

MAPPING THE URBAN FORM. COASTAL FISHING VILLAGES IN ALGARVE. OLHÃO AND VILA REAL DE SANTO ANTÓNIO

M. Pacheco, I. Navarro-Amezketta, T. Heitor

ABSTRACT

The paper examines the urban growth patterns of two coastal fishing villages in southern Portugal: Olhão and Vila Real de Santo António. The goal is to investigate the relationship between the configurational and network properties of their urban forms in order to identify generative or emergent patterns, understanding their particular morphology. The Space Syntax Theory, applied to the syntactical modelling of these cities, is used to understand the urban processes. Topologic variables are calculated by DepthMap Software, to model the evolutionary trends and to identify generic rules using the Theory of the “Deformed Wheel”. The main results demonstrate a contrast between the segregated network of the Olhão's irregular centre and the integrated network of V. R. Santo António's regular centre, revealed by the value of integration variable. The urban expansion of these cities during the last decades decreased the value of integration and aggravated the legibility of the city.

1 INTRODUCTION

The coastal fishing villages in Algarve, Portugal, suffered an intense urban evolution during the last four decades. One of the reasons was a growing demand for leisure and tourism areas, the economic changes from an economy based on the fishery to the tourism, resulting in a very specific kind of urban evolution, that has not been studied yet.

This research examines urban morphology of two fishing villages on the coast of Algarve – Olhão and Vila Real de Santo António (V. R. Santo António) – in order to identify the spatial typologies that characterize the urban fabric.

By analyzing the configuration and shape of the urban form evolution, this research enables understanding the morphological characteristics of the historic fishing villages. This real diagnosis of the urban villages' evolution links quantitative approaches to the traditional urban history analysis and develop a functional urban morphology method to use in future urban interventions.

This study has the follow specifics aims: 1) To calculate the variables of the two cities configuration: the qualitative variables of the irregular and regular urban structure, and quantitative variables connectivity, integration and intelligibility; 2) To analyze the results of the two cities configuration and to identify the sectors of the “Deformed Wheel Model” (Hillier, 2005); 3) To compare the cities according with the actual urban configuration and the two stages of evolution; 4) To interpret the four urban examples according to the intelligibility of the network and the quality of the urban space.

The chosen method is based in the Theory of Space Syntax (Hillier, 2005). The “Syntactical Modeling Analysis” procedure includes topologic variables like line length, connectivity, integration and intelligibility, used to model the evolutionary trends and to identify generic “rules” of an urban growth. The Theory of Space Syntax is applied in the

DepthMap Software, generating a group of digital information and allowing the comparison between past and present urban network of both cities.

The theory of the “Deformed Wheel Model” assumes that the urbanism's evolution of the city is similar to the structure of a wheel. By representing the integration's variable values, from red to blue, it is find the main integrators lines (red, orange and yellow) with a “hub”, or, at least, an intersection of integrated lines at the centre or near it, integrated “spokes”, which link the centre to the “edge” and an integrated “rim” of edge lines. The wheel forms the dominant pattern of public space, where is the commercial area, while the interstices' areas are more residential, with gradations between the two, which relates the urban form with the social and economical life of the town. The model represents the overcoming of the natural tendency for centres to become segregated as the city grows around them by linking centres to the edges (Hillier, 2005).

2 MATERIALS AND METHODS

The investigation follows a comparative method for the study of a population composed by four urban settlements, corresponding to two cities, Olhão and V.R. Santo António, in two different periods: one on the beginning of the 20th century, and the other in 2015. These cities were selected because of their geographic proximity, similar parameters of population and area and different configuration of urban form.

Olhão is a fisherman's town built between the 18th and the middle of 20th century, although the first settlements go back to 16th century. Its historical centre presents a homogeneous urban fabric characterized by an irregular tissue of narrow streets, contrasting with the regular further urbanization of the agricultural areas (Fig. 1a).

V.R. Santo António is the southern Portuguese village, characterized by a regular urban tissue, a grid, planned and built in the last quarter of the 18th century, after the earthquake of 1755 (Fig. 1b).



Fig. 1 Aerial view of Olhão 2015 (a) and Vila Real de Santo António (b).

(Source: Image ©2015 Google Aerodata International. Surveys Cnes/Spot Image Digital Globe, GeoEye, IGP/DGRF).

This research aims to validate two hypotheses: 1) The urban development of the city influences the value of intelligibility, consequently the quality of the city space; 2) the configuration of the coast fishing villages in Algarve follows the model of the "Deformed Wheel" defined in the Space Syntax Theory (Hillier, 2005).

The Space Syntax's variables involved in this study are separated in three groups:

1) "Urban form and distribution" analysis:

- Shape of urban fabric as a qualitative nominal attributes, that can be continuous or discontinuous, measured in each neighborhood type;
- Morphology of axial map as a qualitative nominal attributes, that can be regular or irregular network, measured in each neighborhood type;
- Intersection type as a qualitative nominal attributes that can be with perpendicular or oblique angles of the crossroads.

2) "Topology" analysis:

- Connectivity as a quantitative discrete attribute with average, minimum and maximum values, measured in each city;
- Integration as a quantitative continue attribute with average, minimum and maximum values, measured in each city;
- Intelligibility, in function of connectivity and integration correlation, measured by the quantitative continues coefficient of determination (R^2), which varies between 0 and 1.

3) "Deformed Wheel Model" (DWM) analysis:

- Line count as a quantitative discrete value, measured in each sector of the DWM (1 for the most integrated line, 2 for the integration core, 3 for radius on centre, 4 for radius on periphery, 5 for arch lines, 6 for integrated residential in the core, 7 for segregated residential in the core, 8 for integrated residential on periphery arch and 9 for segregated residential on periphery);
- Percentage of lines as quantitative continuous, measured in each sectors of DWM;
- Mean Integration as quantitative continuous, measured in each sectors of the DWM;
- Mean Connectivity as quantitative continuous, measured in each sectors of the DWM;
- Intelligibility, in function of connectivity and integration correlation, as a quantitative continuous coefficient of determination (R^2), which varies between 0 and 1, measured in each sectors of the DWM.

Using digital cartography of the cities, it was drawn the lines representing the urban structure and imported to the DepthMap Software, where lines were transformed into the Axial Map, the "graph analysis" were run and calculated the descriptive statistics of each topologic variable, such as count, mean, maximum, minimum, standard deviation and sectors diagrams. For the correlation between two quantitative variables, such as Intelligibility (Integration/Connectivity), it was used the graphics "Regression Plot" and "Coefficient of Determination" (R^2).

3 MAIN FINDINGS AND RESULTS

3.1 "Urban form and distribution" analysis for the two cities and urban stages

The city of Olhão has continuous urban shape with an irregular morphology and oblique's intersections (table 1), while the urban core has a continuous urban shape with two kinds of network: regular network with perpendicular intersections and irregular network with oblique intersections, where public space is a result of the dwellings constructions. The beginning of Olhão was a settlement next to the shoreline and the port, where the fishery activity happens. The shoreline determinates the development of the city to north, a rural area, where the reticule layout of the farmland areas originates a semi-regular network. The development of the urban network occurred from the shoreline to north, characterized by discontinuous occupations with irregular network and oblique and orthogonal intersections.

It is an area of low density of lines per m². However, next to the shoreline, the urban core maintains the continuous shape, with regular and irregular sectors and higher density of lines per m².

The V. R. Santo António's core is a regular urban plan, with perpendicular streets organized in a hierarchic system. However the regular network, the urban form has some discontinuities in its core, due to the placement of squares instead of streets, according with the urban plan. The urban development of the village followed an axis from the shoreline to the interior areas at west, in a discontinuous form and creating two kinds of network: the regular ones next to the shoreline and perpendicular intersections of the streets and the irregular network in interior areas with oblique intersections (table 2).

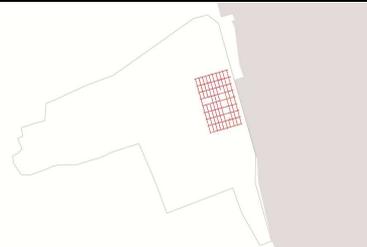
Table 1 Values of topology variables.

TOPOLOGY										
Cities	Line count	Connectivity				Integration				Intellegibility R ²
		Mean	Min.	Max.	Standard deviation	Mean	Min.	Max.	Standard deviation	
Olhão (historic centre)	217	3,96	1	14	2,15	1,28	0,82	2,14	0,2	0,33
Olhão (urban area)	1044	3,09	1	31	2,42	1,08	0,49	2,07	0,25	0,17
V. R. S. António (historic centre)	23	7,56	1	11	2,88	2,75	1,38	3,72	0,86	0,75
V. R. S. António (urban area)	388	3,44	1	50	4,06	1,50	0,71	3,11	0,38	0,32

The historic centre of V. R. Santo António presents the highest mean connectivity value (7,56), but concerning to the actual city, the value lower to half (3,44). The regular plan (perpendicular system with long axis) allows more connections between the streets. Olhão, with an irregular urbanism in both stages of the evolution, maintain the mean connectivity value (around 3).

The actual city of V. R. Santo António presents the “maximum connectivity” value (50), consequence of the urban development around a principal axis (E.N. 125/Av. dos Bombeiros) that crosses entire city. The mean connectivity value concerning to Olhão and V. R. Santo António today's urban form decreased due to the urban development based in the tourism scenario (“sun and beach” requirements and “second residency” tendency, i.e.). V. R. Santo António historic centre has the highest value of mean integration (2,75). Its orthogonal network explains the high integration of a big number of streets into the system. Both actual cities decreases the mean integration value, specially V. R. Santo António (1,50), due to the urban development based in the tourism economy. Concerning to the intelligibility variable (R²), V. R. Santo António historic centre intelligibility is almost the maximum (0,75 of 1), although the actual Olhão has the lowest intelligibility value (0,17) indeed, like actual V. R. Santo António. Both cities decreased R² almost half of the value. The variables integration and connection are directly related with intelligibility value of R. The highest values (near 1) means that the city is highly apprehended and the orthogonal network contributes to understand the city easily. The new urban network, result of the tourism expansion worsened the intelligibility of the cities.

Table 2 Values of “Urban form and distribution” variables.

URBAN FORM AND DISTRIBUTION					
	Urban morphology	Shape of urban fabric	Axial map morphology	Intersection type	
	Urban sectors	(continuous or discontinuous)	(regular or irregular network)	(T or X)	
Olhão (historic centre)	1	red	Cont.	Irreg.	X
	2	orange	Cont.	Irreg.	X
	3	yellow	Cont.	Irreg.	X
	4	light green	Cont.	Irreg.	X
	5	green	Cont.	Reg.	T
	6	dark green	Cont.	Reg.	T
	7	light blue	Cont.	Reg.	T
	8	blue	Cont.	Reg.	T
	9	dark blue	Cont.	Reg.	T
		Summary	Continuous	Irregular/ Regular	XT
Olhão (urban area)	1	red	Cont.	Irreg.	X
	2	orange	Cont.	Irreg.	X
	3	yellow	Discount.	Irreg.	X
	4	light green	Discount.	Irreg.	X
	5	green	Discount.	Irreg.	T
	6	dark green	Cont.	Irreg.	T
	7	light blue	Cont.	Reg.	T
	8	blue	Cont.	Reg.	T
	9	dark blue	Cont.	Reg.	T
		Summary	Discontinuos/ Continuous	Irregular/ Regular	XT
V. R. S. António (historic centre)	1	red	Discount.	Reg.	T
	Summary	Discontinuous	Regular	T	 Figure 4
V. R. S. António (urban area)	1	red	Discount.	Reg.	X
	3	yellow	Discount.	Irreg.	X
	4	light green	Discount.	Irreg.	X
	5	green	Discount.	Irreg.	X
	6	blue	Discount.	Reg.	T
	9	dark blue	Discount.	Reg.	T
	Summary	Discontinuous	Irregular/ Regular	XT	 Figure 5

3.3 Analysis of the “Deformed Wheel Model” sectors

A reading of the urban structures of Olhão and V. R. Santo António topological variables are presented in the next tables (table 3, 4, 5 and 6). It is aimed to do a comparative analysis, to identify the similar and different patterns between the two periods of evolution and the two cities. The first comparison, between the two periods of evolution – beginning

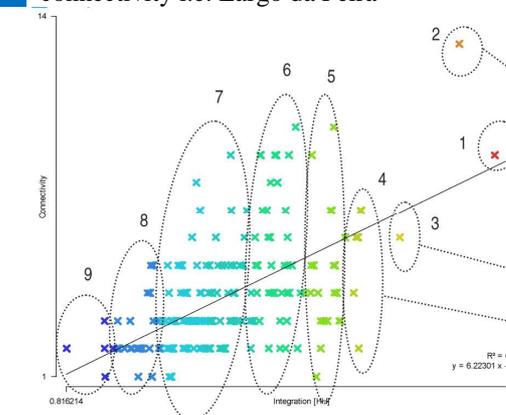
of the 20th century and in 2015 – for each city, allows the identification and quantification of the urban axis' position inside the syntactic modeling of the global integration. A second comparison is done between the two historic core and the actual urban area.

The historic centre of Olhão presents a main concentration of axis (53%) in the category of “low integration and connectivity”, meaning a low intelligibility of the nucleus. Actually, the main concentration of axis (33%) occurs in the category of “median integration and low connectivity” and also decreasing for the same period the axis of “low integration and connectivity” (17%). It is supposed that the urban expansion happened in this period was done following long axis and a regular allotment (see tables 3 and 4).

Table 3 Sectors of the “Deformed Wheel Model” in the Olhão historic centre.

Olhão (historic centre) Streets	Lines Count	Mean Connecti- vity	Mean Integra- tion	Intelligibi- lity value R ²	Diagram of Integration sectors
1 Highest integration and connectivity i.e. Av. 5 de Outubro	2	11,5	2,08	-	
2 High integration and connectivity i.e. Rua Conserveira	1	13	1,92	-	
3 High integration and median connectivity i.e. Rua da Feira, Rua de S. José	1	6	1,75	-	
4 Median integration and connectivity i.e. Rua Manuel Tomé Viegas Vaz,	7	5,43	1,64	0,17	
5 Median integration and connectivity i.e. Rua das Lavadeiras, Rua Gil Eanes	22	4,45	1,54	0,026	
6 Median integration and low connectivity i.e. Rua 18 de Junho, Rua Dâmaso da Encarnação	39	5,38	1,40	0,016	
7 Low integration and connectivity i.e. Av. da República	11	3,48	1,21	0,078	
8 Very low integration and low connectivity i.e. Rua José Saramago	25	2,48	1,02	0,122	
9 Highest segregation: very low integration and lowest connectivity i.e. Largo da Feira	5	2	0,91	-	

- 2,02<i<2,14
- i= 1,92
- i=1,75
- 1,62<i<1,65
- 1,49<i<1,60
- 1,35<i<1,48
- 1,09<i<1,34
- 0,96<i<1,08
- 0,82<i<0,95



Graphic 1

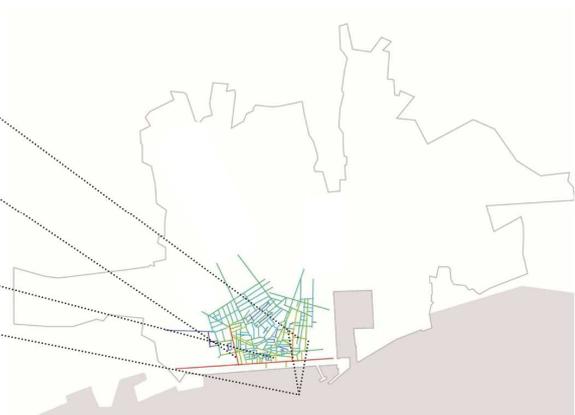
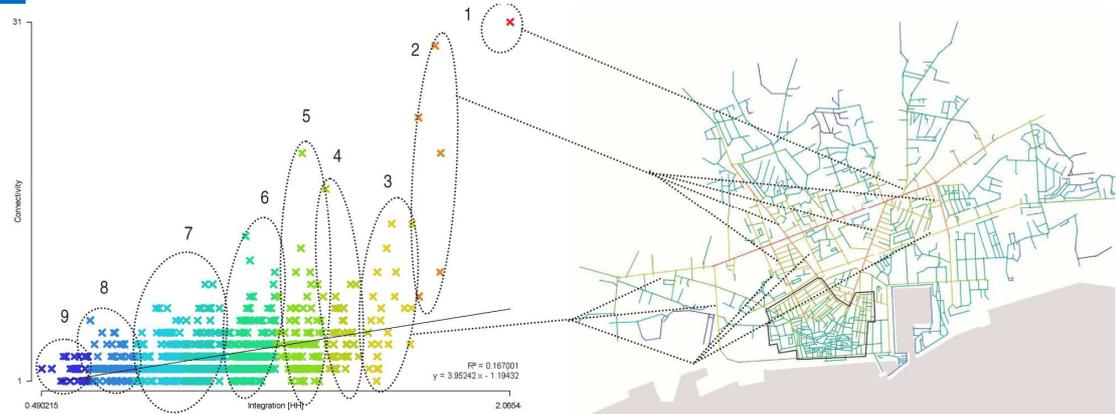
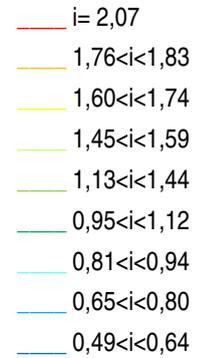


Figure 6

Table 4 Sectors of the “Deformed Wheel Model” in the Olhão actual urban area.

	Olhão (actual urban area) Streets	Lines Count	Mean Connecti- vity	Mean Integra- tion	Intelligi- bility value R ²	Diagram of Integration sectors
1	Highest integration and connectivity i.e. N-125	1	31	2,07	-	
2	High integration and connectivity i.e. Rua Almirante Reis, Dâmaso da Encarnação, 18 de Junho, Av. da República	5	18	1,80	0,017	
3	High integration and median connectivity i.e. Av. 5 de Outubro, Rua de Serrinho, Calouste Gulbenkian	31	5,16	1,64	0,287	
4	Median integration and connectivity i.e. Rua Caminho de Ferro, Av. Dos Operários Conserveiros, Av. 16 de Junho	56	4,21	1,50	0,003	
5	Median integration and connectivity i.e. Rua da Feira, Estrada de Quelfes	344	3,39	1,26	0,027	
6	Median integration and low connectivity i.e. Bairro dos Pescadores, Rua Cerca do Júdice, José Saramago, Azinhaga da Patinha	286	2,81	1,03	0,030	
7	Low integration and connectivity i.e. Urbanização do Turolhão, Bairro do Neves, Bairro 28 de Setembro	182	2,45	0,88	0,015	
8	Very low integration and low connectivity i.e. Bairro Novo, Bairro do Barreta, Bairro dos Sete Cotovelos	110	2,14	0,74	0,007	
9	Highest segregation: very low integration and lowest connectivity i.e. Urbanização Zona Alta	29	1,97	0,60	-	



Graphic 2

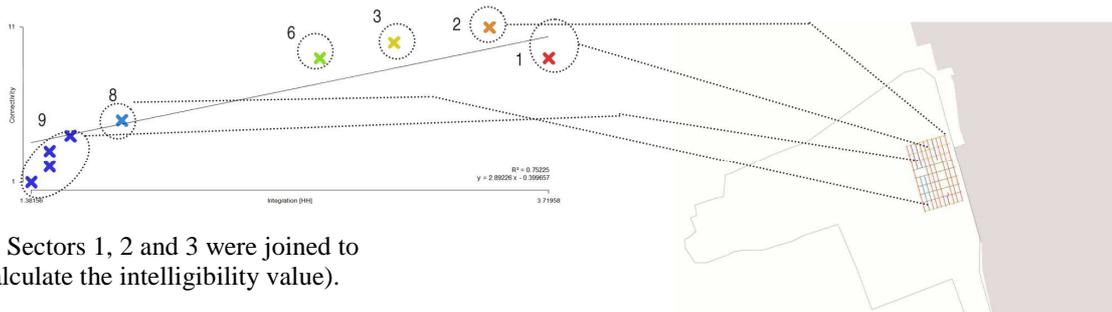
Figure 7

The historic centre of V. R. Santo António presents the mainly concentration of axis in two opposite categories: the “highest integration and connectivity” (31%) and in the opposite extreme “low integration and lowest connectivity”, which means the highest segregation (22%) (See table 5).

For the actual urban area of V. R. Santo António the concentration of axis prevails in the category of “low integration and connectivity” (26%) and “median integration and low connectivity” (23%), also occurring a decrease of both predominant categories in the urban centre, analyzed before, “highest integration and connectivity” (0,5%) and “low integration and lowest connectivity” (6%). The potential of integration for the historic centre is due to the configuration of the regular urban network, and the changes of the urban characteristics for a predominant structure with lower integration and connectivity, is a result of the urban expansion around just one axis (Rua dos Bombeiros/N125) as well as the new allotments following an alike regular geometry (see table 6).

Table 5 Sectors of the “Deformed Wheel Model” in V.R.Santo António historic centre

V. R. Santo António (historic centre) streets	Lines Count	Mean Connecti- vity	Mean Integra- tion	Intelligi- bility value R ²	Diagram of Integration sectors
1 Highest integration and connectivity i.e. Av. da República, Rua da Princesa José Barão, Jornal do Algarve Benemérito, Dr. Sousa Martins, Almirante Cândido dos Reis, Dr. Oliveira Martins, Jacinto José de Andrade	7	9	3,72	0.79*	
2 High integration and connectivity i.e. Rua combatentes da Grande Guerra	1	11	3,45		
3 High integration and median connectivity i.e. Rua 25 de Abril, de Ayamonte, Dr. Manuel de Arriaga, do Conselheiro Frederico Ramires	4	10	3,02		
6 Median integration and low connectivity i.e. Rua Dr. Teófilo Braga, 5 de Outubro	4	9	2,69	0,925	
8 Very low integration and low connectivity i.e Rua Don Pedro V, Dr. António de Passos	2	5	1,79	-	
9 Highest segregation: very low integration and lowest connectivity i.e Infante D. Henrique, Dr. José Francisco Guimarães, Barão do Rio Zézere	5	2,8	1,49	-	



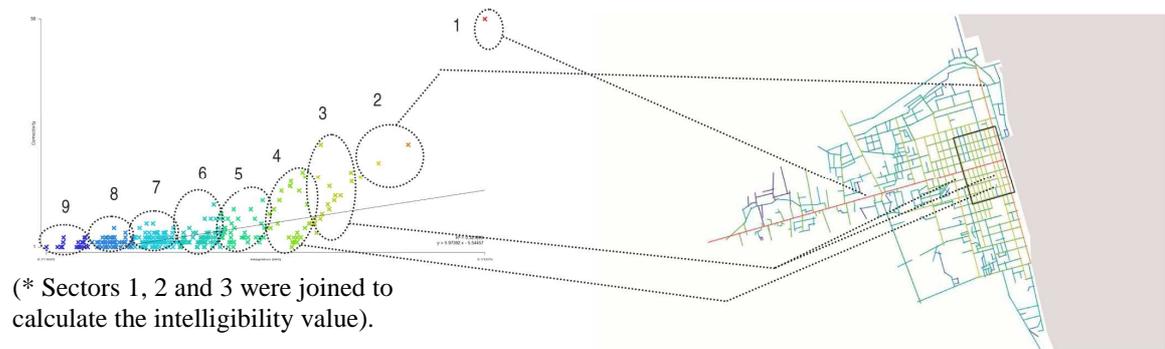
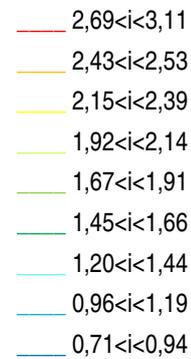
(* Sectors 1, 2 and 3 were joined to calculate the intelligibility value).

Graphic 3

Figure 8

Table 6 Sectors of the “Deformed Wheel Model” in V. R. Santo António actual urban area.

	V. R. Santo António (actual urban area) Streets	Lines Count	Mean Connecti- vity	Mean Integra- -tion	Intellig- ibility value R ²	Diagram of Integration sectors
1	Highest integration and connectivity i.e. Av. Bombeiros, N125	2	36,5	2,90	-	
2	High integration and connectivity i.e. Av. da República	2	17,5	2,48	-	
3	Median Integration and connectivity i.e. Av. Ministro Duarte Pacheco, Rua Jornal do Algarve, José Barão,	17	10,76	2,25	0,275	
4	Median integration and connectivity i.e. Rua de Angola, Francisco Sá Carmeiro, Prof. Egas Moniz	46	4,74	2,06	0,002	
5	Median integration and connectivity i.e. Rua do Exército, de Ayamonte, Dr. Manuel de Arriaga, da Armada	46	4,07	1,76	0,003	
6	Median integration and low connectivity i.e. Rua das Comunidades Portuguesas, M511, Rua H, João de Deus	89	2,7	1,56	0,055	
7	Low integration and connectivity i.e. M511, peripheral streets	102	2,35	1,31	0,006	
8	Very low integration and low connectivity i.e. Bairro do Estádio	62	2	1,08	0,020	
9	Highest segregation: lowest integration and connectivity i.e. Bairro Nossa Sra de Fátima	22	1,64	0,87	0,063	



(* Sectors 1, 2 and 3 were joined to calculate the intelligibility value).

Graphic 4

Figure 9

Comparing the global integration values for the two historic centre and for actual urban area urban area, it is perceptible a similarity between the concentration of main axis in the categories of “low integration and connectivity” and “median integration and low connectivity”. The count of these categories, Olhão and V. R. Santo António presents 50% and 49%, respectively, showing uniformities.

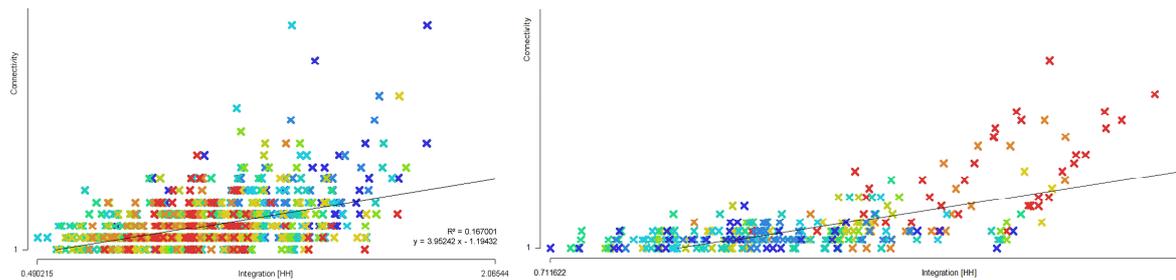
4 DISCUSSION

As seen before, the urban development of the city influences the value of intelligibility and consequently, the quality of the city space. A low integration is representative of the

irregular networks, characterized by a network with huge number of small segments of streets and oblique intersection, displaying a low intelligibility (R^2), low integration of core's sector, and consequently a low quality of public space, like reflected in the study of Olhão, where public space was the addition of the houses plotting, excepting the only integrated street, next to the port, reflecting its economic value (see graphic 5a).

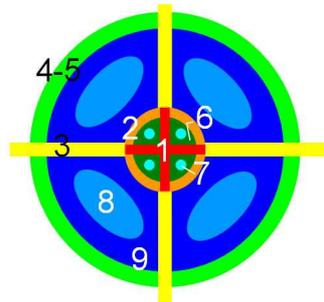
In the other hand, the orthogonal networks display a system of long axis and perpendicular intersections (reducing the number of streets segments), high integration and consequently high intelligibility, translated in an easy approach to the public space (see graphic 5b).

Graphic 5 Intelligibility of Olhão (a) and V. R. Santo António (b), actual urban areas.



a) Different urban sectors in a mixed distribution. b) Different urban sectors in an organized distribution.

The “Deformed Wheel” pattern of the integration values was applied to interpret the urban evolution of the coast fishing villages. The theory was adapted to a “Perfect Wheel” illustrative diagram (figure 10), permitting to synthesize the axial maps of cities' integration into a “Map of Wheel Sectors”.



1. Most Integrated Core
2. Integration Core
3. Radio
4. Periphery Arch
5. Arch
6. Residential Center Integrated
7. Residential Center Segregated
8. Residential Periphery Integrated
9. Residential Periphery Segregated

Fig. 10 “Perfect Wheel” illustrative diagram.

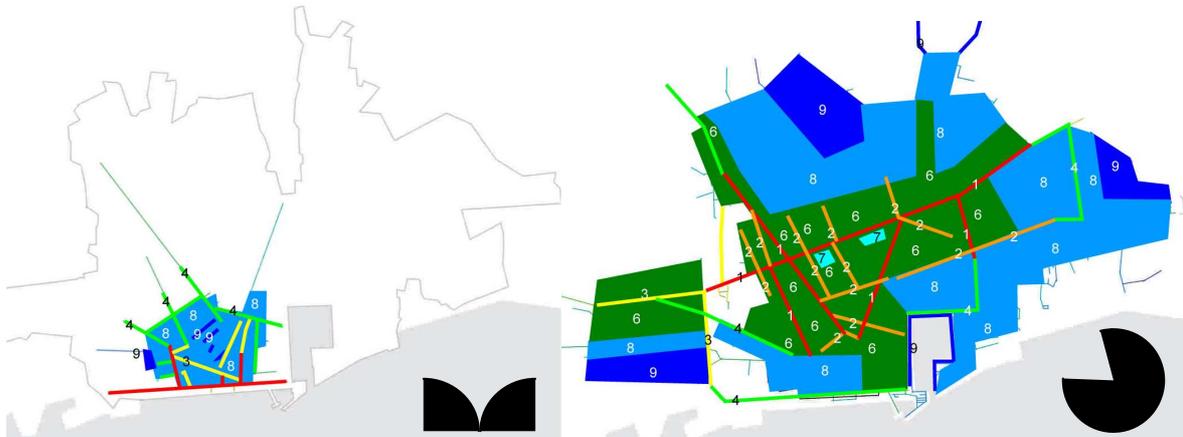


Fig. 11 Deformed wheel sectors in Olhão historic centre (a) and Olhão 2015 (b).

The historic centre of Olhão presents two symmetrical quarters of the “deformed wheel”, composed by two opposite integrators on the perimeter area of the residential centre, crossed by the two radius of each quarter and periphery connected by the arches (fig.11a). The urban evolution of Olhão promoted the displacement of the integration core to north, imposed by the coastline, centering it and creating almost a complete “deformed wheel”, with integration core on the centre, a few arches on periphery and a potential growing sector to complete de wheel (see figure 11b).

The historic centre of V. R. Santo António presents an incomplete wheel, only with the central integrated core, without periphery arch or radius (see figure 12a). However, the urban evolution to the west, imposed by the coastline, originated a half “deformed wheel”, with a defined integrator axis, periphery arches and residential areas (see figure 12b).

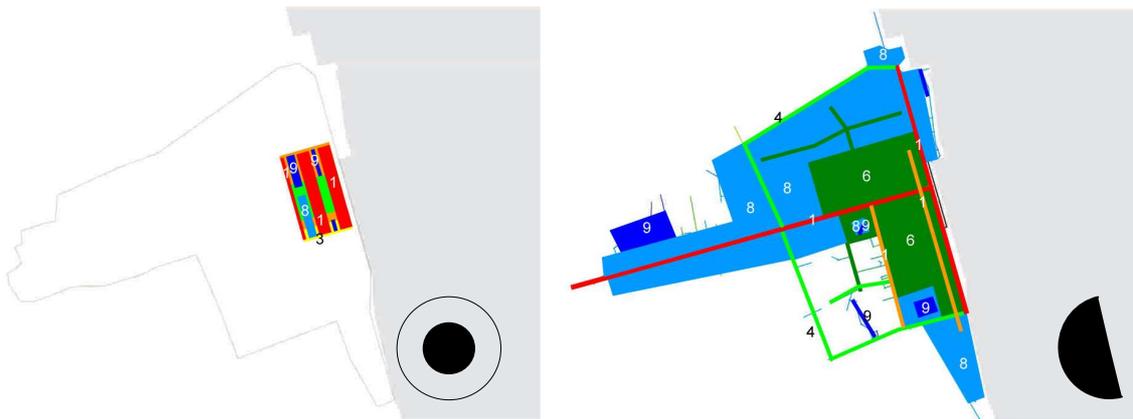


Fig. 12 "Deformed Wheel" sectors in V. R. Santo António historic centre (a) and actual urban area (b).

5 CONCLUSION

This study focused in two questions: first, if the urban development of the city influences the value of intelligibility and consequently the quality of the city space; and second, if the model of the “Deformed Wheel” of the Space Syntax Theory can be applied to the urban configuration study of the coast fishing villages in Algarve.

The morpho-topological study of the cities permitted to conclude that the urban development influences the value of intelligibility and consequently, the quality of the city space. The irregular city, such as Olhão, has a huge number of small segments (streets) and low integration, low intelligibility and low quality of public space. However, regular city, such as V. R. Santo António, has a smaller number of long axis and a high integration and consequently a high intelligibility, translated in an easy approach to the public space.

The changes of the fishery industry to the tourism economy get to worsen the urbanism system, with the decreasing of integration, just like intelligibility (R^2) and the increasing of the segregated area, mainly residential, meaning that the city is losing the urban life and its social movement.

The appliance of the “Deformed Wheel Model” and the “Space Syntax Theory” to the analysis of the urban evolution of the two cities permitted to compare them in different periods, by using a scientific method. It also helped crating a clear idea of the city sectors and to resume it to an iconic diagram, helping to compare these cities with the remaining congeners in the coast of Algarve, in future studies.

6 REFERENCES

Griffiths, S., Jones, C.E., Vaughan, L., Haklay, M. (2010) The persistence of suburban centres in Greater London: combining Conzenian and space syntax approaches, in **Urban Morphology**, 14 (2), UCL, London, 85 - 99.

Hillier, B., Hanson, J. (1984) **The social logic of space**, Cambridge University Press, London.

Hillier, B. (1996) **Space is the machine**, Cambridge University Press, London.

Hillier, B. (2005) The art of place and the science of space, in **World Architecture, Special Issue on Space Syntax**, London, 96 - 102.

Hillier, B., Vaughan, L. (2007) The city as one thing, in **Progress in Planning**, 67. UCL, London, 205 - 230.

Turner, A., (2004) **Depthmap 4: A researcher's handbook**, Bartlett School of Built Environment, London.

References from websites:

Aerodata Internationala Surveys, 2015. Google maps. Cnes/SpotFigure, DigitalGlobe, GeoEye, IGP/DGRF.
<http://www.google.com> (accessed September 2015)

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