Ocean & Coastal Management 114 (2015) 11–20

Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Analysis and trends of the world's coastal cities and agglomerations

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ARTICLE INFO

Article history:
Received 7 November 2014
Received in revised form
19 May 2015
Accepted 9 June 2015
Available online 19 June 2015

Keywords:
Urban growth
Urban pressures
Coastal ecosystem changes
Urban coastal geography

ABSTRACT

This research aims to assess the influence of coastal cities around the world. The main goals are focused on quantifying the urbanization process in coastal areas. Also, the relationship between urban growth and different coastal conditions was studied. In this research two sources of information were used: city population databases of United Nations and Google Earth remote sensing. The method is focused on a detailed study of all cities with over 100,000 inhabitants, from 1945 to 2012.

The results show that half of population living in cities with over 100,000 inhabitants are within 100 km from the coast. This urban settlement has a particular pattern on the south, where is observed a "southern ridge" with a greater growth. The relationship between this development and coastal issues about geographical distribution, ecosystems, social and economic points; allows obtaining areas of interest for integrated coastal management.

1. Introduction and aims

Coastal areas favour concentration of population. Among other reasons, because the marine environment facilitates certain activities such as fishing, industry, tourism and transportation. Different international institutions and authors have studied this concentration in coastal areas (Burke et al., 2001; Creel, 2003; Hinrichsen, 1998; Vallega, 1999). This high global population concentration causes serious damage to very dynamic and fragile coastal-marine ecosystems, often leading to major problems and social conflicts (Barragán, 2014) due to the loss of important ecosystem services (Agardy and Alder, 2010; Miththapala, 2008; UNEP, 2006, 2012). Urbanisation is a process involving a given model of geographic space occupation. It usually increases pressure on ecosystems and respective services. Also, cities organise territory and become core areas in a much larger space.

The world began to experience unprecedented urbanisation rates when average urban growth attained an annual 2.6% from 1950 almost up to the present (ONU-Hábitat, 2009). During this period, the world's urban population nearly quintupled, from 700 million to 3.3 billion people. This led the degree of urbanisation to rise from 29% in 1950 to over 50% in 2008. The trend is on going, with more than 7.2 billion people now inhabiting our planet (UN-DESA-PD, 2013), and is expected to continue. Forecasts indicate that in 2050 70% of the world's population will live in urban areas (ONU-Hábitat, 2009). A large part of the urbanisation phenomenon observed worldwide is closely associated to the pace of urban population growth in the less developed countries (UN-DESA-PD, 2013).

Coastal Cities and Agglomerations (CCAs) around the world are analysed. We use the acronym "CCAs" according to United Nations glossary; this is because of sometimes we have data of the "proper city" and other times we have data of the "agglomeration". Coastal cities are considered what are within 100 km from the coast. This measurement is defined in Millennium Ecosystem Assessment (Agardy et al., 2005). The study of CCAs is of major interest, for several reasons; Firstly, because the 40% of the world's population (Burke et al., 2001; IOC/UNESCO, IMO, FAO, UNDP, 2011) lives in coastal areas, a large demographic concentration on a small part of the Earth's surface (between 4% per UNEP (2006), and 15% per Cohen and Small (1998)). This means that a huge amount of goods and services (associated to supply, regulation and culture) must be obtained from coastal-marine ecosystems (Agardy et al., 2005). Moreover, the scale and speed of the urbanisation process on the coast generates changes in land use never seen before, such as the case of the Chinese coast in the last 70 years and especially the last two decades is very illustrative (Ting et al., 2014). Adjustment to these changes should be reflected in the management model for coastal areas and their ecosystem services. The same occurs in places in Latin America where the 'port-CCAs' are the main focuses of transformation (Campuzano et al., 2013).

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http://dx.doi.org/10.1016/j.ocecoaman.2015.06.004
0964-5691/

Regarding to the extreme weather episodes and the effects of climate change linked to the marine environment, these do not affect all countries the same way. Note that only 10% of deaths from natural disasters are recorded in developed countries. Developing countries account for 98% of the 211 million people affected by natural disasters from 1991 to 2000 (Balk et al., 2009; McGranahan et al., 2007).

The general aim of this article is to quantitatively and qualitatively analyse the evolution of the world's cities and coastal agglomerations (CCAs) with more than 100,000 inhabitants from 1945 to 2012. The number and size of the cities will be examined, along with the inhabitants who live in them. Relationships of interest for coastal and marine management will then be established. It cannot be overlooked that CCAs are 'gateways' that directly, smoothly and intensively communicate in two directions between inland human systems and coastal-marine ecosystems (Barragán, 2014).

The specific objectives are studying different aspects of CCAs around the world that are relevant to coastal and marine management: geographic, environmental, social, and economic. Extending the observation period, beginning the statistical series in 1945. The time perspective is thus improved; the studies from Socioeconomic Data and Applications Centre offers information for 1990, 1995 and 2000 (CIESIN, 2011). However, the relationship between time-space scales, including the analysis of small CCAs, is an innovative concept. Growth of small cities is important from an environmental standpoint. This is because the pressures of population in a few megacities are lower than when they are settled along the coastal area in many small cities.

2. Information sources and method

2.1. Data collection

The significance of the information sources used is the simplicity of their use and the detail of the results when they are combined. Two main information sources were used. The first corresponds to United Nations Demographic Economic and Social Affairs (UN-DESA) databases, requested from the Demographic Yearbooks, supplying details about the world's cities and agglomerations with 100,000 or more inhabitants (UN-DESA, 1955, 1964, 1974, 1984, 1995, 2008, 2013), which accounted for approximately 78% of the world's urban population in 2012. The United Nations definition of cities and urban agglomerations has been used (UN-DESA, 2013). Google Earth was the second source used. Photographs and images from its remote sensors supply a great deal of detail for observation.

Both source types are normally used very much (Angel et al., 2005; McGranahan and Marcotullio, 2004). But what is important about this work is that quantitative aspects from CCAs around the world were cross-referenced with their qualitative attributes. The latter were obtained by observing in Google Earth diverse characteristics of all CCAs. By combining, in a global scale, these two information sources, we could obtain a link between space-time results with a great detail. Moreover, we used the shapefiles from the World Conservation Monitoring Centre in UNEP (WCMC-UNEP), for mangroves and coral reefs analysis. Coral reefs dataset shows the global distribution of coral reefs in tropical and subtropical regions. Data sources include the Millennium Coral Reef Mapping Project (IMaRS-USF and IRD2005, IMaRS-USF, 2005) and the World Atlas of Coral Reefs (Spalding et al., 2001) (scale: variable). Mangroves dataset shows the global distribution of them (scale 1:1,000,000). Obtaining the data to Human Development Index (HDI) for each country, we got the information from UNDP (2014).

2.2. Data analysis

The working method encompasses different tasks; firstly, we organised the information from original databases. The database contains 4285 cities and agglomerations around the world with more than 100,000 inhabitants between 1945 and 2012. Differentiating between coastal (2129) and inland (2156) cities and agglomerations. For this reason a 100 km wide band was used in Google Earth. When the city or agglomeration is on an island, per UNEP criteria (Dahl, 1995), we considered it coastal even if it was more than 100 km from the coast. After that, we enabled our results to be compared to others; the world's CCAs were classified according to number of inhabitants in five separate groups, taking into account the UN-DESA intervals. The result is the following:

Small cities (100,000 to 500,000)
Medium cities (500,000 to 1 million)
Large cities (1 million to 5 million)
Very large cities (5 million to 10 million)
Megacities (above 10 million)

After that, we geo-referenced all CCAs in the world. ArcGIS shapefiles were done for the world's cities, to geo-reference them and indicate their relationship to the coastal zone. Moreover, we have described CCAs based on interpretation of Google Earth images with respect to their geographic location, habitat type, associated ecosystem, relationship to other cities with more or less than 100,000 inhabitants and links with port infrastructures, etc. We analysed 13 attributes for each city by the observation in Google Earth. CCAs were classified in different coastal-ocean fronts. The information was from "Marine Ecoregions of the World" by the WCMC-UNEP (Spalding et al., 2007) adapted to administrative limits of cities and countries (Table 1). Describing CCAs based on other information sources and relevant geographic, ecologic, social and economic data was the next step. In particular, the world distribution of coral reefs and mangroves is analysed. Also, the relationship between HDI of countries and coastal development is studied.

All the above enables analysis of changes occurring in the last 70 years to be arranged according to three different viewpoints which are obtained by the link between the two information sources: quantitative evolution of the urban and settlement model (section 3.1); evolution from a geo-ecological perspective (section 3.2); economic and social analysis (section 3.3).

3. Results

3.1. Quantification of the urban phenomenon in coastal areas, population and settlement

First it must be borne in mind that halfway through the 20th century there were 808 cities and urban agglomerations with more than 100,000 inhabitants; now there are 4285. The distribution is quite balanced between coastal and inland (50% and 50%). That is, a small percentage of the Earth's surface concentrates half of the whole world's cities and agglomerations. In the last 70 years the number of CCAs multiplied by 4.5 (from 472 in 1945 to 2129 in 2012. The period from 1995 to 2004 was the most dynamic. Also, the pace of such fast growth seems to have slowed in the last decade (Table 2). An example of this slowdown phenomenon can be seen in the region encompassing the east of India and Indonesia, where 50 more cities were counted in the 1995–2004 period, while in the last period considered the number only increased by 10. Coastal population growth is more impressive, as it multiplied by 6.6 over the 1945 figure to concentrate 1.453 billion people in 2012. The CCAs' population counts 200 million more people than the inland urban population. It can be stated that the world's urban