Towards territorial development from sustainability

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Universidad Ecotec

TOWARDS TERRITORIAL DEVELOPMENT FROM SUSTAINABILITY

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EDITORIAL NOTE

The works that make up the chapters of this book are the result of research by expert teacher-researchers who contribute to the "Environment and Society" Research Line, in collaboration with the teachers of the ECOTEC University. The authors of this work had the responsibility to select said scientific research, taking into consideration the impact and relevance of the information, by virtue of the dissemination of knowledge.

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PRESENTATION

Sustainability, a key factor in development, is evident in many ways, from current economic thought to the new practices of rurality, urbanism and agricultural production processes. This influences the advances in organization and structure of the concept of the anthropocene.

The traces left by societies and generations from our past are present in our environment, and leads us to reflect on where we are going and how we can mitigate the environmental damage that we've caused, which sometimes seems irreversible.

The book seeks to take into account, from a theoretical and practical evaluation of sustainability in the Ecuadorian territory, the search for problems around the environment and its plausible solutions, which are based on academic research.

The first chapter analyzes ecological principles and processes that must be considered and optimized in the design of agroecological systems. A new paradigm is being established with proposals and applications of strategies in the production of the agri-food system, making the system more sustainable, establishing a symbiosis between the technologies proposed by the academy and the ancestral knowledge of the communities.

The second chapter delves into the modern context of agrarian economy in economics from a sustainability perspective. In the history of economic thought and analysis, agriculture—at the dawn of production relations—is considered an economic activity superior to others, as it provides the population with necessary nourishment. The development of the industry and the markets, and their influence in the agricultural sector, both in theory and in practice, are also addressed.

The third chapter examines, through a documentary compilation, the different types of structures related to green areas for public use within cities, the options in consolidated cases with few green areas and how these allow expanding existing ones, making links and integrating them with nature and urban biodiversity. Likewise, the description of the growth of the cities that are forming in consolidated areas is noted, as it makes the incorporation of green areas not always possible. Here, alternatives are proposed to add spaces that allow a connection between the existing ones and the natural areas that surround the metropolis, increasing the benefits such as air pollution, temperature and noise reduction, among others.

The fourth chapter shows an estimation of general methane in the supply chain of the oil and natural gas systems in Ecuador. The methodology of the Intergovernmental Panel on Climate Change (IPCC) is used, whose guidelines quantify fugitive emissions from the energy sector. The period evaluated is 1999-2019, using the level-1 methodology and through a rigorous segmentation according to national circumstances, the emission factors in each category are calculated.

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CHAPTER 1: PEASANT FAMILY FARMING: THE INITIAL FACTOR OF AGROECOLOGY

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1.1. Introduction

Ecuador is a mega-diverse country of great heterogeneity, with four geographical zones: Coast, Highlands, Amazon and Galapagos, where 14 nationalities and 18 ethnic groups with different ways of observing ecosystems coexist.

Agroecology gained momentum as a discipline from the seventies, whose goal was to remedy the impacts of the green revolution by improving the biological profitability of the soil, social justice and the economic situation of the peasant sectors. The progress and results obtained in the last years of the current decade, understood as the 21st century, are a forceful response by the indigenous communities of the Ecuadorian highlands to the conventional agriculture model responsible for soil degradation, population of rural peasantry reduction, alteration of culture and increased poverty in the rural sector.

The contributions in research and validation of agroecological technologies coming from research institutions and the academy, and the adoption of agroecological technologies in organic agriculture, allow us to speak of a symbiosis between agronomic science and the ancestral knowledge of the communities. In order to clarify this point, it is important to point out that agroecology is not ecological agriculture or organic agriculture, but rather it is the discipline that provides the technologies that serve as the basis for the development of these production models.

Peasant agro-ecosystems or farms are the integration of fauna and flora interacting with their physical and chemical environment, which have been modified to produce food and raw materials for processing and human consumption.

Agroecology is defined as the application of ecological concepts and principles in the design of sustainable agroecosystems, processes that become a basis for evaluating the complexity of agroecosystems. Its application is based on the application of strategies and technologies that contribute to the maintenance of the physical, chemical and biological conditions of the soil, through the agroecological management of crops.

There are multiple business spaces where agroecology has been gaining momentum and showcasing its scope to modify the current situation of peasant agricultural sectors. Currently, agroecology has become a modern paradigm for the resilience of natural ecosystems and agroecosystems, providing answers to the various technical problems that have been caused by conventional extractivist agriculture, thus becoming a theoretical reference that serves as a guide for sustainable agriculture and to strengthen the soil's biological system.

Unlike the conventional model, agroecology is not based on recipes, but rather on observation at the field level and is measurably based on the interpretation of laboratory results. This situation hinders agroecological technology transfer processes and the adoption of recommended technologies. Therefore, agroecological technology transfer projects must be long-term, as educating farmers is a crucial part of the process.

Martin Prager (2002) concludes that the application of agroecology takes into consideration the complexity of ecology, which gives rise to many variables and proposes an approach to agriculture linked to the environment and the sustainability of the production system.

Farmers today can no longer pay attention only to the objectives and goals of their production unit and expect that this alone is enough to face the problems of sustainability in the long term. Sustainable agriculture must go beyond what is done or happens within the limits of the individual production unit. Production is currently perceived as a broader system that includes environmental, economic and social components (Gliessman 2001; Soto-Pinto et al., 2022).

According to Suquilanda (2019), agroecology is a theoretical-practical scientific discipline that provides the basic principles to study, design and manage agroecosystems that are sustainable, productive and culturally sensitive, socially fair and economically viable, and are successful at improving biological efficiency and conserving natural resources. This can be translated into objectives, namely, the preservation of biodiversity, the recycling of nutrients, the optimization of the use of local resources and the use of the ancestral knowledge of indigenous communities.

The various models of agri-food systems practiced by small producers in the Ecuadorian highlands present variable surfaces ranging from micro systems (<1.00 to 1.00 hectares), small (>1.00 to 10.00 hectares), medium (>10.00 to 50.00 hectares) or large (>50.00 hectares) models that present diverse subsystems and that vary significantly within the same community and from one region to another. These differences in the surface of the agricultural systems provide a host of important information for agroecology because they obey the characteristics of each ecosystem and the socio-cultural contexts of the population in each territory (Facundo Correa & Cid Aguayo, 2021; Suquilanda, M. 2019).

The Ecuadorian Center of Agricultural Services (CESA), through the Landcare, LAIF and Allialpa projects in the provinces of Cotopaxi, Chimborazo and Tungurahua, and the Food and Agriculture Organization of the United Nations (FAO) through the World Campaign Against Hunger (CMCH) in the provinces of Imbabura and Pichincha, currently carry out training programs in agroecology and short marketing circuits aimed at agricultural technicians and communities in the Ecuadorian highlands.

The organizational capacity of the indigenous communities of the Ecuadorian highlands has contributed to the adoption of agro ecological models that take advantage of the rich biodiversity of the environment, the ancestral heritage and knowledge they possess. However, they face limitations such as land legalization and access to water, which have led to the development of smallholdings.

In the provinces of the coastal region, there are communities with experience in the production of diversified crops such as rice, corn, cocoa, coffee, bananas, fruit and wild bananas. However, we must note that, in this region, the expansion of monocultures has led to a high percentage of the peasant population being absorbed by a system of labor exploitation, which, in turn, has led to peasant farms suffering from biological degradation due to the continuous and indiscriminate use of agricultural pesticides.

1.2. Materials and methods

To meet the objective of this research, a documentary or non-intrusive analysis was carried out, where scientific articles from indexed journals with the search for the following terms "agricultural AND economics","agroecology","family AND agriculture", "agricultural AND economics", "family AND agriculture" and "agroecology" we included. The search was expanded to include articles from the Journal Indexing Citation Report (JCR) and Scimago Journal Rank (SJR). In the case of Web of Science, the Social Sciences Citation Index (SSCI), Science Citation Index Expanded (SCIE), Art and Humanities Citation Index (AHCI) and Emerging Sources Citation Index (ESCI) were included.

Several articles were selected from 2000 to 2021, for a preselection focused on addressing the problem by reading the title, theme, abstract and keywords. A bank of articles was created on the Mendeley platform and the study of these articles was expanded, building a systematization of the indicated field and a comparative analysis between the various studies.

1.3. Developing

The participation of producers in agricultural development programs cannot be passive and there must be interactive communication with technical personnel without discarding ancestral knowledge (Ezquerra et al., 2014; López, M. 2020).

Landini (2016) states that one of the problems in technology transfer services is the distrust and low interest of producers in the adoption and innovation of recommended technologies because, on many occasions, they are far from their needs, and can be difficult to apply due to lack or absence of credit. The results of agroecological strategies on farmers' farms are measured by field observations and by analyses of sample results in laboratories.

One of the most important points to be considered by the institutions that participate in these projects is the value of the ancestral knowledge of each territory, which should be the starting point and institutions should take time to understand it (Bezerra et al., 2022). Whether for research projects or transfer projects, it is important to understand and value what the inhabitants of the communities know, which is the basis for success in implementing and developing an agroecological technology transfer program, and eventually turning this knowledge into an instrument for sustainable agricultural development where social, economic and environmental components interact.

Thus, agroecology constitutes the new model of agricultural production and has been reinforced by the ancestral practices currently used in the agricultural systems and subsystems of peasant families and in social movements. In the last decades of the 21st century, it has become part of the discourse of international organizations and the public policies of some countries of the world.

Agroecological designs allow us to see the agricultural process as an integrated system whose purpose is not only to increase the productivity of the production units but also to optimize the system as a whole and preserve its sustainability over time (Altieri 2002; Khadse & Rosset, 2019).

Management of the same nature must also be guaranteed from a rational and environmentally safe perspective, managed from the State to the citizens (Severe & Vera, 2014; Vergara-Romero, 2019). This management should seek the stabilization and improvement of the world's ecological situation, creating favorable living conditions to raise the level of agroecological culture of citizens.

To achieve an optimal articulation of the new processes that demand the most sustainable agricultural practices, it is important to correctly link agricultural development policies and agroecology interventions developed in organizations, universities and communities, through long-term management projects.

The practices of technologies based on principles of agroecology are presented as a solution by proposing strategies such as Agroecological Crop Management (MAC), Agroecological Pest Management (MAP) and applying designs with temporary and long-term arrangements including various species of fruit and wild trees.

Agriculture worldwide is in a serious crisis caused by social problems such as the unemployment and aging of the rural population; economic problems such as the increase in production costs/ha and price instability at the farm level; ecological problems such as imbalances of ecosystems due to deforestation and erosion, reductions in the size of populations/communities of living organisms, effects on soil biology due to the indiscriminate use of pesticides and agricultural inputs, air pollution, alterations in the flow of surface aquatic systems and underground, concentration of salts in the soil, adding the migration of young populations to other activities unrelated to agriculture.

Floriani & Floriani (2010) conclude that the application of agroecology focuses on the recovery and preservation of biodiversity, which is one of the basic principles to achieve self-regulation and sustainability in agricultural systems and subsystems. The richness of biodiversity is the basis of the balance of natural ecosystems and, consequently, of the sustainability of the surrounding agro-ecosystems (Pozo-Estupiñan et al., 2021; Schwab do Nascimento, 2020).

The agroecological vision considers that the knowledge created and spread by academia and research centers must be complemented with the perception and knowledge of farmers (Vergara-Romero & Moreno Silva, 2019). The knowledge and management of agro ecosystems should be developed based on the convergence of scientific and farmer knowledge, through a process of interaction with rural communities, with the participation of farmers, researchers and technicians with experience in managing the production systems, residents and people who are familiar with the work areas (Ramos-Leal et al., 2021; Vergara-Romero, 2021).

For the success of the programs, there must be a close relationship between research, transfer and knowledge of local technology to establish a synergy between scientific knowledge and ancestral knowledge. This new knowledge must be participatory, articulating proposals and interests of the peasant organizations and agricultural research and development institutions.

The path to agroecological transition is long and complicated and should combine different strategies, and there is no single way to achieve it (Hanclova et al., 2021; Márquez, 1991). The start and duration of a transition process depends on the conviction, needs and predisposition of the actors that make up the process.

One of the limitations that could be observed is the difficulty of changing a model that has been used for years, which has been influenced by the generalized and consolidated conventional model in the region.

It is necessary to consider that the conventional model is based on the application of recipes, whereas the agroecological model focuses on the knowledge and application of science. Therefore, the advances in the transfer processes and the adoption of the recommended agro ecological technologies are slow and long-term.

The National Institute of Agricultural Technologies (INTA, 2012) in the Path Guide to Agroecological Transition, states that the transition process towards agroecological systems in the current context must take into consideration that it is not enough to propose only a set of appropriate technologies, but it is necessary to know the arguments and variables that influence the decision-making of farmers, to support the organizations participating in the training processes, and to include technical personnel specialized in the management of agroecological technologies in the process.

With the above, it is concluded that the agroecological transition is a complex process in which components such as the farm, the community, the territory intervenes and that it is affected by social, economic, technological, cultural, political and environmental factors. In a transition project, it is necessary that the beneficiaries first understand the functioning of the ecosystems and how human activities have transformed them.

1.4. Conclusions

The agri-food production model based on agroecological principles is highly diversified and self-sufficient, where the production items are integrated and complement each other to self-supply.

Peasant agriculture meets the conditions and practices necessary for the development of agroecology by applying the knowledge acquired and transmitted in communities from one generation to another over time, as well as innovative technologies proposed by academia.

The methods and strategies of agroecology reinforce ecological and economic resilience in the face of today's environmental crises. Additionally, they are useful in the development of public policies on sustainability that guide peasant managers to agroecological knowledge and good practices.

The diversity of agroecological production systems such as agroforestry, silvopastoral systems, the integration of subsystems of various species, livestock, aquaculture and polycultures, contribute to a series of socioeconomic, nutritional and environmental benefits.

Although it is true that peasant communities have ancestral knowledge, they also need to be trained to understand agroecological technologies, including mixed strategies that combine ancestral knowledge with modern techniques.

Food systems must be oriented towards sustainability in order to maintain a balance between ecological responsibility, economic viability and social justice.

1.5. Recommendations

Based on the foregoing and on the multiple research works and comprehensive multidisciplinary knowledge, the following points are recommended:

- The academy must intervene in the creation of new proposals for agroecological technologies considering the needs of the peasant communities and not in an independent or isolated manner.
- The training of agro-ecologists should be encouraged; this is recommended by the analysis of the evolution of today's society. Defining a milestone of progress in agriculture as a factor of production within any world economy.
- When it comes to projects considering farmers as the actors, it is imperative that the project proposal has, in itself, an efficient management of financial resources, with training that involves the entire productive apparatus in this sector of the economy.
- Training projects should be developed with the participation of experts in technology transfer of agroecological strategies.
- Agricultural development projects should begin by organizing and supporting groups of homogeneous producers.
- Agroecological strategies should not be based on recipes and should consider the different characteristics and needs of the farms.
- The results and progress of the applications of agroecological strategies on farms should be evaluated through observation at the field level and based on the results of physical, chemical and biological laboratory analyses.

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CHAPTER 2: AGRICULTURAL ECONOMICS IN THE ECONOMIC THINKING OF SUSTAINABILITY

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2.1. Introduction

The multiple methods of scientific research lead to new inquiries into structural cuts based on macroeconomic theory and non-structural ones, reflecting the properties of time series, space and the organization of society and its individual behavior.

The choice of the cut of the analysis depends on the object, goals and objectives of the investigation itself. In this way, it is evaluated from the point of concentration on the methodology for carrying out a work of human and social thought. This evaluation investigates the different phases of research, location, population, sampling, actors, scientific instructions, expected results of the work, control and production systems (Fusco, 2021; Ghimire et al., 2021; Vergara-Romero, 2019).

Depending on the use of the methods or their convergence, continuity should be preserved until the end of the investigation, where it is expressed in the similarity of the main criteria indicators: Volumes of resources involved, proportion of finished products of a raw resource or net, income, earnings, profitability, among others (Mesa-Vásquez et al., 2021).

The basis of the research methodology is a determining factor in all scientific work, which is why research in the complex scientific discipline of agricultural, agro-industrial and agricultural economics is analyzed by sections of analysis and behavioral inquiry. The results of scientific investigations are mostly of theoretical foundation, manifestation of laws and economic patterns. Under these results, virtual development models are reached with a given direction and expected results supported by a theoretical basis.

The scientific news is in scientific bases that integrate these economic laws and patterns in data that need to be shaped for a more real adjustment that leads to the satisfaction of all the actors related to research in the fields of agriculture and economics.

Agriculture and the economy—linked by their way of producing and distributing on a basic level—are considered fundamental to societies, since they feed on these two converging scientific fields. The conceptual evolution of both disciplines leads to a reflection of the emerging changes with the passing of time and the decision to increasingly analyze the geographical space, which is linked to cultural identity and ancestral practices.

In this way, the agrarian economy is analyzed as a sphere of production with importance in agricultural products, increased food and environmental security, employment and income earning. The aim of the study is to expand on the modern context of agrarian economics in economic thought from a sustainability perspective.

2.2. Materials and methods

To meet the objective of this research, a documentary or non-intrusive analysis was carried out, using scientific articles included in indexed journals with the search terms: "agrarian AND economy", "sustainability", "economic AND thinking", "agricultural AND economics", " economic AND thinking" and "sustainability". The search was expanded to the Journal Indexing Citation Report (JCR) and Scimago Journal Rank (SJR). In the case of Web of Science, the Social Sciences Citation Index (SSCI), Science Citation Index Expanded (SCIE), Art and Humanities Citation Index (AHCI) and Emerging Sources Citation Index (ESCI) were included.

Several articles were selected from 2000 to 2021, for a preselection focused on addressing the problem by reading the title, theme, abstract and keywords. A bank of articles was created on the Mendeley platform and the analysis of these articles was expanded, building a systematization of the indicated field and a comparative analysis between the various studies.

The systematization was carried out through the conceptual representation and the discursive analysis of each author. However, the relevance of the article is measured by its impact factor and immersion in the thought of its scientific discipline, oriented towards the results of substantial changes in praxis and the formative theory of the search for real solutions in multiple problem situations.

2.3. Developing

Since ancient times, leading thinkers, writers and politicians have tried to solve economic problems linked to development. Economic thought and its evolution go hand in hand with the development of human beings and society. Therefore, it can be said that the economy has evolved over many centuries and at each stage of development, it was determined by its productive forces such as the form of agriculture and the nature of production relations (Candemir et al., 2021; Ramos-Leal et al., 2021).

Each stage of development of society has its own relationship of development, organization of production and categories of use of the main elements of the economy: land (natural resources), work (labor) and capital (money, fixed assets), entrepreneurship and science.

Since the 19th century, peasants have been the subject of debates, where different representatives of civil society and political subjects have a common issue: land ownership, being a recursive discourse in social life and programs for public policies that manage the welfare of the society of a specific territory (Ortega-Santos et al., 2021; Vergara-Romero & Rojas Dávila, 2019).

Despite the large number of publications, the understanding of history is revitalized in the different ways of management, organization and agricultural production. Each conceptual genesis was taken within the ideological context of the time, where the bases for statistical studies in the 20th century are established. In each stage of the development of society, social scientists expressed their economic points of view, theories on the organization of the State, production and labor relations, always leading a hegemonic thought that undergoes only slight transformations (Augeraud-Verón et al., 2021; Vergara-Romero & Moreno Silva, 2019; Zhu et al., 2021).

From the political economy framework, classical theory claimed the universality of its laws and, from this position, the existence of an agrarian (not to mention, peasant) economic theory could be questioned (Viaggi et al., 2021). The sources of agrarian economic theory are the observations of the economic reality produced by farmers and the discourse about peasants within the framework of management and public discourse (Durham & Mizik, 2021).

The agrarian economy, from its beginnings, was of an organizational and productive nature, since its vision was the search for the laws of the rational organization of agricultural companies or agricultural management, where the subject and object of study are these companies, including those led by the effects of globalization (Li & Cheng, 2021). Similarly, nature and the peasant community were seen from a purely theoretical point of view, studying certain general conditions of their existence and the practice that actually occurs in the process (Kharkwal et al., 2021) as a phenomenon.

It is remarkable to describe the traditional peasant community as vital and long-lived due to its ability to adapt and its dualistic nature, which includes a closed system of self-government, whose function is to make priority and rapid decisions for a well-defined geographical space. The community contains in its structure a set of simpler elements and relationships of all future social structures, based mainly on private property and also on public property (Adams et al., 2021; Josephson & Smale, 2021).

Under these circumstances, a community can live under different social systems, with private property becoming a fundamental element. It is this property, the socioeconomic compatibility of the community with any environment, which orients the adaptability of systems that can benefit its territory. The internal powers of this environment are life, conservation and development, as a goal to reach full well-being (Klerkx et al., 2019; Pozo-Estupiñan et al., 2021; Sed'a et al., 2021).

The community structures will be fully developed from the internal predispositions of the community, the nature and degree of development of the historical environment in which this community and territorial association lives, directly or indirectly. This implies the theoretical and real possibility of turning the stages of social development and shortening a development path (Tsiouni et al., 2021).

The advance of thought led to an understanding of the differences in the market and agricultural economic structure, termed as a populist agricultural economy. Noting that the peasant, in the first place, is not oriented to the market, but with another scale of evaluation of profitability (Girón & Correa, 2020). The regulator of the agricultural economy is the needs of the consumer, which includes feelings of joy, discontent, sufficiency or poverty according to the demands of the individual, from the horizon of their true and imaginary needs (Dobson et al., 2020; Márquez, 2021).

The academy and modern theoretical principles highlight the importance of learning in university classrooms, since it could have negative consequences in the economy, in the preparation of agricultural economists, postgraduate students, young scientists and international cooperation. These consequences can lead to a lack of interest in financing research projects and specialized studies in this field, resulting in a loss of competitiveness in the general economy of certain countries (Wang et al., 2021).

Also, the evolution of economic thought of the agrarian economy describes that this is not an ordinary sectorial science but a special section of knowledge created from a combination of factors, processes and agrarian relations. It is important to highlight that the agrarian economy, in order to be approached in a comprehensive manner, has to evaluate the problems of the industry and the real life of the entire civil society (Du et al., 2021; Souto-Anido et al., 2020).

Agrarian economic theory is designed by concept to solve problems related to the economy and agriculture, emphasizing its objective of formulating laws, economic categories and their definitions. Its theme is objective agrarian relations for future developments in the agrarian sector, where natural factors play a significant role, both in the strict and broad sense, consisting of foundations and applied issues (Malorgio & Marangon, 2021; Staton et al., 2022).

We can understand that the evolution of economic thought is due to factors of change in society, where changes in agriculture are evident. The most practical example is a society with subsistence agriculture which has a subsistence economy. If we analyze time as a variable, we can see how a society with traditional agriculture can evolve into a traditional economy.

Economic thought incorporates time as a variable, as changes in society are continuous. If we analyze agrarian economy as a commercial agricultural model that encompasses the world, then we come to the concept of multifunctional agriculture, developing rural economic thought. By analyzing time, we can also analyze territorial economies for a breakthrough in peri-urban agriculture.

The variables of space and time rooted in economic thought trigger the comprehensive analysis of the evolution and behavior of societies. This type of analysis focuses on finding generic solutions that can be applied to the majority of societies from different countries, in order to draft public policies with the particularities of each territory.

Agrarian economy is not only a complex production system, but also a special communal way of life. Its role lies in the methodological progress of science, the development of agrarian policy, social reforms of rural economic relations, and the unification of fundamental and applied knowledge (Amaro-Rosales & de Gortari-Rabiela, 2016).

Agrarian economic theory is the basis for the development of agricultural markets and more efficient models, and overcoming historical failures. This theory needs dynamism to improve government decisions with regard to subsidies, allocation of funds for the development of engineering and social infrastructure, and protection of the environment (Jenke et al., 2021). It is important to note that it joins all agricultural sciences, as a more efficient system that works on a common complex result (Loor et al., 2018; Vergara-Romero et al., 2020).

The issues of economic growth and overcoming the crisis in the agrarian economy, its stability and instability, continue to be studied in depth and are poorly used in the strategies and perspectives for the development of agriculture and its markets. The order of cycles and phases in the agrarian economy differs from that of the cycles of industrial production, and therefore, different economic measures and mechanisms for its regulation are required (Simionescu, 2021).

Likewise, creating reserve funds and improvements in agrarian science through public policies is relevant. Public policies should focus on results that encompass convincing, concrete proposals, tested by practice and optimized by economic and mathematical methods.

It is established that neoclassical thought focuses on the problems of valuation of natural resource markets, economic interaction in polluting the land, and the application of external effects regulated by the tax system to minimize negative externalities.

Keynesian theory analyzes the arguments of direct regulation of a State, together with the interaction between society and nature. These relationships, which are caused by the nature of society, establish that the Government should implement and control administrative instruments.

Neo-institutionalist theories consider integral solutions to environmental problems, through the strategy of changes in the behavior of civil society, the influence of the Anthropocene on the environment and the creation of new institutions within the state apparatus.

Agrarian economy is designed to monitor and critically evaluate the results of the implementation of agrarian policy, and to strive to create competitive methods to solve emerging problems (Nikol & Jansen, 2021). The tradition of agrarian theory and practice must continue to focus on the complex and simultaneous use of technological, economic, social and legal knowledge. At the same time, the potential for the development of the agricultural sector must grow, not only in technological or economic factors, but also in the legal sphere (Soto-Pinto et al., 2021; Vergara-Romero et al., 2021).

Historical circumstances and scientific advances have merged the agrarian economy with the industry, forming a powerful agro-industrial complex. It includes not only the multiple branches of agriculture and livestock, but also the industries producing agricultural machinery, fertilizers, herbicides, transportation, storage, reprocessing, and business. Currently, the agrarian economy is linked mainly to the agro-industrial complex, based on large, closely interconnected, integrated and grouped social production (Graubner et al., 2021).

An isolated issue, but one that is gaining strength in contemporary times, pertains to the use of human resources in agriculture. Investments in human resources are effective and alleviate the unresolved problems that revolve around the loss of rural population through intensive migration, automation, robotization, intellectual property and creative property (Nowak et al., 2021). It is also essential to point out that a farmer should not be a temporary worker, but should be a highly qualified specialist who lives in the countryside, is healthy, family-oriented and motivated, and leads a healthy lifestyle (Ma et al., 2021; Mier and Terán Giménez Cacho et al., 2018).

When it comes to human capital, its development implies a person's acquisition of new skills that contribute to an increase in labor productivity for the individual and the collective. These include learning basic professional knowledge and skills in the vocational education system (Nguyen et al., 2021).

From the moment production work starts, there is a development of previously acquired qualities, knowledge, skills and abilities. This process continues throughout life through continuing education and production experience (Márquez-Sánchez & Sorhegui-Ortega, 2021). Human capital, acting as an active component of the industry, can not only increase the level of its own capitalization, but also acts as the main factor ensuring the preservation, effective use and increase in the level of capitalization of the entire agricultural production system and rural area as a whole, at the owner, rural household, organization, industry, region or country levels (Song et al., 2021).

In agriculture, the process of development of human capital and the industry are interdependent (Ezquerra et al., 2014; Georgios et al., 2021). The development of rural human capital implies the development of science and new technologies, which also implies the need to broaden and deepen the modern requirements for the development of production.

The system of development of rural human capital is a set of interconnected processes, objects, phenomena that lead to the development of the qualitative skills of the individual used to generate income (Candemir et al., 2021; Llinas et al., 2021; Hanclova et al., 2021). This system is characterized by the presence of stable relationships between elements and groups of elements, dealing with information flows that allow elements with different functions, tasks and coordination of their actions, to achieve their objectives.

In relation to the problems of rural human capital, it is possible to systematize the factors of its effective accumulation (production), circulation and use. The initial accumulation of human capital takes place in a sociocultural environment, whose basic unit is the family. It is precisely from the family that a person takes values that will be basic throughout their later life (Marston, 2021).

The formation of future rural human capital is influenced by the school, the parents and the social environment. The promotion of a healthy lifestyle, the need to receive education and the accumulation of their professional and cultural potential determine the motivation of the child to make constant and determined efforts to climb the social ladder (Noboa-Salazar et al., 2021). The quantitative and qualitative characteristics of human capital in agriculture are formed under the influence of many conditions and factors that, in their cooperation, determine the quality and synergy not only of rural human capital, but also of the region's agriculture as a whole (Baylis et al., 2021; Castellanos Dorado et al., 2021; Pulina et al., 2018).

These parameters of rural human capital are established within economic thought from an economic conception of development, oriented to the human dimension and the rationality of human societies, directing the course towards an environment of equity, social justice and sustainability. This proposal for sustainable human development begins with the exploration of a profound environmental and social crisis, made up of programs that maximize economic and profitable gains.

From the academy and its discourse, human development is analyzed from the dimensions of equity, sustainability, productivity, empowerment, cooperation and security. These dimensions must have a holistic and guiding vision that takes into account the demands of a political, economic and social nature.

Great changes are reflected in the way international organizations make pacts between states. A long-lasting and established document of this nature is the Sustainable Development Goals, which are incorporated into development actions and seek a fair, inclusive, equitable and sustainable society, where its key vision lies in human progress and human capital.

To elevate economic thought, three aspects of the new rurality should be taken into consideration: economic activities, the community and organizations, and its relationship with the urban. Also, human development, democracy, citizen participation, sustainability, welfare processes, and social capital at the local and national levels, must be taken into account.

2.4. Final thoughts

By way of conclusion, we can summarize this essay by saying that, in the history of economic thought and analysis, agriculture at the dawn of production relations is considered an economic activity superior to the others, as it provides the population with the elements they need for nourishment, as proposed by the physiocratic school of thought. Later, with the development of industry and markets up to the technological development and globalization processes of present times, the importance of the agricultural sector changed, both in theory and in practice. Therefore, its role and specific influence in public policies has also changed.

The purpose of this work was to present methodological and theoretical considerations from a broad view of economic theory, which allows us to present elements that contribute to drafting or improving public policy proposals for agricultural activity. These public policies have to respond to new roles, complemented by global politics, and command a restructuring of institutions in the agricultural sector.

However, the institutional composition and its operation with the real agricultural sector must be more evident when creating, maintaining, modifying and evaluating an agrarian public policy, leading to further collaboration of all spheres of the sector.

The purpose of agrarian policies does not have to be limited to the generation of microeconomic and macroeconomic data, but rather, to seek partial solutions that integrate the total well-being of the urban and rural population, the latter being the most benefited due to its scope in rural, urban and peri-urban areas.

It is necessary to make large change in the country's agri-food system to solve the problem of hunger affecting a significant percentage of Ecuadorians, including hundreds of children suffering from malnutrition. It is, therefore, necessary to increase agricultural productivity and sustainable food production through public policies that lower the risk of hunger.

Finally, it is necessary to design public policies, to address the process of productive reconversion, the modernization of traditional crops, food security, food sovereignty, and the definition and implementation of ad-hoc public goods for agriculture. It is also necessary to have a healthy balance between the urban and rural populations.

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CHAPTER 3: DISTRIBUTION OF GREEN AREAS IN CITIES

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3.1. Introduction

Climate change is one of the main problems affecting the entire planet, and there seems to be no end to it in sight, as it is produced mainly by human activity (Aguilar, 2020). Among its causes is the trend towards urbanization of surfaces, due to the development of cities to meet the needs of the population. Urban areas are so large and diverse that it is expected that by 2050, more than 70% of the population will be living in cities (Habitat, 2016).

The poor planning of cities due to the rapid increase in population and the criteria of urban planners about the importance of green areas have led to the loss of large natural areas despite the fact that green areas are the lungs of cities and encourage community integration (MacHarg, 2000). With this growth, environmental, social and economic issues may arise, such as overcrowding, stress, air pollution, noise and various health problems, so green areas appear as a balance between the city and nature. Among the most prominent experts on this subject are Ebenezer Howard, who between 1903 and 1920 built the first garden cities; Frederick Law Olmsted, who developed open spaces such as Central Park around 1910. These works were the starting point from which concepts related to green areas, planning and distribution were developed, such as sustainable design and urban ecology, which guarantees a better quality of life for the community by reducing the pollution that is a natural element of cities.

In cities, we are faced with artificial environments that are inefficient in handling their components and products. An example is the high parameters that are observed when analyzing air quality, such as NOx, SO4, CO2, noise or temperature, all of them the result of poor management of cities in terms of growth, organization, mobility and public space (Rivers, 2015).

The 2018 Paris Agreement reached the conclusion that it is necessary to reduce global temperature as a way of mitigating the impact resulting from human activities. This translates into the way cities develop from the world's various policies tailored to their local needs. Likewise, this means that many cities in the world are working on plans to mitigate environmental pollution while others are working on plans to adapt to climate change, without this meaning that one should follow the other or that they are independent, and both agree that green areas in cities must be included, improved, and adapted (Reckien, 2018).

When cities are planned, they often are from developmental approaches for urban growth. These spaces are often assigned in an organized way and the growth occurs within the plans of the urban planners. In other cases, a city's growth follows the needs of the community, normally settling in risk areas or in areas close to production sites, whether commercial or industrial, in order to be close to sources of work. This increases the need for living space, and also reduces green areas for these communities.

Within cities, green areas can be understood as representations of nature in the middle of the urban setting, where people find recreation, relaxation, meditation or a connection with nature, preventing it from becoming a strange element with which they have no relationship. Without this contact, people develop a distorted sense of nature, under the false belief that it is a shared and inexhaustible resource (Oliveira, 1996).

In the development and growth of cities through territorial planning, a portion of the space must be assigned for green areas. However, the rapid and disorderly growth of many cities in the world, particularly in Latin America, has resulted in these spaces not being respected, amid pressure and competition for habitability. A clear example is Ecuador, where only 10% of housing developments is dedicated to green areas. This is low in relation to the needs of the community, especially if we consider that green areas are used by urban planners for other purposes but are still considered as such (COOTAD, 2019).

The purpose of this work is to understand how the green infrastructure is integrated into the gray matrix. Knowing the forms of growth of the cities and how they distribute green areas allows us to suggest alternatives for integrating green areas within the spaces already consolidated.

3.2. Cities

Cities are structured around three axes: 1. the road network, which changes according to mobility needs, tending to favor vehicular traffic over pedestrians or alternative means of transport, thus increasingly reducing the width of sidewalks or reducing mass transportation; 2. housing units that, depending on the characteristics of population density can be dispersed or mega structures; and 3. public spaces where, according to the needs of the community, they are considered spaces for cultural exchange or sports, rather than for contact with nature (Hermida, 2015; Cortes, 2015). This is where the urban green areas stand out, as they are considered spaces for the conservation of the natural forestry of the area, although many consider them merely landscapes and introduce foreign species to the area, which can cause damage to the land and economic loss.

However, men have built cities for their benefit. Whilst being completely artificial, however, they are "living entities", where everything within them is constantly modified according to the needs or requirements of the environment. The dimensions of this exchange are produced based on the city's size and population density, which in turn determines the levels and quality of life of that population based on elements such as the environment, public health, urban economy and innovation, producing an inclusive society that results in the growth and development of cities (Maldonado, 2012; Scorza, 2021).

Although cities are considered ecosystems, their functioning is rather atypical, since it produces a series of elements that are not considered when studying natural ecosystems. These elements, all products of human activities, affect their quality of life (Vergara-Romero & Moreno Silva, 2019). Green areas offer the opportunity to improve people's quality of life by offering places to connect with nature, as community and recreational alternatives. In addition, it offers a space for urban biodiversity that is enriched by the presence of species from the surrounding ecosystems, which increases the variety outside of the domesticated species humans keep as pets, and lowers the concentration of greenhouse gasses, captures carbon, and reduces temperature and noise (Liordos, 2021).

The social parameters are those that mark the development of cities in terms of expansion, infrastructure, superstructure, movement, among others. There is a tendency towards two types of city growth: 1. compact, or those that, in a single area, group together all the services people enjoy, reducing the need for mobility, but have a negative effect at the economic level as they are densely populated; and 2. Dispersed, or those that tend to spread in an area with low population density and a high demand for resources. In neither case is the effect and weight on the natural systems that surround it considered (Artuduanga, 2017).

3.2.1. The development of the city

Cities are developing in favor of commercial, industrial, cultural, economic and housing purposes. This development forms poles that become increasingly unsustainable due to space and demand for resources, especially in Latin American cities, where the community and its characteristics favor small cities over mega structures that optimize land use (see table 1). Many times, these forms of growth are copied from other places in the world where there's little respect for the community's traditional lifestyle, the area's climate (which could have effects on the forms of mobility), energy management and consumption, distribution of public space, among others (Cortes, 2015; Hanclova et al., 2021: Schlack, 2007).

Table 1.

City development approaches

TYPE	MAIN FEATURE	POSITIVE ASPECTS	NEGATIVE ASPECTS	URBAN GREEN AREAS
Authoritarian	Government and public interests.	Management of basic services and high-concentration infrastructure.	Population overcrowding, unplanned settlements in risk areas.	The minimum, less than 10%, without conservation of natural resources.
Developmental	Centralized in concentric axes with horizontal and vertical growth.	Organized by zones. The inner zone brings together the social and political areas, the economic strip surrounds it, along with small living spaces.	Irregular settlements used primarily for sleeping and exclusive residential areas.	Conservation of natural resources near the urban areas, reducing pressure on resources and reducing imports.
Neoliberal	Economic interests, with industrial poles.	Concentration of housing with horizontal growth, areas far from residential areas.	Low coverage of basic services, mono-structured growth.	Green areas not prioritized as they are not productive, and areas for productive services or businesses are prioritized.

Sustainable	Based on quality of life in balance with natural resources in a lasting way.	Planned with consideration for the environment, communication routes, sources of employment, land use, recreation areas; all within sustainable parameters.	Reduced mobility, losses, vertical growth.	Green areas are developed for public use and as a source of conservation, linking the city with external natural areas.

Source: Cortes (2015) y Scchlack (2007).

These approaches determine the direction in which the city grows. However, they do not determine the way in which the movement of people is supported, which follows industrial and commercial growth, and thus contributes to the development of irregular settlements, as regular ones are financially unattainable. This can be seen in the organization of the city's growth when the spaces are planned, the community has the opportunity to have all the elements that could guarantee a good quality of life. When the city's growth is unplanned, conditions hampering the community's quality of life appear (Ramos-Leal et al., 2021).

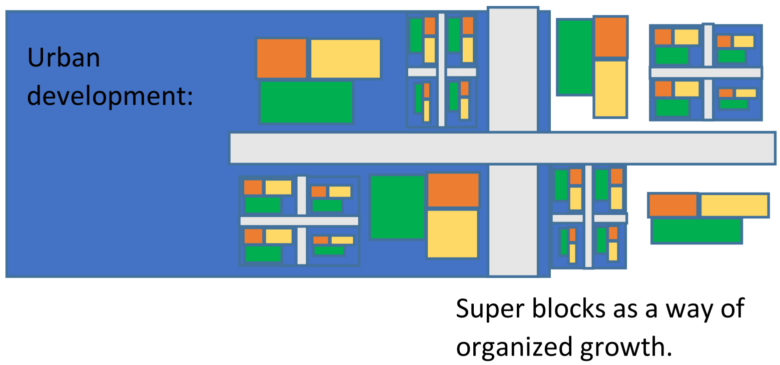
3.2.2. Disorganized cities and their unconsolidated growth

The shape of the growing city is based on the change in land use towards activities other than those of conservation and agricultural production, such as industrial or service areas. When these areas start to grow, areas that do not make any kind of profit are reduced. This is how a city grows by absorbing other small communities, increasing their population and putting pressure on the surrounding ecosystems.

When cities have proper planning and territorial organization, communities have access to all resources and services, making it unnecessary to leave their usual areas. Here, the space for the development of the community is promoted as a unit, prioritizing pedestrianization over vehicular movement, with the appearance of super blocks and an equitable distribution of spaces for cultural development and green integration areas. This contrasts the environmental challenges that arise with cities, bringing innumerable benefits such as good air quality, climate regulation, absorption of pollutants, among others, which will overcompensate the negative effects that green areas have in the city. One of these negative effects is that these areas are usually not equally distributed, which promotes environmental inequalities (Rueda, 2011; Hérivaux, 2021; Vergara-Romero, 2021).

Figure 1.

Organized growth scheme.



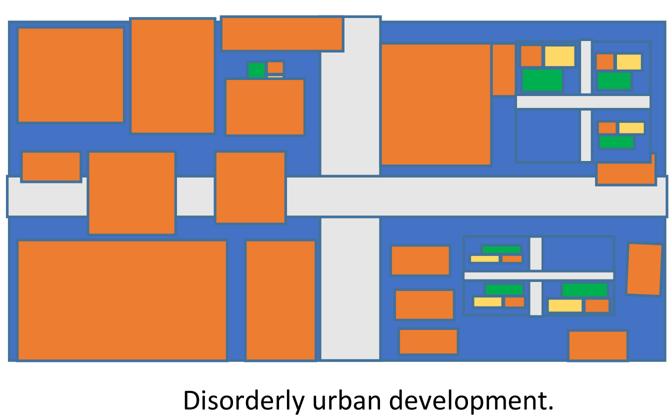
Source: Rueda (2011) y Hérivaux (2021).

As we can see in Figure 1, cultural spaces are integrated with green areas or spaces for physical activities. If alternative forms of transport such bicycles or walking are added to this scheme, residents could experience a healthier environment within a city.

On the other hand, when a city's growth is disorganized, as they move away from the development poles, irregular zones appear for low-income citizens with few green areas due to the need for habitable space.

Figure 2.

Disorderly growth scheme.



As can be seen in Figure 2, habitable areas are prioritized, which creates inconveniences affecting the quality of life of people, mostly in terms of mobility. Also, the distribution of green areas does not allow for people to have spaces to meet and enjoy communal activities, which is an important part of community life. These settlements are usually found in marginal areas, which affects ther natural peri-urban areas, interrupting connectivity. To reduce these obstacles, it is important to incorporate green areas into the urban environment.

3.3. The incorporation of the Green areas

One of the most important parts in a city's development is in the incorporation of green areas. This is often considered in the planning stages for organized sectors and overlooked for unorganized sites. (Is any surface that has at least five square meters considered as green area?) Urban forestry pertains to the trees found on the sidewalks (Carvalho, 2017).

For the planning of cities, three levels are taken into account: 1. the underground, or all those who manage urban services; 2. surface, or water, landscape, biodiversity, use of public space; and 3. elevated, where habitability, energy, mobility are considered, generating spatial segmentation and changes in class structures based on social guidelines. The integration of green areas has been an issue at the surface and elevated levels, due to how limited they are in urban areas in terms of size and distance, and therefore unable to meet the growing demands of residents to interact with nature (Rueda, 2011; Zhang, 2021).

Without the integration of green areas, the community and the city lose their sense of unity. In the case of consolidated spaces, the integration of green areas is difficult because human beings cannot be displaced from their dwellings in order to develop an area that would improve the quality of life of those who will remain. But in areas that are in development and growing unconsolidated, the necessary changes can be made in order to guarantee the presence of sufficient green areas for the community.

The green areas that should be integrated into the development of the city, for the benefit of the community, are described below, classified into three large groups which, properly managed, can lead to other types of solutions that benefit not only the community but also urban and peri-urban diversity associated with mitigation or adaptation plans, according to the development policies of each region.

3.3.1. Superstructures

Superstructures can serve as representative areas of the surrounding ecosystems of the city and allow resting, feeding and protection sites for urban fauna. They are usually medium to large in size and are within accessible distances for the community both on foot and by other means of transportation. They are usually called urban parks, community parks, plazas and squares, linear parks, playgrounds or gardens (Hermida, 2015; Farinon, 2020).

Figure 3 shows an example of a green superstructure in the city of Guayaquil. This shows us the richness and flora diversity a city can host if the planning is handled in an organized manner. Note that most of the vegetation is introduced without taking into account native or endemic species, which could grow even further and connect with other surrounding green areas.

Figure 3.

Example of Green superstructure in Guayaquil

Normally, the design of superstructures takes into account landscape criteria, or parameters established for the exclusive use of green and communal areas. This allows for the appearance of communal spaces in new housing plans that are accounted for as green areas, but do not comply with transforming the area for human use. However, they have a function that is related to some type of activity carried out by the people. These superstructures contribute to the reduction of dust, temperature, noise and filtration of pollutants, which has a positive effect on climate change.

These superstructure-type areas can comprise the bulk of the city's development. However, it should be emphasized that all of these must be connected to each other in some way, as well as with the natural spaces that surround the urban area, reducing the environmental impact resulting from anthropogenic activities.

3.3.2. Infraestructure

Infrastructures can serve as interconnection areas between the ecosystems that surround populated areas and the green superstructures inside the city, turning them from isolated spaces into a whole with the environment. They are not traditionally used by humans, normally going unnoticed (see figure 4). Examples of infrastructures are flowerbeds, roundabouts, tree-lined avenues and pathways, cycle paths, panoramic routes and trees planted on the sidewalks (Ramírez, 2016; Horváthová, 2021).

Figure 4.

Green infrastructure in Guayaquil.

An example of what is considered green infrastructure can be seen in Figure 4, in the urban road of the city of Guayaquil. Note the presence of vegetation accompanied by landscape structures; This plant diversity found here is not always native, which is what should be promoted, but rather meets the criteria of urban planners.

These areas comprise part of the city's growth and architectural style while also fulfilling landscape development by complementing what is found in traditional green areas. They mitigate the harmful effects of the gray area, they serve as a link between the green areas inside the city when they are well distributed, and if they have the right flora they can contribute to climate change.

3.3.3. Transition areas

Transition areas connect the vegetation inside cities with the natural areas that surround them. They are usually found on the outskirts, as protection and conservation areas. They are negatively affected by man-made projects in rural areas, such as nurseries, plantations, agricultural plots, national parks, nature reserves, protective forests, recreation areas, fauna or flora production areas, fragile areas and conservation zones (see figure 5).

Figure 5.

Transition áreas in Guayaquil.

In short, green structures within a city can be grouped in various categories according to the city's needs for growth, and can be superstructures, infrastructures and transition areas. What's interesting about them is that, by connecting them to the natural areas that surround the city (and thus favor urban biodiversity), reinforces the sense of community and mitigates the effects of climate change.

3.4. Alternatives for cities with consolidated disorderly growth

Cities that have disorderly growth or that are developed irregularly do not have the elements that guarantee the quality of life of the community or the tools to face current environmental challenges. In these cases, the pressure for habitable areas exceeds the demand for green areas that can unify the community.

When talking about locating a green area, we can analyze certain parameters, such as diversity, landscape integration, lighting, accessibility, security, activities it allows, infrastructure, environmental contribution (shade, CO 2 capture, oxygen levels, noise reduction, visual pollution, and more. (Rivers, 2015). This is easy to do in organized cities, but it's more complicated in irregular areas, especially when they are already consolidated areas:

3.4.1. Vertical gardens

Figure 6.

Trabsition áreas in Guayaquil.

Vertical gardens are walls turned into gardens. This is a way to turn spaces into green areas. Among the most common are hydroponic systems and green walls. They purify the air, reduce and regulate temperature and promote biodiversity in the city (see figure 6).

3.4.2. Green roofs

These are roofs of buildings that are partially or totally covered with vegetation. They help mitigate carbon emissions, reduce heat island effect and noise, since they also act as acoustic insulation. They can be classified as intensive, semi-intensive and extensive (see figure 7).

Figura 7.

Áreas de transición en Guayaquil.

3.4.3. Green corridors

Green corridors are strips with abundant vegetation that joins outstanding natural areas of the city, increasing the amount of green areas offered to the citizens. They increase biodiversity, help mitigate heat island effect and prioritize both pedestrians and vegetation (thereby reducing noise and pollution). Balconies, windows, roof terraces, patios or dividing walls can be used in order to increase vegetation (Parodi, 2013; Liordos, 2021).

These alternatives are compatible with the environmental and social challenges that arise in cities. Elements of the natural landscape, such as natural watercourses or disused train tracks, among others, can be transformed into corridors through restoration or construction processes, which also leads to an increase in the value of the assets and properties in nearby areas, which benefits the economy (Jiménez, 2013; Li, 2021).

They are multipurpose and multifunctional, as they can also have use in sports, culture, recreation, aesthetics and more. They are oriented towards sustainable development, acting both as biodiversity protectors and a socioeconomic boost. They favor movement, flow and exchange, and also connect landscape elements at different scales (Espinel, 2021).

These are some of the most renown green corridors:

- Manhattan Waterfront Greenway (New York): 51.4 kilometers in length around the island of Manhattan. Today, it has three distinct parts: Hudson River, East River, and Harlem River.
- Parque Lineal Ferrocarril de Cuernavaca (Mexico City): 4.5 kilometers. Contributes to the balance between economic development, heritage preservation and sustainability
- Cheonggyecheon (Seoul): Linear Park of over 400 hectares that managed to lower the average temperature of the area by 3.6 ºC.

In many cases, green corridors are a solution for fragmented cities attempting sustainable development, urban ecology, connection of urban parks with roads, urban forestry, transition areas, gardens and green roofs; they increase the density of species, connect human beings with their natural environment, increase the benefits of natural areas in the city, favor urban biodiversity. In some cases, they can even be used to delimit a city, or as a way to integrate unused spaces. They contribute to use of alternative means of transport and favor many types of activities.

3.5. Conclusions

The growth of cities can affect the implementation of green areas according to the criteria with which the city is developed. It should be noted that development can invariably attract the community outside the planned areas and that these disorderly settlements can bring an increase in the distribution of resources, land use and basic services. They can also affect the transition areas in urban environments or risk areas.

It is important to take into account the organized, disorganized, compact, dispersed, developmental, neoliberal, sustainable city models; the types of displacement (including floating population), mobility with all its alternatives, cultural, sports, meditative recreation and population without forgetting or underestimating the area's climatic, ecosystemic and adaptive characteristics; ecosystemic services that green areas should have, alternatives of size, distribution and connection that promote a union between natural areas and urban green areas.

Regardless of the objective for which green areas in cities are planned, they will vary according to the policies of each region, and the needs of the community or the city, so the planning and development strategies of cities must be improved in order to overcome the current environmental challenges. Alternatives for irregular areas with little planning can help improve the quality of life of these communities by reducing environmental inequalities, thus reinforcing the sense of community.

Cities, as a result of the activities carried out inside them, require a structure with connected green areas in order to to balance the increase in temperature, reduce runoff in the rainy season, and recover the symbiotic relationship with the natural landscape, which allows the flow of urban biodiversity and human beings. It is important to point out that this is the building block of progress and development that focuses on the objective and subjective well-being of territorial planning, taking into account that public policies are oriented to the delimited geographical space that integrates cities and it responds to particular characteristics of said territory.

One of the solutions that are presented as an alternative to the environmental problems arising from urbanization are green corridors, which lead to interconnection of urban green areas of different types, including spaces that have fallen into disuse due to the changes inherent to the city's growth, which would give added value to forgotten spaces, and improve the quality of life of nearby areas. All these elements are being studied in landscape ecology, in order to improve the aesthetics of urban spaces.

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CHAPTER 4: OIL AND NATURAL GAS SYSTEMS IN ECUADOR: AND ESTIMATE OF METHANE EMISSIONS

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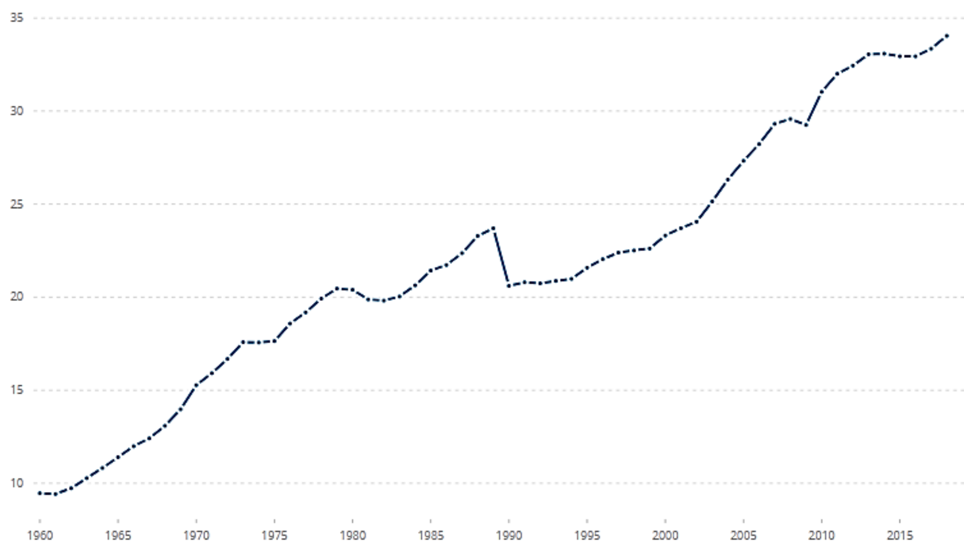
4.1. Introduction

The problem of global warming is caused by the greenhouse effect. Greenhouse gasses (GHG) are atmospheric gasses that retain most of the radiation emitted from the ground, retaining it in the atmosphere. In recent years, anthropogenic activities such as solid waste management, deforestation, burning of fossil fuels, livestock farming, waste generation, agriculture, among others, have increased global warming, causing a series of catastrophes evidenced by the increase in the average ocean and terrestrial atmosphere temperatures (Barboza Lizano, 2013). Studies show that global CO2 emissions (see figure 8), far from stabilizing, have experienced significant growth in recent years (World Bank, 2021). It is known that 97% of the anthropogenic greenhouse effect is caused by six GHGs: Carbon Dioxide (CO2), Water Vapor (H2O), Methane (CH4), Nitrogen Oxides (N2O), Ozone (O3) and Chlorofluorocarbons (CFCs). (León Aristizábal & Benavides Ballesteros, 2007).

Although we can identify all the gasses mentioned above, methane plays a debated role because it is the second most critical greenhouse gas and is estimated to have caused 25% of anthropogenic global warming. Studies show that it has a global warming potential (GWP) 28 to 34 times greater than CO2 within a time period of one hundred years, and 84 to 87 times greater in a time period of twenty years.

Figure 8.

Global CO2 emissions.



The group of experts in charge of quantifying, evaluating and presenting annual reports regarding scientific, socioeconomic and technical knowledge on climate change, its causes, possible repercussions and response strategies, is the Intergovernmental Panel on Climate Change, known as IPCC, created in 1988. This support body established the methodologies to estimate GHG emissions and is periodically updating them in such a way that it allows us to know, in a global context, how much warming each country accounts for. In November 2014, the fifth AR5 evaluation report (Fifth Assessment Report) was completed and approved. It highlights, with certainty, that 95% of the main cause of global warming comes from human activities, and states that the risks will be greater if they are not controlled, which will have irreparable effects on the population and ecosystems (AR5 Synthesis Report, nd) (IPCC, 2015).

Different studies have been carried out to quantify methane in different sectors such as agriculture and livestock. However, few analyses have focused on the oil and natural gas sector.

4.1.1. Methane leakage in the oil and natural gas industry

Most greenhouse gas emissions come from the use of fossil fuels such as coal, oil and natural gas. The growing and demanding extraction of these fossil fuels is exacerbating the problem of global warming due to the constant use of petroleum alloys and their derivatives in most elements of our daily lives. The oil and gas industry represents the largest industrial source of methane, with research indicating that 25% of current warming is due to man-made methane pollution. According to a study conducted by Mexico (Mario Molina Center, 2015), approximately 3.5 trillion cubic feet (98 billion cubic meters) of methane escaped from the global oil and gas supply chain in 2012. The study refers to emissions of unburned methane fugitives, which disappear when pipeline maintenance, leaking tanks or burners (in the oil industry) do not fully consume the gas and leak directly into the atmosphere. The problem is that methane leaks are more harmful and much more powerful greenhouse gasses, causing adverse environmental impacts.

According to the literature, the main sources of leaky methane emissions are found in energy production processes, from oil and natural gas systems, to coal mining (Global Methane Initiative, 2012). Methane, the main component of natural gas, is a much more powerful greenhouse gas when it leaks into the atmosphere. In addition, the use of natural gas (NG) is considered a "bridge fuel" in the transition to renewable energy and has been growing since the large-scale implementation of horizontal drilling and hydraulic fracturing technologies to tap shale resources.

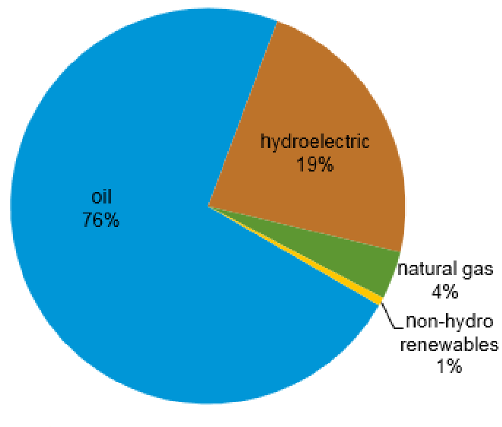
Based on a recent CH4 emissions extract from the well to the end user, (Alvarez et al., 2012) it is estimated that 2.3% of gross NG production in the United States is emitted to the atmosphere. CH4 emissions from the supply chain at this loss rate nearly double the immediate future climate impact of burning NG for energy.

Research also warns that global methane emissions from the oil and gas industry could increase by almost 20% by 2030, compared to a projected 10% increase in carbon dioxide emissions related to energy use (Dlugokencky et al., 2011). The extraction of oil and, to a lesser extent, natural gas, generate important income. However, studies observe that there are high geological risks involved in the exploration of oil and gas that involve the escape of methane. According to the reviewed literature on oil and gas emissions, many authors have focused on measuring emissions from emission sources, such as basins, facilities, abandoned wells (Singh et al., 2021; Waxman et al., 2020), but chain-wide studies of oil and natural gas systems are quite limited.

4.1.2. Main cñimate risk in Ecuador: Energy sector

Figure 9.

Ecuador´s energy sector.



Source: U.S. Energy Information Administration EIA

Ecuador is a mega-diverse country with a privileged location, but it is contemplative in the face of the environmental impacts and conflicts generated by climate change. Ecuador has the third largest oil reserves in South America and is the fifth largest oil producer in this region. In addition, Ecuador's energy mix is highly dependent on oil, which accounted for 76% of the country's total energy consumption in 2016. In October of the same year, Ecuador published its National Energy Agenda 2016-2040, which was designed for the transition of the Ecuadorian energy sector to a more diversified energy matrix (EIA. US. Energy Information Administration, 2021). However, this growth means intense exploitation of natural resources and climate risk (see figure 9).

According to official data from the Ministry of Energy and Non-Renewable Natural Resources (MERNNR, 2020), the country's population increased by 2.5 million people between 2010 and 2020, its GDP had an accumulated increase of 17.4% and energy consumption per capita, in the same period, showed an increase of 33.0%, going from 1,105 kWh per inhabitant to 1,470 kWh per inhabitant. This created a greater demand for energy production coming mainly from fossil sources in Ecuador, with oil being the most important primary energy source. Statistical data shows that, in 2018, the total production of primary energy considering oil exports was 216 million barrels of equivalent oil (BOE); of these figures, 87.5% was oil and only 7.8% was renewable sources.

The critical events caused in recent times by the oil and natural gas industry in the country have caused irreversible damage to both people and the environment. Studies show the correlation between the oil industry and social welfare, especially in areas of the Ecuadorian Amazon. There is evidence of health problems, quality of housing and poverty. Pollution and the propagation of conflicts in oil exploitation areas demonstrate poor environmental management in these sectors and create a hostile environment, generating latent and radical conflicts (Fontaine, 2005). CO_2 emissions are severely linked to the consumption of fossil fuels. Therefore, it is important for institutions to create energy policies to mitigate them.

This concern has been the subject of different studies related to the increase in energy consumption, CO_2 emissions and the policies implemented in recent years in Ecuador. The research of Arroyo & Miguel (2019) includes an analysis of Ecuador's CO_2 emissions and possible scenarios for 2030, and shows that Ecuador does not present an encouraging outlook in terms of economic projections and will not contribute to a decrease in CO_2 emissions, and require necessary policies to improve the quality of life in the country. In addition, the efficiency of the energy required to power a production unit in Ecuador is high, which increases the production of CO_2 emissions. Another study (Robalino-López et al., 2014) analyzes in detail how changes in the energy matrix and the Gross Domestic Product (GDP) would affect Ecuador's CO_2 emissions and underlines the importance of energy efficiency and the reduction of share of fossil energy. On the other hand, it is observed that the technologies used in the electrical matrix of Ecuador that consume locally produced fuels such as oil and natural gas, are inefficient from an environmental point of view, because they are technologies from the 70's (Oscullo & Haro, 2016), which creates great environmental impact.

The objective of this study is to estimate the methane generated during the supply chain of the oil and natural gas systems in Ecuador, within the category of fugitive emissions in the energy sector, to provide an improved general evaluation of the emissions of this supply chain. A national emissions inventory provides the perspective that countries have in terms of emission-capture by sources for the different economic sectors. This will allow identifying the areas of convenience to mitigate emissions by proposing the corresponding reduction measures and their contribution to the national inventory. For this study, historical data from 1990 to 2019 were considered.

4.2. Materials and methods

To learn the environmental impact caused by GHG emissions generated from anthropogenic activities, estimates are made, and it is currently an important practice that is done in most sectors of the industry and in many organizations. In this study, the methodology used to estimate methane (CH4) emissions is derived from the Revised IPCC Guidelines for National Greenhouse Gas Inventories, hereafter (IPCC, 2006).

Based on the Intergovernmental Panel on Climate Change (IPCC) classification, emission factors are divided into three levels, depending on the methodology used to quantify fugitive emissions from oil and natural gas systems (IPCC, 2006). The Tier 1 methodology for estimating emission values was selected for this study due to the limited availability of data on the values of the various parameters and emission factors required for oil and gas systems.

The economic sectors considered as emission sources are those defined by the IPCC in the 2006 guidelines (Vol.1, chap.8): Energy, Industrial Processes and Product Use, Waste and Agriculture, Forestry and Other Land Use. This work provides an improved overall assessment of CH4 emissions from the oil and gas supply chain, which we define to include operations associated with oil and gas exploration, production, processing and transportation, related to the energy sector in Ecuador.

Table 2.

Compilation of subacategories used dor emissions in oil and gas systems.

IPCC Code	Industry Name
1.B.2	Oil and Natural Gas
1.B.2.a	Petroleum
1.B.2.a.i	Exploration
1.B.2.a.ii	Production and Refining
1.B.2.a.iii	Transport
1.B.2.a.iv	Refinement
1.B.2.a.v	Distribution of petroleum products

1.B.2.b	Natural Gas
1.B.2.b.i	Exploration
1.B.2.b.ii	Production
1.B.2.b.iii	Prosecution
1.B.2.b.iv	Transmission and storage
1.B.2.b.v	Distribution

Oil and natural gas systems comprise all the infrastructure needed to produce, collect, process or refine, and bring natural gas and oil products to the market. The system begins at the wellhead, or the source of oil and gas, and ends at the final point of sale to the consumer (IPCC, 2006).

To determine fugitive emissions from oil and natural gas systems, a detailed sector disaggregation recommended in the IPCC guidelines is applied. The industry segments to be considered for the analysis are detailed in Table 1.

To estimate methane emissions by sector, we apply the basic IPCC default standard equations. For this study, total CH4 emissions from the oil and gas industry in Ecuador are calculated as follows:

$$\text{Emission} = A * EF$$

Where:

Emission: Indicates the total CH4 emissions from the oil and gas industry in the year of calculation.

A: Refers to activity data (Activity Data) and describes the magnitude of the activity that results in emissions or removals of greenhouse gasses, which takes place during the year of the period considered.

EF: Emission Factor. Coefficients that quantify gas emissions or absorptions by the unit of activity's data.

IPCC Guidelines provide a comprehensive set of default emission factors (EFs) for oil and natural gas activities. In this research, the IPCC guidelines most appropriate to national circumstances have been selected. In addition, the process to determine emission factors and emission estimates related to the use of the 2006 IPCC Guidelines is addressed, considering that they conform to and incorporate most of the 1996 IPCC Guidelines. After a detailed study, the appropriate parameters are selected for the calculation of the CH4 emission factor in each sector, summarized in tables 3 and 4:

Table 3.

CH4 emission factor (Oil)

Segment	Sub-segment	Value	Uncertainty (% of alue)	Units of measure
Oil exploration	Onshore Conventional	0.02	-30% to +30%	Tonnes/thousand cubic meters onshore conventional oil production
Oil Production	Onshore: Most activities occurring with higher-emitting technologies and practices	3.43	-30% to +30%	Tonnes/thousand cubic meters onshore oil production
Oil Transport	Pipelines	0.0054	±100%	Tonne/thousand cubic meters oil transported by pipeline
Oil Refining	All	0.03	-50% to +130%	Tonnes/thousand cubic meters oil refined
Oil Distribution	Other	NA	NA	Tonnes/thousand cubic meters product consumed

Note: Tier 1 emission factor used for fugitive CH4 emissions from oil operations.

Table 4.

CH4 emission factor (natural gas)

Segment	Sub-segment	Value	Uncertainty (% of value)	Units of measure
Gas Exploration	Onshore conventional Gas exploration	0.06	±20%	Tonnes/million cubic meters onshore conventional gas production
Gas Production	Onshore: Most activities occurring with higher-emitting technologies and practices	4.09	±20%	Tonnes/million cubic meters onshore gas production
	Gathering	3.2	±10%	Tonnes/million cubic meters onshore gas production
Gas Processing	Without LDAR, or with limited LDAR, or less than 50% of centrifugal compressors have dry seals	1.65	±10%	Tonnes/million cubic meters gas produced
Gas Transmission and Storage	Transmission: Limited LDAR or less than 50% of centrifugal compressors have dry seals	3.36	-20% to +30%	Tonnes/million cubic meter gas consumption
	Storage: Limited LDAR or most activities occurring with higher- emitting technologies and practices	0.67	-20% to +30%	Tonnes/ million cubic meter gas consumption
Gas Distribution	Less than 50% plastic pipelines, or limited or no leak detection and repair programsa	2.92	-20% to +120%	Tonnes/ million cubic meter gas consumption

Note: Tier 1 emission factor used for fugitive CH4 emissions from natural gas operations.

4.2.1. Study area

It is important to point out that Ecuador (officially the Republic of Ecuador) has an area of 283,560 km² and a population of more than 17 million (2021) (INEC, 2021). The Ecuadorian territory includes the Galapagos Islands, 1000 km from the west coast and has the densest biodiversity on the planet. To calculate methane emissions from the oil and natural gas sectors, a database of methane emissions organized in detail at the level of subcategories in the oil and natural gas sectors was developed using activity data from the database. data from the International Energy Agency (IEA, 2021), covering the years 1990-2019. In the literature reviewed, the IEA database is widely used as the basis for many methane-related analyses.

Figure 10.

Representative graph of natural gas production in Ecuador.

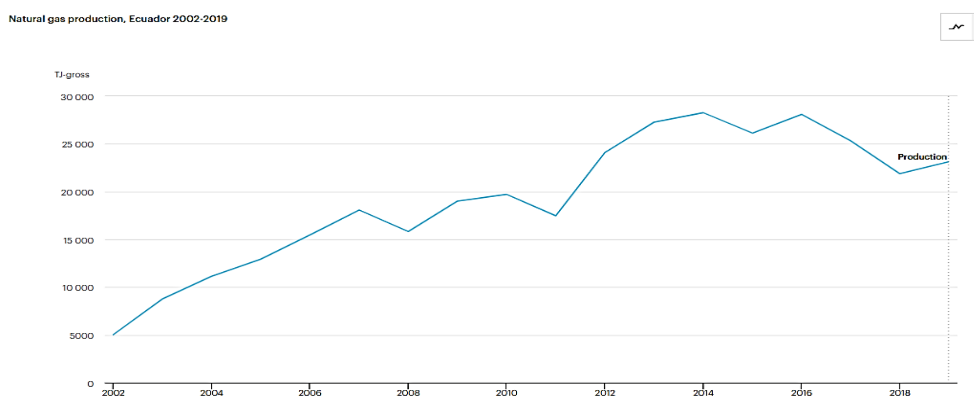
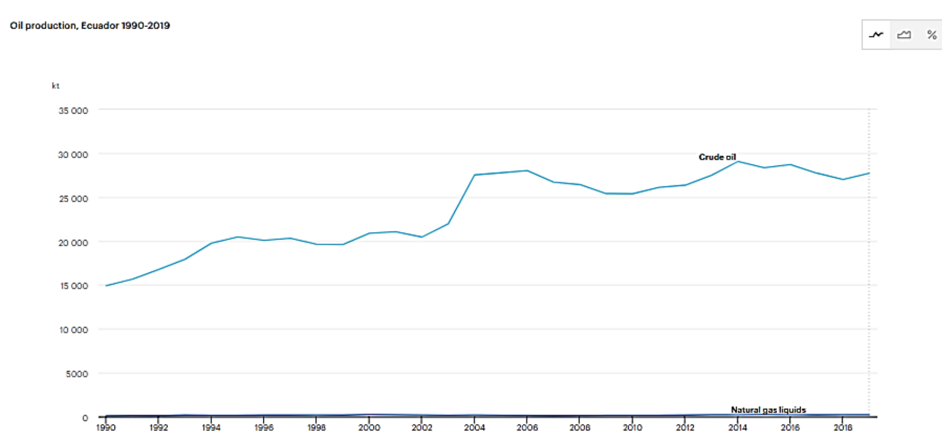


Figure 11.

Representative graph of oil production in Ecuador.



4.3. Results

4.3.1. Oil industry

According to reference materials, methane emissions in the oil industry are calculated from exploration, production, transportation, refining, and distribution, with no emission factor at the distribution stage. Based on currently available data, activity for the oil industry in Ecuador includes production, consumption and consumption of refined oil products; by some accounts, these areas should still be dominated by conventional oil and gas.

Table 5.

Estimates of methane emissions from the activities' categories-Oil.

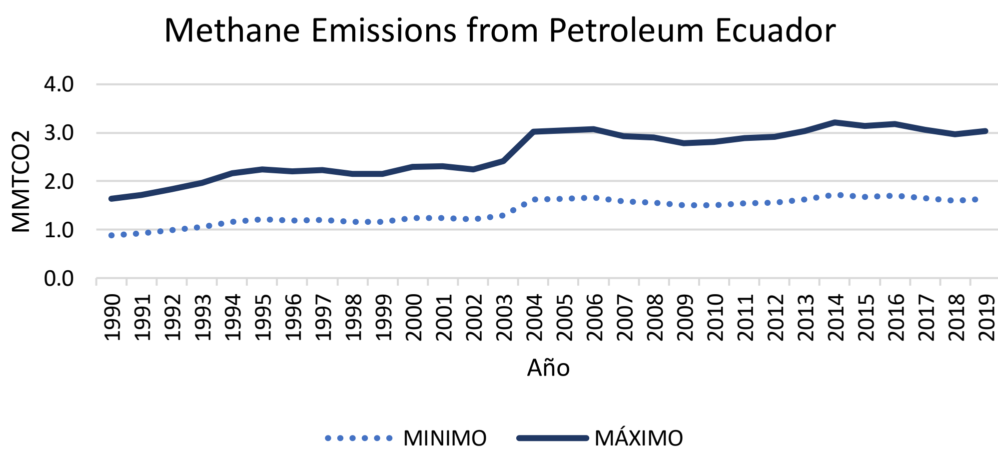
	1.B.2.a.i		1.B.2.a.ii		1.B.2.a.iii		1.B.2.a.iv	
	EXPLORATION		**PRODUCTION**		**TRANSPORT**		**REFINEMENT**	
AÑO	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
1990	0.00511	0.00949	0.87617	1.62718	0.00000	0.00112	0.00000	0.00000
1991	0.00536	0.00996	0.91964	1.70790	0.00000	0.00115	0.00000	0.00000
1992	0.00574	0.01066	0.98426	1.82790	0.00000	0.00112	0.00000	0.00000
1993	0.00614	0.01140	1.05310	1.95576	0.00000	0.00111	0.00000	0.00000
1994	0.00676	0.01256	1.16012	2.15452	0.00000	0.00119	0.00000	0.00000
1995	0.00701	0.01301	1.20183	2.23197	0.00000	0.00116	0.00000	0.00000
1996	0.00688	0.01277	1.17963	2.19073	0.00000	0.00136	0.00000	0.00000
1997	0.00695	0.01292	1.19267	2.21495	0.00000	0.00142	0.00000	0.00000
1998	0.00672	0.01248	1.15290	2.14110	0.00000	0.00138	0.00000	0.00000
1999	0.00671	0.01246	1.15078	2.13717	0.00000	0.00126	0.00000	0.00000
2000	0.00715	0.01328	1.22668	2.27811	0.00000	0.00128	0.00000	0.00000

2001	0.00721	0.01339	1.23696	2.29721	0.00000	0.00141	0.00000	0.00000
2002	0.00700	0.01301	1.20113	2.23066	0.00000	0.00141	0.00000	0.00000
2003	0.00752	0.01397	1.28971	2.39517	0.00000	0.00147	0.00000	0.00000
2004	0.00943	0.01751	1.61671	3.00247	0.00000	0.00154	0.00000	0.00000
2005	0.00951	0.01766	1.63093	3.02887	0.00000	0.00162	0.00000	0.00000
2006	0.00960	0.01782	1.64597	3.05680	0.00000	0.00167	0.00000	0.00000
2007	0.00914	0.01698	1.56802	2.91203	0.00000	0.00168	0.00000	0.00000
2008	0.00905	0.01681	1.55216	2.88258	0.00000	0.00180	0.00000	0.00000
2009	0.00870	0.01616	1.49201	2.77087	0.00000	0.00194	0.00000	0.00000
2010	0.00869	0.01614	1.49054	2.76814	0.00000	0.00203	0.00426	0.01961
2011	0.00894	0.01661	1.53401	2.84887	0.00000	0.00218	0.00427	0.01966
2012	0.00903	0.01677	1.54828	2.87538	0.00000	0.00226	0.00436	0.02007
2013	0.00941	0.01748	1.61378	2.99701	0.00000	0.00238	0.00457	0.02100
2014	0.00995	0.01848	1.70647	3.16916	0.00000	0.00249	0.00493	0.02267
2015	0.00971	0.01803	1.66512	3.09236	0.00000	0.00245	0.00503	0.02315
2016	0.00983	0.01826	1.68597	3.13108	0.00000	0.00240	0.00474	0.02182
2017	0.00950	0.01764	1.62899	3.02527	0.00000	0.00251	0.00472	0.02169
2018	0.00925	0.01717	1.58582	2.94509	0.00000	0.00262	0.00000	0.00000
2019	0.00949	0.01763	1.62787	3.02320	0.00000	0.00000	0.00000	0.00000

For the calculation of the emission factor, the active data unit was unified. The activity data ton/million equivalent tons of oil was multiplied by the corresponding coefficient to convert it to cubic meters, and then multiplied by the emission factor to obtain the methane emission in tons. The conversion of units is preceded again to convert these values to millions of tons of carbon dioxide equivalent according to the guidelines. Table 5 presents the summary of the results obtained in this study for the period 1990-2019 for the oil subcategory corresponding to the category of fugitive emissions from the energy sector. The results indicate that CH4 emissions increase annually. The oil production segment is the one that generates the highest methane emissions, followed by the exploration segment. It can be seen that methane emissions are increasing in the different segments. For example, in 2018 the maximum CH4 emissions of the transport category were approximately 0.00245 MMtCO 2 eq, an increase of 31.30% compared to 0.00180 MMtCO 2 eq in 2008. The main driving force behind this change is the increase in activity data and the trend is also consistent with the trend of change in activity data.

Figure 12.

Summary of methane emissions from the Oil industry within the category of fugutive emissions.



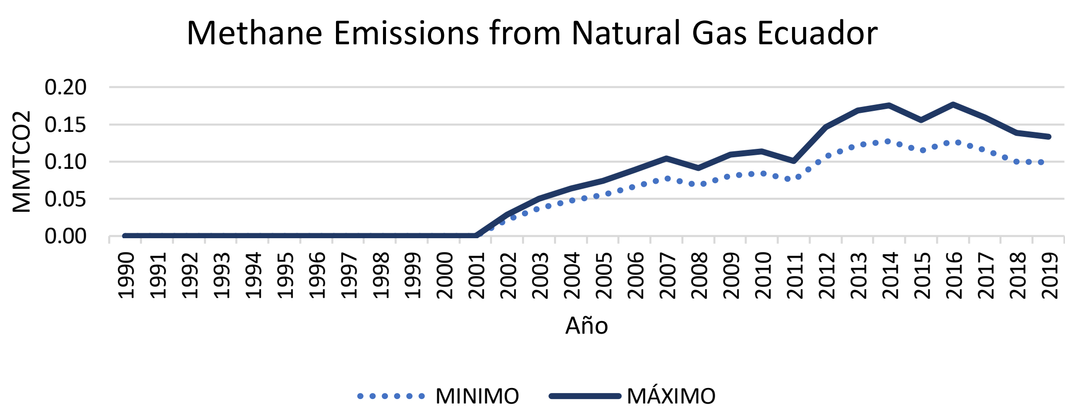
4.3.2. Natural Gas Industry

The calculation of methane emissions in the natural gas industry starts from exploration, production, treatment, storage, transportation and distribution. According to the available data on natural gas, the activity data is also related only to production and consumption. For the calculation requirements, the corresponding emission factor was considered. The basic steps of the calculation can be summarized as follows: first, the activity data unit is unified, then multiplied by the emission factor, and finally converted to millions of tons of carbon dioxide equivalent. The specific results for the study period between 1990 and 2019 of the natural gas supply chain are shown in Table 6.

It can be seen that the segment with the highest proportion of methane emissions was production. In 2019, the maximum CH4 emissions from the production category were approximately 0.0108625 MMtCO2 eq, an increase of 17.82% compared to 0.089268 MMCO 2 eq in 2009.

Figure 13.

Summary of methane emissions from the Oil industry within the category of fugitive emissions.



Figures 12 and 13 show the annual fugitive emissions of CH4 from Oil and Natural Gas, an average annual growth rate (ACT) of approximately 2.16% was observed during the period 1990-2019, in relation to the projected global 15%.

Table 6.

Estimates of methane emissions from the categories' activities - Natural Gas

	1.B.2.b.i		1.B.2.b.ii		1.B.2.b.iii		1.B.2.b.iv		1.B.2.b.v	
	EXPLORATION		**PRODUCTION**		**TREATMENT**		**TRANSMISSION AND STORAGE**		**DISTRIBUTION**	
AÑO	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
1990	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1991	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1992	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1993	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

1994	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1995	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1996	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1997	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1998	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1999	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2002	0.000135	0.000202	0.017239	0.023617	0.004161	0.005086	0.000000	0.000000	0.000000	0.000000
2003	0.000235	0.000352	0.030083	0.041213	0.007262	0.008875	0.000000	0.000000	0.000000	0.000000
2004	0.000298	0.000447	0.038190	0.052319	0.009219	0.011267	0.000000	0.000000	0.000000	0.000000
2005	0.000346	0.000519	0.044353	0.060763	0.010706	0.013085	0.000000	0.000000	0.000000	0.000000
2006	0.000414	0.000621	0.053026	0.072644	0.012800	0.015644	0.000000	0.000000	0.000000	0.000000
2007	0.000484	0.000725	0.061980	0.084910	0.014961	0.018286	0.000000	0.000000	0.000000	0.000000
2008	0.000423	0.000635	0.054233	0.074297	0.013091	0.016000	0.000000	0.000000	0.000000	0.000000
2009	0.000508	0.000763	0.065161	0.089268	0.015729	0.019224	0.000000	0.000000	0.000000	0.000000
2010	0.000527	0.000791	0.067595	0.092602	0.016316	0.019942	0.000000	0.000000	0.000000	0.000000
2011	0.000467	0.000701	0.059892	0.082050	0.014457	0.017670	0.000117	0.000190	0.000085	0.000233
2012	0.000644	0.000967	0.082592	0.113147	0.019936	0.024367	0.002210	0.003591	0.001601	0.004403
2013	0.000729	0.001094	0.093485	0.128071	0.022566	0.027581	0.003268	0.005310	0.002368	0.006511
2014	0.000756	0.001134	0.096889	0.132735	0.023388	0.028585	0.003663	0.005952	0.002654	0.007298
2015	0.000699	0.001048	0.089574	0.122713	0.021622	0.026427	0.001480	0.002405	0.001073	0.002949
2016	0.000751	0.001127	0.096286	0.131908	0.023242	0.028407	0.004184	0.006799	0.003031	0.008337
2017	0.000677	0.001016	0.086798	0.118909	0.020952	0.025608	0.003832	0.006227	0.002776	0.007635
2018	0.000585	0.000878	0.074992	0.102736	0.018102	0.022125	0.003569	0.005800	0.002586	0.007112
2019	0.000619	0.000928	0.079291	0.108625	0.019140	0.023393	0.000000	0.000000	0.000000	0.000000

4.4. Conclusions and recommendations

The estimate made allows us to obtain direct methane emissions (CH4) for the period 1990-2019, disaggregated for the activities concerning the oil and natural gas systems in Ecuador, leading the way for more in-depth studies of emissions from fossil sources in Ecuador. the country.

Methane (CH4) fugitive emissions are increasing by 2.16% annually in proportion to the activity data, with the exploration and production segments as the greatest increase values. In relation to the global 15% projected, we see a significant problem. Under this scenario, the reduction of the consumption of petroleum derivatives should be considered through a change in the electrical matrix in Ecuador using renewable energies, allowing for a reduction in CO2 emissions with the diversification of the electrical matrix.

More attention needs to be paid to oil and gas systems in order to mitigate the spread of methane emissions. The existence of inefficient units from the environmental point of view contributes to the propagation of this GHG, due to the fact that deplorable or quite old technology is used, which makes it necessary, beyond expanding the system, to require a complete technological uphaul in the industry segments and the national electricity matrix.

Another problem we can see has to do with the insufficient levels of investment and financing in both sectors: public and private, in specific programs and projects for mitigation and adaptation to climate change.

The economic wealth of Ecuador is another important issue that influences the emission of these polluting gasses. Although the country has shown a growing trend in national GDP per capita, its economy remains poor, which prevents it from investing in equipment with better energy efficiency technology such as electric or hybrid vehicles, or more environmentally friendly technologies. The technologies used increase the consumption of fossil fuels and the spread of methane emissions.

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