Urban Rivers as Factors of Urban (Dis)integration

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I do not know much about gods; but I think that the river
Is a strong brown god—sullen, untamed and intractable,
Patient to some degree, at first recognised as a frontier;
Useful, untrustworthy, as a conveyor of commerce;
Then only a problem confronting the builder of bridges.
The problem once solved, the brown god is almost forgotten
By the dwellers in cities—ever, however, implacable.
Keeping his seasons and rages, destroyer, reminder
Of what men choose to forget. Unhonoured, unpropitiated
By worshippers of the machine, but waiting, watching and waiting.

T.S. Elliot, The Dry Salvages, Nº3 of Four Quartets

1. Introduction

Rivers have had a crucial part in the emergence of human society, being strongly present in almost every single stage of the human journey, and heavily implicated in the process of human settlement. The city was born “In between rivers” (Mesopotamia) and, throughout history, most cities tended to be founded about or near rivers, with notable events along the river course chosen for location, such as wedges on the meeting of two rivers, sharp bends, high-points overlooking the river, islands or on the river mouth (Kostof, 1992: 39).
This is explained in great part by the fact that both agricultural and industrial activities were, up until very recently, heavily dependent on a close and ever-available water source. Trading also relied on waterways in vast areas of both Western and Eastern civilizations, and so remained throughout most periods in history, only to loose part of this importance after the Industrial Revolution.
The emergence of environmental issues and urban sustainability has highlighted new themes for debate: water quality improvement, waterfront rehabilitation and regeneration of riversides; the restoration and (re)naturalisation of rivers and streams; the quality of urban landscape; the improvement of the current state of rivers and its surroundings through a general valorisation of the ecological, social, economic and aesthetic properties. This kind of preoccupations is also related with the dynamics of land-use transformation on marginal areas of rivers, where old industrial areas are seen as an opportunity to improve leisure activities, valued by people nowadays, and also to the improvement of aesthetics and the quality of public spaces that have clear effects on tourism and, therefore, on economic development of cities. However, this debate is mainly centred at local level and close to the project scale.
In this paper the relation of integration between city and its river is explored at both scales: a less detailed scale – national and regional scale – which is important to the analysis of the city-river system; and a more detailed scale – city scale – to test the local integration level of each city with river (also called fluvial city).
Firstly, the *city-river system* is analysed in order to identify the main factors, internal and external to this system, that are considered important to its description, characterization and measuring. Even knowing that the present state of this kind of urban systems is the result of a long term evolution, involving a very linked urban and river dynamics full of historical, cultural and social influences, it seems that a better understanding of the actual city-river structure can contribute towards a better formulation of policies, in order to enhance city-river integration, and above all, to understand the constraints and limits to that integration. The Portuguese subsystem of cities with rivers is analysed using a set of integration factors and variables. The second part of this paper explores the local integration concept, at the city scale, using space-syntax models based on a Portuguese city-river.

The results presented are part of a three year research project “*RiProCity*”, started in 2005, funded by the Portuguese Foundation for Science and Technology (FCT) and coordinated by CESUR-IST (Centre of Urban and Regional Systems – Technical Superior Institute of Lisbon).

2. The City-River system in Portugal

To better define some relevant concepts, the City-River System is the overlaying of the river system with the urban system, focusing on the nodes that intersect both layers, that is, cities with river. City is, in Portugal, an official designation attributed to urban centres above a certain dimension (usually, more than 8.000 electors living in a continuous and fully infrastructured urban area, but there are exceptions), totalling (as of 2006) 135 cities in Continental Portugal. Of these, 130 (those for which statistical data was available at the time of the latest Census, 2001) where considered for analysis. There are no official Portuguese criteria to distinguish Rivers from smaller streams, so a break point was defined, resorting to flow data, width data, river basin area, and so on. The break point was established at a flow of 500m^3/s, for a 5-year return period, 1000 m^3/s for a 50-year return period, and a river basin upstream from the city of 50 Km^2 or more. Of the original 130 cities, 75 complied with these criteria and are the universe of Portuguese Cities with River considered elsewhere in this study.

The territory now known as Portugal has a long history of permanent settlement. Several civilizations have contributed to today’s urban network, by founding new cities, shifting functions in others, building networks that shaped the way Portuguese cities work nowadays.

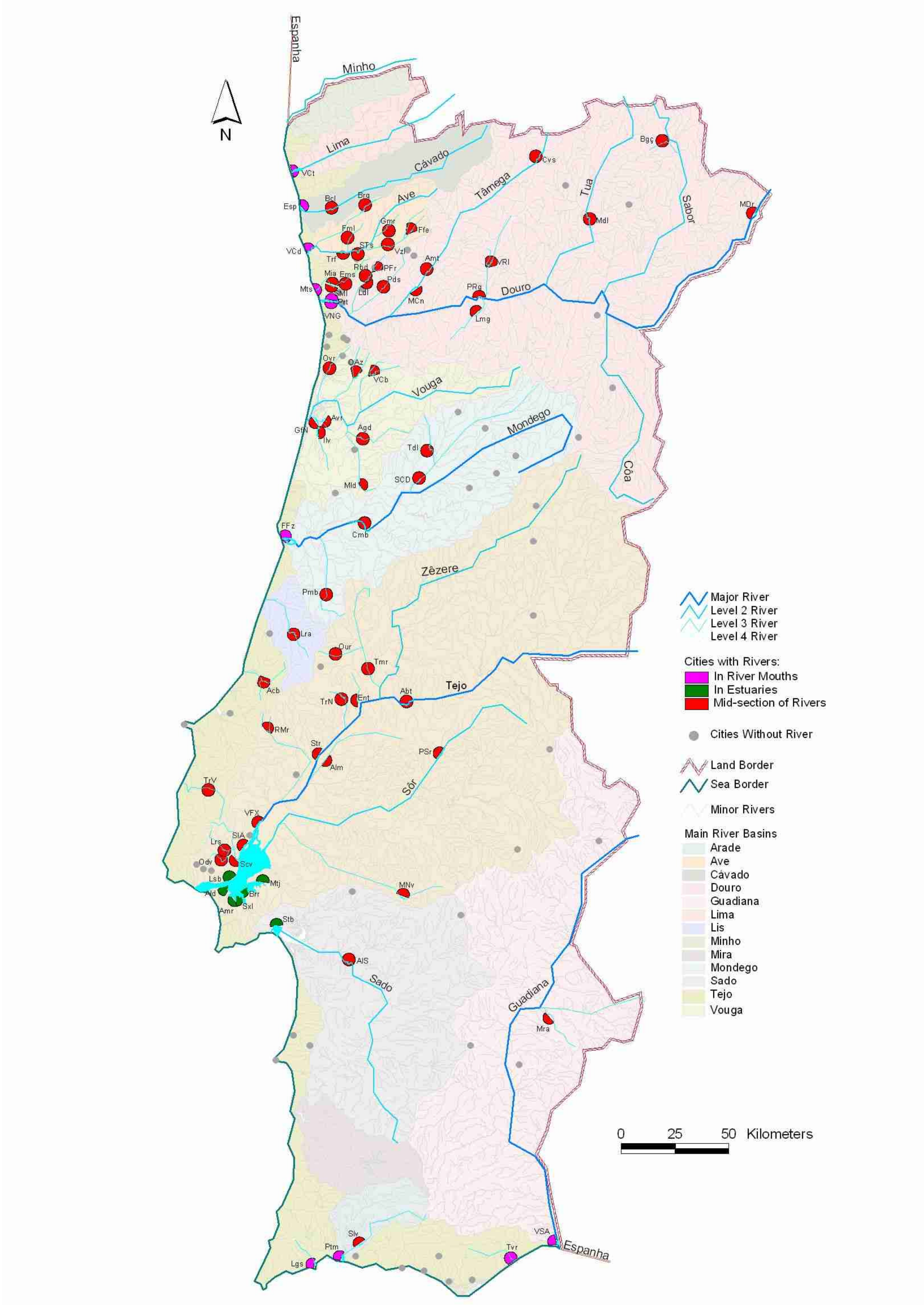
As referred previously, most of these cities had a close relation with rivers in their origin, and that influence is still easily perceived, not only in their location (75 out of 130 portuguese cities are cities with river), but also in city names: Alcobaça lies in the meeting of the rivers Alcoa and Baça; Águeda is named after the river that runs through the city, and so are Vizela and Rio Maior; Paços de Ferreira are the Palaces on Ferreira, Miranda is “on” (do) Douro; Ponte de Sôr is the Bridge-on-Sôr, Santa Comba Dão also refers to the river Dão.

Looking at Map 1, it is noticeable that the greatest concentration of cities with river occurs in North-western Portugal and in the Lisbon Metropolitan Area. This coincides with the most densely populated areas in the country, which is reflected in the existence of a higher concentration of cities. Nevertheless, it is observable that a great number of cities located in the interior of the country or in Alentejo (to the South) do not have rivers, or only have small streams. That is to say, cities are mostly concentrated in areas with important river systems.

It would be abusive to state that river systems were the only consideration in the building of the Portuguese urban network, but there appears to be a very strong spatial coincidence between both networks and, at least in the middle-ages, there is evidence that river corridors and road networks were complementary in ensuring the communication between cities. In Mattoso’s “História de Portugal”, a list of the most important cities in Northern Portugal during the 12th to the 14th century shows that, out of 15 cities considered, only one (São João da Madeira) wasn’t located in the interception of one or more roads with one or more waterways (Mattoso, 1993, pp.169). To this day, some small urban systems still carry the name of the river, such as the Vale do Ave (Ave Valley), the Vale do Ferreira (Ferreira Valley) or the Médio Tejo (Middle Tagus System). So, it is clear that, at least in historic times, river networks were in the basis of urban network integration, that is, integration on a regional and national scale.

Lisbon is situated in the mouth of the Tagus, Oporto in the mouth of Douro: the two largest cities for the two biggest rivers in Portugal. The Metropolitan Area of Lisbon engulfs the estuary, while Oporto and Vila Nova de Gaia create a close binary system bridging the Douro. Mondego, in the central part of the country, is also a major river, and Coimbra, traditionally the third most important in Portugal, spreads over both banks of the river.

Except for the Minho River, marking the north-western border with Galicia in Spain, there is a city at the mouth of every single major river and, of the secondary rivers, only Zêzere, a tributary of the Tagus, and Côa, a tributary of the Douro, fail to have a city with river (although Sabugal, on the Côa, declared a city early this year, will reduce the number to just one…).



Map 1 – City-River System in Portugal -
Source: CESUR with additional information from IGP, INE, IA and INAG.

In fact, of the 18 District Capitals of Mainland Portugal, only Faro (located on the seaside), Viseu, Guarda, Évora and Portalegre (all with small streams, with insufficient flow to be considered rivers) and Beja (located on a hill-top dominating the plain) failed to meet the criteria for entering the study as river cities.

In

, cities with river are shown according to their position relative to the river: a full circle indicates the city occupies both banks of the river, a half-circle signifies the city is located on only the given bank of the river, while a wedge shape means the city is located on a wedge in the meeting of two rivers.

All the Major Rivers are indicated, as are the Level 2 Rivers (secondary rivers running directly to sea or main tributaries of Major Rivers). Of the rivers classed in Levels 3 and 4, only those that run through a city are highlighted. These levels are qualitative classes of importance within the national hydrographical system.

3. Variables of City-River integration

A group of different variables describing important aspects of the city structure, urban tract of the river, and city-river relation were analysed for each of the case-studies. This was centred on the evaluation of city-river integration on a regional and national level, regarding their position within the river systems and urban network and, on the local scale, by analysing the city's structure, the characteristics of the river and its valley, and the way the city relates with the urban tract of the river. These variables were organized according to a set of themes.

3.1 Physical Geography and Morphology

Describing such features as the average slope on each bank and the ratio between the slope on the steepest and the flattest bank, was considered relevant to check if the configuration of the valley and ease of access to the river bed were major factors both to the overall configuration of the city (Veiga, 2004) and to the higher or lower of integration of the city-river system on the local level. The distance from the sea and to the closest district capital, the average altitude of the city and altimetric amplitude, or the Landscape region in which the city is located (Cancela d'Abreu, 2004) are important to place the city within the national City-River System;

3.2 Urban Dimension

Statistical data was processed at the BGRI (smallest statistical unit) level, with data from the 2001 Census, and reflects the most recent demographics of the cities (INE, 2002). The chosen variables are related with the total population for each city, population broken per bank of the river and/or living within the central nucleus of the city and proportion between urban areas on each bank, both in terms of population and population density. These variables are expected to allow for a good description of the way the city was able to balance its development on both banks of the river or, on the contrary, is concentrated on just one bank. It is expected that some sort of correlation with the average width of the river will occur, that is also influenced by historic factors and administrative divisions. The urban sprawl was considered through the use of an indicator of urban areas fragmentation. The position of the city within the ranking of Portuguese cities' population is, of course, an indicator on a national level. Also analysed was the population evolution, given by the rate of variation of the resident population for each urban area and the shift in position within the overall city population ranking;

3.3 River dimension

The average width, estimated average river flow for a 5-year return period (Quintela, 1996), size of the river basin located upstream from the city, and length of the urban tract of the river are used as describers of the characteristics of the urban tract of the river. Except for the width of the river, that in somes cases was altered by channelizing parts of the river, these variables are mainly dependent on factors exterior to the city, be them natural (precipitation, infiltration, evaporation) or human factors (damming, water extraction);

3.4 City-River relation

The length of contact (waterfront) between populated areas of the city and the river, and the ratio between this variable and the total urban area of the city, were considered good indicators of the proximity of city and river. This describes the way the city occupies (or not) a narrow 150 meter-wide strip along both banks of the river. A longer waterfront is expected to allow for a greater level of integration of the riverine areas and a greater diversity of land-uses along the river banks;

3.5 Spatial configuration

The local integration of city and river should be closely related with the City-River Relation. The transposability of the river is given by the number of river crossings within the urban tract, and the number of crossings per kilometre. A greater density of crossings should be inductive of a greater integration of the urban system around the banks of the river, whereas a small number of connections between banks might tend to shift the focus of the city away from the river.

The method of Space Synthax was applied to better understand the way the city's structure functions.The spatial attribute examined in this investigation is the global integration (radius 'n') taking in account the entire urban area with the link (bridges) between different banks and each bank side without river crossing. In order to enable different comparison the attribute 'radius n' was normalized in terms of mathematical calculation. The aim is to analyse whether and how integration values of the urban structure has a whole changed in excess of an urban structure divide by the river, not linked, and defined by independents spatial configurations.

4. The metrics of City-River System

4.1 Geography and morphology

The geographic characteristics of Portugal and its history of human settlements are important factors to understand the actual urban system. The recent (last century) impressive urban growth in coastal areas and the consequent population decrease of interior cities and villages explains also why 65 cities with river (almost 90%) are located up to no more than 60 Km from the sea (Table 1).

	Distance to the sea [km]	Number of Cities	%
Cities in estuaries	0	7	9,3
Cities at river mouth	<2	11	13,3
Other cities	2-10	8	12,0
	11-30	20	26,7
	31-60	19	25,3
	60-120	7	9,3
	120-210	3	4,0
Total		75	100,0

Table 1: Cities with rivers and distance to Sea

The high attractiveness of cities in the coastal strip is clearly presented in Fig. 1, that shows also a positive growth rate in the vast majority of cities with rivers which are located near the sea.

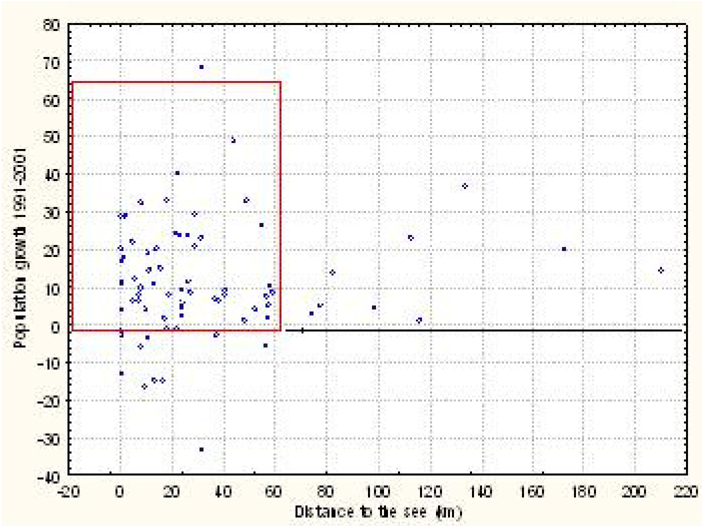


Fig. 1 – Distance to the sea and population growth

Also, 42 (in 75) cities, or 56%, are located up to 100m of altitude (and only 14 in between 200 and 800m), in the area with best climate conditions to settle activities and people. Only 12 of these 42 cities have an altimetric amplitude greater than 50m (44% considering all 75) which can be seen as a city-river system with very favourable conditions for the physical and functional integration between their separate elements, allowing for easy access to the water and the potential fruition of the water body by people. Nevertheless, cities with hills, with a rougher topography, can create a different relation with their river of no lesser value, namely in terms of visual integration, with the scenario and view-points having a high impact in the reinforcement of the character and identity of the city (as is the case with Coimbra and the Mondego River or V.N.Gaia and Oporto over the Douro).

4.2 The urban dimension

The system of cities and their structure are long-lived affairs and very dependent from what their history dictates and how they evolve and reorganize over time. It is commonly accepted to refer Zipf law as a describer of the structure of the urban system. Continuity and persistence in urban development should be based on variants of rank-size relations associated with city populations which have been shown to be stable over long periods of time (Batty, 2005: 357).

Fig. 2 presents the rank order of the 130 Portuguese cities. In blue are the cities with river and in red the other cities. The graphic shows how rivers are important in this system and very especially on high order cities. Most important cities in the urban hierarchy have rivers which are part of their history and evolution.

The Portuguese urban system is characterized by the predominance of small cities – the average is about 30.000 inhabitants -, but also by two big metropolitan areas (Lisbon and Oporto), being that 57% of the population lives in cities that are located in these metropolitan areas (Delgado, 2006).

It is interesting to see that the majority of these cities with rivers have a low-medium density (10-60 hab/Hect) and only few examples of high density of occupation (>80). An indicator of spatial dispersion was also used, [Pr / sqrt(4*Pi*Ar)] that relates the real perimeter (Pr) of the urban polygons of the given city with the perimeter of an ideal compact and circular city (P=2*Pi*R) with the same area (Ar). When applied to this set of cities (Fig. 3) it shows that an important part of this group with low-medium densities also presents high levels of dispersion (>4).

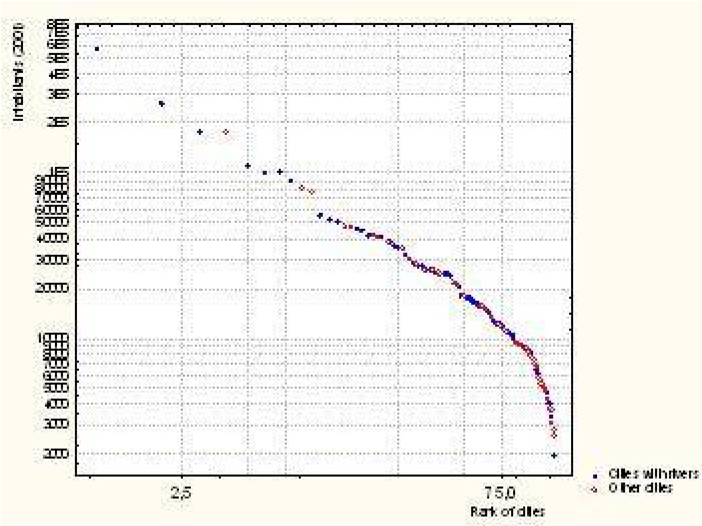


Fig. 2 - Rank size rule applied to the 130 portuguese cities

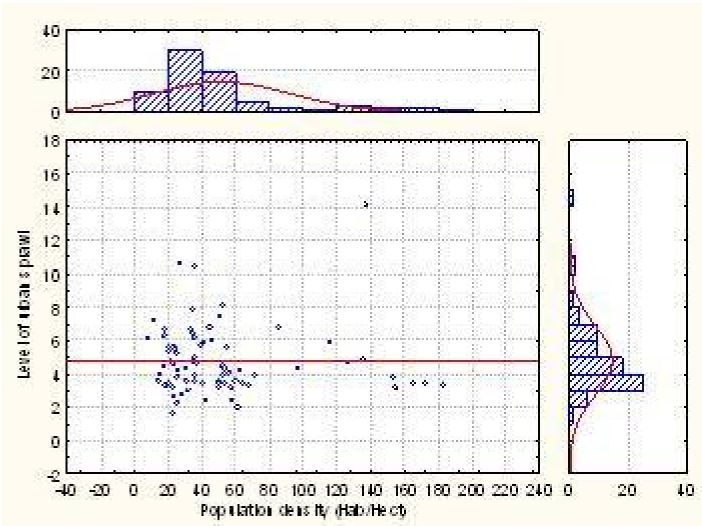


Fig. 3 – Relation between population density and urban sprawl

4.3 The River dimension

The Portuguese hydrological system is dominated by 4 Iberian rivers – Minho, Douro, Tagus and Guadiana - with the bigger water basins, that flow from Spain to Portugal,

Rivers w/ 10 Cities	1	Tejo
Rivers w/ 4 Cities	2	Douro, Leça
Rivers w/ 3 Cities	4	Boco, Ave, Ferreira, Tâmega
Rivers w/ 2 Cities	5	…
Rivers w/ 1 City	35	…
Nr of rivers w/ cities	47	

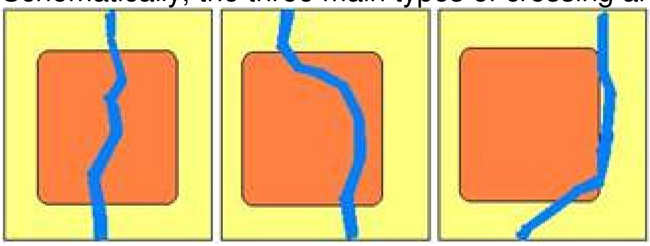
Table 2 – Amount of cities per river

The river Tagus and its basin is, in urban terms, the more important one, in which 10 cities are located including the metropolitan area of Lisbon. But the majority of these rivers containing cities have only one city (Table 2).
The amount of water that flows on rivers is also important to characterize their dimension. The absence of water in small rivers and streams, due to some specific hydrologic regimens,

can make impossible or less interesting some activities by people either on water or on their margins, weakening the integration with city. In other cases torrential regimens, overflows or floods have a psychological effect on people which affects their perception of safety. The previous experiences of hazard, as well as the characteristics of the society are important factors in the development of behavioural adjustments to minimize its threat and mitigate its effects (Burton, Kates e White 1978).
This integration between rivers and cities is highly influenced by this sense of mutual confidence. Sometimes, the city tries to dominate and protect itself from the dangerous river which, many times, forces less appropriated changes on the natural character of the river. When this is not possible the city, and people, learn through time to deal with river dynamics. The city draws back, represses the urban expansion in the direction of river and constrains the urban occupation on watersides and river corridor giving more space to the river needs.
This notion of integration between city and its river is clearly an urban concept influenced by the intrinsic characteristics of the elements that mutually and continuously interact – the city and the river (or rivers) – and is also, no less important, highly dependent from the context in what that relation occurred, namely the geographical and physical relation.

5. The City – River relationship

The position of the river relative to the city was divided into three main types:
- *Diametral*, which means the ratio between built areas on both banks varies between 0,5 (two identically sized banks, that is, the river dissects the city) and 0,7 (the biggest bank is slightly bigger than the smaller one).
- *Eccentric*, used to describe those cities that have clearly a more developed bank, but still cross the river to created smaller nuclei on the opposite bank. This is characterized by ratios between 0,7 and 0,95.
- *Tangential*, meaning the river passes right outside the city, bordering it on one or more sides. This means there is no urban settlement on the opposite bank of the river, or that these urban areas are minute in proportion to the total area of the city. This is given by ratios between banks from 0,95 up to 1 (only one developed bank).
Schematically, the three main types of crossing are:



Diametral Eccentric Tangential

The 75 cities with river distribute themselves according to this criterion as follows:

Position of the River relative to the City	Number of Cities
Diametral	11
Eccentric	23
Tangential	41

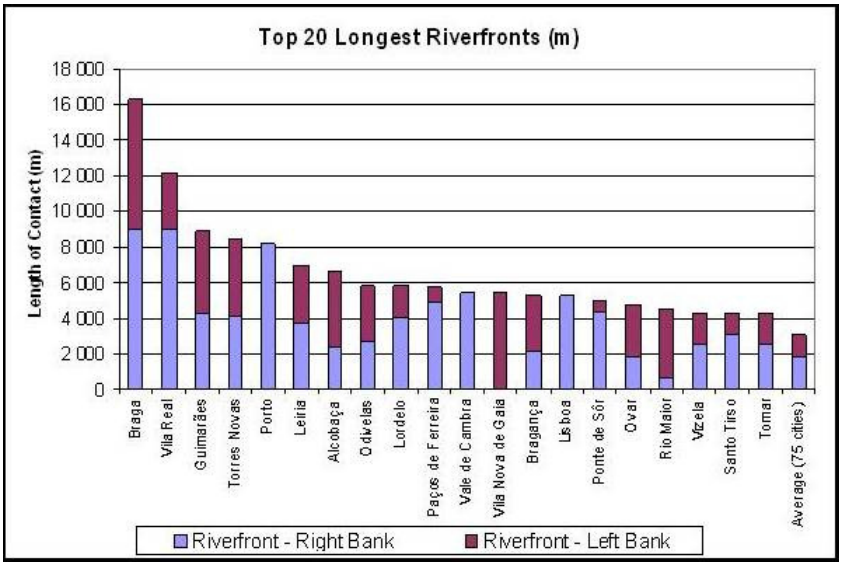
Table 3 – Position of the river relative to the city

Three special cases were identified as relevant for explaining certain awkward results in certain variables:
- *Cities in Estuaries* are characterized by exceptionally wide rivers, near the mouth. This leads to a naturally lower number of crossings, and values for Water Surface in the urban tract of the rivers up to 42 times higher than average. The two estuaries considered are the Tejo and Sado estuaries, with respectively 6 and 1 cities included in the category.

- *Cities in the Mouth of Rivers* are slightly less distorting than the estuarine cities, but still present exceptionally wide rivers. They are also curious cases in that they have two waterfronts, that facing the river, and that facing the sea. This leads to peculiar forms of expansion. These are 11 cities that occupy most Portuguese rivers' mouths.
- *Wedge Cities* are those that are located in, or at least have their centre on, the wedge between the meeting of two rivers. This exceptional position leads to a peculiar situation in both the topographical analyses and the study of the city's structure. The existence of two rivers, surrounding the city, suggests a higher number of crossings, and a longer riverfront. In Portugal, these cities tend to occur on high-points overlooking the meeting of the rivers, as is the case with 5 of the cities. The only exception is Alcobaça, that's spread along all banks of the two meeting rivers in a relatively flat valley, surrounded by hills.

According to the afore mentioned set of variables the metrics of the city-river relationship was characterized by: length of contact; water surface of the urban tract of the river; transposability, i.e., number of crossings and river width.

The length of contact between the city and the river, or riverfront, is given by the intersection of urban areas and a buffer of 150 meters along the river.



Length of Contact – Riverfront	Number of Cities
Over 10.000 m	2
6.000 to 10.000 m	5
4.000 to 6.000 m	15
2.000 to 4.000 m	22
1.000 to 2.000 m	16
Less than 1.000 m	15

Fig. 4 and Table 4– Length of the Riverfront, by bank and by class of Length

Very long riverfronts are rare, and occur, with the exceptions of Porto, Vila Nova de Gaia and Lisbon, in relatively narrow rivers. In these cases, the balance between riverfront extensions on both banks tends to be better. Theoretically, a city with perfectly symmetrical banks will have a length of contact that is double the length of the urban river tract; this however, seldom occurs, especially in wider rivers.

Most cities have reasonably long riverfronts, considering the average dimension of Portuguese cities, with 60% of the cities having over 2.000m of riverfront, and 80% more than 1.000m.

The water surface of the urban tract of the river is the total area of the river section that runs between or alongside the city. It is directly related to the length of the urban tract of the river and its average width.

Water Surface - Urban Tract of River (m^2)	Number of Cities
Over 10 million	4
2.5 to 10 million	6
1 to 2.5 million	6
450K to 1 million	10
125K to 450 thousand	14
50K to 125 thousand	13
Less than 50 thousand	22

Table 5 – Cities by class of water surface

The estuarine cities have, as previously mentioned, water surfaces up to 42 times larger than the average, itself distorted by these "inner seas". The Tagus has, at Lisbon, a surface area of over 140 million square meters, whereas most urban tracts of river have areas between 20 and 250 thousand square meters. This influences enormously the way the city relates to the river, with Lisbon having a riverside not unlike a seafront, whereas the smaller water surfaces tend to be almost absorbed by the city, without much interference in the breaking the continuity of the urban structure.

Water surface in the urban tract seems to be a good variable to describe the importance of city-river. There is a stark resemblance between Fig.5 and the earlier Fig.2 describing the population rank size rule.

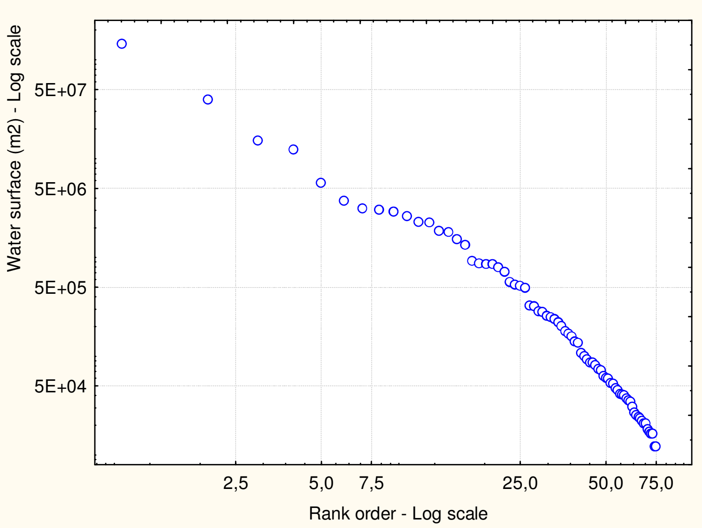


Fig. 5 – Rank size of city-river system based on water surface

An important factor contributing to a better integration of the city-river, especially within cities of two banks, is the Number of Crossings. Manning (1997) emphasizes the importance of bridges (and their different kinds of water crossing) because allows people to see and to have sensorial contact with the river. Their two main functions are:

-Linking function - links two margins allowing uninterrupted circulation along the river;

-Contact zones – where people wait over the water, watch, enjoy the view and set out to explore, from this convenient access point, what happens in different ways.

The majority of the existent bridges allow all kinds of traffic to cross but others are exclusively for pedestrians or bikes.

Another fundamental point that can develop the city-river integration or, sometimes promote their mutual disintegration, is related with the existence or non existence of areas adequately prepared to facilitate the physical contact with water which gives to people an intense sensorial contact of getting close in touch with the river and all that is connected with this experience. The Fig. 6 represents a typology of possible forms of physical contacts between people and the river.

The contact of the city with its river, measured by the length of these areas that are close to the watersides (up to 150 meters) can give an idea of its integrative potential. The statistical relation between the amount and availability of theses areas with the crossings that were present in each city is represented in Fig. 7.

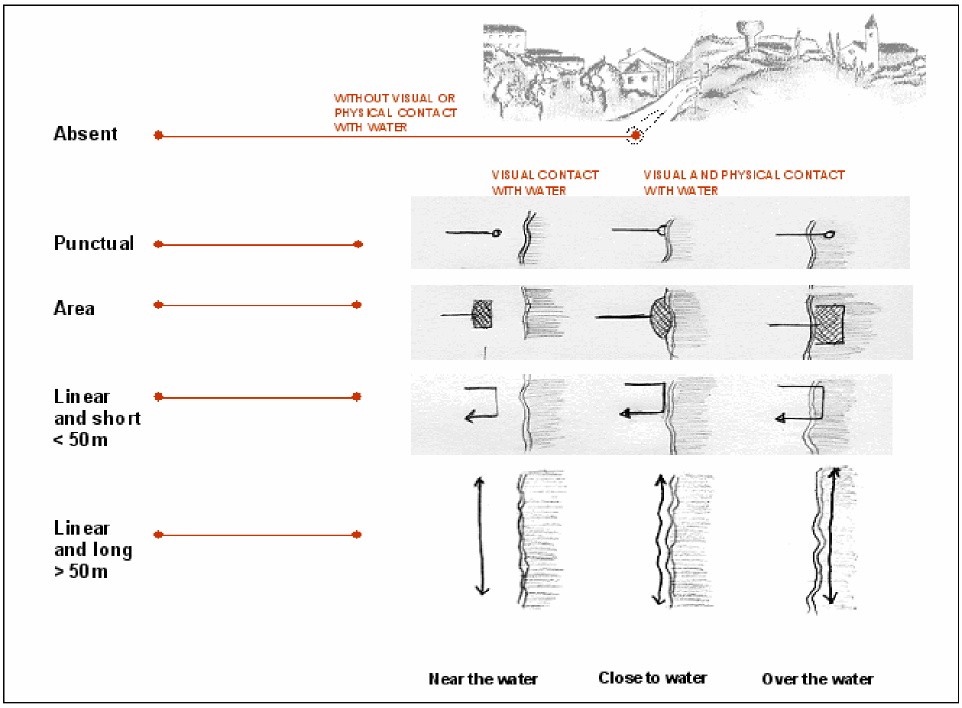


Fig. 6– Typology of contact with water

A small number of crossings is positively correlated with relatively short contact length in cities. The complementary statement is also valid. Cities with high number of bridges also have longer contact areas. This evidence only means that cities, for many reasons, when it is possible or justifiable to become closer to the river, and of course closer to the other margin, it is expectable that more opportunities to transpose the river become also real and happen.

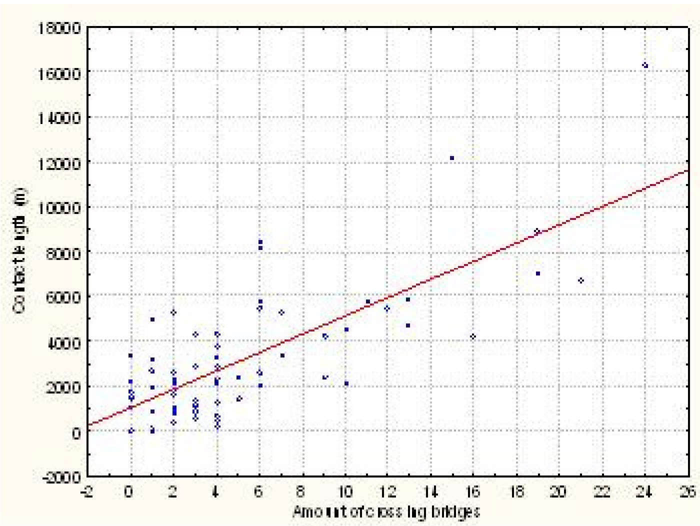


Fig. 7 – Relation between the nr. of river crossings and the contact length

It is evident that the width of a watercourse influences very much the type of relation between margins. River width is a geometric parameter that has a strong influence on the inter-relationships between the river and the city, on the scale of the river corridor, on the waterfront and its uses, on the accessibility network and traffic.

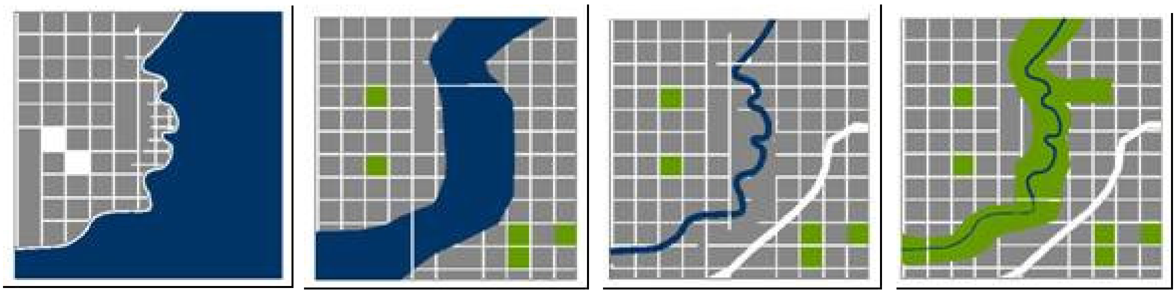


Fig. 8– City/River relationships

To a city or any urban area a river will be always a territorial discontinuity, a physical barrier. This effect only can be minimized trough transposition, i.e., the possibility of cross to the other side. Public perception of an urban watercourse is also highly dependent of its size, where width shows a relevant role, affecting notions such as scale, distance, visual contact, depth, reflection, attractivity, enclosure, among others (Cano, 1985; Moughtin, 1999).

Cano (1982:36) mention that the river begins to be perceived as a physical barrier in some point near the 220-300 meters. Behind this width the amount of bridges is reduced and tends to be more traffic oriented, less pleasant to cross by foot and the margins become more separated.

In fact a very large river cannot have the same amount of bridges as a small and narrow river. Its width influences dramatically the cost of a bridge. Linear density of bridges or the amount of crossings per Km, along the river seems to be a good indicator that will measure reasonably the contribution of river crossings to the usufruct of the river by people, as being a very special place of contact. It is also expectable that the correlation between the number of crossings and the potential of fruition cannot be linear, meaning that, for instance, very long bridges (normally high) are not suitable for pedestrian crossing.

The relation of this parameter (crossings/ Km) with river width was tested for the 75 Portuguese city-river sets and the result is presented in Fig. 9. In Fig. 10, 4 estuarine cities were excluded. Estuaries are city-river situations particularly different from normal. The large width cause special difficulties and high costs to build any bridge. Estuaries are more similar to small seas than rivers. In these cases the other margin is so far away that is difficult to both margins interact. The graph presented shows apparently some kind of hyperbolic relation confirming that the integration between city and river is highly dependent of the scale.

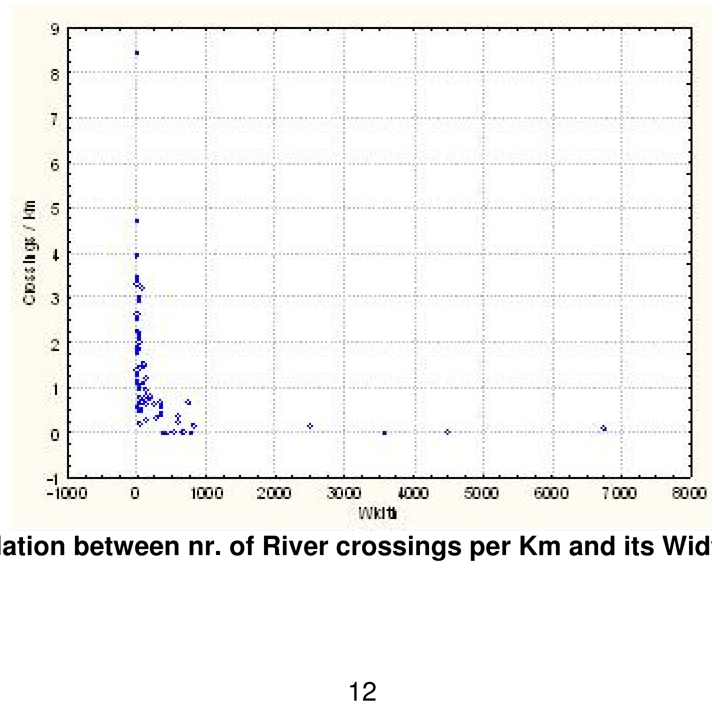


Fig. 9 – Relation between nr. of River crossings per Km and its Width in meters

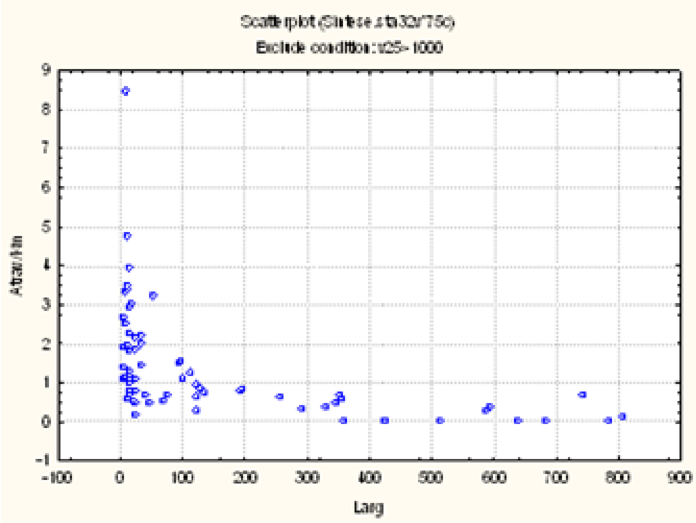


Fig. 10 – Same as fig. 9 excluding estuarine cities

On the city scale the measure “integration-rn”, from the space syntax analysis, can be used to show the importance of the river crossings as a factor of the core integration. Fig.11 shows the axial maps of the city of Tomar, with the connections between banks or analyzing each bank separately. This results in a reinforcement of the centrality surrounding the river. Analyzing each bank as separate systems (without crossings) it is noticeable that there is a shift in position of the core, away from the river. In this case the bridges act almost as a magnet in attracting both riversides and reinforcing city-river relation.

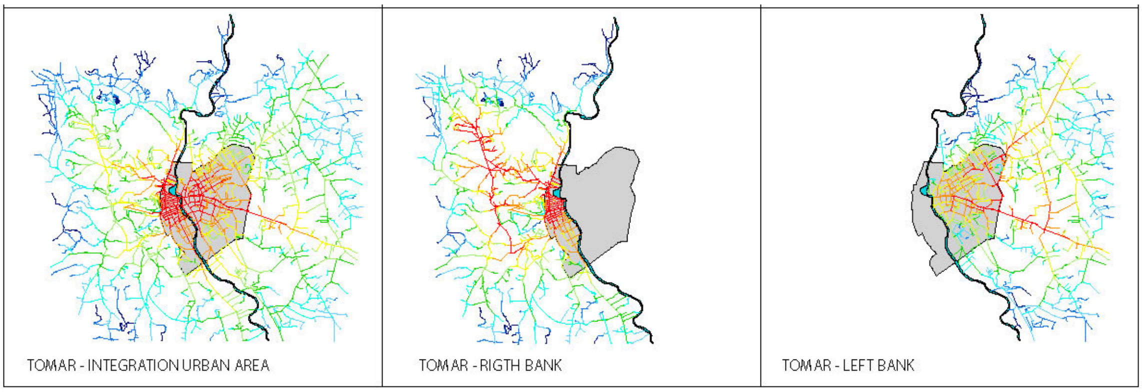


Fig. 11 – Axial maps for the city of Tomar

6. Conclusions

The analysis of the integration of city and river should take into consideration variables linked to the city, to the river but essentially those explaining the relation between them. Rivers, at least in their urban tract, cannot be dissociated from the city it runs through.

There are reasons to speak of a city-river system at a regional scale reflecting the interaction between cities and their territory. The river network reinforces the urban system by conferring it an identity and spatial coherence. The city-river system appears to have a hierarchical property not dissimilar to rank-size rule, using water body surface (in urban tract) in place of the population.

The overall integration should be considered in two different scales: the city-river system scale, that is the national/regional scale, and the city (or local) scale.

There are specific metrics that help understanding the lesser or greater degree of integration between city and river. Some of the variables used in this analysis proved to be particularly important to explain this relation: altimetry, urban dimension, length of the riverfront and river width, surface of the water body and the number of crossings.

Through the analysis of the results it becomes visible that there are thresholds (physical and demographical) affecting the type of relation. These have a strong influence over the city form, determining different types of city-river configurations – wedge cities, cities with one or two banks… The transposability of the river seems very closely related to the width of the river. The presence of river crossings is essential to ensure the connectivity between banks with great influence over the city structure's level of integration.

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