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MEGACITIES AND WATER RESOURCES

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LINKAGES BETWEEN WATER CHALLENGES AND LAND USE PLANNING IN MEGACITIES

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MEGACITIES IN AN URBANIZING PLANET

Defined by UN-HABITAT, a megacity is an urban area with over 10 million inhabitants. To date (2014), there are 28 megacities in the world. UN conservative growth projections predict that by 2030, there will be another 13 megacities in the world. In addition to the soon-to-be megacities, the world's projected future is filled with many other fast-growing cities in an increasingly urbanized world (Figure 1). Megacities' large population concentrations, locations on coasts or in drought-prone areas, and roles as national capitals and/or financial centers make their vulnerabilities to water-related disasters of widespread concern. The growing urban water needs of megacities pose significant social, environmental, and economic challenges for nations around the world.

WATER AND LAND IN URBANIZATION

Megacities are growing bigger and faster than ever before. The speed and scale of their urbanization influence how quickly these cities exceed their local water supply availability and infrastructure capacities, and the extent to which they must seek additional water sources and expand and/or upgrade infrastructure to accommodate such growth. Megacities' rapid urbanization processes involve large amounts of land conversion that often have direct and usually adverse impacts on hydrology, water quality, and aquatic ecosystems. How megacities continue to grow in relation to land is critical to how well they can manage water.

Land is the media connecting water and growth. Most megacities' water issues are inseparable from land use because they are rooted in the spatial discrepancies between available land and water. Where water is scarce, such in arid regions, expanding megacities inevitably

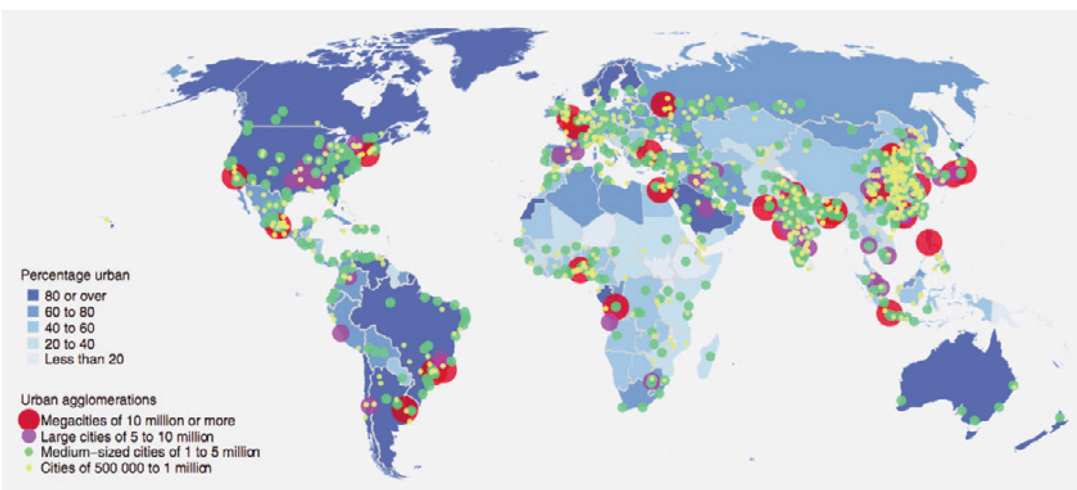

Figure 1. Map Depicting the Percentage of a Country's Population That is Urban and the Locations of Urban Agglomerations With at Least 500,000 Inhabitants in 2014. "Percentage Urban" is defined as urban population/total population. List shows time frame when each city became a megacity.

(Note: Figure is reproduced from "World Urbanization Prospects, the 2014 Revision" by the United Nations, Department of Economic and Social Affairs, Population Division (2014). Retrieved from http://esa.un.org/unpd/wup/CD-ROM/Default.aspx.

	MEGACITY
1950	New York-Newark Tokyo
1975	Cindad de Mexico (Mexico City)
1980	Sao Paulo
1985	Mumbai (Bombay) Osaka-Kobe Los Angeles-Long Beach-Santa Ana
1990	Kolkata (Calcutta) Seoul (dropped off in 2005) Buenos Aires
1995	Delhi Shanghai Rio de Janeiro
2000	Dhaka Al-Qahirah (Cairo) Beijing Karachi Moskva (Moscow)
2005	Manila Paris
2010	Istanbul Lagos Guangzhou, Guangdong Shenzhen
2014	Chongqing Kinshasa Tianjin London Jakarta

reach local water availability thresholds and encounter difficulties trying to sustain urban, land-based human activities (such as in Beijing, Los Angeles, Istanbul, Mexico City, and Cairo). Where water is abundant, expanding megacities run out of desirable land use locations and new development occurs on unsuitable terrain, such as flood plains and land with poor infiltration properties, which exacerbates flooding problems (such as in coastal megacities and megacities located along rivers). In many megacities, construction and management of water supply, stormwater, and wastewater systems cannot adequately keep pace with land conversion.

Urbanization, virtual water trade, and climate change force us to recognize interdependencies among the world's cities and address the processes and dynamics connecting land, water, climate, and people.

In some cases, megacities expand their urban boundaries outward, enlarge city areas and absorb unincorporated areas or neighboring communities to accommodate new growth and development (Sorensen, 2011). Such expansion puts significant pressure on megacities to meet water infrastructure needs and provide adequate services. When megacities incorporate other municipalities during sprawl processes, multiple and multi-level administrations can lead to governance complications and dysfunction. Megacities usually share common water sources and water infrastructure with their adjacent cities, and their mega water challenges are consequently spread to adjacent cities or even much farther. These challenges include loss of an agricultural sector, competition for water resources, reduction of water to maintain ecosystem services, and degradation of water quality.

The often fast and aggressive urban growth and land expansion that occurs in megacities makes their land use planning processes extremely difficult to manage. Failure to anticipate, prepare, and respond to such growth may lead to spatial inequality, either a dispersal of informal development by urban poor or concentrations of wealthy urban dwellers and high-value real estate driven by private investment. In most cases, urban growth of megacities in the developing world is inextricably linked with slum expansion and poverty (such as in Delhi, Mumbai, Rio de Janeiro, São Paulo, and Lagos). Such spatial and social sorting is also reflected in water infrastructure development and water pricing, where various neighborhoods and people do not have equal access to water services. Providing water access and services to slum residents in megacities is a complex undertaking that involves land use policies, regulations, water and land use planning and human rights.

A major question confronting many megacities is how long they can continue to grow under conditions of intense competition for and pressure on limited land and water resources. The interconnectivities between water and land must be addressed by megacities in attempting to cope with their water challenges.

INTEGRATION: A NEXUS OF CONCEPTUAL, INSTITUTIONAL, AND MODELING CHALLENGES

Increasing calls are being issued for research and policy to bridge the multiple gaps that currently exist between land use planning and water planning. Conventionally, water and land have been conceived, managed, and studied in a fragmented fashion. This fragmentation is due to a combination of distinct conceptualizations, disconnected institutional structures, and divergent modeling efforts. Understanding this fragmentation allows for systematic thinking that can help lead to greater integration needed to address the planning needs of megacities.

Conceptually, land is conceived as a base for growth and water is treated as something that will be channeled to land in support of that growth. Providing water service to businesses and citizens is generally a municipal mandate, and moving water to facilitate urban growth is taken for granted from both land use and water planning perspectives. Cities grow under the supposition that "build it, and the water will come." Since water management is heavily dominated by engineering and economic perspectives, the main approach for facilitating urban growth involves transferring water from what is generally seen as low-value land-based agricultural uses to high-value land-based urban uses through constructing water infrastructure and relying on market-driven financial incentives. Pressures to supply water for growth are especially acute in megacities that are centers for their countries' engagements with the global economy and which exercise strong political and economic power to acquire and develop new water supplies.

Fortified by distinct conceptualizations of water and land, the water component is often missing in land use planning as a constraint on continued growth. Likewise land use planning is rarely used in water planning and management as a determinant of water pathways, water flow and water quality. As a result, water researchers and managers often fail to address the linkages between water and land in urban systems, and do not fully analyze how various urbanization patterns can lead to different water outcomes in terms of uses, consumption, quality, and environmental impacts. Similarly, geographers and urban planners often neglect the impacts of the relatively small footprint of urban water supply on basin water balances and quality.

Institutionally, multi-level and multi-departmental institutional arrangements and complex political structures have impeded finding greater synergies between land and water management. Generally, water planning is further divided into two basic realms: water quality and water quantity. Even though each nation may have different governance structures and regimes, similar functional disconnections and institutional complexities exist, which generally intensifies integration challenges. Institutional fragmentation creates gaps in program designs and implementation, and causes overlaps and conflicts among institutions across multiple levels.

Institutional fragmentation reinforces distinct conceptualizations of land and water. Each institution has its own missions and authorities and is staffed by administrators, managers, planners, and technicians trained in different disciplines. Specifically, land use planners address the geospatial relationship of land uses and how to channel growth through planning and regulation; thus, they frame and tackle land issues from a *spatial* and *geographical* perspective. Water supply planners/managers, heavily influenced by the culture of water engineering, focus on the flow, volume, and transportation of water from various sources to end users; hence, they conceptualize and frame problems from a *quantitative* and *directional* perspective. Water quality planners and regulators have duties to control water-related impacts from growth and urbanization; therefore, they construct and manage water from a *compositional* perspective (Arnold, 2005).

Among the welter of institutions and entities at all levels of government that affect urban planning, policies to manage water and land use are often disaggregated or dispersed, each dealing with one part of the big picture (Gober *et al.,* 2013). Sometimes this disaggregation results in policies even being contradictory or working at cross purposes with other policies. Taken together, all types of planners work in a rather complex nexus of laws, regulations, policies, procedures and decision-making criteria related to divergent water and land governance regimes.

Technically, divergent efforts have been put into studying and modeling land and water. In general, water has been incorporated into land use planning models from various perspectives. Most of these models are focused on hydrological responses, ecological functions, promoting public safety, and protecting aesthetic views. Few studies based on land use models use water availability and impacts on water quality as constraints on urban growth. Water planning models generally give insufficient attention to the historical and contemporary emergence of the role of land use planning and development patterns (Srinivasan *et al.,* 2012). In watershed planning models, land use or land cover status is mostly used as model inputs and is considered static, being neither dynamically nor spatially explicit. Though there is some research examining land cover or land use dynamics and the impacts to hydrology, water quality, and water balance, these research-driven and future-oriented land use scenarios often do not respond to local governments' general plans. Usually these models have limited ability to address broader multi-objective (e.g. land and water) and multi-user (e.g., owners of land vs. owners of water rights) policy issues.

Given that models are effective and widely adopted technical tools for public evaluation and policy proposals in the urban planning process, a coupled water management and urban land use planning model would be an effective tool to facilitate understanding connections between water and land. A coupled model also would be helpful for water and land use managers and planners to build mutual understandings, share common visions, and recommend appropriate policy actions. Integrated modeling will help planners, mangers, and government officials envision and move toward more water-conscious urban development and growth.

MEGACITIES AND CLIMATE CHANGE

Climate change likely will exacerbate megacities' existing water problems, making them some of the most climate-change vulnerable locations in the world. Extreme events like droughts and superstorms are impacting concentrated populations ever more frequently. Megacities are on the frontlines of global climate change but are also well positioned to play a leadership role in driving global action to address climate change, due to their strong economic power and political influence. Megacities are taking various robust approaches to improve their resilience to climate change, from managing land use to creating new urban green spaces and building flood defenses.

Climate change has been recognized as a management challenge in both land use planning and water planning, but often different sectorial approaches are taken to dealing with it. A paradigm shift from the current silo planning regime is needed. Such a transformative change necessitates: (1) planning and managing water and land with strategic thinking about climate change impacts on water systems and land use impacts on climate change; (2) collaborative and integrated modeling of the urban water system under climate change scenarios for informed discussions and decision making; (3) institutional cooperation between water and land departments as a new form of governance to support climate change adaptation; and (4) education, outreach, and research capacity to increase public awareness and provide opportunities for stakeholders and organizations to share their experiences.

FUTURE DIRECTIONS

Integrating land use planning and water planning is the foundation of effective approaches for managing population, land, and water, not only in megacities but in an increasingly urbanized world. Unfortunately, there is no well-defined vision of how integrated water planning and land use planning should be, nor a clear map of how to get there. Given the likely difficulties involved in changing deeply entrenched conceptualizations, institutional structures, and modeling efforts that currently disconnect water and land, two general strategies to facilitate and enable such integration have been discussed by practitioners and researchers: water-conscious land use planning and land use-conscious water planning (Bates, 2011). Water-conscious land use planning highlights protecting and restoring water sources in land use practices, reducing humans' water footprint through appropriate development patterns, and limiting growth by recognizing and incorporating water as a constraint to permitting new development. Meanwhile, land use conscious water planning attempts to make the best use of limited water and land resources, rely on regional water planning and collaboration in projecting ahead, and managing water to meet new societal needs while maintaining ecosystem services and functions. Both approaches are needed and their simultaneous application would help to facilitate the integration of water planning and land use planning to help megacities address their water challenges.

Today's world is a planet full of cities joined in a context of global ecological, hydrological, and political-economic interconnectivities. Urbanization, virtual water trade, and climate change force us to recognize interdependencies among the world's cities and address the processes and dynamics connecting land, water, climate, and people. Understanding megacities' water challenges, as well as coordinating actions, are essential to pursue mutual benefits between all cities, and between societies and natural resources. In the last two decades, networks like C40 Cities Climate Leadership Group (C40) and Globalization and World Cities Study Group and Network (GaWC) have achieved successes in knowledge sharing and global coordination. Additional worldwide and regional platforms promoting water conversations and collaborations among cities are needed as the world continues to urbanize.

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Solution to Puzzle (pg. 26)

W	I	N	T	E	R	Y	■	F	M	■	S	H	O	C	K
E	M	E	R	G	E	■	O	R	B	■	N	O	V	A	■
A	M	P	E	R	E	■	R	E	■	M	O	T	E	L	S
T	O	■	E	E	L	■	R	E	N	E	W	■	R	M	■
H	R	E	■	T	E	X	■	Z	O	D	I	A	C	■	A
E	T	N	A	■	C	■	S	I	T	I	N	■	A	S	S
R	A	T	S	■	T	E	E	N	■	E	G	E	S	T	S
■	L	A	I	C	■	N	E	G	E	V	■	S	T	O	A
S	■	I	N	L	E	T	S	■	D	A	M	■	■	P	S
H	E	L	I	O	G	R	A	M	■	L	I	T	M	U	S
O	M	E	N	S	■	E	W	E	S	■	S	R	■	P	I
E	■	D	E	E	P	E	S	T	■	S	L	U	E	■	N
L	B	■	■	D	R	■	■	E	S	T	E	E	M	■	A
E	L	S	E	■	E	L	B	O	W	E	D	■	C	O	T
S	O	U	R	E	S	T	■	R	A	P	■	C	E	D	E
S	T	E	A	L	S	■	S	S	T	S	■	D	E	E	D