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Abstract

Nowadays, the dikes and high walls constructions in the water shore are the solution to protect from flooding in urban areas. However, the rapid and dense urbanization also the climate change indicate the danger of this solution. The urban planning recent research proposes to preserve and to make urban space for water in order to contribute on flood risk management. By this concept, water could be considered as one of urban key components which trace over urban contemporary forms/patterns. Our research questions the relation or the interaction between the urban space and the flood risk. These analyses contribute to improve the actual prevention and management of flood risk in urban areas. We are especially interested in the spatial urban planning, considered as an item, as an arrangement also as a built organization, and its relation with flooding risk. We take the city of Taipei as our case study, and we plan to compare it with the other case studies of CORFU (Collaborative Research on Flood Resilience in urban area, FP7).

Keywords

Urban spatial organization; flood; climate change; non-structural solution; Taipei

INTRODUCTION

During recent years the natural catastrophes, especially flood-related, seem to be getting more and more frequent and destructive. Moreover, they are widely broadcast. The latest research demonstrates that these catastrophes are related to the buildings' locations and to their built forms, especially in the cities, there are numerous constructions situated along the river or along the coastline, and sometimes both. This paper is based on triple findings as follows.

Firstly, the urban population is keeping increasing since 19th century. According to United Nations Human Settlements Programme (UN-HABITAT, 2008), a half of world population lives in the cities. The total urban population is expected to double from 2 to 4 billion over the next 30-35 years (United Nations, 2006). Further, the trend of rapid urban growth throughout the mi-20th century in developed world has shifted to the transition and developing countries of Asia, Latin America and Africa with accelerated speed and enormous scale than ever. An unwanted side effect of this rapid urbanisation process is the increased susceptibility towards flooding by modifications of urban land use: the dense constructions of buildings and roads change the hydrological cycle in urban area. The construction of impervious surface in urban area may increase flood frequency and aggravate the severe damage of flash flood. According to G. Hollis (G.E. Hollis, 1998), over 50 percent of impervious surface in a drainage basin could increase the flood frequency: we observe that the frequency of severe flooding events occurs more often than the historical records. Also, the impervious surface of urbanisation supports the thunderstorm activity by retaining heat in land surface created urban heat island (UHI) effect (WHO, 2009).

Secondly, climate change may cause floods to occur more frequently and severely in urban area because of irregular events such as heavy precipitation, storm, storm surge and the rise of sea level (IPCC, 2008). The frequency of heavy precipitation would probably increase (Brunel and Pitte, 2010).
Finally, in accordance with United Nations estimation, only 5 percent of new development afoot in the world's expanding cities is planned (Gentleman, 2007). Those unplanned urban expansion, such as slum settlement or shanty town, are often formed in the vulnerable to flood-related disaster zones. Asian cities, especially the cities in southern Asian regions, are most vulnerable to flooding events cause by summer monsoon or typhoons. There are several metropolis of these regions, where more than 2 million dwellers with their slum population comprising 43 percent of the city population (Adikari and al., 2010).

The urban crises (sanitary, economic, environmental crises, etc.) stimulated, in different period, the reflection on architectural and urban forms (Choay, 1965; Cerda, 1979, Sitte, 1980). Facing the flood-related disaster, the question is which types of urban spatial structures could better meet the new environmental challenge of climate change from now on. Nowadays, the dikes and high walls constructions along the water shore are the solution to protect from flooding in urban areas. However, the rapid and dense urbanization also the climate change indicate the danger of this solution. The urban planning recent research proposes to preserve and to make urban space for water in order to contribute on flood risk management (MSW programme, 2004; "Room for the River", 2006). By this concept, water could be considered as one of urban key components which trace over urban contemporary forms/patterns.

Our research questions the relation or the interaction between the urban space and its hydrology, or more precisely speaking, between the architectural also urban forms and the flood risk. These analyses contribute to improve the actual prevention and management of flood risk in urban areas. We are especially interested in the urban space, considered as an item, as an arrangement (Lévy and al., 2003) also as a built organization (Eleb and al., 1989), and its relation with flood risk. We take Taipei city, capital of Taiwan, as a principal case study and it might be compared with another case study cities of CORFU research programme.

MATERIAL & METHODS

Brief history of Taipei city

Taipei is the capital and the centre city of the largest metropolitan of Taiwan. Situated at the northern tip of the island, Taipei is located on Dan-shui River, and around 25km to Pacific Ocean. Taipei city is located in the valley, relatively narrow, of the Kee-lung and Xin-dian rivers, which joint to form the Dan-shui River along the urban western border (Figure 1.). The central areas on the western side of the municipality are the low-lying terrain (about 5 to 10 m above the sea level); The slope upward to the south and east and especially to the north, where it reaches 1,120 meters at Qi-xing Mount, the highest (extinct) volcano in Taiwan. Its dwellers started to settle in the junction of Dan-shui, Kee-lung and Xin-dian Rivers, port of Wan-hua (old name: Mankah), where became the commercial centre since 1723. In 1860, the northern port of Da-dao-cheng became the commercial centre because of the displacement of the confluence of 3 rivers.

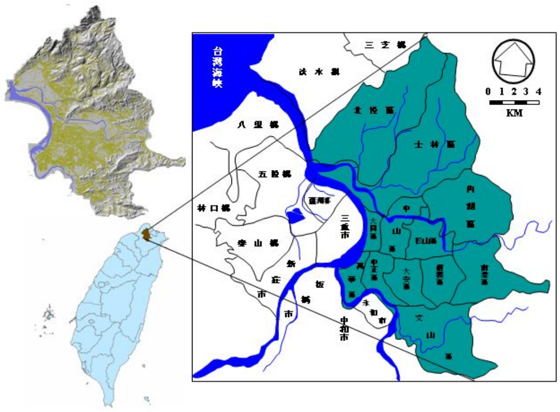

Figure 1: Location of Taipei city and its 12 districts
source: Department of Urban Development, Taipei City Government

Taipei was a distant port of Chinese continent during the Qing dynasty. After French military attack in 1882, Qing dynasty decided to build a fortification city between these 2 existing ports. The choice of city emplacement depends on the principles of Feng-Shui-Xue (風水學), as every Chinese city. After the annexation of Taiwan by Qing dynasty in 1885, Taipei took progressively its political and commercial important role in the island. In 1886, Qing dynasty made Taipei became the provincial capital. When the Japanese acquired Taiwan in 1895 after the First Sino-Japanese War, they retained Taipei as the capital of the island. During Japanese colonisation (1895-1945), the city was transformed by the principals of colonisation city: the destruction of Chinese city fortification and its urban structure, the installation of urban sanitation system without long-term perspective, etc. The city expands progressively towards east hill areas.

Since 1949, the city was densified rapidly as arrival of Republic China government and it reached the first 1 million dwellers in the early 1960s. After 1967, the economic dynamism attracted the population towards northern island and Taipei became a city with 2 million dwellers in the mi-1970s. Until 1980, the city expanded towards east and north; a series of urban projects were launched. The urban transportation system was also elaborated, for example, the establishment the underground rail network, the construction of expressway and of the metro network. The city spread out over hills in the north and in the south, especially in the Nei-hu and Wen-shan districts. The population stopped to increase rapidly since mi-1990s but Taipei is still one of the highest density cities in the world. In 2010, the city composed by 2,62 million habitants in the surface around 272 km². The city is denser in the east of Dan-shui River because there is riskier for the flooding events in the west of the river because of the low-lying terrain (less than 2,3 metres above sea level).

Flood concern and city's protection

The urban densification increases the proportion of urban impervious surfaces and it raises the flooding risk. The flooding risk is elevated because of the geographical condition: the city is situated a low-lying terrain with dense hydrological network (Figure 2.). Furthermore, Taipei has humid sub-tropical climate. The annual average temperature is around 23,2 °c; the annual average precipitation in plain area and in the mountain is around 3 000 mm and 4 500 mm. The precipitation might increase during the rainy and typhoon season, form May to October. According historical records, the typhoon could attack the island 3 or 4 times per year and could bright precipitation over 100 mm per hour. In these circumstances, the concordance of different phenomena: the narrow river mouth, high tide and obstruction on the riverbed by sludge, aggravate the situation.

Figure 2: Location of rivers, the dikes and pomp stations
source: Water Resources Agency, Ministry of Economic Affairs

In accordance with geographical and climatic situation, also with dense and rapid urbanization, the Taipei city established a flood risk prevention and management program during 15 years (1982-1996) and it was divided into 3 phases: the construction of dikes and high walls, the erection of floodway channel and the Kee-lung river rectification (Figure 3.). Firstly, the construction of dikes and high walls along the Dan-shui river (high walls are around 13 meter high), along the Kee-lung and Xin-dan rivers and other streams (high walls are around 6 meter high). The length of dike built is 109 141 meter. Secondly, the creation of pluvial water evacuation system in case of heavy precipitation (78,5 mm/hr) and the installation of more than 80 pomp stations in urban low-lying terrains try to protect against flooding. Afterwards, the construction of Er-chong floodway channel along Dan-shui and Da-han rivers measures 7,7 meter length 450 meter width. This strip of land along the river could evacuate pluvial water; it is also composed by 83 sports grounds, several bicycle paths and leisure parks. Finally, the Kee-lung river rectification between Nan-gan and Shi-lin districts shorten the river trail in order to reduce the flooding. This river rectification project also allows installing a new science business park and residential district with the surface of 238 hectare. However, during Nari typhoon passing in 2001, this solution caused the inundation in the upstream area, so the flooding risk was not really reduced.

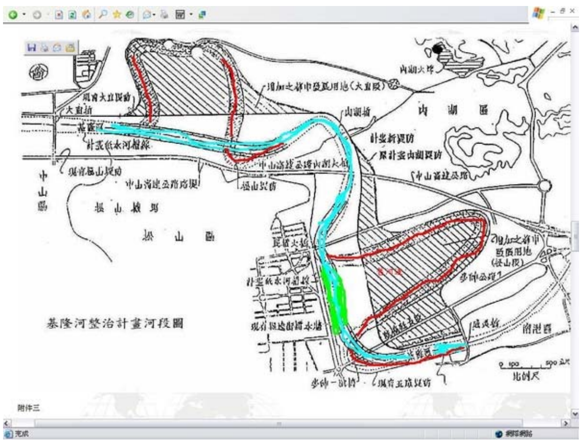

Figure 3: Kee-ling river rectification
source: Department of Urban Development, Taipei City Government

Nari typhoon passing in 2001, during 49 hours, indicated certain points deserved to be studied facing on the heavy precipitation events. During this typhoon passing, whole island of Taiwan was attacked and several cities inundated. According to National Metrology Office, Taipei suffered from the heaviest precipitation, hit the record, during 24 hours in the recent one hundred years: 425 mm. In the whole island, the damage was evaluate about 40 billion NT dollars (0,95 billion euros). In Taipei, the dikes collapses of Kee-lung river have caused the inundation in 16 underground metro stations; the traffic service recovered 6 months later. Also, the roads of centre city were inundated and water poured into the buildings and basements. The city government was aware of the limit of those protections against flooding, and tried to establish an integrated flood risk prevention and management program since 2005.

With its geographical and climatic conditions and its structure experiences against flooding, Taipei city is an interesting case study for our research focused on the evolution between urban form and its hydrology. Further, the dense and rapid urbanization in Taipei modifies the hydrological cycle in the urban area and it aggravates the flood risk.

RESULTS AND DISCUSSION

The geographers specialised in flood risk, for instance, Helga-Jane Scarwell and Richard Lagnier consider two flood risk factors endanger the urban areas (Scarwell and al., 2004). Firstly, the flood risk management concentrated merely on the protections against natural hazard for a long time. The occurrence of flood hazard and flood event depends on seasonal or interannual variations, and climate fluctuation; it also relies on the land use evolution in the catchment area. These two factors allow analysing finer the flood risk management. The notion “vulnerability”, enlarges its small-scale dimension: property and human life. It encompasses the whole ecosystem. They propose that the vulnerability should evaluate its material measure and also in immaterial.
Thus, the vulnerability study issue is to make actual material damage inventory and to put the geohistorical analysis into perspective. By identification of flood risk favourable factors, the urban water management should be reorganized by taking into account its shortage and its excess, also its social and cultural aspects. It is necessary, according to Helga-Jane Scarwelle and Richard Lagnier, to develop an integrated global approach about urban water problems and all environmental related matters.

By mean of territorial planning measures, the urban water management related issues couldn’t be neglected. André Guillerme, hydrologic engineer and historian, shows that henceforth it is necessary to focus on both of logics: integrated urban water management and territorial planning for sustainable development (Guillerme, 1997). We question how could the former assumption influence the future territorial planning politics?

Valérie November, geographer and specialist in urban spatial risk, proposes to think about the “urban risk” as a rational entity. It possesses its own consistency of the urban interactions, and it should be reckoned with territorial/urban planning and with the urban risk management. Certain approaches define the risks by spatial dimension: drawing flood-prone area maps, pointing out the polluted zones or indicating insecure buildings. However, it seems that the spatial risk is more complicated. By Valérie November, the urban risk, especially natural or environmental, isn’t only a threat to the city and its dwellers, but it’s also one of the essential components of urban structure and its urbanisation evolution. Therefore, it is required to translate the relations of urban natural hazards, for example the flood hazards, by urban spatial development. She develops a geographical theory, “Spatiality of risk” (November, 2008), based on Anthropological theory of Bruno Latour (Latour, 2004) and on Economic theory of Joseph

Schumpeter (Schumpeter, 1951). The objective is to realize how the risks emerge and what the relation between the risks and its affected areas is, by urban planning documents analysis also by target groups' and victim's survey. This approach presents not only material and spatial risk dimensions, but also social, political and economic ones. Those dimensions are the major factors of vulnerabilities and risks evolution. According to the result of these surveys, Valérie November found that the coexistence of natural and social risks would reinforce the precariousness of the place. Thus, Valérie November interrogates about the following questions: If is it just at random that different risks accumulated in one place? Why do people choose to live in the risk-prone zone and why do they neglect quickly the threat of risk occurred previously?
Moreover, one of the case studies of flood risk named "Lully Effect" (November, 2009) shows that the prevention and management of flood risk in local scale is as much important as the one in territorial scale.

Chris Zevenbergen and William Veerbeek, researchers in Delft University of Technology, emphasize on the necessity to establish a spatial approach of flood resilience in urban development strategy, particularly facing the climate change (Zevenbergen and al., 2008). At first, the analysis of case studies spatial adaptations in different scales (drainage basin, city and building) leads to identifying the interactions between them. Then, the development of a spatial and temporal approach could be set up. In their point of view, the project UFM Dordrecht in Netherland is a convincing spatial adaptation example in multi-scales.

CONCLUSIONS

Based on above mentioned researches in different fields, the objective of our research is to investigate the relation or, more precisely, the interaction between the forms of urbanisation and the impacts of flood risk. We attempt to distinguish the different architectural and urban forms, which seem more adapted to the local climate and hydrology, also to the means of conceiving the urban spaces. We pay particularly attention to the cultural resolutions since there aren't solely the technical solutions. Furthermore, we seek to analyze their capacity of adaptation, of transformation and of renovation with rapid urbanisation tendency, especially in the high-density cities.

Our primary research hypothesis proposes to consider the flood risk as one of key urban structure components of contemporary city. A research centred on the urban evolution of the relation between urban forms and its hydrology, also of the interaction between flood disaster events' impact and urbanization forms could be a key solution of urban mutation facing on the climate change and flooding disaster caused by it. Moreover, the review upon the urban planning and design methods by taking the flood risk in consideration in urban spatial organisation could assist us with a further comprehension about the impact of urban space recomposition in contemporary city.

Our research consists to review the literature concerning this subject: the relation between urban pattern/form and its hydrology, especially the occurrence of flooding events. We reference the recent research results of EU program, such as MITCH, IMPACT, FloodMan, FLOODsite and ERA-NET CRUE. Even though those research programs have concentrated on the structural solution against flooding, certain results of these programs were applied in urban projects in European cities. It is useful to analyse concretely how the urban patter/form adapts to local climatic and hydrological conditions.

Our research then carries on the case study: Taipei. Our analysis consists, foremost, the comprehension about the evolution of urban structure and its hydrology from 1950 to 2010, significant urban development period (Figure 4.). For analysis the relation between water and the urban spatial organisation, the analysis criteria would be established.

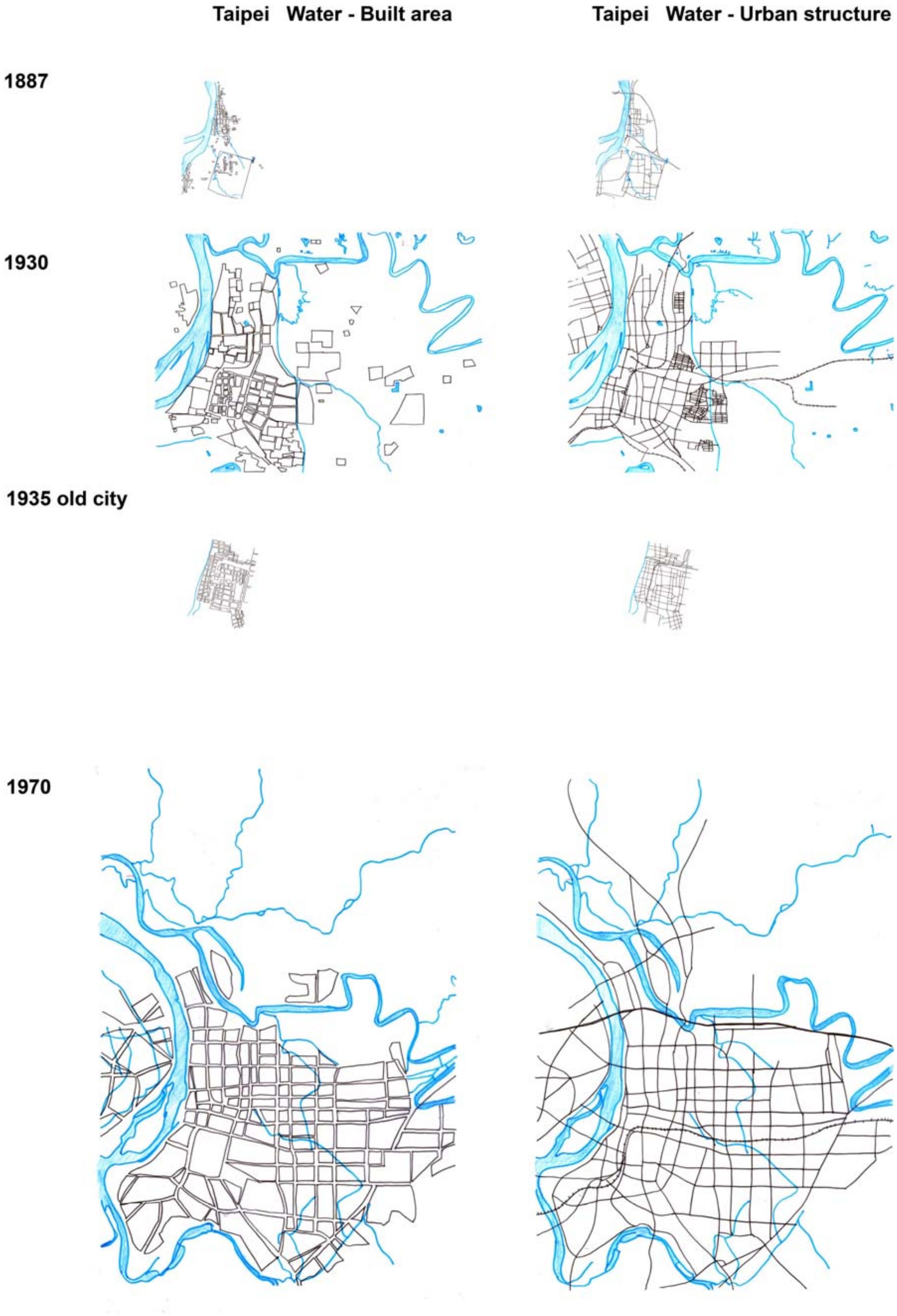

Figure 4: Urban Morphology Analysis

REFERENCES

- ADIKARI R., OSTI R. and NORO T. (2010), Flood-related disaster vulnerability: an impending crisis of megacities in Asia. In: Journal of Flood Risk Management, vol. 3, number 3, pp. 185-191).
- BRUNEL Sylvie and PITTE Jean-Robert (Edited by) (2010), Le ciel ne va pas nous tomber sur la tête, JC Lattès (ed.), Paris, 353 p.
- CHOAY F. (1965) ; CERDA I. (1979) ; SITTE C. (1980) : les transformations de Paris par le baron Haussmann (1852), l'Ensanche réalisé à Barcelone (1859), les cités-jardins en Grande-Bretagne (E. Howard, 1969).
- ELEB M., DEBARRE-BLANCHARD A., (1989), Architectures de la vie privée, maisons et mentalités, XVIIe-XIXe siècles, AAM (ed.), Bruxelles, p.12
- GENTLEMAN A. (2007), Architects aren't ready for an urbanised planet. In: The International Herald Tribune, pp. 11–29
- GUILLERME André (1997), Les temps de l'eau, la cité, l'eau et techniques, Champ Vallon (ed.), Paris, 262 p.
- Hollis G.E. (1988), Rain, roads, roofs, and runoff: Hydrology in cities. In: Geography, vol.73, n°318, pp.9-18.
- IPCC (Intergovernmental Panel on Climate Change) (2008), Climate Change and Water: IPCC Technical Paper VI, pp.13-22
- LAGANIER Richard, SCARWELL Helga-Jane (2004), Risque d'inondation et aménagement durable des territoires, Presse Universitaire du Septentrion (ed.), 239 p
- LATOUR Bruno (2004), Politics of Nature: How to bring the sciences into democracy, Translated by Catherine Porter, MA: Harvard University Press (ed.), 320p
- LÉVY J., LUSSAULT M. (2003), Dictionnaire de la géographie et de l'espace des sociétés, Belin (ed.), Paris, p.46-47
- NOVEMBER Valérie (2008), Spatiality of risk. In: Environment and Planning, vol. 40, pp. 1523-1527
- NOVEMBER Valérie (2009), When flood risk transforms a territory: the Lully effect. In: Geography, vol. 94, part 3, pp. 189-197
- SCHUMPETER Joseph (1951), Capitalisme, socialisme et démocratie, Payot (ed.), Paris, 341p
- SECCHI Bernardo (2005), Première leçon d'urbanisme, Parathèses (ed.), Paris, pp. 67-90
- UN/HABITAT (2008), State of the world cities 2008/2009: harmonious cities. Nairobi, Kenya
- United Nations (2006), World population prospects: The 2005 revision, New York: United Nation Population Division. Department of Economic and Social Affairs (ed.)
- WMO (The World Meteorological Organization) /GWP (Global Water Partnership) Associated program on Flood management (2009), Flood management in a changing climate, p.10
- ZEVENBERGEN C. et al. (2008), Challenges in urban flood management: travelling across spatial and temporal scales. In: Journal of Flood Risk Management, vol. 1, number 2, pp. 81-88.

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