Water Issues and Ecological Sustainability in Areas of Urbanization

SÃO CARLOS, 5-8 MAY,2014

Topics for Discussion

Water and Health

Carmen Anthonj, Institute for Hygiene and Public Health, Bonn

Fragile ecosystems and human health

Rivers, lakes and wetlands are fragile ecosystems that provide livelihoods to millions of people and serve as the most important source of drinking water in rural, but also urban areas. However, due to climate change and due to the man-made conversion, change and use of these fragile ecosystems, the quantity and quality, as well as the accessibility of water can get impaired, impact human health and cause disease. Even the conversion of the ecosystems itself might open new sources of diseases. Such ecosystems are mostly subject to detailed policies and regulations; however, due to population pressure, dense settlement, industrialization among other factors and especially in urban areas, they cannot be reinforced. In order to protect these water sources and to monitor the impact on human health, policy makers, scientists and civil society need to work together with the affected populations in a joint multidisciplinary and multi-stakeholder approach.

Human health, water and health care delivery – the case of flooding

Water is vital resource that is linked with human health in different ways. Good quality water increases health and minimizes disease, while unsafe water is likely to cause a range of different water-related diseases. It is of particular concern for people that are ill already, as their immune systems might be weaker and they might be more susceptible to contracting opportunistic diseases. But not only the quality of water is crucial to human health, the amount of water might also be challenge, especially when it comes to flooding. Floods account for 40% of all natural disasters worldwide and cause several health-related impacts, as well as about half of all deaths from natural disasters. Floods have major implications for human health, increasing the exposure towards water-related diseases and nutritional deficiencies and decreasing water quality, sanitation and hygiene. Besides physical health consequences, they also affect livelihoods, destroy homes, force people to relocate and give up their social networks, cause psycho-social stress situations and traumata. Most floods occur in developing countries and tropical regions, where they are of particular concern, especially in densely populated urban areas. If they cut off roads and destroy vital infrastructure and health facilities, floods can substantially hamper the health system and health care delivery, which itself is overwhelmed by a higher occurrence of morbidity cases. The unpredictability of floods poses additional challenges to the health system´s response. The impact of natural disasters on the health care system needs to be addressed in order to improve human health and health management.

WASH in urban areas

A large share of the total burden of disease worldwide—around 10%—could be prevented by improvements related to drinking-water, sanitation, hygiene (WASH) and water resource management. However, ensuring an access to safe WASH remains a challenge in most of the world´s developing countries and hinders an improved life quality of millions of individuals. Even in urban areas, which are in many of those countries the engine to development, the WASH situation is problematic. Furthermore, industrial pollution and its impact on water quality and human health are underestimated, wastewater remains untreated resulting in a decreased health status and increased health risk for many city dwellers. One major challenge to be addressed in this regard is the need for behavior change among water users, whether it is households, small- or large-scale farming, industry or others.

Petrus Galvão, Biophysics Institute, Federal University of Rio de Janeiro (UFRJ)

Tracing the fate of organic and inorganic contaminants in aquatic costal environment

The Biophysics Institute has as backbone of its research field the biomedical science. The Laboratory of Radioisotopes is one of those that compose the Environmental Science and Biotechnology Program. The concern on public health is always present in our research themes. In this sense, we have been focused on the threat of organic and inorganic contaminants to the human been. We study the dynamic of contaminants in aquatic ecosystem, to evaluate if and how these compounds are incorporated by the biota and go through the food web. A special focus is given to contaminants that have the potential of biomagnification and can reach the humans by the seafood consumption.

Marine bivalves as sentinel species and mariculture activity driving coastal biomonitoring program

The concept of sentinel species has been the ground for the use of a biological model for the study of the dynamic of contaminants in aquatic ecosystem. Marine bivalve is worldwide used in this purpose. The increment of marine rearing of mussels in coastal water represents an opportunity to access animals from a genetically homogeneous population and with known age what reduce the noise in data interpretation. Additionally, a continuous monitoring of reared animals provides a safety certify regarding the analyzed contaminants by the researchers. This activity in large urban areas as in the surround of Rio de Janeiro City requires a special attention, since the release of untreated effluent is remarkable.

Daniel Karthe, Helmholtz Centre for Environmental Research - UFZ, Department Aquatic Ecosystem Analysis and Management, Magdeburg

The future role of water-borne infectious diseases

During the 20th century, water-borne infectious diseases have lost importance as a cause of morbidity and mortality. Three factors contributed to this progress in a significant way: (1) improvements in water supply and sanitation, (2) better knowlegde, education and awareness; and (3) progress in medicine and pharmaceutics. All three trends first took place in "industrialized countries", but later on also in "transition countries" or "developing countries".

Even though there has not been a reverse in this development, water-borne infectious diseases may once again become a greater challenge for urban and periurban populations for several reasons which include the following: (1) emergence of new pathogens; (2) the loss of efficacy of antibiotics (which is related to an overuse and/or improper use in both human and veterinary medicine); (3) new challenges to urban water infrastructures due to demographic and climate change; (4) aging water infrastructures and reduced health care budgets in industrialized countries; (5) growing megacities with high population densities and marginal settlements at their periphery in developing and emerging countries. In the future, water-borne infectious diseases could therefore re-emerge as a threat and require integrated strategies to combat them, including innovative rapid detection methods, global efforts to limit outbreaks, advances in treatment (e.g. development of new generation antibiotics or even antiviral), and, when required, an adaptation of wastewater treatment and drinking water purification.

A group discussion could deal with the in-group expert assessments of the future role of water-borne infectious diseases, key challenges seen, and potential contributions from science towards solving these problems.

Working towards global advances in water supply, sanitation and hygiene (WASH) beyond the "Water for Life Decade" (2005-2015) and the UN Millennium Development Declaration (1990-2015)

The currently ongoing "Water for Life Decade", which was proclaimed by the United Nations in 2005, addresses the water-related challenges expressed by the Millennium Development Goals, i.e. reducing by 50% the number of people without access to safe drinking water and safe sanitation, as well as the long-term objective of sustainable water resources management. In fact, some of the goals are less ambitious than those of the World Water Decade from 1980 to 1990, which aimed at providing universal access to safe drinking water by the end of that period. Moreover, for some indicators it appears that progress was made much more on paper than in reality. One example are statistics related to the access to "improved" drinking water sources, which in practice may nevertheless deliver contaminated water.

Without action, WASH-related challenges might even increase in the future world due to problems raised by emerging pathogens and an increasing age of water infrastructures in many parts of the world. New strategies should be based on a critical analysis of why in the past the more or less ambitious goals in this sector could only partially be fulfilled. While including the science-policy interface, this analysis should also include a critical reflection on the advances in science over the past two or three decades and not simply attribute failures to the political implementation level. Finally, the issues of water, sanitation and hygiene cannot be dealt with in isolation, but have to be regarded in the context of other developments and challenges in (urban) water management and urban development in general. These include but are not limited to conservation of aquatic ecosystems, waste water recycling (e.g. "urban agriculture", which may create new hygienic challenges), increased energy efficiency of water treatment technologies (which may partially compromise purification efficiency).

A group discussion could address a scientific/interdisciplinary assessment of large global initiatives in the past (such as the various "water decades"), and draft a concept for the agenda of a future "water decade" that is ambitious and nevertheless realistic.

The role of new technologies to address challenges posed by water-borne infectious diseases

It is often stated that a focus on "technocratic approaches" failed to lead to developments that are ecologically and socially sustainable. However, in the context of safe water supply, sanitation and hygiene, scientific and technological progress has in the past led to improved living standards and health. With a world population that overwhelmingly lives in urban areas, and a large number of urban dwellers exposed to the risk of water-borne diseases, there might be no solution to this problem without innovative technical approaches.

In the context of water hygiene, the global scientific community currently works on rapid detection methods – both for pathogens in water and diagnosis for infected patients –, new, improved or adapted techniques for drinking water purification and disinfection, and innovations in waste water treatment. Many of these solutions currently exist at the laboratory or pilot/demonstration scale, but have not yet reached a wide operational application.

The group discussion could focus on the role that technical innovation can (or even has to) play in future urban water management, on the potentials of integrating new technical developments into holistic concepts, and the priorization of fields in which there is a need for technical progress (e.g. detection of water-borne diseases; drinking water purification; waste water treatment; treatment of water-borne diseases).

Panagiota Kotsila, Center for Development Studies, University of Bonn

How can we successfully merge scientific fields, bringing public health into the discourse for environmental sustainability and "socialising" medicine?

People in regions with limited water supply networks and poor systems of sewage disposal, often face difficulties in securing water that is safe for human consumption. More importantly, from water at-source to water at-point-of-use, the differences in quality are huge. This is largely because household-based treatments are insufficient, too expensive, not accessible, not applied adequately or not perceived as necessary. Research therefore needs to be made in how to develop household-based water treatment (or more generally, disease prevention) technologies that are

not only efficient and functional but also widely accessible, understandable and relevant to the people the public which they aim to serve. In order for such approaches to be successful, medical and technical advancements need to take into account the social and cultural realities in place. The use of critical social and anthropological research on environmental (water-related) health problems has the potential to reveal some of the structural and cultural reasons behind public health failures. Looking at problems of public health socially can also indicate the way towards a more contextualized design and use of technologies for the prevention of infectious (water-related) disease.

Through which ways can we strengthen the documentation of (water- related) disease morbidity accurately and timely?

The local systems of documenting disease have in many cases proven unable to portray the real extent of health problems, especially in remote areas and for diseases that do not immediately or necessarily cause death. This is due to a number of reasons, including the differences between locally and internationally used definitions of disease, the lack of expertise or capacities in local health centres, the lack of access to healthcare or the lack of trust towards it. Apart from obvious obstacles that this presents in assessing the progress has been made in eliminating diseases, it also inhibits their timely diagnosis and correct treatment, which in turn can easily lead to epidemics. Research should focus on what kind of new/alternative ways could facilitate this process of better documenting infectious disease and particularly pay attention to:

- The role of private pharmacies (as refuge for those who do not have access to public health services or who do not choose to turn to them). Pharmacists could contribute majorly in circulating advice, preventing inadequate medication and overconsumption of drugs and potentially documenting the "undocumented" cases, if they were given the right incentives and tools.
- Developing methods for more inclusive and participatory health education, for the public and for local health workers. This could allow new (medical) knowledge to be smoothly adopted and integrated in each country/locality, taking into account local health understandings and enriching existing perceptions on health risks and preventive practices.

How can we move beyond non-integrated and solely quantitative approaches in the sector of water supply and sanitation?

The development of water supply and sanitation (WSS) has long been considered to be the strongest measure against waterborne and water-related health risks. However, many of such diseases persist, even in contexts where "improved" WSS is seen to be reaching most of the population. This is particularly true for urban and peri-urban areas and might be signifying one or more of the following three phenomena: either the WSS improvements have no effect on the spread of disease, or the coverage of these improvements is not as high as is being documented, or the improvements are not actually effective in providing the preventive benefits that they are expected to. To answer these questions, science needs to examine the links between WSS and disease in more detail focusing on questions around:

a) The social and political context which defines if, and to what extent, the expansion of WSS reflects a wider access to sanitary environments and to water that is safe to consume. How can we include issues of social equity and transparency in the local systems of governance (or the lack thereof) in the national and international evaluations of WSS developments?
b) How to achieve a balance between, on the one hand the use of household-based solutions (that are perhaps easier to implement) and, on the other, the development of widely integrated systems of sanitation-water treatment-water supply (that can avoid transferring the problem of environmental sanitation and water safety "down the river stream" or from one settlement to another)?

Debora Santos, Institute of Veterinary, Federal Rural University of Rio de Janeiro (UFRRJ)

Waterborne diseases have great impact over public health. Many viruses are endemic or are involved in the occurrence of outbreaks in developing and developed areas. Regional government agencies develop their own guidelines to evaluate water quality standards regardless drinking, irrigation or recreational purpose. In Brazil, current indicators for

water quality are mostly relied on value stipulated faecal coliforms and chemical parameters. The normative guidelines elaborated for the assessment of health risk associated with exposure to health hazards through water and the effectiveness of approaches to their control strictly recommend the track of some viruses in an outbreak scenario or in sludge designated for agricultural purposes. To date, virus monitoring for the evaluation of water sources, recreational water, irrigation water and or effluents is not established routinely. Reports of adenovirus outbreaks in swimming pools demonstrate that despite the treatment method some viruses remain infective. Therefore, bacterial parameters seem to be not sufficient to determine quality. Nevertheless, the standardization of methods for the election of a virus specie or a group of viruses as indicator of quality is still a growing subject of research. A unique method of detection considering the biology of the virus, the dynamics of epidemiology, associated risk and infrastructure availability is a real challenge to be achieved. Unquestionably, the development of environmental virology research area is relevant to gather subsides for the improvement general public health.

Raquel Soares, Biophysics Institute, Federal University of Rio de Janeiro (UFRJ)

Risk of cyanobacterial blooms to the public health.

Increasing anthropogenic eutrophication of aquatic ecosystems are intensely favoring cyanobacterial blooms all over the world. Nowadays, that is a worldwide concern once the dominance of these microorganisms reduce aquatic biodiversity and they may produce toxins. Among them are included potent neurotoxins and hepatotoxins that can be seriously harmful to aquatic biota and human populations (1). One of the most common type of cyanotoxin, microcystin, affects mainly the liver of vertebrates where strongly inhibits phosphatases 1 and 2A through covalent and irreversible binding to these enzymes. The ultimate consequence to vertebrates, when a lethal dose is achieved, is hepatic hemorrhage (2). At sublethal and chronic doses, the toxin damages many other tissues and promotes tumor formation (3). However, little is known about the toxicology of long-term exposure to cyanotoxins (especially through oral ingestion and recreation). Concerns about the effects of such toxins on human populations are, in fact, quite recent. For instance, public health authorities began to realize the risk of the presence of cyanobacteria in water supplies only after an incident in 1996 in Caruaru (Northeast Brazil) resulting in the death of 100 patients from hemodialysis treatment using microcystin-contaminated water. This led to the elaboration of specific laws regarding drinking water quality control, including monitoring for cyanotoxins, making Brazil the first country to establish such a measure (4). That illustrates the importance of appropriate management of water resources and toxicological studies to assess the risk of cyanotoxins for human populations. The major challenges regarding this important issue are: 1) Understanding the ecological factors that determine cyanobacterial blooms formation and toxin production; 2) Developing strategies of management of water resources in order to prevent artificial eutrofication and dominance of cyanobacteria; 3) Understanding the toxicological mechanisms under sub-chronic/chronic exposures to cyanotoxins; 4) Develop rapid and cheap methods for cyanotoxins detection in water.

(1) Carmichael, W.W., 1994. The toxins of cyanobacteria. Scientific American, 270:78-86.
(2) Carmichael, W.W., 1997. The Cyanotoxins. Adv. Bot. Res. 27:211–212.
(3) Guzman, R.E., Solter, P.F., 2002. Characterization of sublethal microcystin-LR exposure in mice. Vet. Pathol. 39: 17–26
(4) Azevedo, S.M.F.O.; Carmichael, W.W.; Jochimsen, E.M.; Rinehart, K.I.; Lau, S.; Shaw, G.R. & Eaglesham, G.K., 2002. Human intoxication by microcystins during renal dialysis treatment in Caruaru - Brazil. Toxicology, 181: 441-446.

Alexandra Suhogusoff, Institute of Geosciences, University of São Paulo (USP)

In Brazil there are approximately 57.7 million permanent households, for which 56% of them have no public service of sewage collection and for 21.4% the water supply system is not available. The situation is further aggravated in the north and northeast regions of Brazil as well as on the peripheral areas of large urban centers. The Parelheiros District, situated at the south of the Municipality of São Paulo, for example, has about 28 thousand households, only 55% of them are connected to the public water supply, while only 17% have connection with the sewer system. The lack of public water supply and sewerage system compel the inhabitants to use excavated wells to provide their water needs and septic systems, pit latrines or surface water for domestic wastewater disposal. The precariousness of in situ sanitation systems results in the inadequate disposal of liquid waste, often directly on the aquifer (cesspits are dug up to the groundwater level). In addition to bacteria and viruses, nutrients such as nitrate and phosphate correspond to common contaminants released into groundwater through these systems. The attendance to the drinking water standards makes the search for technologies that enable the removal of nitrate and pathogens in a simple and affordable way a fundamental issue.

Water and Ecosystem Services

Angela Fushita, Environmental Science Department, Federal University of São Carlos (UFSCar)

Evaluating of ecosystem services: Tools and models enable to evaluate this resources are inaccurate or complex and are still controversial and not-well-understood subject in the country. The model can be a decisive element at public policies and should reflect the real value of water. The difficult is the analysis about regulating and support functions. The value (empirical and monetary) should be treated with caution because can generate inaccurate information and mistakes.

Knowledge access or transference: in Brazil, little knowledge about water and ecosystem service are transfer from academic to government institutes. The ecosystem services is a new concept to water resources and the population cannot use or understand what value or index say. There is a barrier between the concept of ecosystem services and the value of environmental functions, mainly water resources

To harmonize the social demand and water protection: actually, the water demand for human use is increasing but the supplies of drinking water are decreasing because the deforestation process, contamination by pesticides, sewage being dumped in the river and land use change. These process operate as direct drivers forces that associated with indirect drivers forces (i.e. demographic increase) reduce the ecosystem services and quality of water.

Perspective: The environmental legislation has important function to planning and implementing action can be increase or stay the water resources and ecosystem services. The public policies and environmental education should a mechanism of the sensibilization about sustainable use of water resources.

Perspective: In Brazil, the payment of environmental services is a tool can be reduce the impact on the rivers, for example. The Basin Committee is a legal institute to management and planning of watershed and water resources.

Pedro Gatti, International Institute of Ecology, São Carlos

Ecosystem functioning and its application

Recent research is related with hydro-geochemistry characterization of watersheds (superficial and underground water, sediments, soil and macrophytes) to understand fluxes between compartments and how human activities will alter the

natural conditions. Moreover, we are developing the use of ecosystem processes in watershed of Lobo-Broa reservoir for reduction of human impact and enhancement of water ecosystems services.

The biggest challenges are to understand how the interaction of compartments (water, soils and sediments) and their interactions with biodiversity that regulate ecosystem services. Our outlook is once we understand that abiotic-biotic dynamics, we will be able to properly manage the watershed and maintain its environmental functions.

Saskia Knillmann, Helmholtz Centre for Environmental Research - UFZ, Department of System Ecotoxicology, Leipzig

Role of sentinel species in (peri)-urban areas

Freshwater ecosystems are exposed to a diversity of pollutants. Although, ecological effects can be observed in the field, contamination patterns are often very costly and hard to assess due to unknown substances, short exposure times (e.g. pesticides) or exposures below the detection limit. Technology will progress with time, but chemical assessment of freshwater quality might remain a Titanic effect due to the high amount of emerging stressors. On the other side, the use of sentinel species and effect based indicators have a high potential to serve as the first stage of early warning systems for the general water quality or the control of specific contaminants from known contamination sources (e.g. community-based indicators SPEAR*). Biomonitoring of sentinel species and simple test systems (e.g. in situ test systems with sentinel species for WWTP's) are very sensitive, can be designed to be selective and once established, they only require a little amount of resources. For a better visualization, costs and benefit analysis could be performed in the frame of the workshop for different monitoring strategies.

Recovery sites and renaturation of urban rivers

Important drivers and parameters for essential ecosystem services need to be understood and not only qualified, but also quantified. This knowledge is essential for the implementation of land use management to maintain for example good water quality under increasing land use pressure. For example it is known that upstream recovery areas with a minimum size and distance can buffer effects from diffuse contamination in downstream river sections (Schäfer et al., 2012) and hence enable sustainable agricultural land use in urban areas. The integration of such recovery areas will also serve for recreational aspects or controlled pasture / forestry activities. Furthermore, renaturation of especially urban rivers will not only improve water quality and human health aspects, but also significantly increase quality of life and the appreciation of biodiversity that can be valuated in the cost of land.

Climate change versus land use management

Direct and indirect effects of global climate change negatively affect in combination with other natural and anthropogenic stressors the ecological status and thus the water quality of aquatic ecosystems. For example, the use of pesticides is predicted to increase under temperate climate conditions (Kattwinkel et al., 2009). This increase will in turn enhance the exposure of non-target organisms to pesticides (Boxall et al., 2009). However, recent outcomes show that current land use management (buffer strips, recovery areas) have a higher impact on the ecological quality of freshwater systems due to pollution than the expected increase in toxicant concentrations due to climate change (unpublished data). Such results prove the need for more detailed understanding of water quality under different land use and climate scenarios.

Boxall, Alistair BA, et al. "Impacts of climate change on indirect human exposure to pathogens and chemicals from agriculture." Environmental Health Perspectives 117.4 (2009): 508.

Kattwinkel M, Kühne J-V, Foit K, Liess M (2011) Climate change, agricultural insecticide exposure, and risk for freshwater communities. Ecol. Appl. 21 (6):2068-2081. doi:10.1890/10-1993.1

Schäfer R, vd Ohe P, Rasmussen J, Kefford B, Beketov M, Schulz R, Liess M. 2012. Thresholds for the effects of pesticides on invertebrate communities and leaf breakdown in stream ecosystems. Environmental Science and Technology. 2012, 46, 5134–5142.

* SPEAR (Species At Risk) = trait based approach that links specific environmental stress and community composition. The approach analyses those characteristics of species traits that are shaped according to the ecological requirements of a specific stressor. This analyses provides a quantitative assessment of the magnitude and the ecological effects of stressors.

Kinga Krauze, European Regional Centre for Ecohydrology of the Polish Academy of Sciences, Lodz

Possibilities of use of green infrastructure to re-link cities with the landscape

Approaches, which for centuries have been adopted to structure and manage the cities, were based on perception of nature as increasing a risks to human security and well-being. To decrease this risk, man created artificial environment with channelized rivers, complex storm water and sanitary systems, carefully delineated and limited greens, extended impermeable areas. Alongside we developed legislation and system of societal rules, which considered wildlife as not being desirable element of urban space. In a consequence, with increasing area of cities, they became an isolated element of the landscape, not only in terms of being a barrier for biodiversity, but also ecosystem processes, e.g. water circulation, flow of energy and matter.

It is quite recently, when we initiated a discussion of how to create more sustainable urban spaces, and prominent part of this discussion has been devoted to ecosystem services and an importance of green infrastructure from the perspective of bringing them back to cities.

There is a number of approaches originating from landscape planning, city planning or architecture that bring water and green infrastructure back to the attention of managers, e.g. Water Sensitive Urban Design or Low Impact Development. However there is not much evidence on how those activities really support integrated management of catchments and biodiversity, do they support ecological process, and what can be the improvements. Thus there is a need to involve ecologists with knowledge on long-term ecosystem dynamics to make alternative landscape management techniques ecologically sound.

Methods for linking soft and hard data in analysis of socio-ecological systems, and the cause-effect analyses *sensu* DPSIR

With increasing understanding that social, economic and ecological realms are linked together in the way that makes them one complex entity, scientists and practitioners started to look for ways to improve understanding of cause-effect relations between them. The two most commonly applied conceptual models to structure such information are DPSIR of EU and ISSE of LTER-US. Together with adoption of the SES concept (socio-ecological systems, Redman et al. 2004), we began a search for methods to bring together data series of different accuracy, qualitative and quantitative, numeric and descriptive. It is one of the biggest challenges for current transdisciplinary environmental science to develop right methods for comparing and analysing information, which in principle is widely available. The target is delivery of information that can serve both nature and humans, and empower management solutions, which are ecologically reasonable, economically applicable and socially acceptable.

Human perceptions and attitudes in preservation of values of nature

In citizen society the bottom up activities have a prominent role in setting a goal and streamlining management. Despite that, individual decisions may significantly influence performance of socio-ecological systems, especially when they are repeated over the time or over the space, or when they affect opinions of decision-makers. Not much effort has been devoted to understanding what is a motivation of people, which features of nature they value or devalue, why, but also how appreciation is translated into action and what might be its positive and negative consequences. Such knowledge is critical for increasing efficiency of regulations, for developing locally demanded and accepted best-practices, and building overall awareness. It is also crucial for reducing number of cases of mismanagement linked to conventional perception of nature as generating risks to society, and working towards resilient society – the one able to accept and deal with environmental uncertainty.

Natalia Periotto, Ph.D Student at Federal University of São Carlos (UFSCar)

The challenges related to studies (focused on a hydrographic basin with constructed dams and consider them as elements of the landscape that influence on the ecosystem services of the whole basin) in São Paulo State (Brazil) are to integrate them with individual and governance management actions that should include better land use planning and

forest recovery in order to ensure biodiversity conservation, quality and quantity of ecosystem services delivered for human well-being (especially water resources) and improve the situation of local and regional communities. These studies are also important to create new areas of protection and add new values to existing ones with no market value, but crucial for the maintenance of environmental flows.

Jorge Luiz Rodrigues, International Institute of Ecology, São Carlos

Interactions between terrestrial and aquatic ecosystems and consequences on ecosystems services

In our biosphere, natural environments are interconnected by many processes, such as the movement allochthonous material from terrestrial to aquatic ecosystems, which are considered downhill receivers. Owing to these processes, many characteristics of terrestrial ecosystems influence on quality of water bodies inserted in the same or in a subsequent hydrographic basin. The water cycle, the chemical composition of drainage water, intensity of runoff and discharge of aquifers directly depend on the conditions of riparian vegetation. In watersheds with riparian forest well preserved, the environmental quality is maintained, providing conditions to control the floods, the biogeochemical cycles and the biodiversity conservation. Also, areas with well preserved forest require few investments in water treatment to supply human requirements when compared with areas deforested.

The increase of the pressures on natural resources is a global phenomena associated with population boom and his demands. In Brazil, the accentuated increase in the past few years is not only changing the face of economy, but also shaping the use of resources. The Brazilian cities are getting bigger and the agricultural productions in the last decade grow 33%, being these real threats for natural areas in all regions of the country. A possible consequence associated with this situation is removal of vegetation around urban areas and too in agricultural landscapes. Deforestation in watersheds causes topsoil loss, modifies nutrients (phosphorous and nitrogen) cycles and increases the concentration of these nutrients in water bodies. These factors area usually correlated with loss of services of the aquatic ecosystem and could compromise the future replacement of water in aquifers, the quality of surface water and groundwater with costs economic. Also, this scenario could to threat human health and will require more sophisticated systems and higher cost as opposed to the regulatory role of cycles performed by natural forests in has brought concern on the quality of water resources. The challenges to be addressed in this regard are to use appropriate methodologies to quantify the impacts on water quality resulting from human uses in the hydrographic basin and generate scientific information useful to society and doable to use by stakeholders.

Florian Selge, University of Technology, Department of Water Quality Control, Berlin

Sustainable management of ecosystem services under scarce water availability and climate change in semi-arid areas

Water availability has a great impact on economic development. For sufficient agriculture and drinking water supply it is necessary to hold water in the region. To balance the various land uses, each with an impact on the water storage capacity, will be a future task that enough water will be available, not only for agriculture also for drinking water and with this a sustainable land use. Climate change will shift weather conditions and thereby water availability as well. This implicates that land use may have to change in the capacities of water availability to meet different water demands in future, especially in semi-arid areas.

Nutrient management and cycling for sustainable water use and re-oligotrophication potential

A nutrient management in the limits of the carrying capacity of a water body can lead to a sustainable use of water as resource and consequently to a re-oligotrophication. Nutrient management should take place mainly in waste water treatment, agriculture and erosion control belong others to meet the capacity limits of a water body. Additionally, closed cycles of nutrients can reduce the external input of commercial nutrients by re-use of sediments in agriculture as fertilizer or texture upgrade of soils, macrophyte harvesting for biogas production and organic fertilizer. Closed and adopted cycling of nutrients can help to increase water and soil quality on one hand and on the other hand to an increase of further ecosystem services. The trend for this sustainable increase is highly important to meet the enhanced requirements by various water and land uses from society.

Water level changes of lakes and reservoirs and impacts on water quality by water use and climate change

Predicted effects of climate change are temperature increases with higher evaporation rates and changing rainfall patterns which can lead to changing water levels of lakes and reservoirs. These can already be observed in semi-arid areas where water level increase takes place during the rainy period and decreasing in dryer periods, especially, when water use is not adopted. Mineralization of desiccated margins and re-flooding of those indicates nutrient releases into the water body. This nutrient pulse is highly potential for eutrophication processes and thereby loss of ecosystem services can occur. Rivers and water bodies may be managed in an adopted way in future to reduce climatic induced water level changes so that water quality is not affected negatively by this reason.

Michael Strohbach, Humboldt University, Geography Department, Berlin

With whom do we want to live tomorrow? Managing wildlife in urban areas

The term “urbanization” describes the process of more and more people living in urban areas. Specialists as well as the lay public commonly use it. The term “synurbization” is much less well known. However, it describes a process that probably affects people in all cities: the adaptation of species to urban conditions (Luniak 2004).

In cities, where humans usually have limited access to natural areas, many species are a welcome addition because they allow for human-nature interactions (e.g. environmental education or wildlife watching). Other species are not so welcome and can cause human-wildlife conflicts. Besides the usual suspects like rats, mice or cockroaches that have plagued human settlements for a long time, mid sized mammals have recently gained attention. Examples are wild boars (*Sus scrofa*) in Europe, raccoons (*Procyon lotor*) in central Germany, Japan and North America, coyotes (*Canis latrans*) in North America or dingos (*Canis lupus dingo*) in Australia (Cohn 2005; Allen et al. 2013). These species can cause considerable nuisance and need to be managed.

The management of urban wildlife, however, is a challenge. For example, direct population control commonly used in rural areas is usually neither popular nor feasible in cities (Sterba 2012). Often, management involves changes in human behavior (e.g. provision of food resources) and several organizations and local residents have to be involved (Strohbach et al. in press). With urbanization and synurbization continuing in the future, a better understanding of the interactions between urban wildlife and humans is needed if we want to manage how we share our cities with other species.

Allen, B. L., M. Goullet, L. R. Allen, A. Lisle and L. K. P. Leung. 2013. Landscape and Urban Planning. Landscape and Urban Planning 119:131–135.

Cohn, J. P. 2005. Urban Wildlife. BioScience 55:201.

Luniak, M. 2004. Synurbization–adaptation of animal wildlife to urban development. Proc. of 4th Intern. Urban Wildlife Symposium. Arizona: Tuscon:50–55.

Sterba, J. 2012. Nature Wars. Crown, New York.

Strohbach, M. W., M. N. Peterson and P. S. Warren. in press. Urban Wildlife Science in Coupled Human-Natural Systems. in Urban Wildlife Science: Theory and Practice (R. McCleery, C. Moorman & M. N. Peterson, eds.). Springer.

Which ecosystem service do we want from green infrastructure and who gets their way?

Green infrastructure is considered an important factor for creating more sustainable and resilient cities. Significant progress has been made with respect to quantifying regulating ecosystem services provided by green infrastructure. However, when it comes to quantifying cultural ecosystem services, many challenges lie ahead (Haase et al. in press).

Green infrastructure is often multifunctional and can provide a multitude of services. Not all have a synergistic relationships and increasing one service might lead to the decrease of another one. To complicate matters further, different social groups have very different demands for ecosystem services from green infrastructure, especially recreational green spaces like parks. The challenge for the future is how to consider multiple and potentially conflicting preferences for the provisioning of ecosystem services by green space in planning processes.

Haase, D., N. Larondelle, E. Andersson, M. Artmann, S. Borgstrom, J. Breuste, et al. in press. A quantitative review of urban ecosystem services assessment: concepts, models and implementation. Ambio.

Green spaces in arid cities – functionality vs. water use?

In recognition of the multiple benefits it provides to humans, increasing the amount of green space is on the agenda of many cities. Two prominent examples are the million trees initiatives of New York City and Los Angeles, USA (Pincetl et al. 2012; http://www.milliontreesnyc.org/). Recently, there has been a backlash against this approach in Los Angeles: Increasing the amount of trees in an arid city, where trees and green space have to be irrigated, has been criticized as unsustainable and costly (Pataki et al. 2011; Pincetl et al. 2012; Pincetl 2013).

One of the problems is that our model of green space was developed in temperate regions with enough precipitation to sustain lush lawns and trees. In arid regions, the naturally occurring vegetation might only be lush for a few months of the year or not at all. It might therefore provide less ecosystem services (for example no shading and cooling from transpiration during the hottest time of the year), have a limited recreational value, and in addition, might be prone to fire. Obviously, there are reasons for investing precious water resources into green infrastructure. Future green space research in arid cities must help modifying and creating green space that is both functional and needs little water.

Pataki, D. E., H. R. McCarthy, E. Litvak and S. Pincetl. 2011. Transpiration of urban forests in the Los Angeles metropolitan area. Ecological Applications 21:661–677.

Pincetl, S. 2013. Urban Ecology and Nature's Services Infrastructure: Policy Implications of the Million Trees Initiative of the City of Los Angeles. Pp. 61–74 in Urbanization and sustainability: linking urban ecology, environmental justice and global environmental change (C. G. Boone & M. Fragkias, eds.). Springer, Dordrecht, New York.

Pincetl, S., T. Gillespie, D. E. Pataki, S. Saatchi and J.-D. Saphores. 2012. Urban tree planting programs, function or fashion? Los Angeles and urban tree planting campaigns. GeoJournal.

Ingo Wahnfried, Geosciences Department, Federal University of Amazonas (UFAM)

Social and economic impacts of groundwater overexploitation in Manaus

Manaus, capital of the State of Amazonas, is a large city, were almost half of the state's population of 3,8 millions live. It is also an important industrial area, with over 500 industries, attracted by a tax-free zone policy that generated a long-term exodus from the interior of the state to the capital. This, together with the very limited highway network, had a positive impact on deforestation: by 2012, only 2,4 % of the state's area had been deforested, compared to 22,7 % and 20,8 % of the states of Mato Grosso and Pará, respectively (Santos *et al*., 2013). But the lack of groundwater management plan may endanger this model. In spite of the fact that the Negro and Amazonas Rivers lie at the doorstep of the city, public water supply for about 20% of the population comes from groundwater, and almost all local industries use groundwater for their own supply. Very little planning has been done on the governance of the groundwater resource, and distribution of heavy groundwater users is not planed at all. Locally, the water level of the Alter do Chão Aquifer is falling year after year, and water flow between the aquifer and local polluted creeks has probably been inverted to influent. Besides the usual social impacts of water quality and quantity degradation, local industry may decide to leave the area, or new industries may not come. The historic interior to capital exodus may face a flux inversion, possibly having an impact on deforestation, due to the necessity of the population to find new occupation, such as agriculture. Identifying the consequences and elaborating solutions for these problems is the local hydrogeological challenge.

Santos, D., Pereira, D., Veríssimo, A., 2013, O Estado da Amazônia – Uso da Terra, Instituto do Homem e Meio Ambiente da Amazônia (IMAZON), 70 p.

Groundwater as a proxy for plant distribution in the Amazon

Sedimentary rock is present in a significant part of the Amazon River Basin, and phreatic aquifers are abundant. Large precipitation amounts and gentle topography add up to create predominantly shallow water levels in the region. Yearly river water level fluctuations of up to 15 meters create vast flooding areas, were the connection between groundwater and surface water is even more intense. These factors increase the influence of groundwater hydrology on plant

distribution. Some studies already defined these eco-hydrological relations looking into related factors, such as topography, soil texture and distance between water bodies. Few, though, are using hydrogeology as a direct proxy for establishing plant distribution structure. Once the relations are understood, the changes the Amazon is facing, such as deforestation, artificial flooding due to dam construction, and extreme climatic events, as the 2012 record flood in Manaus, or the 2009 draught, may help to predict and prevent impacts.

Impact of deficient sewage systems on groundwater quality in Brazil

Brazil is very inequitable in terms of public water supply and sewage systems. More than 11 million Brazilian citizens live in poor peri-urban or urban areas, were access to treated water or sewage collection systems is usually limited. The worst areas are in the north and northeast of the country. Properties in the poor areas of Brazil are usually very small, forcing their owners to build cesspits close to wells, thus creating an ideal situation for spreading water-borne diseases. Advances are being made, but on a slow pace. New and accessible cesspits, that are more effective to protect against waterborne disease, are being tested and developed, and education campaigns show the importance of using simple water treatment techniques, such as chlorination or boiling. But other solutions should be discussed.

Eugenia Zandonà, Department of Ecology, State University of Rio de Janeiro (UERJ)

Ecosystem function as a measure of land-use impact

The majority of studies on land-use impact in streams focus on community structure, mostly macroinvertebrates, but very little is known about the overall effects on ecosystem processes and thus its functioning. Ecosystem structure and function are closely linked, so that alterations in the ecosystem structure must lead to modifications in the functional parameters and vice versa. However, the functional approach is rarely used in the assessment of impacts caused by land-use, even if new studies are showing its utility and applicability. Ecosystem function measurements (i.e. leaf decomposition, metabolism, nutrient cycling) are advantageous because they represent an integration of several structural parameters across time without the geographical restriction of the occurrence and distribution of some taxa.

Longitudinal effects of land-use in stream ecosystem structure and function

Stream and river ecosystem are strictly linked to the surrounding terrestrial ecosystems and changes in riparian vegetation profoundly affect stream structure and functioning. Considering the unidirectional flow in rivers, these influences accumulate longitudinally throughout the stream. I am interested in researching how riparian vegetation and land use affects laterally and longitudinally the structure and function of Atlantic Forest streams, in areas with different land-use, such as pristine forest, pasture, mixed areas with only a strip of riparian vegetation left. This is especially important and represents a big challenge in the light of the Brazilian Forest Code legislation for riparian vegetation, in order to assess how effective it is in preserving stream ecosystem function and structure.

Cascade effect of land-use in stream ecosystems

Riparian vegetation affects the amount of organic matter and light entering into the streams, primary production, hydrology, geomorphology, and nutrient concentrations, acting as a buffer and biogeochemical filter retaining and transforming nutrients. Perturbations in the riparian elements produce a cascade of reactions that propagate in all compartments of the stream ecosystem, which is indicated as land-cover cascade. The change in land-use (i.e. forest to pasture) acts as a stimulus of a series of cascading effects first into physical elements (i.e. discharge, type of substrate, etc.) and consequently altering the biotic compartment (biofilm, invertebrates, fish). It is challenging to understand which is the most important trigger and through which paths the land-cover cascade acts.

Water and Land Use

Samuel Beskow, CDTec/Hydric Engineering, Federal University of Pelotas (UFPel)

Hydrological monitoring as a basis for water resources management

It has been noticed a pronounced increase in population worldwide during the last decades and this can be considered alarming in the context of water resources, given the growing needs for water supply for urban and rural zones and for industries, irrigation, electrical energy and navigation. There should be equilibrium between the economic development of a country and the impact that this has on natural resources, especially water resources. Several examples can be cited with respect to anthropogenic impacts on the environment of watersheds as a result of increase in population, such as expansion of agricultural frontiers, irrigation systems, urbanization, adjustment of drainage network, construction of bridges, roads, culverts, reservoirs and levees, deforestation, etc. In this context, it is of great importance to manage water resources at the watershed scale in order to allow for practitioners to appropriately take decisions related to water.

The existence of data sets describing the hydrological behavior, in particular at the watershed scale, is crucial to support the water resources management in a given region. As it is necessary to understand the hydrological pattern in the watershed of interest, information related to precipitation, stream flow, sediment transport and water quality, are notably important when practitioners are supposed to make decisions in terms of water resources in a watershed. Hydrological studies should be preferably based on hydrological monitoring, which in turn, is able to support and/or facilitate the planning, utilization and control of water resources.

An additional difficulty is that hydrological processes vary in both space and time. The hydrological monitoring in watersheds is a great challenge, primarily in developing countries, because depending on their area, the implementation of a hydrological monitoring network may be a laborious and costly task. In many countries, the reality is a limited number of monitored watersheds, having priority those used for purposes of water supply for urban zones, irrigation and electrical energy production. There is a predominance of hydrological monitoring in large to medium watersheds due to the aforementioned reasons. Therefore, there is a gap from the scientific and practical point of view in developing countries. Studies, researches and public policies should encourage the improvement of hydrological monitoring networks in developing countries, especially in regions with limited information.

Hydrological modeling at the watershed scale

The area of hydrological modeling and simulation has experienced substantial advances and numerous practical applications during the last years. The development of new models and approaches as well as the adoption of existing models have been observed for planning, utilization and control of water resources, primarily in regions where there is no a satisfactory hydrological monitoring.
Procedures for hydrological modeling allow for designers to evaluate various hydrological processes and to understand their variation in space and time. These procedures can be represented by simple or complex approaches, demanding a variable amount of information, which sometimes is not available in specific regions.

This area of knowledge also presents challenges from the scientific and practical point of view. Some questions arise after a rapid reflection: Is there an appropriate number of existing models? Can the models be employed in any watershed? Do the models give reliable results for a given watershed of interest? Are the models compatible with the reality of information available in the region of interest? Are the models used by practitioners, society, companies, watershed committees, etc.?

Fernando Dornelles, Institute of Hydraulic Research, Federal University of Rio Grande do Sul

Urban water education and knowledge acquirement

For Brazilian panorama we are in transitions stage, the measures for drainage rainwater were changed to more sustainable approach, but the designers (engineers and urban planners) have no instructions for this in yours graduations courses. As well, for the decision makers it is unfamiliar too. The general sense due the lack of good knowledge to use sustainable measures on urban water is that these measures are inefficient and expensive. So, to revert this scenery is necessary improving more ways for the sustainable measures dissemination. But how it will be possible with efficient success?!

Sewer Rainwater treatment

In Brazil the treatment of sewer rainwater is not a great concern yet. Highlight the potential pollution of sewer rainwater is an alternative to drive a change in this area. So, looking for feasible ways to perform the treatment of sewer rainwater is a challenge, especially for Brazilian climatic and social conditions, with high rainfall intensities and levels of contamination.

Hydrologic data monitoring on urban basin

Especially on big cities a continuous hydrologic data monitoring is fundamental to deal with relationship between community and water resources. These data can be utilized to drainage projects, flood forecasting and alarm, urban impact evaluation and hydrologic modelling research. The monitoring lack (telemetric networks, meteorological radars, rain gauges, water level recorders) is due two main reasons: high cost of equipments and lack of importance for decision makers. Overcome these obstacles can propitiate a solving of some important problems of urban water management.

Caroline Galharte, Post-doctoral student at Embrapa Southeast Livestock

The surface water and groundwater is considered as one of the most valuable natural resources in the world. Thus, the processes of land use change and land cover arouse great concern to better understand and plan them in order to avoid impacts such as the contamination of water resources. Moreover, monitoring the quality of water resources and the use and occupation of land constitute a work of great importance to understand the system and plan rules for supply and consumption, indispensable to the maintenance and enhancement of this feature .

Environmental monitoring in watersheds, to characterize relevant aspects that allow diagnosing the changes that occur in the use and land cover, making it possible to evaluate the effects of human activities on watersheds exercised on ecosystems. Therefore, monitoring is indicated to be sensitive to changes that may occur environmental variables. Knowledge about the quality of watercourses in a watershed is of utmost importance, since from this information it is possible to infer about the conditions of the watershed as a whole.

Björn Gücker, Department of Biosystems, Federal University of São João del-Rei

Human water security and/versus ecological sustainability of peri-urban and agricultural areas

Ecological sustainability of water resources and human and agricultural water security are often viewed as mutually exclusive in developing countries. Conservation of riparian areas, floodplains, wetlands and mountain ranges can, however, ensure human and agricultural water security in sustainable landscape development approaches, with stakeholder acceptance and agriculture lobbyism as mayor obstacles.

Functional assessment and management of ecosystem integrity

Ecosystem functions, i.e. the biogeochemical and -physical processes that are the basis of ecosystem services, are rarely considered in the assessment and management of ecosystem integrity. This topic focuses on the integration of ecosystem functions in integrated modeling and management approaches of catchment sustainability.

Education for sustainability

Early education is an essential – and in developing countries often neglected – tool for achieving environmental take-off and sustainable development of societies. Transference of knowledge and experiences between countries especially successful in education for sustainability (Netherlands, Denmark, Germany, Costa Rica etc.) and developing countries may be an important strategy.

Anke Hildebrandt, Max-Planck Institute for Biogeochemistry, Department of Biogeochemical Processes - Ecological Modelling, Jena

Socio-hydrology

Urban and per-urban areas influence the water flows by short-circuiting the water cycle, moving water between catchments, regulating it with dams or trading it in form of green water, just to name a few. Changes of the water cycle are usually targeted at providing uses (drinking, cleaning, industrial, irrigation), and the change of the original water cycle is but a side effect. Management does not automatically involve considerations on how to (re)close the several cycles at the various different scales involved. The climate change shows how strongly humans affect how the Earth works and this also reflects on the water cycle. A newly emerging trend within the hydrological sciences has been named “socio-hydrology”, which deals with the interactions between the hydrological and cycle and humans and includes issues like the co-evolution of societies and the layout of hydrological catchments. For hydrological predictions, anthropogenic changes are a hindrance and understanding how they depend on the flow itself and reflect on other related systems, like ecosystems, are a current challenge.

Infiltration management in environments with a large proportion of impermeable surface

Urbanization leads to an increase of the impermeable area and subsequent decrease of infiltration and groundwater recharge. More water flows overland, which may lead to inundation both locally but also in areas further downstream. Also, the long-term water storage of the catchment receives less water for replenishing.

Technological solutions are available, which mitigate the above-mentioned problems, in particular building dams that prevent both floods and provide water during times of drought. However, those technical solutions do not mitigate decreasing groundwater levels, and may even worsen the situation. Particularly in drier regions this may also induce ecosystem damage or lower water availability in areas, which depend on ground water. There is a need to understand how we can more efficiently manage rainwater and enhance infiltration in urban regions, and if possible also improve the overall clean water storage of the catchment. There is already some research available, dealing with understanding of how infiltration can be enhanced with different vegetation. This could be also applied and expanded towards urban and peri-urban areas.

Ecological sanitation

Sanitation is a pre-requisite for assuring health. On the other hand, in the developed world, a great deal of clean water is used in water toilets (in Germany around 30%). Essentially, cities import a great deal of water, pollute it and flush it down the drain in large quantities, while at the same time contributing little to groundwater recharge (see above).

This raises some urgent questions with regard to holistic water management within urban areas: How can we implement more ecological ways of sanitation, and how can we make them safe? How can we divert the water falling on impermeable surfaces to serve us instead of importing clean water from elsewhere, polluting it and flushing it in large quantities towards the waste water facilities? Do established sewer systems require the large volumes of sanitation water to flush the system or can we establish new solutions, which require less water (and energy to clean it)?

There are alternative solutions, for example using vacuum systems. One example is the new building of the Kreditanstalt für Wiederaufbau (KfW).

Contamination management

Cities and peri-urban areas house a great deal of infrastructure and industry with great potential to pollute or otherwise degrade the soil and shallow ground water, thus destroy important resources. A great deal of research is dedicated, and should further be dedicated to understanding how such polluted regions can be managed. This may relate to securing the polluted region and / or re-using it instead of moving the new clean areas. Regeneration of polluted or degraded landscapes has many facets. Using biological methods is one option for remediation in situ and requires a special kind of process understanding across disciplines, such as microbiology, ecology and hydrology.

Paul Lehmann, Helmholtz Centre for Environmental Research - UFZ, Department of Economics, Leipzig

1)

Why do actors in peri-urban areas fail to safeguard water security? Presumably this may be due to a mixture of insufficient information, incentives and resources. These may themselves be functions of a set of underlying factors, such as the actor-specific characteristics (preferences, background, etc.), the institutional environment and the broader physical and socio-economic framework conditions. Understanding these obstacles is decisive for developing appropriate solutions, and should best be made on the basis of a specific case study.

2)

To address problems associated with water security, the focus is often on conventional regulatory approaches - such as command-and-control or environmental taxation - which are imposed by a government authority on private actors. Typically, however, these approaches fail to deliver expected results in peri-urban environments, which are often characterized by a large degree of informality (e.g. lack of legal land titles) and strong dynamics (e.g. population growth, land use changes). Consequently, it should be explored to what extent top-down approaches could be complemented by bottom-up, community-based arrangements, such as water cooperatives and others.

3)

Promoting long-term concerns of environmental conservation is often difficult in developing countries where actors' decision may be more guided by presumably more urgent and short-term concerns, such as mitigating poverty or improving public safety (which are often underlying land-use changes). Consequently, it is decisive to reveal possible synergies (and also conflicts) between the different relevant public concerns and policy fields. Thus, it is important, for example, to explore to what extent improving water security can also be useful to reduce other problems, such as poverty, health, public safety or education - and how it depends on these other problems to be solved.

Priscilla Moura, Department of Hydraulic Engineering and Water Resources, Federal University of Minas Gerais

Urban streams restoration

Urban water courses are very often damaged. Restoration techniques are frequently used to bring the water courses to their equilibrium state; however the choice of what restoration technique use and which reaches prioritize is complex. The choice must involve several aspects, such as hydraulic, hydrologic, environmental, social, sanitary and economic.

The use of low impact development techniques

Urbanization cause significant hydrological impacts, among them we can mention the increase in runoff and reducing in the times of concentration, most of them are caused by the increase of impervious areas. As a result of urbanization and drainage piping it is observed the increase of peak flows, as well as the increase in the pollution that reaches the water bodies. Classic drainage systems currently adopted in urban areas are responsible for increasingly floods having important social, economic and political implications.

Alternative stormwater management techniques are seen nowadays as one of the most important options for flooding control, mainly to already urbanized areas, where the existing drainage system became inadequate. These structures are based on temporary retention of rainwater and, eventually, infiltration, for flow attenuation, mitigating flooding in the basin.

Although essential in big cities and with great possibilities of use and adaptation, these systems cannot be seen as an unquestionable solution to drainage problems. Despite alternative stormwater management techniques are currently widely used, the consequences of the use of such measures have not yet been properly considered. Planning and care in the design of systems is essential, as well as consideration of operational difficulties, mainly of maintenance and management, strongly affecting environmental quality.

Antonio Leal, Institute of Biological Sciences, Federal University of Pará (UFPA)

Environmental Monitoring and Diagnostic

In the Amazon region have a great lack of data, both from biophysical and socioeconomic order. Some indicators have been better observed and described, as is the case of deforestation, monitored by INPE, and pedological characterization of the region, through the work of Embrapa, for example. However, there is still a deficiency in more refined studies directed to describing the quality of natural resources, such as weather data, water quality, river data, monitoring of landscape change and socioeconomic data, land suitability, production chains and others. Environmental monitoring is an initial step in developing any activity that requires modifying the environment and that requires some kind of control, management and environmental planning. In the case of the Brazilian Amazon region, especially the northeast region of state of Para, which has gone through a process of economic and social development disordered, creating a complex mosaic of use and occupation of land and a number of environmental impacts arising especially from the lack planning, such as silting and contamination of water resources, as well as obstruction of nascents due to the intensification of erosion processes and consequent soil loss, reduced fertility and creation of voçorocas. Find ever more generate diagnostic data, monitoring and examples of management and territory planning is crucial to build a framework of sustainable development applicable to Amazon.

Planning and Environmental Management

The National Policy of Water Resources defines the watershed as a Basic Unit of Territorial Planning (Law No. 9433), recognizing the importance of water resources for society and the environment as, as well as putting the basins and sub-basins as territories favorable to the integrated planning of the soil uses and occupations focusing on sustainable development. However, to apply measures of planning and management of natural resources at watershed level sometimes rapidly stops at barriers of different relationships of political, socio-economic and environmental interests of states, municipalities and companies. Thus, it becomes necessary to plan the proper use of water resources and soil, since agriculture, industry, livestock, urban centers, mining and any activity needs and impacts directly or indirectly the water resources. Environmental modeling has been an important tool in the diagnosis and monitoring of environmental changes the landscape of short and long duration in small and large territorial extensions, and contribute directly in decision-making and strategic planning and management of the territory.

Talita Silva, Department of Hydraulic Engineering and Water Resources, Federal University of Minas Gerais

Urban lakes and catchment changes

Among the many substances loaded by the urban runoff, nitrogen and phosphorus are of particular concern for lakes which are especially vulnerable to nutrient enrichment because of the high water retention time. Eutrophication is responsible for reducing the ecosystem biodiversity and disrupting water uses such as drinking water supply and fishing. Moreover, eutrophic lakes are frequently affected by cyanobacteria blooms, including potential toxic species which can be harmful to human and animal health. In the future, the frequency and the intensity of cyanobacteria blooms are hypothesized to increase in response to catchment and environmental global changes. On the one hand,

the predicted climate warming is supposed to enhance cyanobacteria proliferations. On the other hand, higher nutrient loads are expected as a consequence of urbanization process. Increasing impervious areas in the catchment will raise runoff volume and speed, causing greater carrying capacity and greater nutrient load to receiving water bodies, therefore favoring cyanobacteria proliferation. Actually, there is a very strong need to investigate the links between the ecological lake functioning and environmental changes (watershed and climate), in temperate urban regions as well as in tropical ones.

Land-use, soil conservation and integrated water resources management

Land-use planning through ecological and economical zoning and through municipal director plan directly impacts water resources in urban and peri-urban catchments. Soil conservation through conservation of riparian areas and floodplains and through soil management practices are important tools in the water resources management primarily in peri-urban catchments where rural land-use remains. Brazilian law for water resources mentions the need of articulation between water resources management and municipal land-use management, however, presently this integration is still incipient. There is a lack of guidelines, financial and human resources and a lack of integration between municipal and catchment scale which hampers the integrated water resources management.

Ingo Zasada, Leibniz Centre for Agricultural Landscape Research; Müncheberg

Peri-urban agriculture and orientation to changing urban societal demands

Often parallel occurring urban growth, suburbanisation and shrinkage processes in urban and metropolitan areas increasingly lead to the observation of spatial entities characterised by a complex, heterogeneous mix of land-use types, comprised of urban (settlement, infrastructure) and rural elements (agriculture, forest, wetlands), but differentiated from pronounced urban and rural areas – coined as Zwischenstadt (Sieverts 2003), semi-urban (Meeus & Gulinck 2008) or neo-rural areas (Gulinck 2004). In such urban landscapes, the remaining green open spaces as green infrastructure need to comply with the multitude demands from an urban society for the delivery of environmental and social values in a multifunctional manner.

Particularly the peri-urban agriculture and forestry as a major land use actor in these green open spaces is increasingly required to provide goods and services beyond conventional commodity production, such as recreational and social space and services (e.g. horse keeping, care farming), specialised production and alternative food chains, but also the valuable non-commodities, such as the provisions of freshwater/groundwater recharge and flood retention area, the regulation of the urban climate as well as the provision of flood retention areas (Zasada 2011). On the other side, due to intensive farming management practices and irrigation, peri-urban agriculture represents a major water consumer in urban regions. Here, adapted monitoring instruments and management practices are needed to cope with the specific water supply situation. Still, due to fragmented administrative and decision-making structures and interests, oftentimes it lacks a common understanding and 'Leitbild' (vision) for future development for the peri-urban areas and which role agriculture should fulfil to provide public and private goods is not negotiated as part of regional governance.

Therefore, prospective research should take up on several aspects: (i) analysis of local urban demands and consumption pattern e.g. through urban footprint analysis for the abiotic resource use, economic market (e.g. for land market and rural goods), (ii) analysis of supply side to provide (e.g. cost-benefit analysis, input-output models, land preservation evaluation) as well as (iii) study of new local and regional instruments and arrangements to connect the demand (urban society) and supply side (rural land use) as well as analysis of their implementation efficiency and cost-effectiveness.

Gulinck, H. (2004). Neo-rurality and multifunctional landscapes. In: Brand, J. and Vejre, H. (Eds.). *Multifunctional landscapes – Volume I Theory, Values and History*. WIT Press, Southampton, pp. 63-73.
Meeus, S. and Gulinck, H. (2008). Defining semi urban areas in landscape research. *Living Reviews in Landscape Research* 2(3).
Sieverts, T. (2003). *Cities Without Cities: Between Place and World, Space and Time, Town and Country*. Routledge, London and New York.
Zasada, I. (2011): Multifunctional peri-urban agriculture – A Review of societal demands and the provision of goods and services by farming. *Land Use Policy* 28(4): 639-648.

Cultural Ecosystem Services in urban and peri-urban landscapes

Increased standards of living and extended leisure time of urbanites are mirrored by a tendency to spend leisure time in the near countryside, or even to permanently settle down in the countryside around towns. The surrounding countryside as a recreational space of cities and agglomerations has become increasingly relevant as soft locational factor within the international competition of urban regions. Due to their natural amenity capacity, water courses, like rivers, lakes and coastlines are of particular interest here. To this end, the provision of cultural ecosystem services, such as aesthetic appreciation and recreation through landscape management (of green landscape elements) and endowment of natural capital is beneficial for creation of attractive urban and peri-urban environments and ecological quality (Aldous 2007).

Despite this role, the production cultural ecosystem services and suffers from (i) its subjective nature of perception and inappropriate methodologies and instruments of monitoring and evaluation as well as (ii) inadequate arrangements and policy instruments for compensation and incentives. As a public good and joint non-commodity output from commodity oriented land-based production activities, cultural ecosystem services provision often misses certain targetedness to actual societal and user demands and preferences and more directed compensation of the provider, but also questions of property rights, such as accessibility, management or compensation.

Therefore research should focus here more on a broader base of empirical evidence about (i) user perspective, i.e. human behaviour, perception and preferences related to nature and landscape (e.g. monetary and non-monetary preference studies, including residents, visitors or different ethnic groups) and the (ii) the development of new models and institutional arrangements of compensation for provider of cultural ecosystem services.

Aldous, D.E. (2007). Social, environmental, economic, and health benefits of green spaces, *Acta Horticulturae* 762.

Urban Agriculture a part of a green infrastructure in urban and peri-urban areas

In the face of increasing relevance of enhancing urban resilience against a variety of global driving forces, food production in urban areas through gardening and agriculture has gain increasing attention among the academic and planning community. This is particularly relevant in the context of the fast urbanising societies of the transition countries, where strong rural rooting, community and family orientation as well as the prevalence of dietary traditions is confronted with a high pace of urban growth, changing lifestyles and nutrition security of the urban poor. Between these poles, both traditional forms of urban agriculture (UA) remained in the private domains and are additionally complemented by urban lifestyle-oriented micro-scale gardening in and on buildings.

Often small-scale, but frequently and flexibly applied, UA represents an important element of urban green spaces, which is used in a very public and community sense. This is especially important in urban areas with underproduction of public green spaces, which is the case in many fast growing cities of developing and transition countries. There is some evidence and assumptions, that UA provides a multitude of ecosystem services. Beyond the its (i) contribution to food security (and urban resilience) through contribution to adequate and healthy diets (Gerster-Bentaya 2013), effects reaches from (ii) microclimatic and evapotranspiration effects through canopy cover (Dimoudi et al. 2003) or greening of buildings (Qiu et al. 2013), (iii) the increase of the plant diversity and contribute to ecological niches and habitats for species as edible plants are (re-)introduced into urban ecosystems to (iv) reduction of water run-off by providing non-sealed surfaces and (v) mental and physical health and aesthetic appreciation (Draper & Freedman 2010).

However, despite the multitude of benefits of urban quality of life, UA is also under pressure from increasing limitations by the urban real estate market, neighbourhood conflicts, pollution but also water supply. Therefore, depending on the sub-topics related to urban agriculture research a number of potential research questions occur for a research agenda. (i) Phenomenon and dimension: Which forms of agriculture are carried out in urban areas with which purposes? Which management and cultivation methods (i.e. irrigation, crop selection, pest control, and fertilisation) are applied? (ii) Interrelation into the urban context: In which building-morphological context is urban UA carried out? How does the cultivation practice cope with the framework conditions and the demand for ecosystem service? (iii) Ecosystem services: How do these forms of agriculture land use contribute to urban ecosystem services? (iv) Knowledge and embeddedness into the socio-ecological system: How are urban societies or parts of it (neighbourhoods, communities) are involved in food growing in which way? Who carries which type of knowledge and how is it conserved and transferred between the different agents? (v) Water resources: How to manage the water supply and consumption of city farming in urban areas with water stress (e.g. use of grey water, innovative irrigation systems)?

The urban agriculture debate is frequently carried out in a normative way. Missing is first of all empirical knowledge on its actual dimension as part of the socio-ecological system. Here, transdisciplinary empirical case study research from social, agricultural and environmental sciences, including stocktaking surveys, long-term observations and accounting, (stakeholder) network analyses/ analytic network processes as well as the application of ecosystem models are necessary.

Dimoudi, A. and Nikolopoulou, M., 2003, Vegetation in the urban environment: microclimatic analysis and benefits. *Energy and Buildings* 35, 69-76.

Draper,C. & Freedman,D. (2010). Review and Analysis of the Benefits, Purposes, and Motivations Associated with Community Gardening in the United States. *Journal of Community Practice* 18(4), 458-492.

Gerster-Bentaya,M. (2013). Nutrition-sensitive urban agriculture. *Food Security* 5(5), 723-737.

Qiu,G., Li,H., Zhang,Q., Chen,W., Liang,X. & Li,X. (2013). Effects of Evapotranspiration on Mitigation of Urban Temperature by Vegetation and Urban Agriculture. *Journal of Integrative Agriculture* 12, 1307-1315.