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*Recent urban development in Gijón (Spain). Historic aerial photography as a tool for sustainability assessment of the process.*

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**Abstract**

The digital collection of historic aerial photography, held by the Department of Geography at the University of Oviedo, has proved to be an important resource when analyzing the processes of urban development. Imagery helps us identify the different pieces of urban fabric in their context, and furthermore, to understand how the process of change unfolds. Photo interpretation techniques are used in order to detect the spatial pattern of the new urban developments.

Gijón, in Spain, is a very good example of a Southern European city. Generally, these cities tend to be denser than those in Northern Europe or even in North America. Even today the outskirts in South European cities are not synonyms of low-density residential zones. The built-up area in Gijón has increased over the past decade; as a result, several examples of new urban developments are available today, from densification and suburban infill to urban regeneration policies. The new districts Nuevo Roces and Viesques are pointed out to explain the relationship between urban form and social sustainability. Physical factors such as compact building forms, cycling lanes, surrounding green areas and walkable neighborhoods are complemented by other aspects like social housing, public transport connections and urban design with mixed land use in order to achieve socially-compatible urban areas.

To sum up, our proposal involves the use of historic aerial photography with the purpose of gaining effective knowledge on new urban developments in Gijón.

**Keywords:** urban sustainability, compact city, Gijón, Spain, aerial photography.

## 1. Introduction

Gijón is the largest and most populated city in Asturias, the autonomous region in Northern Spain. The city is located along the coast and the urban development process was triggered by industrialization and its port. During the past century, a huge urbanization process has transformed Gijón from a small town into a port and industrial city; moreover, population soared up from 101.341 in 1940 to 255.969 in 1981.

This fast increase led to an urban growth in spatial terms. This could be studied thanks to aerial imagery, which proves to be a valuable asset not only to make thematic inventories and monitor changes, but also to describe holistic aspects of complex landscapes (Antrop and Van Eetvelde, 2000). Thus, it helps us identify the different pieces of urban fabric in their context, and furthermore, to understand how the process of change unfolds. The digital collection of historic aerial photography, held by the Department of Geography at the University of Oviedo, has proved to be an important resource when analyzing the processes of urban development. The archive holds aerial photographs collected from different flights since the 1940s, which offers the possibility of analyzing urban evolution through time. In the current or older aerial photography, the landscape elements are enshrined with the appearance they had at the time the shot was taken, and among them, traces of past forms of land use and organization can be seen more or less clearly; even if they are recognized in the image, they are no longer related to the process by which they were created (Fernández García, 2000).

The photograms were scanned at 600 DPI for further digital processing with the photogrammetric software Agisoft PhotoScan, which solves the triangulation and the block adjustment of a set of frames in order to perform georeferenced orthophoto mosaics radiometrically and geometrically corrected. As a result, it is possible to integrate them into a GIS.

Taking into account that urban changes mainly happen at a slow rate in relation to the time scale perception of the inhabitants, aerial images constitute a way of being aware of changes (Svenningsen et al., 2015). Therefore, aerial photography can help us perform a reading of inherited urban landscapes, which will be more successful as we gain knowledge of the historical processes shaping the urban landscapes (Fernández García, 2000).

The construction process of Gijón in relation to industry has been deeply studied by Alvargonzález Rodríguez (1977) and Llordén Miñambres (1978). Focusing on the peri-urban areas, Fernández García (1986) suggests the transfer of certain urban functions such as industrial, educational or commercial to the surrounding rural areas and some kind of social aggregation process in these areas; this view is supported by López Fernández (1989), who analyses the income differences and other socioeconomic aspects within the urban fabric. Since the 1980s, Gijón's economy has shifted from one determined by heavy industry, such as metal, coal, shipyard and manufactures, to one dominated by tertiary sector activities, whose spatial implications in the townscape have been reported by Sendín García (1990). In addition to the urban fabric growth, the suburban space has been characterized by the spread of the one-family house, as Alvargonzález Rodríguez (1999) pointed out; this model is related to the urban sprawl, whose guidelines and impacts have been broadly studied in the regional context by Fernández García (2003, 2007).

However, many of the previous studies merely consider the dynamic of urban growth, only a few approaches explored the relation between urban form and its consequences; hence, there is

no previous analysis considering the sustainability of the different urban forms through the use of historical aerial photography in the Spanish context. We aim to address the degree of sustainability of the new urban developments within the suburban space in Gijón through the use of photo interpretation techniques.

## **2. Sustainability and urban form**

Over the past decades, the notion of sustainability has become a plastic word (Poerksen, 2010) in the urban debate around the world, sometimes losing its original meaning. According to the definition by the World Commission on Environment and Development (WCED, 1987), a Sustainable Development is that which meets the needs of the present without compromising the ability of future generations to meet their own needs. One of the problems faced by exploring urban sustainability is the difficulty to set criteria for measuring the phenomenon; some authors have investigated this question and many indicators are offered in the specialized literature. However, in this paper we adopt a theoretical approach based on concepts that take into account urban form, such as compactness, land consumption, public transport and social amenities; and through the use of aerial photography, we can assess urban sustainability within the urban fabric of Gijón.

As the ecological economist Herman Daly (1991) suggests, there are three criteria to assess sustainability:

- Rates of use of renewable resources do not exceed replacement rates.
- Rates of use of non-renewable resources do not exceed rates of development of renewable substitutes.
- Rates of pollution emissions do not exceed the assimilative capacity of the environment.

The Food and Agriculture Organization of the United Nations (FAO) considers the soil a finite resource, meaning its loss and degradation is not recoverable in a human lifespan; consequently, if the rate of land consumption exceeds the pace of soil replacement, we should consider this procedure as unsustainable. For this reason, we regard the compact city model of the continuous built area in Gijón as an example of sustainable urban good practices in contrast with the urban sprawl which is entirely unsustainable.

Exploring the literature related to urban sustainability, it appears that compactness of the built environment is a widely acceptable strategy through which more sustainable urban forms might be achieved, as Jabareen (2006) has remarked; according to him, urban sustainable forms are determined by compactness, sustainable transport, density, mixed land use, diversity, passive solar design, and greening. Some arguments are given to support his statement, such as: better access to public services, more frequent use of public transport instead of private car dependency, as Burton (2000) and Dieleman, Dijst & Split (1999) have pointed out, reinforced by the studies carried out on land management, which prevents urban sprawl and achieves an effective protection of rural areas (McLaren, 1992). Also, reduced energy consumption and others, such as proximity of social amenities, public facilities, walkable environments, and cycling lanes.

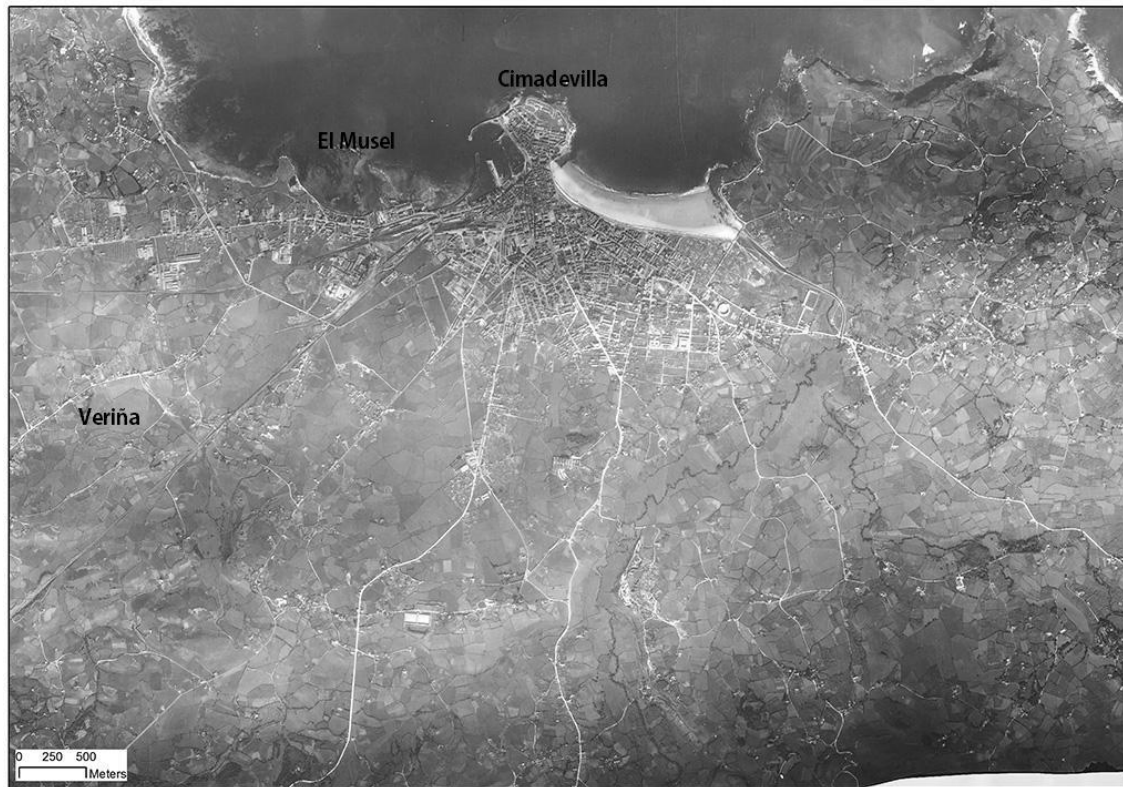
Following the sustainable urban form matrix proposed by Jabareen (2006), Gijón new urban developments can be classified as Compact City, which distinctive concepts are high density

and compactness. The use of aerial photographs provides complementary information in order to identify urban patterns; therefore, complements the lack of empirical findings stated by Jabareen.

Density is only a measure, but it is also a key concept in urban planning. In Spain, before the emergence of the urban sprawl in the 1980s, density carried a negative connotation due to high-density housing promotions, built during the Franco's dictatorship. However, in today's North American and European context, the increase in density is argued to aim to achieve the compact city model, because those cities are generally characterized by low-density residential zones and the spread of urban functions to the suburban areas. Therefore, in the case of Spanish cities, promoting an increase in density could be merely understood in those suburban areas with a similar morphology to the urban sprawl, rather different from the traditional Southern European compact city model.

Some lessons on urban sustainability issues are addressed by several academics and institutions; the Department of the Environment, Transport and Regions (DETR) of the United Kingdom is one of the main stakeholders when it comes to recommending policies or good practices; reports on urban sustainability showing support for increasing residential density in order to use land more efficiently were published periodically (Dempsey et al., 2012). In Germany, the guided principles of a spatial theory are known as Leitbild; thus, a trend or idea is integrated into the scientific debate and the legal framework. Concerning urban sustainability, in the past decade the development of the so called *Das Leitbild der Stadt der kurzen Wege*, the city of short distances, promotes mixed land use and a compact city model to prevent cities with urban sprawl, fostering pedestrian friendly neighborhoods and linking new urban developments to the implementation of public transport. Examples of these practices can be observed in Kronsberg, an eco-neighborhood in the urban fringe of Hannover. Within the Spanish context, the White Paper on sustainability in Spanish urban planning is a similar report to those published by the DETR; this publication provides rules for strategic actions aiming to achieve a more sustainable urban planning in Spain.

### **3. The urbanization process in Gijón**



*Fig. 1: Gijón (1945). The town was witnessing an incipient industrialization and the reduced size of the urban fabric is arranged around the tombolo of Cimadevilla, where the historical centre is located. The urban growth follows the road network, and its surrounding rural area was characterized by agricultural uses. Source: Orthomosaic derived from the photogrammetric flight of the Serie A (performed by the USA Army) 1945-1946. CECAF. Dept. of Geography, University of Oviedo.*

In the 1940s, Gijón was a coastal town with a modest port in the Eastern end of the city. The industry was composed of manufactures, such as tobacco producers; food companies, such as canning factories, cider producers; and other small factories like glassworks, gas factories, wood warehouses and tiles factories, among others. This incipient industrialization was originally driven by private investors linked to coal mining in the Asturian mining areas. Mining and industry were both highly dependent on transport; hence, the authorities supported the connections between railways and the enlargement of the El Musel port. This context fostered the start of an industrialization process which was characterized by the establishment of ENSIDESA, the SOE steel company, in Veriña.

These factors meant a huge demand for workers and therefore for housing. As a result, a rapid urban growth took place during the francoist regime, i.e. from 1937 to 1977; this expansion on the urban fabric was characterized by a failed urban planning; the public investments, the lack of control on the social function of soil and the role of real-estate speculation produced cities based on the so-called Desarrollismo, Developmentalism. The city built during this period is depicted by poor-quality buildings, narrow streets, lack of public facilities, illegal increase in building heights, and the absolute predominance of brick as the building material. Today, the expression Brick-Based economy is still used to depict this sort of behaviors and outcomes.

With the reinstatement of democracy in Spain, municipalities acquired jurisdiction over urban planning; as a result, the first Urban Plan (PGOU) was developed. Gijón City Council addressed its first comprehensive planning instrument between 1982 and 1985, thanks to a team led by Ramón Rañada, whose plan has marked the course of urban planning during the past three

decades. The plan pursued some objectives, such as a compact city model, a better quality of life and a reduction of the damages caused by the organic urban growth inherited from the previous regime. To achieve these goals, the plan presented some strategic plans:

- Densification of urban fabric avoiding the persistence of disjointed urban pieces.
- Improving urban mobility and connectivity between districts and the surrounding rural area.
- An urban regeneration program, especially in those districts affected by urban deprivation and brownfields.

In the absence of a comprehensive conception of urban planning during the Franco's dictatorship decades, the industrialization and the land speculation process characterized Gijón during the second half of the 20th century and determined the current urban morphology; as a consequence, the social structure of their population is strengthened by processes of spatial aggregation, leading to a clear dichotomy between the working class districts in the West and the South, where the port and the industries are located, and the middle and higher-income households in the East. For that reason, the first PGOU had the difficult task to reduce the social disparities and in addition, to develop a city following the principles of a compact city model. Nowadays, the principles of the first PGOU could be understood as a sustainable policy. Gijón is a very good example of a Southern European city. Generally, these cities tend to be denser than those in Northern Europe or even in North America; in other words, Gijón meets the requirements that define a compact city.

However, since the 1970s, the spatial pattern that arose shows a progressive increase in the discontinuous urban fabric. This could be understood as a diffusion of the traditional urban functions to the immediate periphery; the process started when the local authorities tried to reduce the environmental impacts of the industries settled in the urban fabric. The solution proposed gave rise to the industrial parks in the suburban areas. This movement from the inner city to the urban fringe was followed by other functions, such as shopping malls or academic institutions, and so an unstructured suburban space emerged, merely articulated by the road networks. Simultaneously, some residential promotions of single-family and row houses emerged in the outskirts, thus the fulfillment of the periphery in some areas was evident. The expansion process of the single-family and row houses in the East end of the city is evident in the dismantling of a rural and traditional residential area, due to a weak town planning and the interest of real-estate speculation (Alvargonzález, 1990). Despite this spatial pattern, the parish of Somió does not follow the principles of Garden City, since it emerged from a totally unplanned settlement characterized by the private initiative, especially by those who could afford living in the area. Therefore, it is more similar to the sprawl phenomenon, but more precisely, it is the spread of the housing function from the city to its surrounding rural areas, which should be properly identified as an urban diffusion product (Fig. 2).



*Fig. 2: Parish of Somió. Left (1945); right (2011). Located in the Eastern side of the municipality, this rural community shifted from an agricultural use to a residential one. The social aggregation process mentioned before has strongly determined the social profile of this part of the town. The dynamic could be explained due to the weak control instruments in town-planning during the Franco's regime, the will of the wealthier classes to build their own house with a garden and far from the industry and the port, and the interest of real-estate speculation, which since the 1980s has been fostering the consolidation of the urban sprawl model through the introduction of row houses. Sources: Left, Orthomosaic derived from the photogrammetric flight of the Serie A (performed by the USA Army) 1945-1946. CECAF. Dept. of Geography, University of Oviedo. Right, Orthomosaic derived from the photogrammetric campaign of PNOA 2011. IGN.*

To summarize, the built-up area in Gijón has increased over the past decade; as a result, several examples of new urban developments are today available, from densification (Fig. 6) and suburban infill (Fig. 4) to urban regeneration policies (Fig. 5), but also other urban forms like the urban sprawl in the surrounding rural areas. Moreover, the expansive economic cycle in Spain between 1996 and 2007 has supposed a dramatic increase in built-up areas (Fig. 3). For this reason, Gijón, like many cities, is constituted by the interaction of multiple narratives (Massey, 1999) and therefore, the use of aerial photography through time allows us to identify features within multiple space-time configurations.

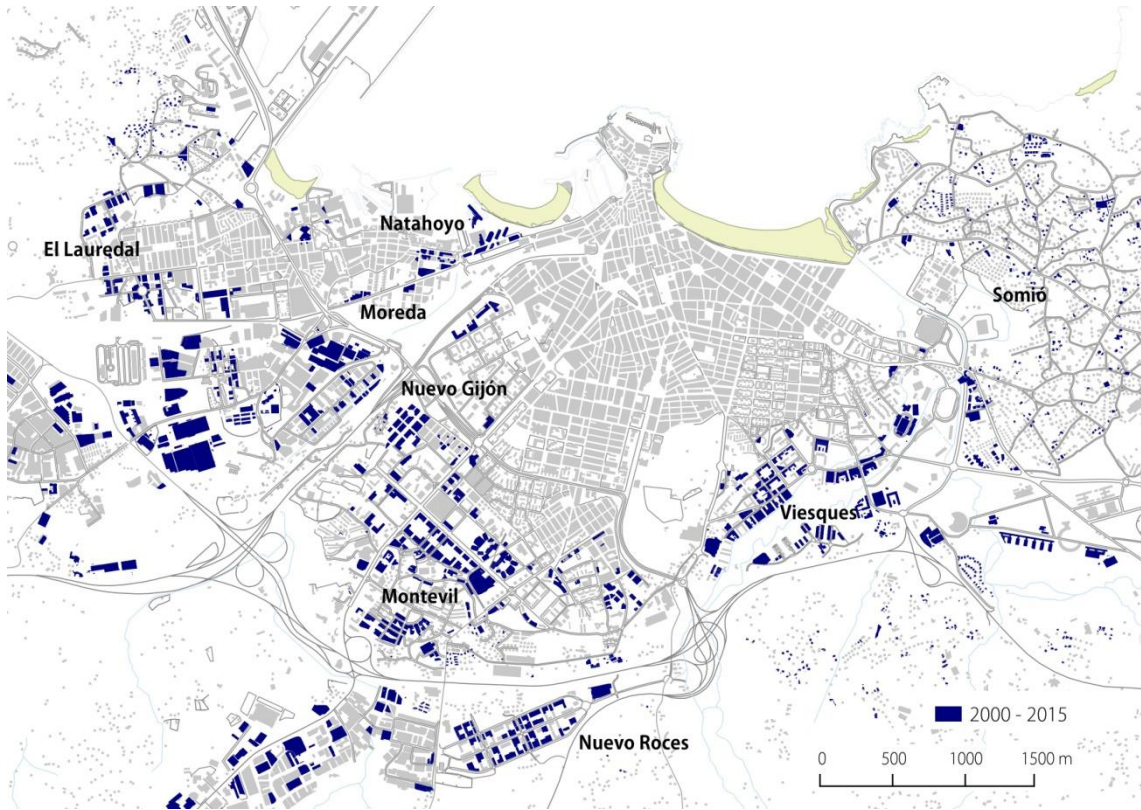


Fig. 3: New buildings built in 2000-2015. Source: Map produced from orthomosaic derived from the photogrammetric campaign of PNOA 2011. IGN and Spanish cadastre.

By using aerial photography, the different classes of urban forms were identified; for example, the urban diffusion or sprawl, the inner city regeneration or the new developments in the urban fringe. Thus, the recognition of the urban forms through photo interpretation techniques allows us to show the dynamic of some suburban spaces within the municipality of Gijón.



Fig. 4: Montevil-Rocés neighborhoods. Left (1970); right (2011). The figure shows the suburban infill process characterized by multi-storey building blocks with several floors disposed in an open-block urban design with mixed land use and a pedestrian-friendly network of paths, in addition to some cycle lanes in the most important streets. The presence of retail, public transport, public facilities and social amenities promotes the social sustainability of the neighborhoods. Sources: Left, Orthomosaic derived from the photogrammetric flight of the Asturian Deputation 1970. Dept. of Geography, University of Oviedo. Right, Orthomosaic derived from the photogrammetric campaign of PNOA 2011. IGN.





*Fig. 5: Moreda-Natahoyo neighborhoods. Left (1984); right (2011). The industrial decay of the 1980s led to important changes within the urban landscape. Thus, some of the old heavy factories were removed from the city. As an example of that process, the Moreda factory was replaced by a new urban development characterized by its compactness, green areas, retail and social amenities. Moreover, the shipyards were gradually dismantled and a new beach was built; simultaneously, some urban regeneration policies have been addressed. Sources: Left, Orthomosaic derived from the photogrammetric flight of the Agriculture Ministry. 1983-1986. Dept. of Geography, University of Oviedo. Right, Orthomosaic derived from the photogrammetric campaign of PNOA 2011. IGN.*



*Fig. 6: Pumarín neighborhood. Left (1957); right (2011). With an open block urban development partially inspired by the Athens Chart, a public housing complex was designed by the State to satisfy the housing demand. This neighborhood was planned with a structure of hierarchical streets and separate itineraries for cars and pedestrians. Sources: Left, Orthomosaic derived from the photogrammetric flight of the Serie B (performed by the USA Army and Spain) 1956-1957. CECAF. Dept. of Geography, University of Oviedo. Right, Orthomosaic derived from the photogrammetric campaign of PNOA 2011. IGN.*

#### 4. New urban developments



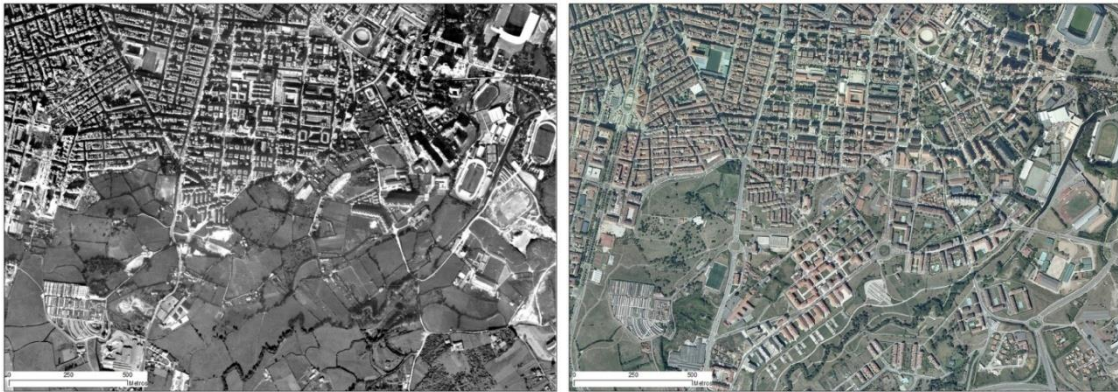
*Fig. 7: Gijón (2011). The city has reached its traditional limits, some of them natural, such as the Cantabrian Sea, Monte Areo in the West, the Piles River in the East, and the highway in the South, which was considered an urban limit until a few years back. The aerial photography shows different pieces within the urban fabric such as industrial zones, open blocks, planned urban expansion, green zones and a rural area scattered with traditional houses and the urban sprawl phenomenon placed in the East side. The new urban developments are both highlighted in the figure, Viesques (orange) and Nuevo Rocés (purple). Source: Orthomosaic derived from the photogrammetric campaign of PNOA 2011. IGN.*

Aiming to avoid the persistence of urban sprawl around the built-up area, the town council assumed the role of planning new urban developments based on the principles of the compact city model and fostering sustainability policies, both strongly related to the strategic lines drawn by their first comprehensive plan designed by Ramón Rañada. By focusing on two of them, Viesques and Nuevo Rocés (Fig. 7), we intend to shed light on the relationship between urban form and social sustainability. Physical factors such as compact building forms, cycling lanes, surrounding green areas and walkable neighborhoods are complemented by other aspects like social housing, public transport connections and urban design with mixed land use in order to achieve socially-compatible urban areas.

Holding 5.642 inhabitants, Viesques is a district located in the South end of the city; its urban design is determined by the floodplain of the Piles River, which serves as an axis and as a park (Fig. 8). High quality materials are used for the buildings and there is no public housing; therefore, the social structure is characterized by middle and high-income households. The urban form is well integrated within the green areas and it is a pedestrian-friendly environment; however, there are some social demands unfulfilled, such as more public transport connections and measures for relieving traffic. Due to the proximity of the highway, there are two streets that channel the traffic flows. The neighborhood construction started in 2000 and since then,

some signs of social sustainability were developed, such as a nursery school, retail in the ground floor, primary school, cycle lanes and a Neighborhood Association.

Gijón is well known by its civil associations, partly due to the industrialization and the trade unions; thus, there are several organizations in fields like culture, politics, sports, environment and also neighborhoods; for this reason, it is common to find this sort of citizenship engagement.



*Fig. 8: Viesques neighborhood. Left (1984); right (2011). The integration of housing, commerce, public facilities, and retail embedded in green areas with pedestrian ways near the Piles River floodplain is achieved with a high-quality urban design. This new urban development is characterized by the real-estate promotions where no public housing was included; therefore, there is no heterogeneity in the social structure. Sources: Left, Orthomosaic derived from the photogrammetric flight of the Agriculture Ministry. 1983-1986. Dept. of Geography, University of Oviedo. Right, Orthomosaic derived from the photogrammetric campaign of PNOA 2011. IGN.*

Holding 3.842 inhabitants, Nuevo Rocés is located South of the highway (Fig. 9). This barrier supposes a problem on pedestrian accessibility; as a consequence, this is one of the neighborhood's demands. In 2004, the Gijón town council and the Asturian government developed a joint project that exceeded the continuous urban form defined in the South by the highway for the first time. This urban development coped with a double challenge: on the one hand, the lack of soil qualified as developable by the PGOU, and on the other, the increase in housing prices, as SOGEPSA –the public-private partnership society that performed the promotion– declared. 3.700 homes were projected; between 2008 and 2015 only 2.300 were built. This new urban development is characterized by their mixed social structure due to the presence of price-limited public housing, hence affordable.



*Fig. 9: Nuevo Rocés. Left (2003); right (2014). The grid layout and the urban compact form are well equipped with pedestrian paths and cycle lanes, green areas, retail, and a nursery school. Sources: Left, Orthomosaic derived from the photogrammetric flight of the Government of Asturias. 2003. Right, Orthomosaic derived from the photogrammetric campaign of PNOA 2014. IGN.*

Apart from the accessibility deficits, some issues arose because of the recent construction, such as lack of public facilities like a pharmacy, schools, and medical services. In contrast, the urban design is determined by a grid layout that is economically efficient in the provision of urban services like water supply or energy. The neighborhood is equipped with pedestrian paths, parks and cycle lanes and also endowed with public transport connections and a nursery school, a key factor for the young population. As mentioned before, the civil organizations are commonly established in the different urban districts. In spite of the recent construction, Nuevo Rocés has its own association as well.

Further studies should be performed in the future if the planned eco-neighborhood Eco-Jove in the Western end of the city is built at last.

## **Conclusions**

The industrialization and the consequent organic urban growth led to an unstructured urban fabric, characterized by a clear dichotomy between the working class districts in the Western end of the city near the port and where the industry was mainly located, and the Eastern end, where the housing function is predominant. Since 1977, the Spanish municipalities acquired jurisdiction over urban planning and the first urban plans were carried out. The first urban plan developed in Gijón shows different policies regarding urban sustainability, such as urban regeneration of the inner city and the pursue of a compact city, avoiding social disparities.

The digital collection of historical aerial photography helps us analyze the process of urban development, and therefore perform an effective reading of inherited urban landscapes. The use of photo interpretation techniques allows us to map the city growth in the past decades and especially in the past fifteen years, when some new urban developments were built. Historic aerial imagery could serve as appropriate tool to identify ineffective planning instruments and the disorganized urban growth in other cultural contexts where the huge consumption of soil has a major social and environmental impact.

We focused particularly on Viesques and Nuevo Rocés, examples of compact city developments. Both are characterized by a high-quality urban design with good integration in the suburban area. Notwithstanding some present shortcomings and considering the early analysis performed, there is some evidence that leads to the conclusion that these new developments follow some principles of the urban sustainability theory; for instance, public transport connections, green areas, a pedestrian-friendly environment, social mixed structure, and most importantly, in our opinion the compact form, which is more sustainable when it comes to consumption of land, a finite resource not recoverable within a human lifespan.

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