

Original Article

Climate change adaptation and urbanism: A developing agenda for Lisbon within the twenty-first century

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Abstract Divided by interdisciplinary realms of application, both climate change and urbanism are ultimately bound together by cause-and-effect in our ever mutable cities. Although suggested that cities are changing faster than Mankind have been able to adjust out thinking, the yearly dissemination scientific data on climatic change is continually improving the efficiency of urbanism to tackle new looming paradigms. Respectively, it is considered that urbanism encounters its greatest opportunities in this uncertain 'third modernity', where flexible approaches such as 'what if?' scenarios allow urbanism to continuously uphold the ever evolving identity and continuum within eventful horizons. This collaboration between these two interrelating realms of contemporary practice is currently being applied upon the case of Lisbon, where regional and local climate change scenarios are assessed in terms of their potential territorial impacts. This originated the opportunity to evaluate how the city components and functioning within its waterfronts shall be affected by climate change. Resultantly, and embedded within its niche, urbanism presents a new creative laboratory where flexible and innovative urban adaptation strategies can be developed to counter-act the impending impacts upon Lisbon within the XXI century.

URBAN DESIGN International (2014) 19, 77–91. doi:10.1057/udi.2013.15; published online 4 September 2013

Keywords: urbanism; climate change adaptation; flooding; 'what if?' scenarios; tipping points; waterfronts

The online version of this article is available Open Access

Introduction

It is nowadays established that 'ten or fifteen years ago, the international community was focused on mitigation, everyone was convinced that this would solve the problem. It was politically incorrect to speak about adaptation. Today, things have changed' (Santos in Ecosfera, 2011; author's translation). As such, the adaptation agenda has been experiencing a visible progression in recent years.

On the other hand, implied by this headway, is the particularity of including and incorporating

significant 'bottom-up' dynamics. Since the establishment of the third International Panel on Climate Change (IPCC) Assessment Report (IPCC, 2001), data outputs dealing with possible territorial impacts of climate change have been enhanced both locally and regionally. This encourages developing countries to promote studies regarding their own regions and countries – for Portugal this resulted in Portugal's first SIAM Project Report (Santos *et al*, 2002). According to Filipe Duarte Santos, and his view regarding the historical record of CO₂ global emission in 2010, 'if we continue down the path of "business as usual",

which is likely, we will reach a 4°C increase in global average surface air by 2100 (...). It will be a very different world, also for Portugal' (Santos in Ecosfera, 2011; author's translation).

Several agendas have already presented themselves before the practice of urbanism. Among these numerous agendas lies the comprehension of how climate change adaptation has ascended both in importance and connectivity with the interdisciplinary that is urbanism. Interlaced with this paradigm lies the question of how adaptation of cities can serenely incorporate uncertainty without tripping over surprises as Mankind prepares for future horizons.

Interdisciplinary Practice and Factors of Uncertainty

The interdisciplinary realms of urbanism and climate change

Within an existing 'third modernity', urbanism today faces two correlating paradigms regarding how to face the inevitable impacts of climate change. The first paradigm has strived to mitigate and diminish the greenhouse gas emissions that our modern day cities release into the atmosphere. The second, and more recent paradigm, is now facing the task of establishing adaptation methods to best address the inevitable future impacts on contemporary cities.

It is within the pursuit of effective adaptation methods that urbanism stands before one of its greatest challenges. Climate change is already taking its toll on contemporary cities and coastal lines, but bigger impacts are expected to occur on the medium- to long-term scales within the enfolding of the twenty-first century. The balance between urbanism and climate change as a result, raises new considerations that concern each of their segregated realms of interdisciplinary application. Yet, these realms are nevertheless bound together by the cause and effect of climate change upon the contemporary city.

Future effects of climate change hence remain uncertain and fall victim to insecurities and hesitations that inhibit scientists to venture upon concrete future projections. Consequently, this is hindering the urbanists to dwell on these subjects, and even more so in applying them within the vastly interdisciplinary sphere that is Urbanism. There is nevertheless the opportunity to complement the practice of urbanism and climate change

adaptation without the need of exceeding each of their disciplinary realms of practice. On the other hand, this junction between the two spheres requires proactive thinking among the public sector, agencies and investigation centres. It is a vital priority that this synergy of contemplation be rehearsed between those agents. Irrespective of their professional area, be it urban planning, architecture, geography or engineering, there must always be an unyielding commitment to consider their role in preparing for a changing climate.

Urbanism beneath the blanket of uncertainty

Understanding what the future reserves under its blanket of uncertainty is a deliberation that has positioned itself strongly upon the pillars of contemporary urbanism and agendas of global scientific investigation. Although the trepidation of scientific investigation burdens the practice of urbanism, new and innovative adaptation measures are conversely becoming more lucid and effective. For urbanism, the information needed to evaluate the impacts of climate change on our landscapes is not irrelevant nor by any means unviable material. It is in reality feasible to use existing information to estimate scenarios on future impacts based on the yearly outputs of scientific knowledge. The amalgamation of this information does contain undeniable margins of error, yet with the continuous output of new data the blanket of uncertainty is progressively unveiled.

In summary, the predictability of recurrently published data regarding Sea-Level Rise (SLR), emissions of greenhouse gases and socio-economic tendencies (Figure 1) continues to consolidate and alumnate the relevant tools that urbanism has to use in creating adequate adaptation measures.

As a consequence, Urbanism must be 'in', or in other words, must be 'in synchronisation' with, the continual outputs of new data brought forward by scientific experts (Table 1). These outputs will affect the approaches of urbanism at different scales: first, it shall have impacts at the planning and management level, and second it shall impact the infrastructural level by the creation of contingency plans for extreme climatic scenarios.

Reflectively, future adaptation plans that are supported by scientific outputs will only be feasible if we initiate a more proactive thinking, and improve the equilibrium between professional practice and continuous scientific endeavours. This incorporation furthermore requires the rehearsal

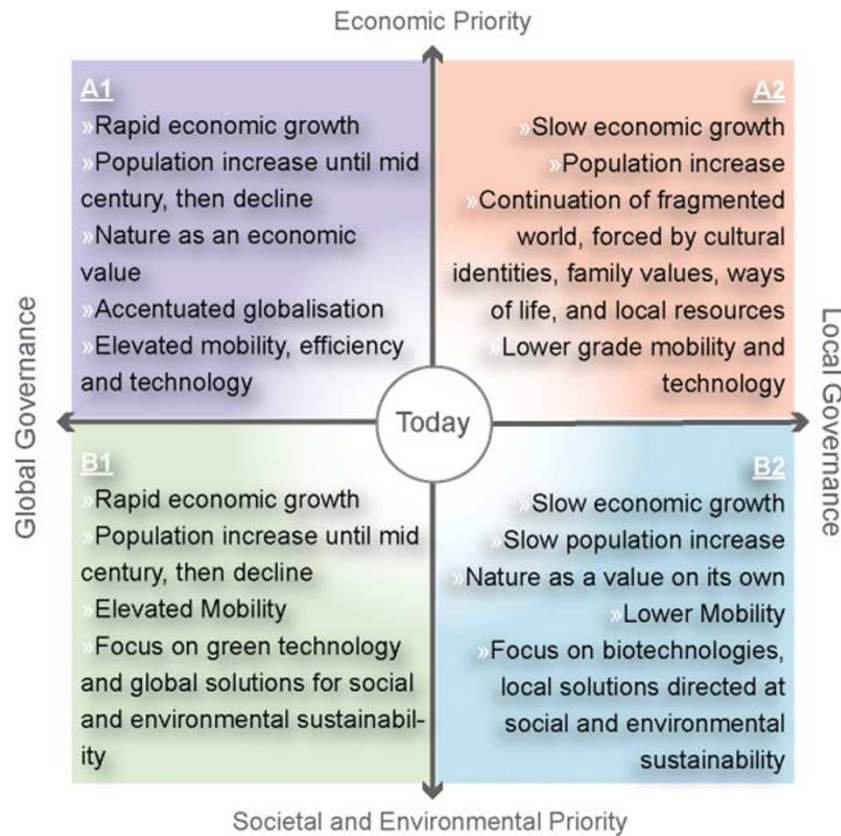


Figure 1: Synthesis of the socio-economic scenarios: A1, A2, B1 and B2 based on the IPCC’s Fourth Evaluation Report (SRES). Source: IPCC (2007a), Santos and Miranda (2006).

of more flexible processes that exploit the full scope of urbanism and its interdisciplinary practice in a way that accompanies the rapid advances of knowledge.

Anticipating Impacts

The ‘what if?’ agenda

On the basis of scientific outputs to date, we can confidently accept that there will be significant climatic impacts upon cities and that they will very likely increase in frequency towards the end of the century. This raises the imperativeness of generating adaptation measures and transposing these actions upon our territory. Although this requires us to work with unpredictable factors, we are able to shift our contemplations around these impediments by approaching them in a new flexible manner. This flexible approach is rooted within ‘what if?’ scenarios that focus on anticipating the possible climatic impacts upon our landscapes,

Table 1: Summary data of the 4th IPCC evaluation report (2007)

Scenario	Variation of average temperature (2090–2099, relatively to 1980–1999)		SLR (2090–2099, relatively to 1980–1999)
	Best estimate	Likely interval	Intervals based on models, excluding rapid changes in future defrost dynamics
Constant CO ₂ concentrations (Year 2000)	0.6°C	0.3–0.9°C	NA
Scenario B1	1.8°C	1.1–2.9°C	0.18–0.38 m
Scenario A1T	2.4°C	1.4–3.8°C	0.20–0.45 m
Scenario B2	2.4°C	1.4–3.8°C	0.20–0.43 m
Scenario A1B	2.8°C	1.7–4.4°C	0.21–0.48 m
Scenario A2	3.4°C	2.0–5.4°C	0.23–0.51 m
Scenario A1F1	4.0°C	2.4–6.4°C	0.25–0.59 m

Source: IPCC (2007a).

environments and also socio-economic realms of deliberation.

This approach is an output of the Foundation for Science and Technology (FCT) Project

'Urbanized Estuaries and Deltas' that has proposed a systematic and pragmatic approach to climatic events in uncertain horizons. The obstacles originating from the lack of scientific knowledge are overcome by establishing 'possible' scenarios based on literature and research of various authors. The generation of these scenarios may contain margins of error, yet they allow an insight into risks that are otherwise difficult to assess. With the aid of continual scientific endeavours, the development of 'what if?' scenarios presents the opportunity to aid urbanism into new temporal contexts. The objectives of these scenarios are to disseminate the extent of contemporary urbanism and identify, with the support of scientific outputs, the impacts of future climatic variability throughout different chronological timeframes.

Requiring constant re-evaluation, 'what if?' scenarios can be deconstructed into a two-phased methodological approach. The first phase estimates the climatic impacts within an array of different scenarios in order to determine the adequate adaptation measures. For each scenario, and focusing on waterfronts, there should be considerations made upon: (i) the territories that are regularly affected by SLR; (ii) of these territories, those that will be affected by more severe climatic phenomena such as flash floods, and additionally those that are more vulnerable to tidal cycles and undulation; (iii) the establishment of whether these territories are susceptible to geographic and/or pattern modifications due to severe meteorological phenomena such as storms and/or hurricanes; (iv) the impacts that will emerge as a result of altering natural ecosystems within our waterfronts due to global warming; (v) the consequences these occurrences will have on citizens, infrastructure, public/private bodies, and on socio-economic contingencies; and (vi) the role that waterfronts will possibly dwell upon tackling circumstances such as dry patches and heat island occurrences.

Consecutively, the 'what if?' scenarios will also embark in anticipating potential resolutions and prospective alternatives as a response to these previously made assessments. Loyal to flexible meditation and anticipating risks that are presently uncertain, new orientations should be courteously premeditated by: (i) re-evaluating the predominant features of our city infrastructures; (ii) investigating the practicability of alternative solutions for urban areas that are to be progressively affected by flooding threats; (iii) reassessing any plan that will give new edification rights, be them private or

public, in areas prone to climatic hazards, without at least having guidelines for resilience construction; (iv) discouraging solutions that are immediate responses to short-term contemplations that will invariably substantiate further problems in the future; (v) re-evaluating the strategies of risk management and civil protection in accordance with new available data.

Enclosed in the 'Urbanized Estuaries and Deltas' research project the elaboration of the first Portuguese 'what if?' simulations were undertaken. The 'what if?' scenarios within Lisbon's waterfronts are focused around the risk of flooding, where numerous phenomenon congregate, starting with: (i) rising of sea level; (ii) storm surges;¹ (iii) effects of progressive Tagus floods² (Figure 2); and (iv) 'flash floods'.

Within Lisbon's coastal area, the use of tipping points were used to identify the vulnerabilities triggered by the risk of flooding. Succeeding an in-depth and analytical site analysis within the city's waterfront's, there was an understanding of the impacts that flooding could have upon the areas uses, building typologies and construction (Figures 3, 4 and 5). The values of the tipping points were of 4.00 m, 5.00 m and 4.50 m, where a particular emphasis was made upon the 4.50 m tipping point.

The results demonstrate that if the flooding area of the 5.00 m tipping point is considered to be 100 per cent within the possible flooding range (that is, 4 929 501 m²), then the 4.50 m threatens 86.5 per cent (that is, 4 267 282 m²) of this total flooding range. On the other hand, when comparing this with the 4.00 m tipping point that threatens 61.5 per cent (that is, 3 036 536 m²) of the total flooding range, it can be noted that because of Lisbon's topography the slight addition of 0.50 m beyond the 4.00 m tipping point increases the flooding in Lisbon's waterfronts by 25 per cent.

As the 4.00 m tipping point is already considered a very likely phenomenon within the twenty-first century, the 4.50 m tipping point will be considered as the spectrum of the research. The 4.50 m tipping point is more likely to take place in comparison with the 5.00 m tipping point, yet has a much vaster impact area in contrast to the 4.00 m tipping point.

New temporal horizons for urbanism

The methodological approaches incorporated in the new adaptation agenda directs urbanism to



Figure 2: View of Terreiro do Paço during a high tide of 4.26 m.
Source: FCT Project 'Urbanized Estuaries and Deltas', FA/UTL and FSHS/UNL, 2011.

face the ongoing assignment of accompanying the constant exponential change embedded within our climate, environment and ecosystem. This has implanted a new viewpoint within urbanism, a view that extends the temporal deliberations within previous urbanistic concerns.

Processes that are associated within (re)-generation, (re)-urbanisation and (re)-infrastructural interventions are now interwoven with longer timescale reflections, be them encapsulated within small scale projects, or within larger scale projects with a timeframe of two to three decades. This new perspective will conceivably shift the deliberations beyond the urbanist's lifespan, and encourage the meditation regarding whether his professional contributions will be favourable for the future. In other words, the professional practice should stimulate what Aldo van Eyck describes as *continuum* whereby '... the past, present and future must be active in the mind's interior as a continuum. If they are not, the artefacts we make will be without temporal depth or associative perspective' (Choay

et al, 1972 [1969], p. 91). In summary, adapting our thinking and professional practice to this *continuum* raises the invaluable necessity to appreciate that the amount of climatic impacts cities have to face depend on humanities attitudes in the future (Kjellstorm *et al*, 2011).

This synergy that urbanism today encloses around its field of co-operation with climatic adaptation has henceforth invoked the need to look beyond the short term, beyond the present stature of a project and beyond condemned practices that shall further hinder us. This by no means suggests that there should be a deterministic devaluing of short-term contemplations. Instead, it is suggested that the importance of the life cycle within medium- to long-term considerations are just as vital as the initial stages of implementation. Henceforth we will be able to ask questions and anticipate answers to problems that we are destined to face in the future. The years 2030, 2050, 2080 and 2100 are hence timeframes of work and opportunity.

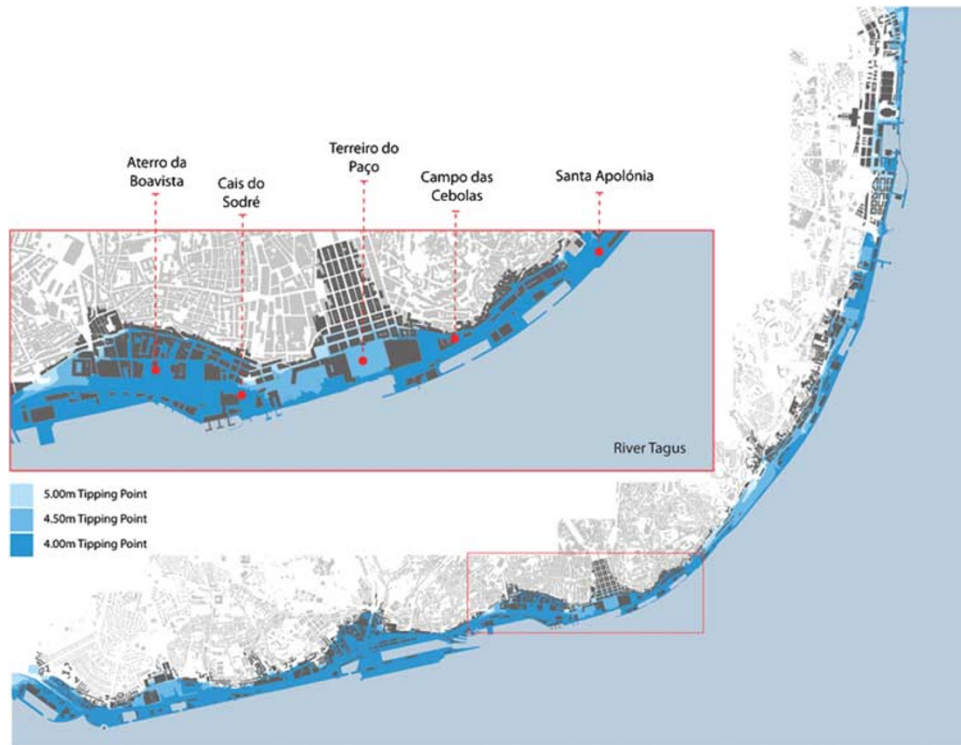


Figure 3: Map of Lisbon with illustrated flooding tipping points.
 Source: FCT Project ‘Urbanized Estuaries and Deltas’, FA/UTL and FSHS/UNL, 2011.

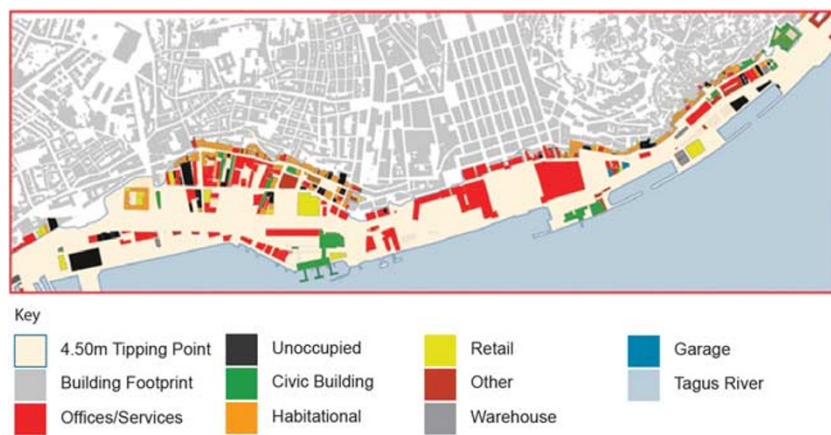


Figure 4: Map of illustrated area with building uses affected by the 4.50 m tipping point.
 Source: FCT Project ‘Urbanized Estuaries and Deltas’, FA/UTL and FSHS/UNL, 2011.

A first-hand look at local risk factors

Although climate change can be measured globally, its impacts present specific characteristics within each particular local territory. Consequently, it is possible to observe international examples that are orientated towards waterfronts and that have attuned to relevant ‘risk factors’

brought forward by local impacts of climate change. This analysis of waterfronts encourages the nurturing of questions upon our own national, regional and local scales such as: (i) What are the ‘risk factors’ that climate change will bear on specific territories? (ii) What are the current and future responses these areas will have in reaction to these bearings? (iii) How are our cities to

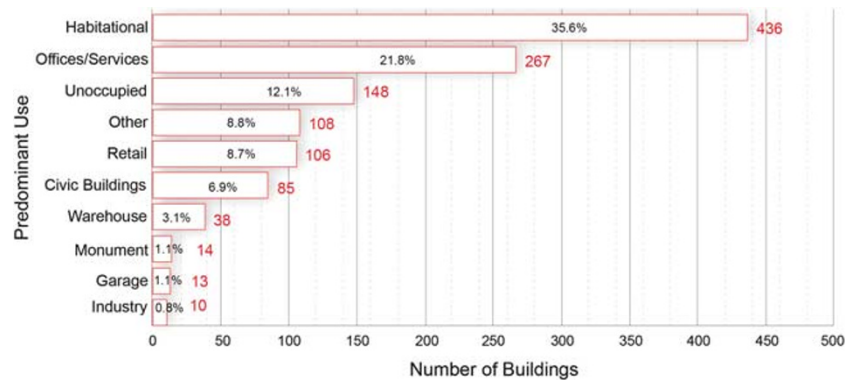


Figure 5: Bar chart showing the building uses affected by the 4.50 m tipping point within Lisbon's waterfronts. Source: FCT Project 'Urbanized Estuaries and Deltas', FA/UTL and FSHS/UNL, 2011.

sustainably embrace these 'risk factors' in medium- to long-term timeframes?

These questions lie within the 'Hot Spot' agenda of the World Bank that expresses the hurried necessity to identify and test each city in terms of its sustainable development, climatic impacts upon the territory and future risk hazards (Prasad *et al*, 2008, pp. 41, 53).

Waterfronts, coastal areas and estuaries are nevertheless destined to tackle a more specific problem regarding water and its impacts upon these localities. Following this perspective, working with waterfronts requires a more predominant in-depth analysis within this particular factor of risk. Respectively, this originates the necessity to understand: (i) the management of flooding phenomena within all possible scenarios by establishing today an agenda that addresses problems for tomorrow; (ii) the average rising of sea levels that is constantly cross-referenced with scientific outputs; (iii) the changes within coastal and estuarine ecosystems, and the respective implications on these landscapes and on the economical protocols they entail; (iv) new reflections regarding the junction between the city and the water in retrospect of arising climatic implications. Similarly, with the previous reflections on Aldo van Eyck's *continuum*, 'risk factors' also require the analytical viewpoint towards the future, or in other words, the comprehension, once again, of the city's life cycle.

For a dynamic and relevant example, we can reflect upon the perspective of 'living with the water' (Deltacommissie, 2008) outlined by Holland's political agenda of 2008. This perspective proposes the most sustainable response in dealing with unpredictability within the medium- to long-term timeframes. It pragmatically sets out to comprehend both present and future dynamics regarding

ongoing 'risk factors' and moreover linking these reflections to extreme scenarios. This process is also further reinforced by the cautiousness and effectiveness in consolidating safety with urban quality, and to furthermore harmonise risk management within the Dutch cityscape and encapsulating public realm.

Climatic Adaptation

A methodology for Portuguese adaptation

Presenting itself as a new challenge for urbanism, the climatic adaptation agenda provides a number of opportunities for Portugal, and henceforward endorses a prognosis upon the city of Lisbon. In this regard, the identification and synthesising of recent scientific knowledge outcomes are partly accomplished by the 'Circle 2 – Deltas Cooperation in Europe' (Climate Impact Research & Response Coordination for a Larger Europe). With this information being already well recognised, the focus at this point will be made to the Portuguese National Strategy for Adaptation to Climate Change (EN AAC). Following the resolution of the Council of Ministers in 2010, the delineated document aims at 'providing the country with an instrument that enables the identification of a number of action procedures and of adaptation measures to be adopted (...) furthermore, under the United Nations Organisation, this topic has been acquiring an increasing international interest and climate adaptation measures are being one of the fundamental pillars in the global agreement post-2012, which will undoubtedly result in additional obligations for Portugal. (...) scientific consensus is today sufficiently robust,

and that this is a topic where it makes particular sense to evoke initial precautionary measures. This uncertainty should therefore not be an excuse to prolong the awareness of the need for societies to adapt to climate change and to initiate their adaptation activities' (ENAAAC, 2010, p. 1090; author's translation).

Upon the inaugural launch of this agenda, the initial and invaluable first steps are underway, hence justifying the agenda's interdisciplinary meeting with Portuguese urbanism as well. As a result, the ENAAAC establishes four principal intentions, those being to: (i) implementing the fundamental exercises of climate change adaptation and consolidating corresponding scientific bases and solid application techniques; (ii) reducing vulnerability by identifying required endeavours, priorities and the prerequisite adaptation measures; (iii) increasing participation and awareness regarding the knowledge of climate change and transmitting the necessity of action during the definition and application of the strategy; and lastly (iv) strengthening the cooperation at an international scale, where Portuguese responsibilities are assessed in order to cooperate within the arena of global climate change adaptation (ENAAAC, 2010).

These principal intentions define the strategic sectors for Portuguese climate change adaptation by considering elements such as spatial planning, water resources, safety of goods, health, energy and industry, biodiversity and agriculture, coastal areas and others. This henceforth establishes a development methodology and also specific application measures.

Addressing solutions with innovation and creativity

The agenda for climatic adaptation should be seen as a creative laboratory in which urbanism can express new and innovative approaches and practices. In other words, climate change new paradigms have given urbanism the opportunity to explore new possibilities. A phenomenon that instigate the reinforcement of both the old and new interdisciplinary duties that urbanism encompasses around its own sphere of practice.

The conjuring of interdisciplinary practice is one that takes place in the design of the city by rethinking its network systems, paying particular attention to infrastructure and entrenched natural settings.

Waterfronts should correspondingly be enclosed around this design approach by aiming at accomplishing resilience and ensuring their capacity to respond to future impacts. This requires the generation of innovative solutions within the realms of urban design, architecture, materiality and building technologies capable of accommodating impacts such as, and among others, the rising of sea levels, flooding and also 'flash floods'. Facing these scenarios, cityscape is presented with the challenge of adapting existing urban fabric to new contexts and the pursuit of new urban morphologies.

With respect to the first challenge, one can reflect on a number of conceptual alternatives developed by the British and Dutch to address severe impact scenarios. Their approaches towards these challenges are relevant in that they have adapted their defensive systems in the long term in an incremental and pragmatic way.

The American approach, namely, in New York city, also shows similar resilience methods that have gained ground in preparing urban areas for the occurrence of extreme events. It can be further observed that their public spaces within the more consolidated districts flourish with multi-functional creative dimensions that are directed at controlling water levels during storm surges. This links with the second challenge, whereby the adaptation measures establish the base to rework the existing frameworks into new settings. Once established, it can be used to reach new approaches contained within a 'Plan B', or in other words, a contingency plan, that shall guaranty the continuation of the life cycle regarding that specific locality. It is at this point where new innovative outcomes are encountered and disseminated.

New forms of governmental practice

Urbanism within a third modernity (Ascher, 2010 [2001]) and its relationship to the agenda of climatic adaptation also faces questions regarding governance and its 'bottom-up' approaches. With regard to this relationship in alternating countries, regions or localities, Verschoor (2009, p. 26) adds that 'Adapting to climate change will become part of everyday policy making'.

Policy elaboration that addresses the agenda entails a number of requisites, those being: (i) a leadership that is proportionate to the development of the agenda in the next few decades, where Merlin (2002, p. 436) suggests there should be a

'strong intervention interest' within spatial planning attitudes; (ii) a consolidated and unique strategic vision (Pascual i Esteve, 1999, p. 18); (iii) a flexible managerial practice that is both adaptive and incremental, and supported by 'processes of co-operation, compatibility, mediation, that assume uncertainty and consequential accepting of adaptation' (Portas *et al*, 2003, p. 18; author's translation); and (iv) the established support of a coherent, solid and interdisciplinary technical body that services governmental probations.

In retrospect, Robinson and Hamer (2009) state that 'we are failing to move beyond the *status quo* and traditional lowest common denominator solutions' that characterise 'the line of least resistance – demonstrating a lack of inspiration, ambition and long-term sustainability' (p. 26). For these authors, this is a topic that requires pro-active action that is both flexible and adjustable to medium- and long-term horizons. For the short term, the progressive awareness of technicians, politicians and general society is a governmental strategy; one that informs the communities of their role in deciding their future duties in light of climate change. This course is one that Russell (2011, pp. 15, 34) also refers to as 'climate change in the landscapes of speculation'.

As a result, the 'what if?' scenarios have a primary duty: to determine the territorial impacts of climate change scenarios, identifying the variables and, as such, refining the outputs of applicable scientific knowhow. In addition, if the construction of new infrastructure or large city investments conflicts with 'risk factors', the expected life span should already consider possible eventful scenarios in distant horizons such as 2100. This is based around the evaluation of risk identification in order to better identify challenges in different temporal horizons (Alcoforado *et al*, 2009, p. 58).

Nonetheless, it is important to recognise that the assessment of risk hazards presented by the Portuguese National Program of Lisbon's Regional Planning Policy (PROT-AML) and its Municipal Master Plan (PDM) are only focused towards the present day, and therefore do not consider any climate change scenarios and their consequential territorial impacts. Nevertheless, as guiding principles, Lisbon's PDM proposes two principal objectives that are orientated towards a number of announced adaptation measures, first, in 'the creation of prevention and minimizing measures towards local and regional climatic effects that results in not only natural variability but also in the

aggravation of their effects due to land usage alteration' (CML, 2011, p. 61; author's translation). Moreover, in 'interlinking prevention measures with increased risk situations' (CML, 2011, p. 61; author's translation).

With this limitative perspective on only the mitigation perspectives, it is hence necessary to transpose local climatic change scenarios into national territories. For this to take place within Lisbon, it is necessary to first 'understand the impacts', and second to 'evaluate the vulnerabilities' and later to launch a 'your own way' strategic adaptation plan (Prasad *et al*, 2008).

Consolidation of the Urban Waterfront

Urban design and adaptation measures within waterfronts

On a Friday morning in ravaged New Orleans, Louisiana, Joe Brown learned just how fiercely people value their homes. Along with several dozen other disaster experts, the veteran urban planner had been recruited by Urban Land Institute in Washington D.C., to develop a rebuilding plan for the city, which had been devastated by Hurricane Katrina in August 2005 (...) about a quarter of the city lay in utter ruin and remained at high risk of flooding. Brown displayed diagrams that suggested turning some blocks, for the time being, into open space.

Reaction was swift and harsh. A council member accused Brown of aiming to 'replace these fine neighbourhoods with fishes and animals' he recalls. A couple of audience members rose up and declared, 'All we want to do is get back our homes'. The planners were startled. 'We got shock and amazement to what, to us, were fairly obvious truths', Brown says. (Couzin, 2008, Vol. 319, p. 748)

Referring to the reconstruction of New Orleans after Hurricane Katrina, the quote of Couzin contextualises central urban design issues within the agenda of climatic adaptation. The practice of these construction techniques that were resilient to flooding hazards were met by a distinguishable impulse within local society, and supported by institutions such as the 'Make it Right Foundation'³. However, beyond the phenomenon particular to this case, Couzin also quotes the experience of Joe Brown in

order to alert the scientific and professional community of various possible disparities. These discrepancies can be found between science and its application techniques, and the perceptions of society and common sense. This strengthens the importance of the dissemination of scientific knowledge and the continual understanding of society within the agenda of climatic adaptation.

Conclusively, applying the climate change adaptation agenda can create problematic circumstances where undertaking 'the line of least resistance' or the 'lowest common denominator' are not the most viable approaches, as it impairs the necessity for leadership (Robinson and Hamer, 2009). However, it should be noted that, at any point, the urban design, architecture and 'the art of restricting to and conforming the habitable space' (Pinto, 2007, p. 21) incur the risk of affirming solutions, and advancing proposals while contemplating alternative theories.

The reconstruction of New Orleans illustrates another aspect that combines urban design and the agenda of climatic adaptation. In this case, this interdisciplinary practice emerges with particular stringency (Olshansky and Johnson, 2010), determining, in the act of the project, the correlation between urban networks, natural setting frameworks and city infrastructure. Within this harmony of subject matters, 'interdisciplinary practice is as unavoidable as the solutions for problems that arise, and that were originally less evident. Interdisciplinary approaches, are not only the answers to technical complexity, but above all, to the requirement to achieve coherence between objectives on multiple levels (that are many times contradictory), and responding to the incongruities surrounding us' (Portas, 2006, p. 12; author's translation). Interdisciplinary approaches consequently allow us to stabilise governance as an open-ended framework. As a consequence, this aids the task of designing cities and going beyond the simple layout of the architect or urban planner in his rigorous capacity of creating fruitful spaces. It is hence this blueprint elaborated by various hands that synthesises a wholesome response to the numerous challenges of the project.

In light of waterfront adaptation to climate change, eight interdisciplinary obstacles are presented before contemporary urbanism: (i) constructing a more succinct liaison between the two subjects; (ii) planning, projecting and managing urban landscapes in scenarios of climatic uncertainty; (iii) anticipating impacts through the establishment of investigative and analytical 'what if?'

scenarios; (iv) prolonging urbanism into new temporal horizons; (v) encouraging new bottom-up perspectives upon local risk factors in light of climatic changes; (vi) recovering previous yet relevant teachings concerning city planning and design; (vii) the tender of innovative and creative concepts within adaptation strategies; and lastly (viii) perusing novel forms of flexible governability.

On the basis of these challenges, two in particular respect the practice of urban design: recovering new teachings and developing solutions with the utilisation of innovation and creativity. This way, the design of the city faces two distinctive challenges. First, it is important to incrementally prepare the existing cityscape for estimated hazards in function of temporal horizons and scenarios for climatic adaptation. Second is the opportunity for new and resilient forms of urban occupation that are adapted to cope with the transformation of current risk factors. As has been done so far, this document will concentrate on waterfronts being a partial, yet relevant, representative of this urban phenomenon.

The adaptation of a consolidated city towards climatic changes

Focusing on waterfronts, the project 'Urbanised Estuaries and Deltas' encloses the focus on the transposition of climatic impacts upon our territories where waterfronts are analysed within the enclosure of urban contexts. It is in this undergoing stage where the 'comprehension of facts' are delineated, later allowing the 'identification of vulnerabilities' (Figure 6) and 'alternative adaptation strategies' to be analysed (Addressing alternative adaptation strategies are the following published items by the research project: Costa *et al* (2012) and Coelho *et al* (2012)) and respectively incorporated.

Directing our attention further on Lisbon's waterfronts, the convergence of various phenomenon have resulted in the risk of flooding being the 'critical factor' in light of climate change (Figure 3). This convergence is established by seven predetermined issues, those being: (i) rising of sea level (Table 2); (ii) storm surges; (iii) effects of progressive Tagus floods; (iv) 'flash floods' events within Portuguese coastal lines; (v) tidal cycle effects; (vi) undulation; and lastly (vii) topographic correction of national cartography.

Having in mind the various scenarios of climatic change (and the variation of estimates regarding

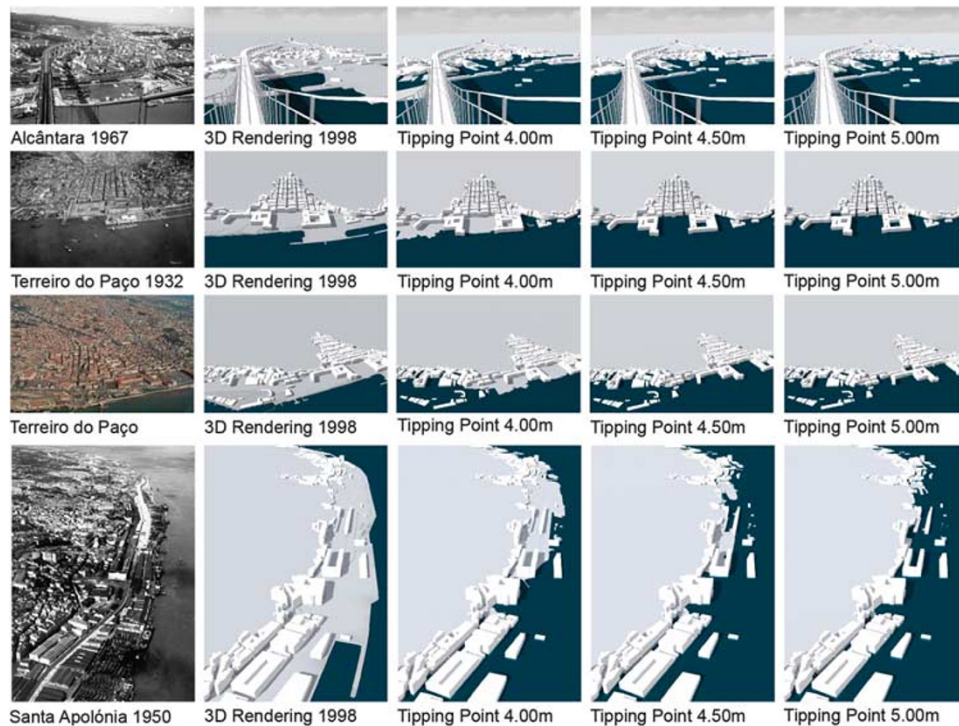


Figure 6: Identification of possible flooding vulnerabilities through tipping points in Lisbon's waterfronts.
 Source: FCT Project 'Urbanized Estuaries and Deltas', FA/UTL and FSHS/UNL, 2011.

average SLR), the combination of the two to seven referenced issues have been methodologically approached through the identification of tipping points (Marchland, 2010). The use of this methodology within the undergoing research project has allowed the elaboration of the comprehensive 'what if' scenarios as discussed in Chapter 2. As such and by working with tipping points, urbanism will no longer be hindered by contradicting information regarding SLR and other variables when considering the *continuum* of Lisbon's waterfronts. It is argued that this approach shall result in the stabilisation of goals regarding specific impacts, and moreover allowing the identification of vulnerabilities and quantification of looming future damages.

These anticipative considerations permit more concise and effective adaptation measures to be considered and identified, regardless of them being two or three decades before or after they are expected. In addition, in its later stages, it is anticipated that the application of this methodology can also be applied in tsunami simulations in order to calculate future climatic impacts upon the coastal city of Lisbon.

This approach harmoniously interlaces with the Dutch approach of 'working with nature', a policy

that delineates a very clear and pragmatic orientation towards the design of their cities. This policy enforces the adaptation to new contexts and, in turn, decreases the dependency on infrastructure that can prove to be inefficient and inept at a certain point in time (Meyer *et al*, 2010, p. 36). Accordingly, it is an approach that shall significantly increase Portugal's progression in adjourning to both its national and international commitment to climate change adaptation.

New forms of urban occupation in waterfronts

Liberating from the constraint of protecting or minimising impacts in the existent city, investigations that scrutinise new forms of urban occupation unlock diverse potentialities, such as the application of resilience concepts. In new waterfronts, 'working with nature' consists in conceiving the city, the architecture or new forms of technological construction in order to prepare and continue to work on flood scenarios of diverse origin.

Adaptive systems hence punctuate the motto, and elucidate two different conceptual approaches. In the first approach, resilience partakes in the integration of a 'Plan B' so that it can be applied in

Table 2: Factors of calculation regarding flooding upon Lisbon’s waterfronts in the 2100 horizon

<i>Scenarios for 2100</i>	<i>Rise in sea level</i>	<i>Correction of cartography</i>	<i>Rising of tides</i>	<i>Undulation</i>	<i>Flood elevation</i>	<i>Storm surge</i>
IPCC (2007b) scenario A1	+0.60 m	+0.16 m	+1.92 m	+0.20 m	+0.15 m	+0.40 m
Rahmstorf (2007) scenario B1		Antunes (2011)	(62 events in 2011)	(frequent elevation)	(progressive flooding of Tagus river)	(1 event in 5 years)
Taborda <i>et al</i> (2010) scenario B1			2.12 m (21 events in 2011)	+0.35 m (extreme events)	+0.45 m ('flash flood' on urbanised coasts)	+0.50 m (1 event in 25 years)
			+2.22 m (4 events in 2011) APL (2011)	Santos <i>et al</i> (2006)	Ramos and Reis (2001).	+0.58 m (1 event in 100 years) Andrade <i>et al</i> (2006)
Rahmstorf (2007) scenario A1	+1.00 m					
Taborda <i>et al</i> (2010) scenario A1						
CRC (2010) recommended						
Vellinga <i>et al</i> (2009)	+1.20 m					
Defra (2006) recommended scenario worst scenario						
Deltacommissie (2008) worst scenario	+1.30 m					
Vellinga <i>et al</i> (2009)	+1.40 m					
California Climate Action Team (2010) A1f1						
CRC (2010) worst scenario						
Taborda <i>et al</i> (2010)						
Defra (2006) worst scenario	+1.60 m					
NYCPCC (2009) worst scenario						
Hansen (2007)	+2.00 m					
Pfeffer <i>et al</i> (2008) extreme scenario						
EA (2009) extreme scenario						
UK Climate Projections (2012) extreme scenario						

Source: FCT Project ‘Urbanized Estuaries and Deltas’, FA/UTL and FSHS/UNL, 2011.

a flooding scenario in order to diminish potential city damage. Anticipating water hazards and/or climatic change scenarios, the various urban dimensions (such as accessibility, water supply/sanitation, construction and public spaces) are cooperatively addressed to prepare a determined urban area that tackles dynamic risk factors imposed by bordering water. Being a practical example of this conceptual approximation, the 255 ha ‘HafenCity’ regeneration project in Hamburg’s harbour area can be used as a relevant and current precedent. Situated outside the city dam perimeter, and acknowledging that it is not sustainable to continually remove areas from River Elba for urban occupation, this occupation permits the occurrence of regular urban flooding. It also

tackles the challenge of avoiding possible city damage and simultaneously maintains normal urban functionality. Consequently, and between other project options, alternative accessibility systems are applied, and the construction solutions are developed for ground floors to resist flooding events.

The second conceptual approach incorporates the development of new forms of occupation that are immune to flooding scenarios. As an historical example, one can reflect upon the biblical archetype of Noah’s Arch or the ancient practices of the Uros tribe (Nordenson *et al*, 2010, p. 132; Olthuis and Keuning, 2010, pp. 179–180).

The conception of floating structures is an excellent resilient solution to flooding, one that

correlates to the technological capacity to conceive buildings, infrastructure and part of a city with those very characteristics. The developments of adequate construction components hence assume a key role in sustaining these forms of urban occupation. As a consequence, this converges: (i) innovation challenges enclosed around the consistency and floatability of supporting structures; (ii) light-weight construction in the urban, architectural and infrastructural spheres; and (iii) joint sustainability that is ultimately strengthened by its multi-cooperative autonomy. Some authors argue that Man shall progressively occupy the aquatic domain in search for more occupational space, nourishment and energy (Wang *et al*, 2008, p. 18). A variant of this second conceptual approximation are floating super-structures; however, this conception is limited to utopian projects.

Moreover and just like all the forms of urban occupation, utopian conceptuality also finds its niche. It is therefore argued that the combination of floating structures with resiliency principals that exploit and investigate all of the potentialities in neighbouring water is a present and relevant ambition.

Conclusion

Climate change adaptation is not a 'vague concept' (Bourdin, 2010); contrariwise, it is the concrete bond within specific localities that substantiates its preciseness and importance. The territorial impacts associated with global warming are today exponentially increasing upon urban frameworks, city infrastructure, public spaces and city equipment. This thus reinforces the imperativeness to link climate change with the practice and execution of urbanism upon contemporary cities.

Supported by existing scientific knowledge, a new adaptation agenda has emerged, one that shall not diverge or wander from its established objectives. Owing to the dissemination of consolidated scientific data in recent years, urbanism is now able to evaluate possible consequences of climatic impacts in both local and regional scales. Undoubtedly, this newly established agenda will gain importance when impacts progressively increase their bearings upon cities and landscapes. This implies that the progression of the agenda for climate change adaptation shall proportionately shadow the anticipated exponential increase of climate change within and beyond the twenty-first century.

Enclosed in the Lisbon case, the initial 'what if?' simulations of 4.00 m, 4.50 m and 5.00 m tipping

points have already been applied to different zones within Lisbon's coastal areas (Figure 3). This presents a contemporary examination of how climate change effects, such as the impacts of SLR, will affect different city components and uses (Figure 4). Through 3D rendering and plan simulation, the impacts are measured at different levels to establish both local and regional impact predictions (Figure 6).

The present investigation suggests therefore an inaugural study in the way urbanism is to face climate change within present-day Portugal and its enveloping coastal cities. More specifically, and reflecting back upon the eight challenges in correlating the spheres of urbanism and climate change within waterfronts, the project 'Urbanized Estuaries and Deltas' inaugurates for Lisbon a: (i) more concise understanding of how urbanism can incorporate climatic issues within its own realm of practice; (ii) better comprehension of how urban and spatial planning can challenge factors of climatic unpredictability; (iii) more lucid anticipation of future impacts by establishing 'what if' scenarios; (iv) expansion into new temporal horizons and potentials for Portuguese urbanism; (v) more articulate and coherent look upon local risk factors in light of climatic changes; (vi) recovering of lessons regarding the composition and design of city's layout; (vii) proposal of solutions that encourage innovation and creativity; and lastly (viii) review of existing and propositions towards new forms of Portuguese governability.

Enclosed within this study, and based as the fulcrum of the methodology, the use of the 4.50 m tipping point has already launched the project into the 'comprehension of facts', 'identification of vulnerabilities' and has opened up appreciations towards 'alternative adaptation strategies' for Portugal. As such, this methodology shall hence propagate the propulsion of Portuguese urbanism into new horizons of application. This approach will also concede the appreciation of new innovative and creative adaptation measures that shall contour the hindrances of climatic uncertainty.

Climate change adaptation should not be an explosive sprint, rather a progressive marathon that regards each case as an individual step towards the finish lines of 2050, 2080 and 2100. Although there may be other impending agendas, climate change adaptation has already defined horizons for an interdisciplinary practice that is conscious of the estimated impacts of climate change. Inevitably, however, only the future can tell when cities, such as Lisbon, will embark on this

progressive journey in order to avoid the imposingly acute bearings that the future will rigorously disclose upon urban landscapes.

Acknowledgements

The authors would like to acknowledge the research project 'Urbanised Estuaries and Deltas. In search for a comprehensive planning and governance. The Lisbon case.' (PTDC/AUR-URB/100309/2008) funded by the Portuguese Foundation for Science and Technology and the European Social Found, 3rd Community Support Framework.

Notes

- 1 In Cascais, there is a tidal gauge that registered a 0.43 m storm surge between 2000 and 2010 (Santos and Cruz, 2010). Previously, the estimated values were of 0.40 m, 0.44 m, 0.50 m, 0.54 m and 0.58 m for return periods of 5, 10, 25, 50 and 100 years (Santos and Miranda, 2006). Empirical data from 1978 and 1981 registered the occurrence of 0.42 m and 0.52 m of storm surge (ARH-Tejo, 2009a). Thus, for riverside occupation guidelines, ARH-Tejo follows the value of 0.50 m as a reference for a return period of 100 years (ibid.).
- 2 For the purpose of accounting of progressive flooding of the Tagus River, the value of 0.15 m is established by the LNEC for the Trancão River and adopted as a reference by the ARH-Tejo (2009b).
- 3 Founded by Brad Pitt in 2007 (<http://makeitright.org/about/>).

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