities

The complexity of the administration of cities makes it imperative to develop smart cities as a tool through which technology is put at the service of citizens, allowing not only the collection of data but also the processing of these for the benefit of government entities under the principle of governance.

The smart city is measured in six dimensions: economy, transportation and communications, environment, community, quality of life, and management and smart administration [40]. For this reason, an smart city is a territory with the capacity to learn using technologies as a differentiating element in the hands of institutions dedicated to research and development to improve the quality of life of the community.

5. Conclusions

It is inevitable that the conceptual evolution of each of these topics Urban Planning, Sustainability, Resilience and Smart Cities will vary according to the historical moment we are going through, together with political needs. However, the main changes in public policies have been unleashed as a result of natural disasters that show the vulnerability of human beings as one more population in this ecosystem.

It is important to emphasize that such situations should have been generated to allow the concepts of land administration to mature, focusing on a common objective that guarantees the well-being of the ecosystem, leaving aside the perception of land from an anthropocentric concept and in turn generating tools that allow us to implement the concept of sustainable development and sustainability.

It could be argued that the diversity concept of each of these topics is due to the multidisciplinary nature fragmenting such terminology, however, one of the common points is to evaluate the territory as a complex system explaining these concepts through temporal scales, understanding that can be present in the long-term, through a cycle of adaptation, where impacts are assessed in the short-term by applying the framework of the panarquia.

Sustainability requires predefined results by generating tools that drive a transformation in society in the long term, understanding it as the goal we want to achieve while Sustainable Development is the path we must chart, allowing to adapt and reorganize public institutions and policies proactively.

It is clear that there is still a long way to go to achieve a practical instrumentalization that addresses and groups all the environmental, social and economic variables for the optimal administration of the territory, and in addition prepares it for the new challenges.

It is also important to highlight the importance of citizen participation in the creation of territory, which involves identifying and involving groups that may be positively and negatively affected by the transformations in the territory, allowing their free expression, giving importance to debates, cooperation in turn awakening the understanding of the territory as a bioregion and facilitating citizen participation in the search for compliance with governance.

We urge the academic community to deepen scientific research that considers nature-based solutions as a pillar for the understanding of adaptive cycles in complex ecosystems such as cities, in order to strengthen resilience to risk management, and thus improve public policies that will lead to the fulfillment of sustainable development objectives.

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Conflicts of Interest

The authors declare no conflict of interest.

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