Water infrastructure and urban landscape development

Water in an urban landscape serves many purposes. It is an integral part of urban infrastructure, it offers habitat for plants and animals and it is also an important design element. However, the exchange of ideas among the different professions that are dealing with water and water infrastructure is rather poor. This leads to a standardised approach to water, which creates isolated and expensive systems without synergetic effects. Modern cities have fully detached themselves from the natural landscape. Infrastructure for wastewater and rainwater discharge has disappeared into complex underground pipe systems, hardly visible in the townscape. The open space on top is largely reshaped. Parks and squares have become highly decorative in which water primarily serves as a design element. Also, in contemporary Vietnamese context, water is often regarded merely from a technical engineering aspect. In a time when urban regions are rapidly growing this standardised and one-sided approach to water constrains sustainable urban development. Inflexible centralized sewage systems do not meet the challenge of the process of urbanisation. In many Vietnamese cities the development of conventional water infrastructure cannot keep pace with the rapid population growth. Inadequate or completely missing wastewater treatment causes rampant water pollution, and open space in the urban areas disappears to make space for building construction. (Aprodicio, 2005) (Stokman 2007)

The liquid geography of the Mekong Delta – structure of settlements and land use

Floods can be dangerous and unpredictable in the Mekong Delta, but water is also the basic source for trade, transport and productive agriculture. The monsoon climate and the tides of the Chinese Sea have a very strong impact on the Mekong River and the water households in the Delta. The risk of flooding increases dramatically when storm tides occur during the rain season. An area of about 1,4-2 million hectares gets flooded every year. The water surplus influences the long-term development of settlements and the landscape in the Mekong Delta.

The land in the Delta is characterised by a patchwork of highlands and lowlands. The height range between these areas is less than one meter in the city of Can Tho and its surroundings. This topography is hardly visible in the landscape, but has an enormous impact on the structure of settlements, land use and water infrastructure. (Fig. 1)

Over the course of time three basic methods of habitation in the vast flood plains of the Mekong Delta emerged. In order to avoid floods people traditionally settled in linear structures along the watercourses. This land is naturally elevated because of the sediments that the river has formed. (Fig. 2, Fig. 3) Adapting to natural conditions of changing water levels the settlements were in a constant state of transformation.

Fig. 1

Fig. 2

Fig. 3

Gradually the settlers started to raise the land artificially and became more independent from the naturally formed highlands. On the countryside, excavation material from fishponds or ditches was used to build dwelling mounds for houses or to heighten roads. When the surrounding agricultural lowland flooded, the single houses and roads remained unaffected. (Fig. 4, Fig. 5)

Fig. 4

Fig. 5

Fig. 1: Water system and structure of settlements in the greater area of Can Tho

Fig. 2: Schema: Naturally formed highland

Fig. 3: Photo: Linear settlement structure

Fig. 4: Schema: Dwelling mound

Fig. 5: Photo: Settlement on dwelling mound

The lowlands were traditionally used for agriculture. The annual floods deposited nutrient-rich sediments into the plains making them a location of enormous productivity. The fertile soil, the climate and the geographic location led to the early development of a commodity economy in the Delta region, wherein rice and other agricultural products were traded along a series of river ports. Providing 55 percent of the national rice and half of the aquaculture production, the Delta remains the major food-supplying region in Vietnam and the aquaculture sector is still growing at a considerable rate.
Delta inhabitants began to fill large areas of the lowlands with sand and gravel from the rivers creating large-scale artificial highlands. The first market cities were established and began to spread into large urban settlements. (Fig. 6, Fig. 7)
All three methods of habitation of the Delta are occurring in parallel to this day: the linear settlement structures along the rivers, the building of punctual dwelling mounds and the creation of large artificial highlands. The latter method is the most common, and the artificially elevated land is expanding rapidly due to the fast growth of population. (Sansed 2005: 11) (Shannon 2004: 434)

Fig. 6

Fig. 7

Centralised and decentralised systems – wastewater infrastructure in the Delta

The three ways of settling in the Mekong Delta led to the creation of the different wastewater disposal methods still used today. On the natural highlands the wastewater is discharged directly into the rivers or canals without any treatment. (Fig. 8, Fig. 9) In the rural lowlands of Can Tho, where the inhabitants built their houses mainly on dwelling mounds, wastewater disposal is also carried out decentrally. Here, sky toilettes, which are traditional latrines above fishponds, are the most common solution to deal with black water. (Fig. 10) The nutrients from human excreta are consumed by fish in the pond, mostly carp or Asian catfish, thereby cleaning the water. The fish are consumed by the family living on the dwelling mound beside the pond. The small amount of grey water in the rural areas is reasonably unpolluted and is discharged into the natural watercourses or infiltrates into the ground. (Fig. 11)

Fig. 8

Fig. 9

Fig. 10

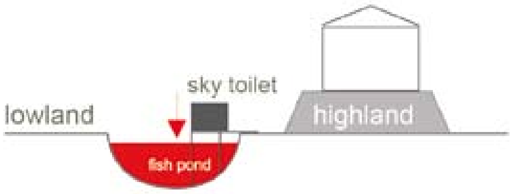

Fig. 11

On the artificial highlands centralised and semi-centralised water infrastructure solutions are preferred. In urban areas most of the households are connected to a drainage system, consisting of underground pipes and covered or open ditches. The wastewater is

Fig. 6: Schema: Large artificial highlands

Fig. 7: Photo: Settlements on large artificial highlands

Fig. 8: Photo: Natural highlands - wastewater discharge

Fig. 9: Schema: Natural highlands - wastewater discharge

Fig. 10: Photo: Sky toilette

Fig. 11: Schema: Dwelling mound wastewater discharge

discharged into the local river. (Fig. 12) In some cases the domestic wastewater is pre-treated decentrally in septic tanks, which takes out the solids and about 20% of the pollutants. (Fig. 13) Wastewater treatment plants only exist in larger industrial or commercial areas to treat wastewater from breweries, hospitals and other enterprises. There is no municipal sewage plant for domestic wastewater in the Mekong Delta. (Sansed 2005: 16f) (Sansed 2009: 34ff)

Fig. 12

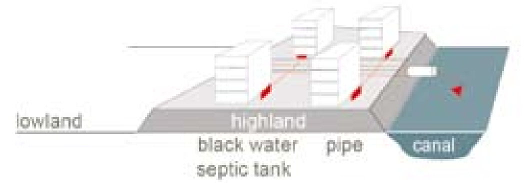

Fig. 13

Le Binh - a growing district in a booming city

Paddy fields, stilt houses and an endless net of canals and ditches characterise Le Binh, a district of the "Delta Capital" Can Tho. (Fig. 14) Water is a central aspect of everyday life. Still today, most of the farmers transport their goods on wooden boats, women wash the laundry in the rivers and children swim in the canals. (Fig. 15) In the North of Le Binh on the Can Tho River there is a large floating market, a central reloading point for tropical fruits and vegetables. Every morning dozens of farmers come by boat from surrounding rural areas to sell their harvest to retailers. (Fig. 16, Fig. 17)

Fig. 14

Fig. 15

Fig. 16

Fig. 17

While age-old traditions are still followed, the peri-urban Le Binh is about to change fundamentally. Le Binh is a growing district in a rapidly growing city. With its 15 000 inhabitants on an area of 2,5 km², Le Binh is still considered to be a rural district. Today, Can Tho, with 1,17 million inhabitants, is the fourth-largest city in Vietnam and is forecasted to grow significantly. In the year 2002, 9,07 km² of rural area was transformed into city and by 2007 the built-up area doubled to more than 20 km². In 2011 Can Tho will cover more than 25 km².
Le Binh is located on the edge of Can Tho, on the border zone where urban landscape merges with the countryside and where new modern lifestyles replace traditional ways of life. In the master plan for 2025 the whole sub-district of Le Binh is planned for new housing development. The development has already reached

Fig. 12: Photo: Large artificial highlands - wastewater discharge

Fig. 13: Schema: Large artificial highlands - wastewater discharge

Fig. 14: Photo: Le Binh today

Fig. 15: Photo: Le Binh - water in everyday life

Fig. 16: Photo: Le Binh - floating market

Fig. 17: Plan: Le Binh today

the northern part of Le Binh, which is closest to downtown Can Tho. (Fig. 18) An urban centre with new five-story apartment houses, hotels and restaurants is emerging. (Fig. 19) (Pham Thi Mai Thy, Venkatesch Raghavan, N.J.Pawarr, 2010)

Fig. 18

Fig. 19

Water pollution and minimal open space

With the expected growth of population, the pressure on the natural water system and the open space in Le Binh will increase substantially. Can Tho´s urban districts give an impression of Le Binh´s future development. Agricultural land is consumed at a considerable rate, large-scale landfills reshape the landscape and open waters are forced into underground canals. (Fig. 20) In central parts of Can Tho, high-density areas have developed with minimal open space. (Fig. 21) The use of the waters is becoming more and more constricted because of the increasing water pollution. Many of the urban water bodies have turned into neglected and avoided places. The poor and marginalised class of the population in particular suffers from insufficient sewage disposal, increasing the risk of diseases and epidemics. (Fig.22)

Central parts of Can Tho (150.000 inhabitants), are planned to be connected to a combined sewerage and rainwater run-off system, which will include a central wastewater treatment plant. There are no plans to connect peri-urban districts like Le Binh to the central treatment plant. (Schweizer, 2008) (Hess, 2008) The long distance to the central treatment plant, the low natural hydraulic gradient in the flat Delta landscape, and scattered settlements, which would require a complex pipe system, are all factors that would make the construction of a centralised system very expensive and technically difficult to realize. Also, the uncontrolled fast urban growth complicates estimating the dimension of the sewerage system. (Sansed, 2005)

Fig. 20

Fig. 21

Fig. 22

Fig. 18: Plan: Natural and artificial highland, lowland and water system in Le Binh

Fig. 19: Photo: Le Binh – Northern centre

Fig. 20: Photo: Large artificial landfill, Can Tho

Fig. 21: Minimal open space, Can Tho

Fig. 22: Photo: Water pollution of urban water bodies in Can Tho

Research and implementation – decentralised wastewater treatment solutions for the Mekong Delta

The aim of the research project Sansed (BMBF, 2002 to 2008) was to develop effective, low-cost, ecologically sensible and hygienic safe sanitation systems for the peri-urban areas in the Mekong Delta. The project was carried out by a network of German and Vietnamese partners, including the University of Can Tho, the University of Bonn, the University of Bochum, and various private German companies. During the first phase of Sansed, an evaluation of the actual land use, the natural conditions and socio-economic situation in the project area Can Tho and its surroundings was carried out. The purpose of the second phase was to develop simple decentralised systems for wastewater treatment, which help to close the nutrient cycle. The key sanitation techniques were biogas plants, urine-diverting systems for nutrient recycling, and soil-filters. Modular solutions for the approved wastewater treatment technologies were tested and adapted to tropical conditions on the campus of the Can Tho University. Sansed also calculated the efficiency of the different sanitation systems in relation to their dimensions and the population density.
The project Green Lines – Red Dots builds upon the research of Sansed and applies the approved decentralised wastewater treatment technologies to the larger context of fast growing district of Le Binh. Green Lines – Red Dots is based on a diploma thesis carried out at the Leibniz University Hanover and STUDIO URBANE LANDSCHAFTEN. The work is being pursued further as research topic at the Institute for Landscape Planning and Ecology at the University of Stuttgart.

Green Lines-Red Dots - green infrastructure for Le Binh

A new planning strategy is needed to deal with the unpredictable urban growth and loss of open space in the peri-urban areas. By combining wastewater treatment with a network of open space a sustainable green infrastructure can be created. This system merges multiple infrastructural functions that increase its ability to withstand the strong pressures of urbanisation. A resistant system of open space can be established and the safe quality of waters secured. The idea of the design strategy is an urban landscape where technical use of water and life quality go hand in hand.
The guiding concept of Green Lines - Red Dots describes how a sustainable and multi-functional water infrastructure in Le Binh can be established. The Green Lines represent a network of green infrastructure consisting of linear parks with constructed wetlands, open water channels and productive agricultural land. It provides water treatment, space for rainwater runoff as well as open space for leisure activities. The Red Dots describe strategic points within the Green Lines: city farms or biogas plants. (Fig. 23) The individual components of the concept and their interactions within the whole system of green infrastructure are explained in the following paragraphs.

Fig. 23: Schema: Green Lines - Red Dots

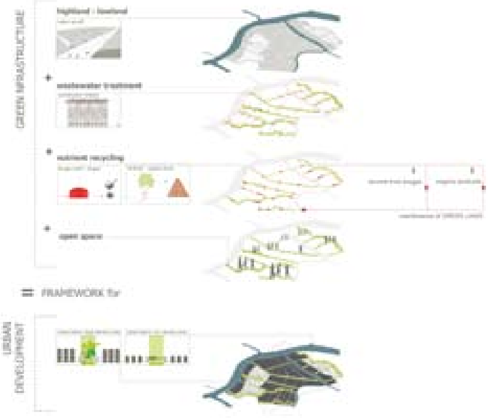

Fig. 23

Highland – lowland; the green infrastructure is based on the existing system of natural watercourses, pipes, open ditches and canals for both sewage and rainwater. It makes use of natural gradient between highland and lowland in order to prevent congestions in the pipes and minimise the need for electrical pumps.

Wastewater treatment; the domestic wastewater in Le Binh is transported to the Green Lines by an underground pipe system and is treated there biologically in different types of constructed wetlands. The treated water is then discharged through open canals into the rivers.

Nutrient recycling; the nutrients from the wastewater are being recycled in city farms, the first form of the Red Dots. Rather than being flushed away, valuable nutrients are extracted to replace the artificial fertilisers currently used in agriculture. In the second form of the Red Dots, biogas plants, gas can be extracted and used for cooking. The income from biogas and organic food production is put towards the maintenance of Green Lines.

Open space system; engineering approaches are made with design considerations in order to create a green infrastructure both functional and attractive. Linear city parks, pocket parks, city farms and tropical fruit gardens combine the techniques of wastewater treatment and agricultural production with the creation of rich and healthy exterior spaces. They offer public spaces for sport activities, calm spots for recreation, frequented meeting points as well as a connected path system for cycling and walking.

Urban development; the system of Green Lines and Red Dots integrates rainwater runoff, wastewater treatment facilities and at the same time provides public open spaces. Because of its many functions this green infrastructure can resist construction pressures while creating a framework for urban development. The decentralisation of wastewater treatment enables the gradual extension of the system to meet the demands of urban growth.

Green infrastructure as a modular site-adapted system

The concept Green Lines - Red Dots guides the process of transformation of present-day Le Binh into its urban future. It integrates the needs of the society into the planning process to create a sustainable net of green infrastructure. The process of urbanisation is accompanied by a number of challenges, which are related to the water infrastructure and open space system. A new lifestyle with a higher level of comfort and luxury and the transformation towards a consumption-based society will place a number of new demands on housing, services and the quality of open space.

To implement the engineering methods of Sansed effectively and adjusted to local needs, three new typologies for Le Binh´s urban future have been developed: the City Type Inland, the City Type Riverside and the Garden Type. These typologies differ in population density and the method of habitation in the flat Delta landscape: settling on naturally created highlands along the rivers, on small dwelling mounds, or on large-scale artificial highlands. The green infrastructure is different in each of the three typologies. They vary in size and structure, implemented wastewater treatment solution and the design of open space. The City Types meet the requirements of the increasing population in Le Binh and provide space for high-density building areas with multi-story apartment houses. The City Type Riverside represents the dwelling zones on the naturally created highlands along the watercourses. The settlements of the City Type Inland are built on large-scale artificial highlands. The Garden Type represents a low-density residential area. This type reflects the increasing demand of family houses with productive gardens, where fruits and vegetables are grown for both self-sufficiency and sale. The family houses are built in the traditional way by constructing a dwelling mound.

The three different types set different conditions for the implementation of water infrastructure and open space planning. In the dense housing areas of the City Types the amount of wastewater output and pressure on the land is high, whereas in the Garden Type the single-family houses produce less wastewater and pressure on open space. Those preconditions determine the used water treatment techniques, the number of inhabitants connected to one decentralised wastewater treatment facility, its capacity, and the size of the wastewater catchment area. The decentralised wastewater treatment system enables a modular extension according to the population growth in Le Binh. New housing areas and the net of green infrastructure are constructed in steps according to the conditions of one of the three types.

City Type Inland

The high-density building area on the artificial highlands of the City Type Inland covers more than two-thirds of Le Binh. Modern apartment houses, bars and restaurants and an integrated green infrastructure system form the new urban landscape. In the City Type Inland the wastewater is transported through an underground pipe system and treated in linear constructed wetlands. For each extension, about 3000 inhabitants are connected to one unit of constructed wetland. Wastewater is treated in horizontal soil filters alongside open watercourses, both integrated into a linear park system (Green Lines). (Fig. 24)

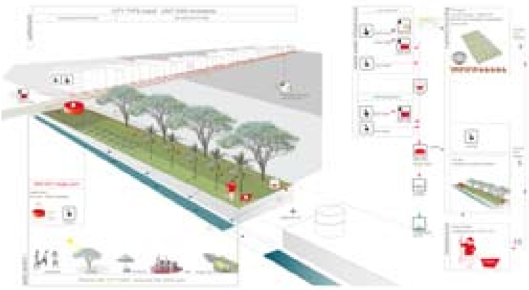

Fig. 24

The constructed wetlands are planted with various trees and flowers providing shade and attractive sceneries. Wastewater flowing through the constructed wetlands supplies the vegetation with water and nutrients. The Red Dots are also designed to be used as an open public space. The view of palm trees, greenery, water and vibrant social life can be enjoyed from the top of the biogas plant (Red Dot). The park is accessible by a net of foot and cycle paths, equipped with seating facilities. Boardwalks alongside and across the canal make it possible to experience the water. A network of paths and boardwalks is created that hasten the transportation in Le Binh. (Fig. 25) The design of the Green Lines considers the extreme fluctuations of water levels during daily tides, the high tide in the rain season and low tide in the dry season. (Fig. 26 - Fig. 29)

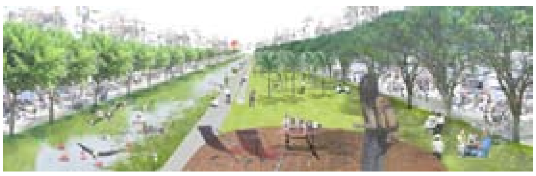

Fig. 25

Fig. 26

Fig. 27

Fig. 24: Schema: City Type Inland, module for 3000 inhabitants

Label for Fig. 24:
1 *In new built apartment houses of the City Type Inland, urine-diverting toilets are installed and urine is collected in tanks for a further use in agriculture.*
2 *About 20 houses are connected to one urine-collecting tank. The nutrient-rich urine is transported to the rural surroundings of Le Binh and sold as fertiliser for agriculture. A unit of 20 apartment houses (500 inhabitants) supplies 60 000 sqm of cultural land with fertiliser.*
3 *Brown water from the new houses and black water from the existing houses are pre-treated in septic tanks.*
4 *Afterwards it flows together with the grey water through underground pipes to the biogas plant (volume: 300 cbm).*
5 *Biogas is produced through anaerobic degradation of organic sewage pollutants. (This is not a cleaning process.) The extracted gas can be used for cooking in local households.*
6 *The polluted water is lead through pipes from the biogas plant into a horizontal soil filter (6000 sqm).*
7 *After the biological treatment, the clean water flows together with the rainwater through open canals into the river. In the canals the water is treated again, via bio-filtration, by passing through soil and hydrophilic plantings.*
8 *Municipal green keepers carry out the maintenance of soil filters, biogas plants and urine tanks. The income from the sale of fertiliser and biogas serves as their salary.* (Klaus, 2008)

Fig. 25: Perspective: Linear park

Fig. 26: Section: Linear park

Fig. 27: Perspective: Linear park - water level during low tide

Fig. 28: Perspective: Linear park - water level during high tide

Fig. 29: Perspective: Linear park - water level in the rain season during high tide

Fig. 30: Schema: City Type Riverside, unit of 500 inhabitants

Label for Fig. 30:
1 *Black water from approx. 500 inhabitants is pre-treated in septic tanks.*
2 *Afterwards it flows together with the grey water through pipes or covered ditches into a vertical soil filter on the riverbank. The catchment area for one filter includes between 80 and 120 households. The wastewater supplies the vegetation of the soil filter with nutrients and water.*
3 *After the biological treatment the clean water flows into the river.*
4 *The maintenance of the soil filters is carried out by municipal green keepers.* (Klaus, 2008)

Fig. 31: Plan, section: Pocket park

Fig. 32: Schema: Garden Type, unit for 50 inhabitants)

Label for 32:
1 *Yellow water is separated from black water by urine-diverting toilets. The urine is collected decentrally in small urine tanks. Two households are connected to one tank (2 cbm), which is installed between the house gardens.*
2 *The urine serves as fertiliser for the cultivation of private gardens with a size of approximately 600 sqm.*
3 *The black water is pre-treated in septic tanks.*
4 *It then flows together with the grey water through pipes into a horizontal soil filter within the Green Line. The soil filter has a size of 100 sqm and can be used for the cultivation of cut flowers.*
5 *After the biological treatment, the water is collected in a pond.*
6 *It is used to irrigate and fertilise cultivable land or for aquaculture within the Green Line.*
7 *Each of the Green Lines is allocated to one City Farmer who lives within the line. The farmer cultivates fruit trees, vegetables and flowers and breeds fish and shrimp. He gets the land for his own use; in return he is responsible for the maintenance of the water infrastructure.* (Klaus, 2008)

Fig. 33: Perspective: Urban farm

Fig. 34: Section: Road greenery adapted to different water levels

Fig. 28

Fig. 29

City Type Riverside

The City Type Riverside is a high-density building area, like the City Type Inland. The wastewater flows by natural hydraulic gradient into the vertical soil filters to be treated. A unit of about 500 inhabitants requires a soil filter of approximately 400 sqm. (Fig. 30) Each soil filter is integrated into a pocket park on the waterfront. In regular intervals the pocket parks break the otherwise dense structure of settlements along the waterfront and provide views of the river. With palm trees and flowerbeds the parks create attractive green spaces for neighbourhoods. Boardwalks with deck bars and coffee shops become popular places to overlook the activities on the river. (Fig. 31)

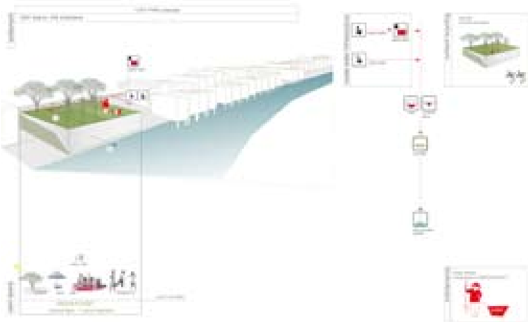

Fig. 30

Fig. 31

Garden Type

The Garden Type satisfies the demands on family houses with private gardens. These more sparsely populated areas of Le Binh are reminiscent of the countryside. A little bit of traditional Mekong Delta life is preserved in the City Farm. Small-scaled fields and fish ponds bring an interesting diversity into Le Binh and combine the production of organic food with nice scenery.

In the Garden Type the low density leads to higher decentralization of wastewater treatment in order to lower the cost of pipe systems. The catchment area for one soil filter includes 10 family houses, which are home to approximately 50 inhabitants. The domestic wastewater flows through pipes into a horizontal soil filter within the Green Line. The soil filter has a size of 100 sqm for each unit of 10 family houses. The pre-treated wastewater is further used for agricultural production on the urban farm also located within the Green Line. (Fig. 32, Fig. 33)

Fig. 32

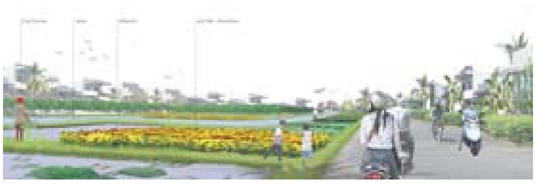

Fig. 33

Depending on the spatial situation, the soil filter can be located alongside the streets. The treated water is lead into an open canal with a stepped profile. In the dry season the water flows in the deepest and narrowest part of the canal that is covered by a grate. The higher situated steps can be used by residents and street vendors. During the rain season the canals fill with rainwater and become an efficient rainwater runoff system. Trees planted in the soil filter provide shade and greenery, valuable in the hot climate for pedestrians and vibrant street life. (Fig. 34 - Fig. 36)

Fig. 34


Fig. 35


Fig. 36

Conclusion

In recent years a great deal of research has been carried out on integrated decentralised wastewater treatment technologies for fast-growing urban areas in Asian countries. Two notable examples are "Solutions for semi-centralised supply and disposal systems in urban areas – a case study in Hanoi, Vietnam" (BMBF, 2008) and "Semi-centralised supply and disposal systems in China's urban areas – second subproject" (BMBF, 2009)". Those research projects often follow a multidisciplinary approach with the participation of different specialists, including water engineers, agricultural scientists, social scientists, economists and specialists for regional and environmental planning or land use management. Currently, however, the urban design disciplines are not included in those research teams.

At "The 4th Conference of the International Forum on Urbanism" (IFoU) in 2009, a team of engineers, specialists in development work and architects presented their experience from the implementation of sustainable sanitation systems in the global South and North. In their conference paper, "Rethinking Sustainable Sanitation for the Urban Environment" (Lüthi at al., 2009) they presented concepts and visions worldwide of what future cities could look like. So-called "Eco-cities" or "Sustainable cities" are currently planned in China, Dongtan and Incheon in South Korea. New concepts and strategies have being developed, such as the "Eco-City movement", the "Permacity" or the concept of "Environmentally Sound Technologies". In those new approaches the topic "water and waste management in the urban context" is explicitly addressed, and some of them can be seen as ways to put "Integrated Water Recourse Management" (IWRM) into practice." (Lüthi at al., 2009) To implement some of those concepts and strategies the specialists at IfoU pointed out the necessity to bridge the gap between practice communities including architects, urban designers, planners, and sanitation engineers.

Design disciplines such as architecture, urban design and landscape architecture often get involved only after the water infrastructure systems have already been developed and implemented. They have to adjust their planning and design solutions to the layout and characteristics of the implemented infrastructure. Consequently, potential synergetic effects of linking the water infrastructure with other urban infrastructures often cannot be reached. The separation of water engineering from planning and design approaches leads to the implementation of isolated urban water infrastructure systems and to the creation of strongly decorative, high-maintenance landscapes.

The concept Green Lines - Red Dots shows how the discipline of Landscape Planning and Design can contribute to the development of a sustainable multifunctional water infrastructure. The concept aims to implement engineer-approved decentralised wastewater technologies into the urban fabric of Le Binh. The proposal has been developed through a process of state discussion and exchange of information between engineers and designers. This process enabled a combination of water infrastructure with the open space system, where technical solutions are an integrated part of the design and accessible to the public.
A system of green infrastructure has been proposed, in which wastewater is treated, nutrients are recycled, and open space is created and maintained, all for the direct benefit of the local community. The layout of the green infrastructure is guided by the natural landscape, its topography and hydrology. It involves the existing system of natural and man-made watercourses, which provide space for continuous rainwater runoff and is followed by a network of functional open space interwoven with roads and paths.
The concept also presents a strategy of how local food production can be integrated into an urban area to create an attractive and productive open space. Its design and technology harness natural processes to optimize system performance while lowering input and maintenance costs. By closing nutrient loops and reducing the need for artificial fertilizers the system contributes to environmental protection. In the implementation phase of the green infrastructure, construction costs could be lowered because several infrastructural projects are completed simultaneously rather than in separate phases, as is current practice.

Worldwide, urban boundaries shift fast and take over open land. "Green Lines - Red Dots" shows how decentralised wastewater management could be implemented to deal with rapidly urbanising areas. The peri-urban landscapes are in a constant state of transformation, offering an opportunity to implement new sustainable site-adapted systems. The flexibility of the proposed systems makes them especially suitable for areas with unpredictable population growth. The concept shows how a new infrastructural system can be implemented on a large scale. Modified and adapted to local sites, the concept of green infrastructure could be transferred to other parts of the world.

Fig. 35: Perspective: Road greenery during rain season

Fig. 36: Perspective: Road greenery during dry season

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Dipl.-Ing. Eva Nemcova
Born 1983 in the Czech Republic, studied Landscape Planning and Design at the University of Brno, Czech Republic and obtained her masters degree in Landscape and Open Space Planning at the Leibniz University of Hanover, Germany where she received the Alfred Töpfer Foundation Scholarship. She worked with Chris Reed in his office Stoss Landscape Urbanism (Boston, USA) and later with Prof. Antje Stokman in her office osp urbanelandschaften (Hamburg, Germany) on projects dealing with integrated water design on different urban scales. Since 2010 she is a researcher and lecturer at the Institute of Landscape Planning and Ecology, at the Faculty of Architecture and Urban Planning at Stuttgart University.
She specializes in green infrastructure and strategic landscape design and development. In her current research she is dealing with water sensitive urban planning and design in Lima, Peru.

Contact:
eva.nemcova@ilpoe.uni-stuttgart.de

Dipl.-Ing. Christoph Wust
Born 1979 in Germany and has studied Landscape and Open Space Planning at the Leibniz University of Hanover, Germany and at the Swedish University of Agricultural Sciences in Alnarp. 2008-2010 he was researcher at the Institute for Open Space Planning and Design at the Leibniz University of Hannover, where he also has specialized in Ecosystem Design and Watershed Management. Since 2011 he works freelance as a lecturer at the workgroup "water and environment" at the Leibniz University of Hannover and on water projects in cooperation with the engineer office Aquaplaner. Christoph Wust is member of the STUDIO URBANE LANDSCHAFTEN, a transdisciplinary network for teaching, research and praxis.
Further publications: Stokman & Wust 2011: Optimierung des Regenwassermanagements, In Stadt und Grün, 2011/04

Contact:
christoph_wust@hotmail.de,
wust@aquaplaner.de