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# Challenges and Opportunities of Urban Fabrics for Sustainable Planning In Cuenca (Ecuador)

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**Abstract.** In recent years attention has been given to the reduction of greenhouse gas emissions, causing climate change, without recognizing the importance of urban form. In Latin American cities, spatial dynamics, urban fabrics and territorial distribution, among others, are not always considered when plans are developed. The cities of Ecuador, particularly Cuenca, show processes of dispersion as a result of their own growth disconnected from urban centers, which is evidenced by the high rate of use of the private vehicle per capita and implies a high consumption of fossil energy and environmental pollution. Additionally, urban fabrics affect the functioning and social dynamics of a city and therefore have a direct relationship with planning. With this background, this project seeks to identify and categorize different urban fabrics in the city of Cuenca using a visual methodology that takes into account street and block patterns; patterns of parcelization and land use; building form, scale and placement on lots; street and parking design; and typical relationships between “green” and “gray” landscape components. As a result, eighteen urban fabrics were identified in the city, with different challenges and opportunities for sustainability. The produced knowledge allowed the generation of sustainable and resilient planning recommendations and opened a wide field of possibilities for future research.

## 1. Introduction

Functioning and spatial distribution of urban fabrics continue to be little-studied subjects in most Latin American cities [1]. The lack of attention to these aspects, suggests problems in urban planning, since its components: streets, blocks, plots and buildings, make up the city and affect its social dynamic [2], mainly in the so-called intermediate cities where urban actors, being unaware of these factors, are unable to integrate effective strategies into planning processes [3]. Several authors [4-5] that have studied urban fabrics stated that urban areas evolution and develop, and its respective functional complexity, have led to the formation of urban fabrics; therefore, they make up the city. Likewise, Kropf [6] considers urban fabrics as a synthesis of all the components, as an organic whole that can be studied at different resolution levels. However, for this research, urban fabrics are considered as areas large enough for individuals to perceive it as a distinctive type of place, and to be adapted to planning and development processes [7]. Urban fabrics, according to their characteristics, present opportunities and challenges for sustainable planning; furthermore, urban fabrics in consolidation process are expanding rapidly and represent a major challenge for planning due to the environmental impact that they produce and the implications they have with transportation [1-8-9]. In addition, getting an adequate relationship between urban fabric and land use is particularly complicated; nevertheless, both



help to determine the sustainability and habitability of an area [7]. The concept of sustainability is quite ambiguous and has evolved over time; however, according to Brundtland [10], sustainable development is understood as the capacity of current generations to satisfy their needs, without compromising the capacity of future generations to satisfy their own. On the other hand, the concept of habitability has different definitions; though many authors agree on concepts related to the quality of life, standard of living [11], social participation, well being, healthy life and pursuit of happiness [12-13]. Cities continue expanding, therefore, several challenges lie ahead, and the reasons for studying urban fabrics in Latin American cities are not only relevant but also emerging. In the local context, research on the subject has not been developed, thus it results appropriate so as to understand urban fabrics and their implications for sustainability. With this background, the purpose of the research is to identify and categorize urban fabrics in Cuenca, in the urban and expansion area (18.678,06 ha) [14], in order to generate urban planning recommendations towards sustainability. Cuenca is located in Andean region of Ecuador, is the third most populated city in the country with 333,888 inhabitants.

## 2. Theoretical background

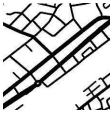


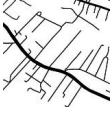








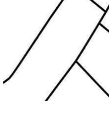








A smart and planned growth will be obtained through a complete understanding of urban form and the necessary policies for each city [15]. Thus, several authors have studied urban form and for its definition take into account different criteria. Capel [4] and Oliveira [5] relate urban form with main physical elements that structure and shape the city: streets, blocks, plots and buildings. Lynch [16] identifies seven aspects of urban form: topography and natural features, built form, uses-activities-movements, control, perceptual/qualitative aspects, energy flows and materials, development and evolution. Solá-Morales [17], developed a theory of the physic form of the city, in which he defines the basic urban form elements: plots, streets, buildings and infrastructure; and the processes that happen over time: construction mechanisms, performance, use, property and transformation. In this way, he states that the different combinations of elements build the urban form. Nevertheless, in each city these elements are merged in different ways, resulting in diverse urban fabrics, which makes each city unique. These phenomena depend on time; they are the result of a construction and development process [4]. Therefore, urban form is mainly a spatial construct inextricably related to development patterns and human activity [18]. However, the vast majority of authors agree on topics such as connectivity, land use types, density, distribution, contiguity and built environment shape [18-19-20]. Wheeler [7] defines urban fabric as an “area of consistent form at a neighborhood scale, often 1 square km or greater. This is an area large enough to determine much of a resident or user’s daily experience, and has a significant influence on shaping resident behavior” [7 p167]. Five main elements determine an urban fabric: a) Street and block patterns. Streets form a network in which nodes are the intersections and streets and nodes configure a geometry that can be repetitive and establish a pattern. Blocks are polygons whose properties are easily measured and are originated by streets design. b) Patterns of parcelization and land use. It refers to what happens within each block. Both are related but don’t depend on each other. c) Building form, scale, and placement on lots. Building form is visually determined; usually related with the function and the context in which it is located. Scale refers to building height in relation to road width. Placement on lots refers to how the building is placed in the plot. d) Street and parking design. Street design is recognized on the street function: highway, avenue, path or other; and the possibility that it offers for other uses such as pedestrian sidewalks and green stripes. Parking design refers to places for motorized vehicles parking. e) Relationships between "green" and "gray" landscape components. It is visually recognized comparing the green spaces with constructed area. Although urban fabrics have the same components, each city presents differences in buildings, blocks, plots and road systems that have developed over time in relation to the place.

## 3. Methodology

The visual methodology developed by Wheeler [7] was adopted. It has been applied in 24 metropolitan regions around the world, presenting a classification of 27 basic urban fabrics. The results from its

application allow performing different comparative analyses between urban fabrics of the same region and between different regions. So, as to apply the methodology in Cuenca, a cultural validation was made. Later, a first observation of the city was completed so as to know which urban fabrics exist in it. Thus, each urban fabric was identified and spatially located. In addition, a classification table was made, which included a brief description of each urban fabric and images of the street pattern, building type and a satellite view of the zone (Table 1). To identify the different urban fabrics, the following tools were used: a) Satellite images available in Google Earth (2017) and Google Street View (2015), with a resolution of 1263x728px; b) Geographic information of Cuenca: streets, plots, urban and expansion area boundaries, facilitated by the Municipality of Cuenca; c) Software ArcGIS to manage geographic information and generate maps; and the software Excel for statistical analyses of the results. In addition, the following considerations were taken into account: a) the minimum area of each fabric to be identified as such is variable, depends on the urban fabric type and the scale of the city. In the case of Cuenca, most urban fabrics do not reach a square kilometer, so a more detailed identification scale was used; b) extensive parks, open spaces, river banks, agricultural fields and unused land, are not contemplated in the classification and will remain as blank spaces; c) individual land uses do not determine an urban fabric type, unless they are very extensive (such as campus, airports or industrial uses level); d) street pattern was the most important aspect taken into account for the identification of urban fabrics; e) the limit of the drawn polygons for each urban fabric was the sidewalk's edge, if it did not exist, then the plot's border was considered; f) highways and main avenues are not included in the classification, so, whenever possible, streets were left free as the limit between different urban fabrics; g) each type has its respective RGB color code.

**Table 1.** Urban fabrics in Cuenca

Description	Street pattern	Satellite view	Street view
<b>Airports:</b> Large access roads, landing strips or parking spaces for transport buses. Land use is commercial, with large-scale terminal buildings and parking. Few green spaces.			
<b>Allotment gardens:</b> Lane access is generally narrow and not paved. Housing units have ample green or recreational spaces; they may also have small agriculture fields. Parking is usually external to the garden area.			
<b>Apartment blocks:</b> Medium and large blocks with moderate connectivity. Multifamily residences with shops or offices on the ground floor. Buildings are relatively tall (at least three stories). Parking lots and little or none green spaces.			
<b>Campus:</b> Internal circulation routes. Single-use large plot (institutional, corporate or recreational). Buildings are scattered on the site, with parking lots and green areas.			
<b>Country roads:</b> It develops linearly following rural paths. Connectivity is deficient, intersections are infrequent and there is no formal block pattern. Long and narrow plots. Single-family homes, small multi-family buildings and some shops. Agricultural fields and open spaces.			
<b>Garden apartments:</b> Access roads to the apartment buildings; however, connectivity is deficient. Large plots of multifamily residences, with parking spaces, and many green and recreational areas.			
<b>Garden suburb:</b> Streets are irregular but well connected. Main avenues could be present within short distances. Single-family residences and some multifamily buildings or shops. Plots are medium size, with retreats and gardens. Parking is on the street or at the entrance. Occasional parks.			

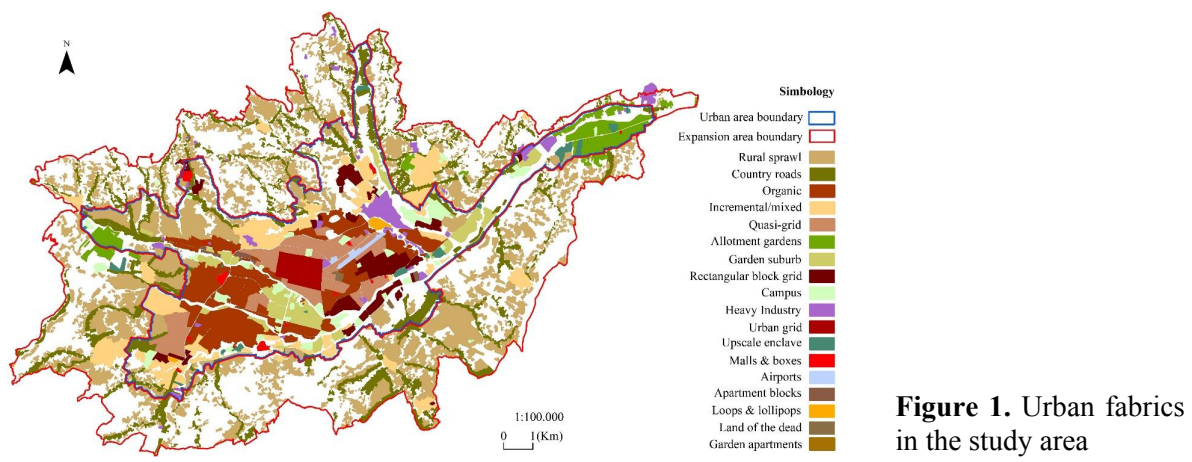
Description	Street pattern	Satellite view	Street view
<b>Heavy industry:</b> Access roads are irregular and blocks are large. Land use is intended for heavy manufacturing. Large-scale buildings, warehouse spaces and parking. Vegetation is minimal.			
<b>Incremental/mixed:</b> Generally rectilinear streets with disordered patterns and bad connectivity. Block's size and shape vary. Single family homes, some multifamily buildings and shops. Density varies between low and moderate. There may be plantations and random green spaces.			
<b>Loops &amp; lollipops:</b> Curvilinear and irregular streets. Land use is mainly single-family residential, there may be multifamily buildings and shops. Plots are homogeneous, and dwellings are usually row houses. Parking is on the street or at the entrance. There may be neighborhood parks.			
<b>Land of the dead:</b> Usually fenced to restrict access from the outside. Single-use large plot (burial). Small services and parking buildings. Abundant green area and trees.			
<b>Malls &amp; boxes:</b> Usually connected to main streets, avenues or highways. Large plot of commercial use with typically low but large buildings. Parking lots and minimal vegetation.			
<b>Organic:</b> Street patterns are irregular and according to the topography with moderate connectivity. Land use is mixed, and density varies from moderate to high. Buildings are diverse in form and scale. Parking lots can be on the street, and there are occasional parks.			
<b>Quasi-grid:</b> Street patterns are rectilinear but irregular, with high connectivity. Block's size and shape vary, and plots are small to medium size. Building's shape is diverse and present small retreats. Green spaces and occasional parking lots.			
<b>Rectangular block grid:</b> Streets form a regular grid of rectangular blocks, with high connectivity. Homogeneous plots of residential and commercial use. Row houses, and some multifamily or duplex buildings may exist. Parking lots are in the street or at the entrances. Occasional small parks.			
<b>Rural sprawl:</b> Few discernible blocks and low connectivity, it is located near urban access roads. Land use is mostly residential, there may be small shops, offices and multifamily residences. Buildings size vary and retreats are present. Lot of vegetation and original ecosystem remnants.			
<b>Upscale enclave:</b> Usually a closed set, with varied street patterns and bad connectivity. Low density. Plots are generally large with exclusive single-family homes. Parking lots are located in adjacent garages or at the houses' entrance. Gardens and communal recreational areas.			
<b>Urban grid:</b> Well-connected rectilinear streets that form a grid pattern. Blocks are small and have a mixed land use. Buildings' size and scale vary, and may have interior patios. There are lots and parking buildings. Formal parks and plazas (civic squares).			

Original source: Wheeler (2015). Image source: Google Earth, Google Street View. Local adaptation: Authors

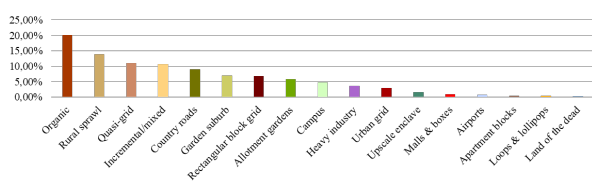
#### 4. Results

Eighteen urban fabrics were identified (Table 1 and Figure 1), out of 27 that Wheeler [7] identified in his analysis. These cover 97.40 km<sup>2</sup> equivalent to 52.15% of the total study area. In order to compare what happens inside and outside of the urban area, the urban fabrics were analyzed separately. Seventeen urban fabrics were identified in the urban area (Figure 2); *Organic* predominates, it is located mainly in the southwest zone of the city and represents 20,07%. *Rural Sprawl* represents the 13,96%, it is located in the city's peripheries, occupies large land extensions and maintains a strong

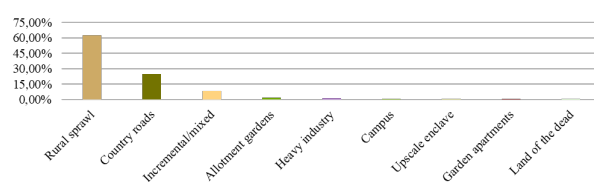
relationship with *Country Roads*. *Quasi-grid* occupies 10,94%, it is mostly located around the city center. Besides, *Incremental/mixed* represents the 10,72% and it is located in many peripheral areas of the city. *Country Roads* occupies the 8,95%, it is the rural sprawl promoter and connects urban areas to the city’s peripheries. *Garden Suburb* occupies 6,94%, it is mainly located close to the city center at the south. Another important type is *Rectangular Block Grid* that occupies 6,84%, it is located at the east of the city, and is similar to *Urban Grid*; however, it has bigger blocks with rectangular form. Even though *Urban Grid* represents 2,92%, it is a traditional urban fabric of the city, and one of the reasons why Cuenca was declared as Cultural Heritage of Humanity in 1999. *Urban Grid* is located in the city center and it is characterized for having mixed-use big buildings (commercial-residential); however, the majority of its residents have moved to other zones of the city. There are also important institutions such as the Government, the Municipality, and administrative offices. *Allotment Gardens* represents 5,83% and is characterized for being located in the city’s peripheries. *Campus* urban fabric occupies 4,92%, it is scattered in the city; and is constituted by mainly four universities, some large educational establishments, and equipment such as coliseums, barracks and museums, among others. Another urban fabric that is easily identified in the city is *Industrial*, which is located at the north and occupies 3,68%; numerous factories and industries are located in this type. Nevertheless, there are also some factories in other sectors, generally away from the city center. Finally, the *Upscale Enclave* has an area that represents 1,55%. This urban fabric is dispersed across Cuenca, and according to Wheeler [7], it could be similar to the *Garden Suburb* type, but more insular. Nine urban fabrics were found in the expansion area (Figure 3). *Rural Sprawl* occupies the largest area with 62,60%. This urban fabric is greater in the expansion area, because there is still a lot of empty space ready to be urbanized. Therefore, cropland and land used for domestic animals breeding and related activities can be found. *Country Roads*, which represents 24,70% is also important. It connects urban and rural parishes. Lastly, *Incremental/mixed* is the third predominant urban fabric that occupies 8,41% and it corresponds to the rural parishes centers.



**Figure 1.** Urban fabrics in the study area



**Figure 2.** Urban fabrics in the urban area



**Figure 3.** Urban fabrics in the expansion area

## 5. Discussion

Each city is different and has its own characteristics; however, there are similar urban fabrics that present analogous behavior despite belonging to different cities. In the case of Cuenca, and comparing it with the results obtained by Wheeler, there are some interesting differences explained because of the large-scale that metropolitan regions have or due to the different cultural behavior. Cuenca is considered an intermediate city in expansion; therefore, in its urban area there are still many empty areas and green spaces. According to Wheeler, nowadays-suburban development prevails throughout the world and corresponds to urban fabrics named as *Degenerate Grid*, *Loops & Lollipops* and *Upscale Enclave*. Nevertheless, in Cuenca, these urban fabrics exist in a fairly small percentage. The growth of these urban fabrics is worrying from the sustainability point of view, for the low densities, connectivity and diversity they present [21]. Furthermore, the private character of many suburban neighborhoods discourages mixed-uses and public spaces use, which have traditionally functioned for community meetings or civic events; and regrettably act against the social dimensions of sustainability [22-23]. *Degenerate Grid*, in all its variants, present rectilinear streets, but the high connectivity and the different land uses has been lost. In the case of Cuenca, this urban fabric was not identified. Rather urban fabrics with high connectivity are still conserved and predominant, especially those closest to the city center. *Apartment Blocks* is very common in urban regions. This urban fabric offers high residential densities considered necessary to prevent land consumption outside the urban area boundary, and to support people's mobilization and local businesses development [24-25]. In Cuenca, *Apartment Blocks* is beginning to spread, however, there also exist numerous scattered residential buildings that could be the beginning of new urban fabrics conformation. Traditional urban fabrics, such as *Urban Grid*, *Quasi-grid* or *Rectangular Block Grid*, constitute a small percentage in twentieth one-century urban regions [7], including Cuenca. In Cuenca as in other Latin American cities, *Urban Grid* constitutes the city downtown, and the other types are located close to it. In most regions, *Rural Sprawl* occupies large areas, and in the case of Cuenca it is predominant. In recent decades, this fabric has grown rapidly as a result of city development and growth, due to accelerated population increase and land speculation [1]. This urban fabric works against sustainability because it consumes large extensions of land, has a low density, is scattered, presents high-level segregation, and as it is located in the periphery, promotes private vehicle use [26-27-28]. The *Mall & Boxes* and *Commercial Strip* were not identified in Cuenca; these are located in the periphery of North America's cities [7]. In Cuenca large-scale malls are found almost anywhere, but in small quantities, since retail stores are still located within *Urban Grid*, *Quasi-grid*, and similar urban fabrics. In general, integration of green and built areas in urban fabrics around the world is uncommon. Most urban fabrics are constructed and expanded, paying little attention to preserving the natural landscape [29]. Urban fabrics identified in Cuenca highlight the urbanization processes that the city has experienced, and has a prevalence of certain urban fabrics different to global results, probably due to its smaller scale. It is important to mention, that urban fabrics found in Cuenca could vary according to the researcher perception; the types presented here are a first step to understand the urban fabrics and their implications in the city.

## 6. Conclusions and recommendations

The urban fabrics identification and categorization in Cuenca allows understanding the city dynamics and, at the same time, permits the generation of sustainable urban planning recommendations. However, there is still a lot to explore. Each urban fabric presents opportunities and disadvantages depending on its characteristics. Some of them, such as *Rural Sprawl*, *Incremental/mixed* and *Country Roads*, offer the opportunity to generate planned, responsible and sustainable development if the appropriate regulations are applied on time. Cuenca is expanding and these fabrics correspond to the 21 rural parishes, which in most of the cases do not have a Territorial plan. On the other hand, *Organic*, *Quasi-grid*, *Garden Suburb* and *Rectangular Block Grid*, can encourage compact growth, that promotes mixed land uses and integration, and diminish private vehicle dependence motivating other mobility modes, like walking, cycling or increasing the use of public transportation [28-30-31]. It is necessary to consider these recommendations not only in the consolidated area, but also in the rural parishes. Nowadays, residents from these sectors usually have to move large distances to work,

study and perform diverse activities, which are generally in the city's center. In addition, in all urban fabrics, the balance between "green" and "gray" must be maintained, there should be an adequate proportion among built and green, recreational or public spaces [32]. In Cuenca, urban fabrics such as *Campus* or *Land of the Dead* offer great possibilities to achieve lower levels of pollution [33]. Additionally, *Allotment Gardens* also promote urban gardens implementation, taking into account that Cuenca is characterized for having an appropriate weather and land for sowing. At the moment of designing and planning, the smallest intervention could generate a change in the city [34]. Before thinking in expansion, it is recommended to consider filling the empty plots in urban fabrics such as *Organic*, *Quasi-grid*, *Rectangular block grid* and *Urban Grid* [1]. In *Urban grid* existing buildings could be rebuilt and reused, offering new habitable spaces [35]. According to Rueda [34], density and compactness are essential in ensuring the city's vitality and habitability. In this sense, it is recommended to encourage the development of urban fabrics such as *Apartment Blocks* and *Garden Apartments*, which should have commercial activities on the ground floor. *Upscale Enclave* should be regulated or discouraged so as to reduce land consumption and its privatization. As well, urban dispersed fabrics should also be prevented because they entail higher resources consumption [26-27]. *Malls & Boxes* should be avoided because according to many authors, including Wheeler [7] and Artmann [36], it is one of the promoters of transport models based on the private vehicle. Likewise, it is important to boost the constructions of efficient, accessible and sustainable buildings in all urban fabrics, so they can be used and adapted according to the changing needs of society [28]. Municipality planners should be informed about urban fabrics so that they can take actions towards sustainability. In addition, they can also assess local regulations, ordinances and design guidelines to ensure that they allow desired urban fabrics composition, and discourage those types that are problematic for sustainability [27]. The challenge is to find a way to promote the most sustainable urban fabrics and, to be able to design and plan a better city for its inhabitants. The identified urban fabrics are flexible, so they are open to other analyses from different approaches or scales, thus, new urban fabrics can be found or the definition of the existing ones can be modified. New research proposals which use free software and new technological tools, are recommended. Topics to be explored in the future are broad: each urban fabric could be correlated with specific sustainability criteria; also, algorithms that automate the identification of urban fabrics for intermediate cities in Ecuador and Latin America could be created, so new comparisons and new planning criteria could be generated.

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