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SETTING OUT URBAN WATER ISSUES EXAMPLES FROM ALGERIA AND WORLDWIDE

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ABSTRACT

Water has emerged as a pivotal global issue encompassing quantitative and qualitative dimensions, albeit with variations across the world. Successive dedicated reports have attributed the causes to i) population growth, leading to an increasing demand, ii) pollution resulting from mining and industrial transformation activities, and iii) climate change impacting the global water cycle.

However, the implementation of the integrated water resource management and water sensitive urban design approach still appears to be limited worldwide.

Therefore, this paper aims to contribute to stating the water urban issue and facilitate understanding the complexity of the problem at hand through relevant literature. Concrete examples from Algeria and around the world are cited to reveal these aspects.

Keywords: Integrated water management, Urban water uses, Sustainable urban planning

INTRODUCTION

Water issues have long been a matter of critical interest for humankind, consistently capturing the attention of both city planners and users. However, currently, there appears to be a growing awareness regarding the degradation and fragility of this vital resource, as well as its social vulnerability. Indeed, water has emerged as a pivotal global issue encompassing quantitative and qualitative dimensions, albeit with variations across the world. Successive dedicated reports have attributed the causes to i) population growth, leading to an increasing demand, ii) pollution resulting from mining and industrial transformation activities, and iii) climate change impacting the global water cycle (UN-Water, 2023).

Based on the scenarios developed by the Intergovernmental Panel on Climate Change (IPCC), altered rainfall patterns could elevate the exposure levels to extreme hydrometeorological hazards, such as droughts and floods (IPCC, 2023). While these events play a vital role in maintaining the hydrodynamic balance, they could also pose critical challenges for the safety, health, and comfort of populations living in prone risk areas.

Considering the global socioeconomic and political context, which includes factors such as population growth, conflicts and migrations, water-related risks are expected to intensify within urban areas. Cities that are exposed and fragile inherently become vulnerable. For instance, regardless of the bioclimatic location, nearly all Algerian cities are currently grappling with water-related challenges. Both the rainy northern regions and the arid southern areas are experiencing recurring issues of water scarcity, floods, contamination and subsequent environmental and health risks. However, amidst these challenges, pollution may stand out as the most insidious phenomenon, leading to irreversible and even fatal consequences. In such cases, the water resource itself transforms into a risk, carrying the potential for serious impacts on natural ecosystems and human health.

The context can be alarming, as some prescribed and/or implemented solutions paradoxically appear to be as perilous as the problems they aim to address. Indeed, some Algerian cities are already witnessing adverse effects from structural measures undertaken by the government or self-implemented by the local populations themselves. As an example, Biskra is currently experiencing an unprecedented decline in groundwater levels due to overexploitation for irrigation. Meanwhile, several Saoura oases, including Touggourt, el-Oued and Laghouat, periodically suffer from water contamination resulting from excessive water spills from the Albian aquifer (Bensaad, 2011; Khadraoui, 2011; Bouselsal, 2018; Remini, 2019). Such is the situation within coastal cities such as Algiers and Oran.

Given the intrinsic interconnectedness of water realms, which span ecosystems, societies, practices, and disciplines, there is an urgent need for a comprehensive management strategy that effectively restores the vital balance between the city and nature, including hydrosystems. This strategy ultimately benefits the health, security and well-being of the local population. Notably, the adoption of the integrated water resources management approach (IWRM) stands out as a relevant strategy explicitly designed to tackle these challenges while addressing associated risks and vulnerabilities at the watershed scale.

IWRM derives from a sustainable development strategy and aims to ensure a safe water supply, proper sanitation, and protection against hydrometeorological hazards and water-related risks. The process is guided by the management of the urban water cycle, with the primary objective of minimizing disturbances to the global water cycle, both qualitatively and quantitatively. This involves incorporating the dynamics and geography of local hydrosystems into land use and urban planning strategies while also integrating measures to mitigate short-term and long-term irreversible impacts into action plans (Aroua and Zemmouri, 2019).

In Algeria, for instance, water is managed at the watershed scale by hydrographic basin agencies. This marks a significant step toward sustainability. However, this approach seems to remain isolated as long as the territory and city planning process is confined within administrative borders rather than considering the broader bioregion or the watershed scope. While cross-sector, cross-municipality dialogs, as well as participatory approaches, are regulated, their generalization appears to be limited and poorly implemented on the ground. This limitation may stem from a lack of commitment or conviction among local authorities and partners, as well as outdated training programs for urban designers, planners and managers. Thus, barriers may emerge from political, economic and scientific perspectives (Aroua and Mellouk, 2023).

The water issue within urban environments is actually complex. Water interconnects everything—environments, communities, practices, disciplines, and more. Wetlands and riverine basins interact with human behaviors and actions influencing the continental phase of the water cycle. Urban settlements, in particular, disrupt or even interrupt hydrodynamic processes through inappropriate land and natural resource usage. An example is Lake Fetzara (located in the wilaya of Annaba, northwestern Algeria), designated under the Ramsar Convention in 2003. Despite its protected status, its ecological balance is threatened and even degraded due to urbanization, as demonstrated by research (Mellouk and Aroua, 2015).

Even when situated far from urbanized areas, wetlands are vulnerable to pollution resulting from liquid and solid waste discharges. The issue becomes even more intricate when dealing with existing cities, where interventions are more challenging. Therefore, when planning future urbanization, it is imperative to consider wetlands as both natural environments and physiographic units. However, the implementation of any water-sensitive urban design approach still appears to be limited worldwide. Several factors contribute to this situation, including a lack of awareness among urban stakeholders about the specific of the approach and the concrete steps that should be taken (Aroua and Mellouk, 2023; Aroua and Zemmouri, 2019).

METHOD AND TOOLS

Therefore, this paper aims to contribute to stating the water urban issue and facilitate understanding the complexity of the problem at hand through relevant literature. Concrete examples from Algeria and around the world are cited to illustrate the discussed aspects.

The following questions should be addressed:

First, what are the competing uses of water within urban settings?

Second, what are the water-related risks and their cumulative impacts on the urban social ecosystem?

Third, how are cities planning to mitigate these effects while enhancing resilience to related hazards and associated risks?

Thus, the first specific objective of this paper is to analyze urban water issues, the second specific objective is to trace and discuss global progress in urban water management, and the third specific objective is to provide an overview of some relevant practices implemented by cities in the face of hydrometeorological hazards and associated risks.

COMPETING URBAN WATER USES

Water serves diverse purposes within urban areas, including i) domestic uses such as drinking, cooking, and personal hygiene; ii) public uses, encompassing the cleaning of public spaces, maintenance of sanitation facilities, supplying public ponds and fountains, and watering green spaces; and iii) industrial applications such as manufacturing processes. All these activities often lead to the discharge of specific and/or mixed wastewater. Inappropriate management of water services for each user can result in chemical, organic or biological contamination. This contamination poses significant social, environmental, and economic risks with the potential for cascading effects on cities designated as urban ecosystems (Aroua, 1983).

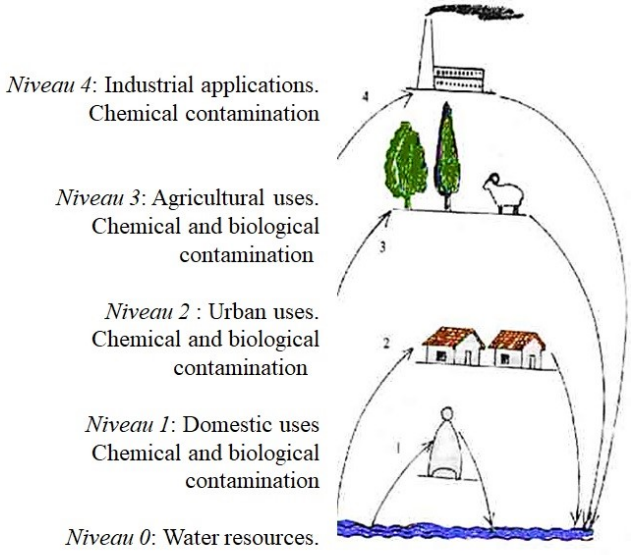

Figure 1: Competing water uses (Aroua, 1983, p. 104)

Associated environmental risks have implications for ecological balance, individual and public health and safety, property protection, and land and natural resource usage. Additionally, as highlighted by the IPCC, the anticipated increase in the frequency and intensity of hydrometeorological hazards will significantly impact the water cycle, exacerbating human and environmental damage (IPCC, 2018). Given the projected global demographic growth and economic development, these challenges further

complicate urban planning, design, and local governance practices. Therefore, the convergent effects on the sustainable development pillars can be delineated as follows:

Social and environmental effects

The water issue is inherently intertwined with human health requirements and environmental integrity. Despite advancements in providing access to safe drinking water and sanitation services in developing countries, the adverse effects of the water crisis extend to both health and food security (UN-Water, 2023). Subsequently, the connection rate to drinking water and sewage networks can no longer be considered a reliable indicator of quality of life or local socioeconomic development. Water supply efficiency appears to be linked to natural and anthropogenic causes, as revealed by a study conducted in the city of Algiers (Aroua and Zemmouri, 2019).

However, while the causes of pollution and contamination differ, climate change and pathogen resistance are expected to present similar serious challenges to the water sector in both developed and developing countries (Howard, 2021; WHO, 2022). Indeed, developed countries reveal vulnerability to waterborne diseases and environmental risks (Aboah and Miyitta, 2022; OECD, 2016). For instance, waterborne diseases continue to threaten public health in the United States of America, with over 7 million reported cases of illness annually (Collier and al, 2021). Similar situations can be observed in Europe due to water pollution and contamination (WHO, 2022).

Effects on water management

Urban water management needs to address the growing demand resulting from population growth and rapid urbanization. However, unprecedented urban growth worldwide has intensified the long-standing debate on the carrying capacity of local hydrosystems to provide water for human settlements, alongside urban blueprint mitigation. Additionally, water governance beyond the administrative boundaries of cities has revealed complexity (OECD, 2015). In the meantime, lessons learned from past and ongoing experiments worldwide have highlighted the benefits of managing water at the watershed scale, which has been proven to be more economically efficient, socially equitable, and environmentally sustainable (UN-Water, 2023; OECD, 2015; Gupta and Pahl-Wostl, 2013).

The water issue is widely regarded as one of the most complex governance challenges, requiring expertise from various fields and levels of interest and applications. However, until recently, urban design and planning have shown little investment in hydrosystem features, primarily due to single-sector programs and fragmented scientific knowledge, among other factors (Aroua and Zemmouri, 2019; OECD, 2015).

Economic effects

From a financial standpoint, the actual cost of water, which encompasses funding for water infrastructure (such as mobilization, sanitation, and purification) and water services (including production, supply, distribution, and wastewater management), is disproportionately borne by users (OECD, 2016).

This places a significant burden on public budgets responsible for water management as they strive to achieve both social equity and economic viability. However, human needs, when ethically prioritized, are quantitatively smaller and qualitatively more demanding. However, they are economically less profitable for water suppliers. In the meantime, the water bill cannot exceed an acceptable threshold for the majority of the population while ensuring a consistent and equitable quality of public service. Given that industry and agriculture are the primary water consumers and the largest polluters, it is recommended to mandate a substantial financial contribution from these two strategic sectors to implement sustainable water resource management (UN-Water, 2023).

Human rights to water and sanitation were definitively reaffirmed by the United Nations assembly in 2013 and are also reflected in Sustainable Development Goals 6 and associated targets (UN, 2014). This has led to a growing advocacy for community management projects, often supported by international organizations such as UNESCO, the World Bank, and the United Nations, as seen in countries within the Mekong region (UNESCO, 2021) and Kenya (WB, 2021) as examples. The challenge is to successfully engage various stakeholders in participatory projects ensuring benefits for local communities (Lara Garcia et al, 2022).

Water-related risks

Population growth, industrialization and urbanization have significant implications for local microclimates, air quality, and circulation, thereby influencing evaporation patterns. Consequently, annual precipitation in large industrialized cities tends to be substantially higher than that in surrounding areas (IPCC, 2023; Da Silva et al., 2022; Liu and Niyogi, 2019). Additionally, as shown in Fig. 2, construction activities and extensive road paving contribute significantly to surface sealing. The resulting acceleration of rainwater runoff increases the risk of flooding, impedes infiltration into deeper soil layers (potentially lowering the water table), and diverts water flow from natural outlets such as rivers and seas. Concurrently, the increasing water demand results in the overexploitation of conventional water resources, depletion of watercourses, and heightened discharge of contaminants through inadequately or not at all treated wastewater into the surrounding natural environment.

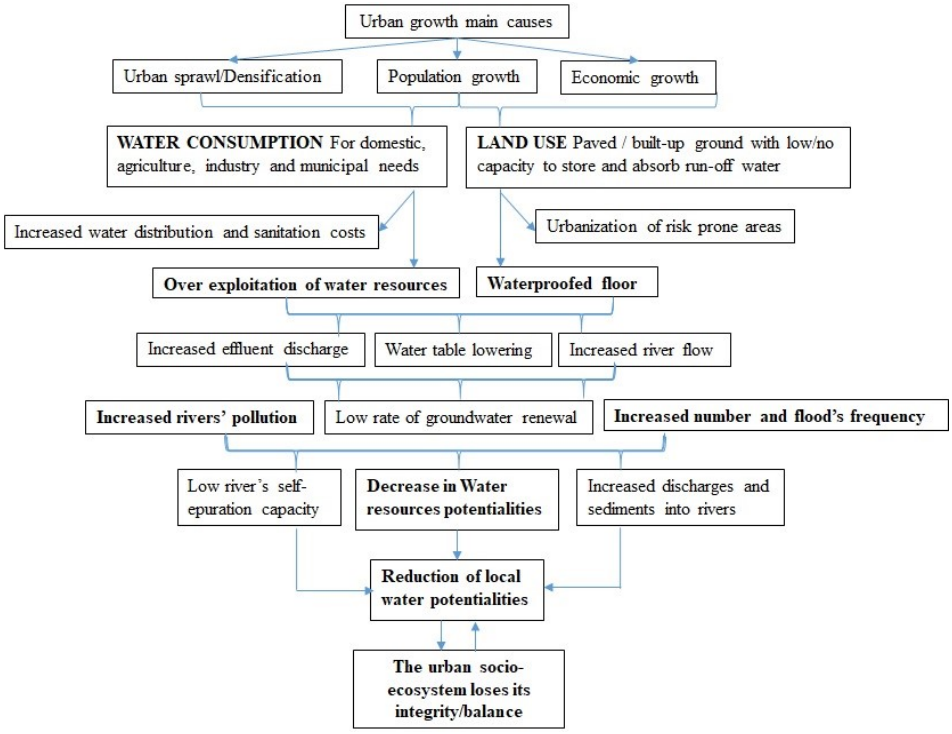

Figure 2: Impact of urbanization on the water cycle (the author, after various documents) Conventional water management models typically prioritize the swift evacuation of rainwater through sewer systems. While this approach reduces on-site water volume, it significantly raises downstream water levels, leading to an increased risk of sewer network overflow and subsequent flooding. The retention of excess water in basins and the use of storm overflows also impede natural groundwater recharge. Additionally, these practices elevate pollution risks when stormwater combines with wastewater and discharge through sewer systems. Unfortunately, these techniques continue to be widely implemented worldwide, including in Algeria (UN-Water, 2023; Howard, 2021; Volkan Oral and al, 2020).

Coastal cities, in particular, are highly vulnerable to flooding and sea level rise (IPCC, 2018). The global incidence of natural disasters reveals that many cities also face water scarcity (UN-Water, 2023). The extent of impacts and damages recorded worldwide is typically influenced by the level of development. However, despite the inherent risks to populations, it is worth noting that hydroclimatic phenomena shape the dynamics of the global water cycle. Any disruption to that natural cycle, whether in terms of quality (e.g., pollution) or quantity (e.g., hindrance to infiltration or runoff), may amplify their intensity and the level of associated risks, resulting in more pronounced impacts on vulnerable

urban ecosystems. Conversely, a resilient urban ecosystem would effectively contribute to preserving hydrosystem integrity and mitigating water-related risks (Aroua, 2012).

The resilient city should embrace the concepts and models of natural systems while embodying the metaphor of the ecological city (WB, 2010). This perspective expands the resilience framework beyond static adaptation, which aims to restore the initial state after a disruption. Instead, it involves a dynamic process for transformation and flexibility. Instead of being closed, finite, predetermined, and repetitive, the urban ecosystem shifts into an open, interconnected, and interdependent system that perceives external events as catalysts for development rather than for mere catastrophic disasters. In this context, the watershed regains relevance to land use and urban planning.

Water resources in the framework of sustainable urban development

An essential aspect of the solution pertains to water resources within the context of the sustainable urban development strategy.

Henceforth, the sustainable development goal 11 "Sustainable cities and communities" (SDG 11) is – or at least should be – to contribute to the wise use and governance of water as a valuable and threatened resource. Extensive literature on sustainable development since the Rio Summit in 1992 underscores the widespread recognition that sustainable water management is closely intertwined with sustainable urban planning and design.

In highly urbanized areas, hydrosystems undergo extensive impacts resulting from inadequate land use and management (WMO, 2017). Consequently, plains and valleys re-emerge as relevant spatial entities for urban planning, with the aim of conserving and/or restoring ecosystems, wetlands, and natural landscapes.

Indeed, socioeconomic development policies traditionally prioritize actions to meet the increasing urban water demand at any cost. Now, the sustainability strategy recommends i) limiting the urban growth process and optimizing land use at the county, regional, and local levels and ii) observing the carrying capacity of local hydrosystems at the watershed scale (UN-Water, 2023; WMO, 2017). Furthermore, navigable rivers and wetlands could introduce substantial benefits to cities and help maintain a dynamic balance among their environmental, social, and economic features (Stefanakis, 2019). The preservation of water quantity and quality, coupled with the integration of preventive measures against water-related risks such as scarcity, pollution, flooding, and landslides, should be integral components of the urban planning process (Aroua and Mellouk, 2023; Aroua and Zemmouri, 2019).

Sustainable urban planning strategies favor systemic approaches that address social, spatial, economic, and environmental aspects simultaneously. These strategies emphasize the importance of transdisciplinary and participatory approaches, drawing lessons from the past, estimating the present context, and exploring future prospects for preventive measures, impact studies, and risk assessment.

At the operational level, addressing the water issue necessitates a comprehensive examination of planning programs, facilities, equipment, and easements related to watershed features. This includes the evaluation of potential treatment processes, such as sedimentation and primary purification. Furthermore, it mandates efficient supply systems capable of transferring water to urban and/or rural settlements, alongside appropriate storage and distribution mechanisms. Additionally, ensuring proper discharge through sewerage systems and implementing secondary wastewater treatment for potential reuse are essential criteria that must be fulfilled (UN-Water, 2023; WHO, 2022). In fact, the consideration of nonconventional water resources and demineralization often seems highly recommended, if not imperative, within arid contexts.

As an example, drawing from the Australian experience in an arid climate similar to Algeria's, a locally integrated water management plan for the long term (30 years) has been implemented. However, this plan should receive support from the state while maintaining flexibility and profitability for both the surface and subsurface components of the local hydrosystem. Its primary objectives include optimizing resource utilization, minimizing wastewater volume, mitigating impacts on water quality, promoting water and energy conservation and fostering recycling (Doolan and Hart, 2017).

The preservation of water, quantitatively and qualitatively, as well as the effective management of associated risks, are indeed of paramount importance. In this case, priority should be given to biotechnologies and nature-based solutions to reduce pollution and erosion and prevent floods and severe droughts. The ecohydrology approach and alternative sanitation techniques, such as rainwater harvesting for groundwater recharge, also play a significant role. Both rainwater and recycled wastewater can effectively contribute to alleviating water shortages, provided that specific measures related to security, hygiene and comfort are implemented. For example, in Algeria, the use of treated wastewater for irrigation and watering must meet some specific requirements (Aroua-Berkat and Aroua, 2022).

Integrated flood management, including rainwater management, plays a pivotal role in mitigating flood risk and addressing water shortages, especially in arid or semiarid climates such as Algeria. Simple and cost-effective facilities such as rainwater harvesting tanks, drainage channels, filter lawns, and retention ponds are essential tools for integrated flood management. Additionally, the use of drought-resistant plants and the reuse of treated domestic wastewater for irrigation and toilet flushing are highly recommended practices (UN, 2002).

The Integrated Water Resources Management (IWRM) approach addresses two crucial challenges in urban water planning by involving the implementation of mechanisms to regulate and control the urban water cycle (UN-Water, 2009). First, it shifts the focus from solely increasing water supply to reducing demand. Second, it aims to balance the competing interests for health, environment, economy, and urban development. However, effective implementation of IWRM requires ongoing coordination among stakeholders and urban institutions. This coordination should account for diverse levels of water usage and incorporate various social, technical, ecological, urban and organizational aspects.

Accurate delineation of spatial and temporal planning references, along with legislative tools facilitating intermunicipal coordination, is essential for any successful implementation (Aroua and Mellouk, 2023).

Hydroclimatic hazards can affect territories ranging from small individual parcels to watersheds, persisting from a few hours to several months. Considering the space, time and dynamics of these events separately can exacerbate local and regional consequences (UN-Water, 2009). Moreover, the dynamics of a large river basin differ from those of smaller tributaries. Therefore, when managing a natural space such as the watershed, it is crucial to ensure stakeholder consultation and consistency in up- and downstream programs (Aroua and Mellouk, 2023; Aroua and Zemmouri, 2019).

Harmonizing conflicting interests related to land, subsoil, and water use within river basins is crucial. This encompasses surface components such as rivers, tributaries, and natural and artificial wetlands, as well as subsurface components such as water tables.

Achieving this goal requires comprehensive planning schemes. The local implementation of national strategies encompasses a range of measures, including management and development plans, regulatory procedures, environmental assessments, zoning regulations, land use policies, and the spatial distribution of activities. These measures are intertwined with the management of natural hazards and urban development, all of which contribute to a comprehensive integrated approach. Urban planning assumes a crucial role in proactively addressing associated risks, in addition to fulfilling water cycle management objectives. The adoption of a water-sensitive approach offers a framework for designing road layouts aligned with water paths, landscapes, landmarks, and functionalities. This approach aims to contribute to preserving hydrogeological features such as water tables, springs, and watercourses (Aroua and Mellouk, 2023; Fogarty and al, 2021, Aroua and Zemmouri, 2019).

MEASURES DEALING WITH URBAN WATR ISSUES: AN OVERVIEW

The integrated management of watersheds and coordinated managing efforts of water and land resources remain crucial to any urban setting. Connecting the city with nature allows for thriving within a specific environment and unique landscape. For instance, the landscape eco-design approach can transcend the competing interests of stakeholders by overlapping space and time scales and integrating green and blue infrastructures, as well as biological corridors. In this case, urban open spaces contribute to conserving specific ecosystems and landscapes and, ultimately, transforming hazards into opportunities (Byrne and Parwinder, 2008). Generally, mitigating potential damage caused by hydroclimatic hazards and water-related risks requires the following measures, as recommended by the UNISDR (UNDRR, 2021):

1. ***Moving away from hazard-prone areas*:** While this measure is more easily applied in new urban settings, it is often necessary to address the existing urban fabric and prevailing conditions. In such cases, immediate protective and/or incremental

preventive adaptation measures may be needed. Controversy surrounds the usual relocation of activities and populations, as some cities, facing urgent needs or limited land resources, may be compelled to invest in risk-prone areas, providing major infrastructures that offer a temporary sense of security. Nevertheless, ecohydrology offers a proactive and preventive option (UNESCO, 2007; UNESCO, 2006).

2. ***Restoring the river's dynamic space*:** Preserving or revitalizing the biological and physical integrity of the river beyond the city's administrative boundaries is crucial. This ecological approach involves urban planning, environmental regulations, and water laws (Aroua and Mellouk, 2023). Through the integration of water bodies, urban spaces can be designed to leverage their structuring effects. The city blueprint approach enables the modulation of protection levels through zoning and landscape networking.
3. ***Limiting disasters within their occurrence perimeter*:** Hydroclimatic events rarely reach critical severity thresholds locally. Therefore, preventing the propagation or domino effect of their impacts is crucial. In human-altered environments, alternative drainage techniques can be employed to restore natural processes. The ultimate goal is to reduce the risks of water scarcity and flooding by maintaining optimal permeability levels on each plot, allowing for on-site storage or stormwater infiltration. These low environmental impact techniques aim to replicate surface runoff and subsurface infiltration pathways. For instance, the sponge city model may facilitate rainwater infiltration and storage (Zhang, 2017; Zevenbergen and al, 2017). An example of permeable pavement is shown in Fig. 3.

Figure 3: Permeable pavement, Santa Maria Assunta di Praglia- Padova (the author, 2018)

Figure 4: Guidalquivir riverbank development- City of Sevilla (the author, 2011)

4. ***Controlling the urban growth process*:** This measure extends beyond regulating land use and encompasses the overall management of water and vegetation. It can be achieved by considering the watershed as the starting point for space planning, embodying the complex relationships between the natural environment and local communities. Indeed, the water dynamics across the watershed are influenced by precipitation, evaporation, transpiration, infiltration, vegetation, hydrogeology, and the presence of agricultural, industrial, and/or urban activities. (Aroua and Mellouk, 2023).

   Simultaneously, the urban ecodesign approach significantly contributes to enhancing the rate and efficiency of impermeable paved surfaces and shaping the arrangement and gradients of the road network. For instance, ecourbanism prioritizes the regulation of land use through the rehabilitation and/or conservation of natural flood or retention areas, all while safeguarding the dynamics and morphology of the local hydrosystem. Furthermore, integrated water management seeks to reduce runoff volumes, promote groundwater recharge, and allocate 10 to 30% of rainwater for public use.

CONCLUSION

This paper has examined water challenges facing cities and their impacts on this vital yet vulnerable resource, involving rising demand, industrial pollution and the effects of climate change. Urban expansion persists globally, occurring through formal and/or informal processes in disaster-prone areas with limited land and scarce water resources. Such land-use patterns gain legitimacy when aimed at rebalancing or improving the

distribution of infrastructure and urban facilities, as observed in Algeria. However, this inevitably heightens risks, disproportionately affecting poor communities in particular. The anticipated qualitative and quantitative depletion of water resources poses a significant threat to the health, development, and survival of humanity. The resulting water crisis becomes more severe and unjust when considering geographical dissemination and long-term implications. The stakes are high, involving ecological balance, individuals and property safety, land-use patterns, natural resource exploitation, and local governance.

In parallel, studies on water-related issues are intensifying under the auspices of international and national scientific bodies. However, the implementation of research findings often proves insufficient or lacking, with water policies generally prioritizing conventional and nonconventional resource production to meet increasing water demand rather than focusing on resource preservation and waste reduction (UN-Water, 2023). Although IWRM emerged as a solution, barriers to its implementation persist, possibly due to limited involvement and fragmented urban planning praxis. Addressing these challenges requires a comprehensive strategy hamonizing urban needs and ecosystem balance, including hydrosystems, to mitigate hydrometeorological hazards and associated risks. Moreover, expanding urban centers seek tailored solutions adapted to their specific hydroclimatic context. Indeed, global experience reveals that relying solely on technological or legal measures is generally insufficient to ensure the integrity of water systems within cities. Human activities inevitably disrupt natural balances, emphasizing the imperative of wise governance of ecosystem features. Achieving this goal requires a paradigm shift focusing on cross-cutting geographical scales and time horizons, among other considerations.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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