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Content

News Brief

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2008 International Low Impact Development Conference

LID for urban ecosystem and habitat protection

Date: November 16-19, 2008
Location: Westin Seattle in Seattle Washington
Sponsored by the Environmental & Water Resources Institute of ASCE

One of the jewels of the Pacific Northwest, Seattle's waterside location and vibrant culture make it an ideal conference destination. A number of national and regional **LID** Conferences have been held in the United States, including University of Maryland, College Park, and North Carolina State University in Wilmington, respectively 2004 and 2007.

The 2008 International LID Conference will highlight new and continuing work including research, developments, and community adoption of LID throughout the United States and other countries. In there have some objectives want to spread LID such as in the below.

- To continue to promote the use of LID as an effective alternative for traditional stormwater management, as well as to examine successful watershed management practices related to stream restoration;
- To inform practitioners throughout the U.S. and other countries on how to anticipate and address impediments for implementation of these techniques to accelerate change in the practice of stormwater management, including an information exchange to refine design processes, review procedures and construction standards related to LID technologies;
- To improve our collective understanding of how amended soil and vegetation helps manage stormwater, intercept precipitation, expand urban greenspace, and improve urban livability**.**

Reference:

1. http://content.asce.org/conferences/lid08/index.html

Stormwater Management at EPA Headquarters

LID practices help retain as much stormwater as possible on the land.

LID is development that results in low impacts on natural resources. This is done by using planning and designs that preserve green space and manage stormwater to minimize increases in flow and pollutants. LID techniques include conservation of forests and sensitive waters, water reuse, and stormwater controls that detain and retain runoff.

There are many practices that have been used to adhere to these principles such as bioretention facilities, rain gardens, vegetated rooftops, rain barrels, and permeable pavements. By implementing LID principles and practices, water can be managed in a way that reduces the impact of built areas and promotes the natural movement of water within an ecosystem or watershed. Applied on a broad scale, LID can maintain or restore a watershed's hydrologic and ecological functions. LID has been characterized as a sustainable stormwater practice by the Water Environment Research Foundation and others.

Practices at EPA Headquarters

EPA promotes the use of LID techniques in several of its water pollution prevention programs. While LID techniques reduce the amount of pollution entering the nation’s waterways, they are still not widely used. To encourage more government agencies and developers to use LID, EPA is demonstrating several LID techniques at the Agency’s Headquarters in Washington, DC. The demonstration project illustrates what LID practices can accomplish and shows their visual appeal.

The project involves LID and other stormwater management practices at three sites: Ariel Rios South Courtyard, Constitution Avenue, and West Building Parking Garage.

Project Partners

This demonstration project is a collaborative effort involving various partners. EPA’s Office of Water provided conceptual designs for the LID practices being demonstrated. The Facilities Management Division of EPA’s Office of Administration and Resources Management oversaw their construction. The General Services Administration (GSA) designed and maintains the landscape, including trees and plants. Others parties joined as this project evolved, including the U.S. Commission of Fine Arts, the National Capital Planning Commission, the DC Water and Sewer Authority, and a variety of contractors.

Figure. 1 Porous concrete walkway and rain garden at Ariel Rios South Courtyard.

Figure. 2 Bioretention cell in front of EPA Headquarters West Building on Constitution Avenue.

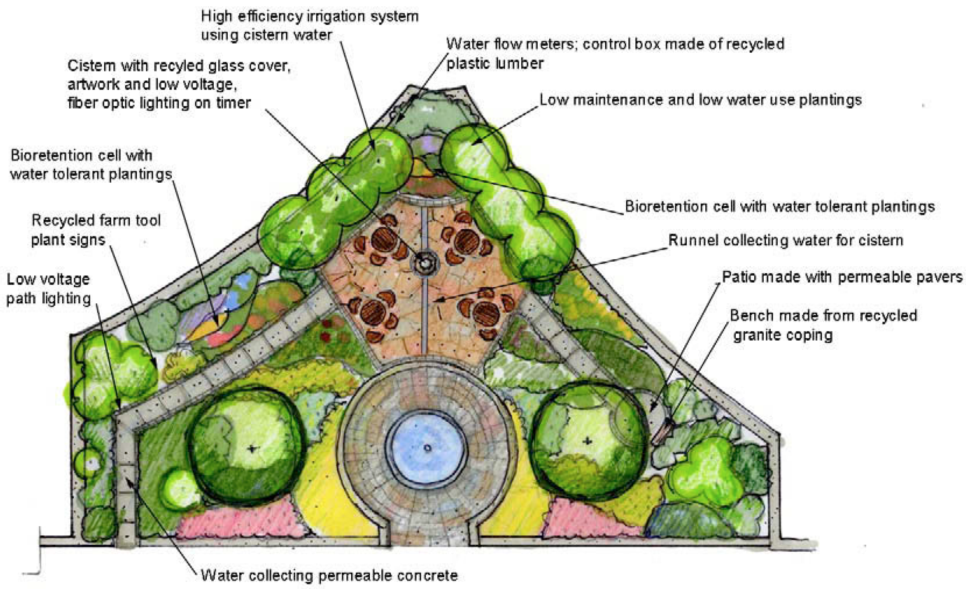

Figure. 3 Drawing of Ariel Rios South Courtyard demonstration site highlighting various LID and other demonstration practices.

Reference:
http://www.epa.gov/owow/nps/lid/
http://www.epa.gov/owow/nps/lid/stormwater_hq

O'Hare aims at environmentally friendly skies

With its acres of concrete and hundreds of jet-fuel gobbling airplanes passing through every day, O'Hare International Airport isn't a tree-hugger's paradise. But Chicago officials are working to change that image, one green roof at a time.

This November marks the opening of the first new runway at O'Hare since 1971, located at the facility's north end. Along with the runway comes a new air traffic control tower that has a garden atop the first floor of its base building.

The rooftop has been planted with sedum, a low-maintenance ground cover. The garden will insulate the building - reducing cooling and heating demands -- retain and filter and prolong the roof's lifetime by about 20 years. It also mitigates the "heat island" effect created by one of the world's busiest airports.

O'Hare is in the midst of a major rebuilding program, aimed at creating six parallel runways running east-west. As part of the new construction, workers have created 33,000 square feet of rooftop gardens. These include plantings atop a guard post, the air traffic control base building, a transformer building and a facility holding lighting control systems.

Before proceeding with the green roof at the air traffic control building - the first of its kind at a Federal Aviation Administration facility - airport planners had to convince agency officials it wouldn't leak and damage essential equipment.

"They had to prove to us that it wouldn't harm operations in the future," FAA spokesman Tony Molinaro said. The garden is lined with a leak-proof membrane.

In spring, Chicago will start construction of another east-west runway at the airport's south end, which has been embroiled in controversy. At the runway's center is St. Johannes Cemetery. Both its owners and Bensenville are fighting airport expansion, which would involve demolishing about 600 properties in the village.

Despite legal action, Andolino said the city will go ahead and build the ends of the runway, located on land Chicago owns.

The runway and air traffic control tower will begin operating on Nov. 20. President Bush and Transportation Secretary Mary Peters are expected to be among the first people landing there, officials said.

Figure. 1 The new north air traffic control tower's base building at O'Hare International Airport has a 10,000-square-foot green roof.

Figure. 2 Rosemarie Andolino, executive director of the O'Hare Modernization Program, center, gives a tour of the 10,000-square-foot vegetated green roof atop the new north air traffic control tower's base building.

Reference:

http://www.dailyherald.com/story/?id=244430

Asian Wetland Convention and Workshop

First SWS (Society of Wetland Scientists) Asia Chapter's

Date: **Oct. 23- 26, 2008.**

Venue: **International Convention Center of NTUH**

Asian Wetlands, Global Position, Common crisis, Immediate Action

At the present time, Taiwan has designated 75 wetlands as wetlands of national importance. These wetlands not only are important habitat environment for wild animals and plants, but also are excellent ecological tour attractions for international visitors. In recent years, the Taiwan government has made great efforts in implementing wetland conservation strategies.

The first Asian Wetland Convention and Workshop was held at the National Taiwan University Hospital (NTUH) International Convention Center in Taipei, Taiwan during October 23-26, 2008.

The Conference invited noted wetland conservation scholars, experts, and senior officials from United Nations. and the Government of Taiwan. Over 600 participants from all over the world participated at the Conference. The meeting provided a good opportunity for the World to see the progress Taiwan has made in wetland conservation and protection.

Reference:

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Water Environmental Education

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Introduction

Water is the mother of life; almost all organisms rely on it to survive. A river is an important wetland, and a key to urban rejuvenation and humanity enrichment. All civilized countries regard it as a treasure of the people, and makes every effort to preserve and protect it. For example, Amsterdam of Holland and Venice of Italy built their rivers in the urban areas into sightseeing landscape by integrating the culture and water. England invested heavily to dredge the Thames River, and restore the glorious riverside civilization. Paris, with a population of only five million, but with tourists of over fifty million each year, has attracted tourists with historic relics, but more importantly, with the Seine.

In 2008, Typhoon Kalmaegi, Sinlaku and Jangmi struck Taiwan one after another, and resulted in severe landslides, bridge and building collapses, and flooding in many areas. These disasters also caused casualties, and forced people to leave their homes. Facing with these challenges, the new government and all levels of agencies have worked cautiously and deligently in disaster relief. Taiwan has a long history of typhoons and floods. Flood control is not a new issue, yet over the years typhoon disasters have continued to occur. Regardless of the policies, flood control is definitely a main concern to the government, and an urgent matter in land planning.

Just several months ago, as the world was deeply concerned about the Sichuan, China earthquake, few people paid attention to the Myanmar typhoon disaster whose casualty may be on the same scale as the Sichuan earthquake. It is possible that even fewer people would recall Hurricane Katrina that struck New Orleans several years ago. Over the past decade, as a result of the close interaction of sea conditions and the climate, extreme weather events have become more severe and occur more often and have gone beyond the planned standard for disaster prevention. Once-in-a-century flood or storm appear more regularly nowadays. Therefore, flood control policies from mere traditional engineering or economical perspectives may no longer be effective. Taiwan must “adapt” to drastic climate changes in the future. Therefore, it is imperative to integrate “water” and “land” regulations in land use planning, and bring reforms into the concept and system. It is not only important to execute the flood control, but also enhance the public understanding of the nature and value of water. Thus, water environment education becomes an important topic.

New water environment management concept

It can be said that men's concepts dominate their behaviors. The essence of water environment education should focus on people's attitude, ethics, lifestyle toward water, and develop a "water culture" of "live along the water, live with the water". Laozi emphasized that "Tao is the source of all things", thus, people should learn from water. He said, "True goodness has similar characteristic as water, water benefits all things without contending, and is situated at places where most people would disdain, therefore it is close to Tao." However, over thousands of years, mankind has much misunderstanding of water. In the development history of the Yellow River Valley in China, the Ganges Valley in Central Asia, and the Nile Valley in Africa, seasonal floods brought abundant resources to the land, nurtured numerous lives, and even prospered the economy. Ancient people learned how to accommodate themselves to the flood and cohabit with water, thus creating brilliant civilization of mankind.

At modern times, some people regard water as a monster or inorganic matter, instead of holding respect toward it. In contrast to water, fire is aggressive, yet fewer people die of fire; water is feminine, so it is more easily ignored and violated. Most obviously, "competing for land with water" simply invites or aggravates hazards. Whether the greed of "compete for land with water" can be fully changed is a major challenge in water control. In Ancient Tainan region, two-thirds of the area was covered by Taijiang Inland Sea and Do-Feng Inland Sea over a hundred years, so that floodwater had not been drained properly. Chia-nan coastal land was often waterlogged. Marsh systems in Kaohsiung area, including Niaosong, Big and Small Bei Lake, and Aotzedi, which were known as the "large ponds" in ancient times, were once home to water birds, and various species of animals. However, after hundreds of years of consistent reclamation, Niaosong area is now frequently flooded during storms. Competing for land with Keelung River in the past greatly reduced water flow section, thus resulted in frequent flooding in the Taipei basin. Over-development of mountain areas has led to landslide, river impediment, accelerated water flow, and endangerment of dozens of bridges in Taiwan, which is now a common scene after a typhoon and big storm.

For example, the Huanhe Expressway in Taipei County along the Hsindien River of Taipei basin is currently under construction. In addition to the NT$30 billion budget for the 21 km long expressway, the road between Shioulang Bridge and Fuhe Bridge is to be built by means of the so-called "co-construction of road and the embankement", in order to raise the 20 ha land above the river surface for future development of residential communities. Such construction method raises the doubt of whether it is designed for developing "transportation" or for a hidden agenda for "housing" development. Further implementation of such "established program" or rigid concept may jeopardize the most precious riverside scenery in Taiwan, and even sacrifice the aquatic eco-environment. If a water control authority cannot learn a lesson from it, respect the nature, and accommodate to floodwater, but rather concern about "additional benefit" from time to time, then this nuisance will be hard to solve thoroughly. In summary, Taiwan should have new concepts and plans with respect to water, river, and water control.

Water control strategy

Based on many practices, Taiwan flood and tide control policies basically follow the concepts of the Great Yu, an ancient legendary figure for flood control in China, , and adopted the "Rigid Engineering Method" to block the water, instead of accommodating to natural condition and adapting to the climate changes. For example, in Lanyu, where there is no problem of water shortage or flood, cement engineering method was adopted to surround the rivers in the wild with cement, thus sacrificing the vigor and scenery of the nature. Water control strategies should be studied by all circles, and are serious challenges to water environmental education.

Laozi stressed on "the weak outpaces the strong". He said, "nothing in the world is weaker than water, yet even the strongest one may not be able to defeat water." Hence, to fight against floodwater and adapt to change, more developed countries have adopted the "Low impact development" plan, also known as the "Flexible Engineering Method" to enhance land utilization, in order to supply more lawns and ponds. Flood detention areas are also established extensively to minimize disasters based on concepts of "flood-alleviation", "flood-diversion". However, whether these plans can mitigate the impact on the environment and also promote local social and economy benefit is an issue to be further discussed. For example, the Yuanshantzu Flood Relief Tunnel has substantial benefits to flood diversion of Taipei Metropolitan Area, but there are no researches concerning its ecologic impact on the fish in the river ecosystem, since the freshwater fish would not survive the saltwater as they are flushed into the ocean. Similarly, dam construction on rivers or water diversion across watersheds have led to serious problems, such as insufficient "river base flow", river ecology protection, and severe sand and stone slides, and dust spreading in many river sections. These problems have resulted in serious impact on air quality, but none have reached cross-department consensus on the solutions.

At the time of volatile climate and even frequent extreme weather, water control must have new countermeasures. Over-development or over-utilization may lead to irremediable and serious losses. Taiwan should study the new actions taken abroad in recent years. Take the United States for an example, in response to new water control concept of "Flexible Engineering Method", relevant authorities or private institutions have published many guidelines, appealing developers and planners to create proper artificial wetland to preserve water spaces. In Holland, where land is low-lying, the policies of “city above water” or “buoyant building” have begun to be executed to prevent flood and prepare for climate changes. In China, the Changchun Wetland Research Center has expanded the functions of the wetland from ecology, water purifying, and landscape to flood regulating, attempting to resolve the flood problem in Yangtze River and Yellow River. Such water control strategies or actions can serve as important references to Taiwan.

Water environmental education and management system

Reciprocal and respectful interpersonal relationship, such as a monarch and his subjects, father and son, husband and wife, brothers and sisters, etc., is generally referred to as “ethics”. Thus, the relationship between men and environment is called “environmental ethics”. Water environmental education not only should educate people about the right concepts of water, but also associate the concept with their lifestyle or culture, in order to develop a “water civilization”.

Environmental education has three aspects or stages: (1) Education about the environment: teach people to understand the value and mechanisms of the nature; (2) Education in the environment: initiate outdoor education to cultivate appreciation and affection toward the nature through hands-on experience; and (3) Education for the environment: promote environment protection awareness, determination and action based on the understanding and affection. Therefore, from perspective of environmental education, “Perceptive Education” and “Affective Education” of water are both important. People should have a basic understanding of water, thus frequent water activities and education should be promoted. Before building water-related facilities, it is important to have in-depth understanding of the “beauty” and “value” of water or river; and conduct thorough planning before any engineering construction or development, in order to give water, watershed, river or waterborne ecosystem their due space and respect.

In terms of administrative management system, river management in Taiwan is a multi-faceted management system formed along river sections of upper, middle and lower reaches, thus, agriculture water conservancy authority, local government and water resource administrations each takes its own role. “Integrated watershed and coastal management” is a very important issue, as concerned by many developed countries and in the Ramsar Convention. For example, the College of Civil Engineering of the Asian Institute of Technology has offered integration course on this subject. These can serve as useful references to Taiwan on implementing “water, land, woods” or “watershed, coastal” integration in water resource administration, water environmental education or land planning.

Although the water resource and engineering authorities in Taiwan have made considerable efforts in the "ecological engineering method", "ecological engineering" and "sustainable development of public construction" in recent years, these systems still have room for improvement. In regard to river control, its "Water Act" focuses on flood and tide control, which stays at the stage of "controlling" hydrology and disaster. The water control policy in Japan starts from "flood control", and introduces water resource management and ecological engineering methods, and has evolved into the level of "biodiversity". Such progress complies with the environment change and international trend, hence, could be provided as references to authorities in Taiwan.

In terms of legal system, the U.S. has exerted much effort on protecting the natural value of rivers. The "Wild and Scenic Rivers Act (16 USC 1271-1287, Public Law 90-542, approved October 2, 1968, 82 Stat. 906)" enforced protection on river sections with no human interference and with the most natural scenic ecology, implemented restoration program for river sections with mild human interference to preserve the areas for hydrophilic recreational usage, and reinforced development or restoration program on riverside that had suffered from severe interference. This Act aims to preserve river features, i.e., "selected rivers in the United States are preserved for possessing outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values. Rivers, or sections of rivers, so designated are preserved in their free-flowing condition and are not dammed or otherwise impeded." Based on this Act, over 150 national rivers have been listed for protection across the U.S. at present. The preservation of the natural appearance of these rivers has endowed new life and value to the rivers.

Considering the limitations of the Water Act of Taiwan, the water resource administrations should refer to the essence and framework of the U.S. "Wild and Scenic Rivers Act" as the direction for river control and policy making in the future, thus allowing people to have new interaction with water, and develop new "water civilization".

Conclusions

Water is one of the most important resources on earth, and water environment is also the venue with the most abundant animal and plant ecological diversity. People should have more understanding of and respect to water. Good water resource administration and water environment planning should focus on preserving the natural riverside, so that water can play its diversified functions and values in ecology, landscape, flood-regulating, water purification and recreation. In recent years, drastic climate change has led to more frequent occurrence of typhoon and flood, thus, based on the concept of "the softest in the world yet the strongest to run the world", the new concept of "respect for water" should be cultivated, instead of conquering this "monster". As Laozi said, "Only whoever does not compete can rest without worry." Learn from water, do not compete with water, the future shall be a new era to give water sufficient space and basic respect.

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水環境教育

水是生命之母，幾乎所有生物都需要賴以存活。河川則是重要濕地，也是都市起死回生和豐富人文的命脈，文明國家莫不視為都市瑰寶，傾盡全力維護保存。例如，荷蘭的阿姆斯特丹、義大利威尼斯，以市區河道塑造了人水合一的觀光勝境；英國泰晤士河耗費鉅資進行整治，挽回河岸輝煌的文明；法國巴黎的塞納河水岸文明與空間環境改善，使得該地區一年觀光客達到五千多萬人次，其水岸環境無疑扮演了重要關鍵。

2008 年卡玫基、辛樂克和薔蜜颱風接踵而至，造成許多地區嚴重的土石流、坍方、斷橋、屋倒和淹水的災情；但台灣並非今天才面對風水威脅，「治水」已是老問題。歷次風災卻嚴峻地考驗災害仍不斷發生。颱風之後，姑不論將來採取哪些方案，治水一事肯定是國家的大事、國土規劃的當務之急。

水是地球是最重要的資源之一，亦是動植物生態最豐富的地方，人們對於「水」應有更多的瞭解與尊重。良好的水政和水環境規劃也應能盡量保存自然護岸形態，才能發揮水在生態、景觀、調洪、淨水和親水等的多樣性的功能和價值。近年來，地球的氣候變異詭譎，未來的颱風洪水可能越來越頻繁。我們該深切瞭解水為「天下之至柔，馳騁天下之至堅」的特性，好好培養國人與規劃師新的「尊水觀」，而不是時刻想要征服這頭「猛獸」。老子說，「夫唯不爭，故無尤。」學習水，不與水爭，今後該是還給水自然宣納的空間和基本尊重的新時代了。

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Storm Water Management strategies in urban and rural areas regarding water flow and quality

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Abstract

In recent years decentralize (on-site) or non-structural storm water management techniques have become more and more popular. Nevertheless, decentralized storm water management is not applicable everywhere. Especially in existing urban areas there are many restrictions.

This paper introduces an approach for storm water master planning with decentralized onsite measures which implied a closer view to the urban and rural environment. This approach takes several boundary conditions for storm water management measures into account. It is supported by a simple but flexible tool called FLEXT, which helps to solve spatially-distributed decision problems, i.e., on-site for rainwater in an urban area. Within FLEXT an Expert system (ES) is coupled with a GIS. The main advantages of using an expert system are 1) to convey knowledge, 2) liberation of experts from complicated but routine tasks, 3) integration of knowledge or expertise from different experts in the same field, 4) automation of a large amount of repeated processes. Because of the amount of data that has to be processed, a Geographical Information System (GIS) is useful to collect, analyses, transform and present the data.

The approach and the application of FLEXT are demonstrated by the case study in the area of the river basin Wupper. For an area of 401 km² the potentials for on-site SWM measures had been investigated.

Keywords: Urban storm water management; scenario development, risk screening, expert system, GIS, flexibility

都市與鄉村地區之水體水質暴雨管理策略

近年來結構性 BMPs（現地）或非結構性之暴雨管理技術越來越為普及。然而，結構性 BMPs 並非各處皆適合，特別於都會地區更受到許多限制。

本文中係介紹「FLEXT」應用於暴雨管理之規劃方法。「FLEXT」模式是種簡單且彈性之工具。該方法藉由許多的暴雨邊界條件所計算結果而得，顯示出都市與鄉村地區所需之 BMPs 設施之規模。其亦可解決空間分散之決策問題，例如結構性 BMPs 於都會地區之應用。於 FLEXT 中之專家系統(ES)是結合地理資訊系統（GIS）。其使用專家系統的主要優點在於 1)傳達訊息、2)從專家的複雜訊息中釋出標準程序作業、3)整合相同領域之專家專業知識或訊息及 4)以電腦大量自動化重複處理。因為需要大量之前處理數據，故地理資訊系統是一個實用性之分析、收集、轉換與呈現數據之工具。

本文以研究 Wupper 河流域之 401 平方公里為案例。應用 FLEXT 方法調查出現地 SWM 可能的規模。

關鍵字：都市暴雨管理、情境開發方案、風險篩選、地理資訊系統、專家系統、適應性

Introduction

On-site rainwater management is becoming a significant and prevalent supplement method in urban drainage planning and has many advantages compared to conventional discharge processes. The question of whether a piece of private property or public space can be disconnected from the sewer system and infiltrated on-site, however, depends on the evaluation of multiple parameters. A systematic and automated evaluation with the computer is not possible at present. This would be rather sensible, in particular, when one considers planning on-site storm water management measures for large urban catchments.

A transparent, knowledge-based and spatial decision support system was developed as an instrument to automate the evaluation of on-site storm water management measures. This instrument integrates a knowledge-based system or an expert system (ES), because the solutions to the above-mentioned problems require dynamic, experiential and professional knowledge.

The expert system developed in this task, however, has a distinctive feature compared to a normal expert system. Because this expert system is supposed to be used as a decision support system, the knowledge base must be transparently available to the user, as well as modifiable by him. For this purpose, a GIS-integrated expert system tool was developed that fulfils the requirements mentioned above. The overall solution consists of “GIS + ES tool + Knowledge Base.”

The established knowledge-based spatial decision support system for the Wupper catchment was applied to the prepared GIS databases respectively and the results were presented graphically in GIS. For each evaluation, the fundamental result is in fact a map of the spatial distribution of possible on-site storm water management measures. In the database, the expert system also indicates information regarding upon which influencing factors an evaluation was made. Likewise, comments about missing data in certain sub-areas are pointed out too.

The developed transparent knowledge-based decision support systems give the engineer a flexible and general instrument for planning on-site storm water management measures.

Integrated planning of on-site SWM measures

With the development of the economy, the migration of people from rural to industrialized areas, i.e. urbanization, accelerates worldwide. As a result, large amounts of natural areas, such as meadows, forests, agriculture lands, etc. become sealed, due to the construction of apartments, factories, institutions, sports and entertainment buildings or yards, roads, streets etc. For example, nowadays in Germany, statistically about 122 ha of natural area are consumed for new apartments and streets daily, of which around 50 percent becomes impervious (Sieker, et al, 2002). In fact, the urbanization process is occurring even more rapidly in developing countries, like China, India, etc. Following text cited from “the Key Facts About Cities, Issues for the Urban Millennium, United Nations Environment Programmed” should give a general idea of the world urbanization process.

In 1950 less than one person in three lived in a town or city. Today nearly half the world’s population is urban. By 2030 the proportion will be more than 60 percent. Virtually all population growth in the next quarter-century will be in urban areas in the less developed countries.

Urbanization, on one hand as a symbol of economical development, brings out on the other hand many negative effects. One of the most direct problems is the overloading of the city sewer system, which is at present the prevailing urban water drainage system in the world. The overloading of an existing sewer system is due to more and more surface runoff converged from continuously newly connected impervious areas.

For a combined sewer system, that is, rainwater and wastewater drained together in one pipe system, the overloading means on one hand the hydraulic overload in different points inside the pipe system, on the other hand the overloading of the wastewater treatment plant at the end of the pipe system, or more overflow of the combined sewer directly into the receiving water.

For separate sewer systems, that is, rainwater drained in its own pipe system, the overload on one hand means the hydraulic overload at different points inside the pipe system, and on the other hand more rainwater without any treatment directly into the receiving water. So in both cases, urbanization will cause hydraulic overloading inside the pipe system and a higher pollution load in the receiving water.

To solve the hydraulic overload problem in the city, the conventional method is rehabilitation of the sewer system by enlarging relevant pipes. However, this actually worsens the second problem, i.e. receiving water pollution, because more and more rainwater or combined sewage will be directly drained into the receiving water. Although the combined sewer overflow can be reduced through construction of central water retention basins, there is the same problem as for the existing sewer pipe system, i.e. the retention basin must be continuously enlarged, or new retention basins continuously constructed, with the continuous increase of inflow from the sewer system. This is furthermore a problem of available space to construct the retention basins and the high cost of construction for basins and pumping stations.

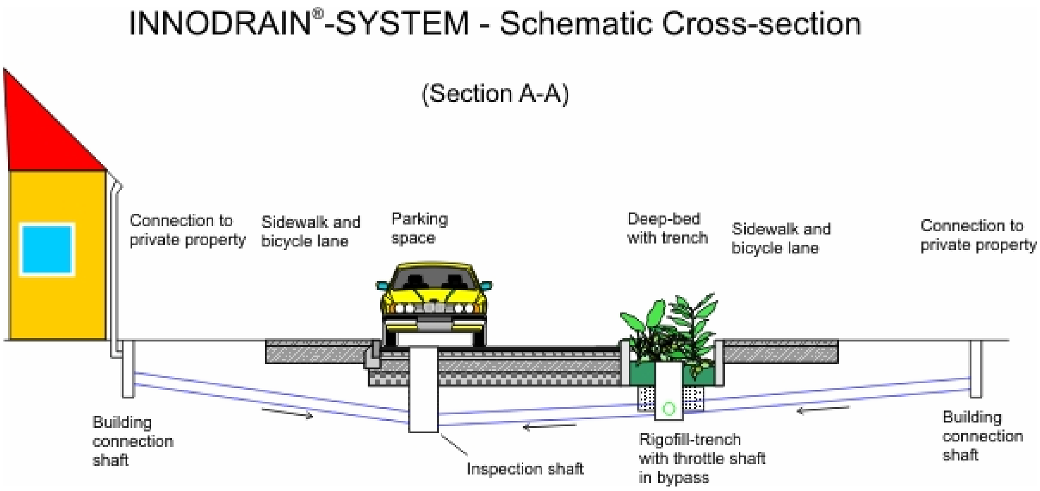
Aside from the water pollution problem, the continuous enlargement of sewer pipes could transfer the flood problem caused by urbanization from inside the city to nearby streams or rivers. This is especially significant in some small river basins with high urbanization. Another negative effect of draining rainwater totally through a pipe system is that the water balance in the drained area will be worse because of the reduction of evapotranspiration and groundwater recharge. The reduction of evapotranspiration affects the local climate to some extent, while the reduction of groundwater recharge endangers sustainable social development regarding water resources.

New concept on Urban Stormwater Management (USWM)

Considering the above-mentioned problems originating from urbanization and the shortcomings of the conventional solution, a new concept of urban water management, decentralized rainwater management, which aims to reduce surface runoff to the existing sewer system during rain events, is being gradually put into practice. For example, Sydney, Australia, has a stormwater system that is completely separate from the sewerage system by using on-site detention (OSD) measures (S Beecham et al, March, 2005). In USA, many states have a stormwater best management practice (BMP) manual which includes among others detailed instructions to the selection, design and construction of the most suitable on-site stormwater management measures. On-site stormwater management becomes popular nowadays also in many other countries. Figure 1 shows two photos of practical examples of on-site stormwater management structures in Auckland, New Zealand (On-site stormwater management manual, Auckland, New Zealand)

Figure 1. On-site stormwater management measures applied in Auckland, New Zealand

In Germany, on-site stormwater management, especially on-site infiltration has been extensively researched and widely put into practice. Researchers have developed many new concepts on on-site infiltration and have accumulated a lot of theoretical and practical knowledge in this aspect. For example, Figure.2 demonstrates schematically the application of the combination of on-site infiltration and the traditional underground pipe drainage, which introduces the concept of the incomplete infiltration of on-site infiltration measure, which is otherwise usually considered only as complete infiltration method.



(Source: IPS, Germany)

Figure 2. Scheme of the cross section of an INNODRAIN-SYSTEM

Integrated planning of on-site stormwater management measures in whole urban stormwater drainage system

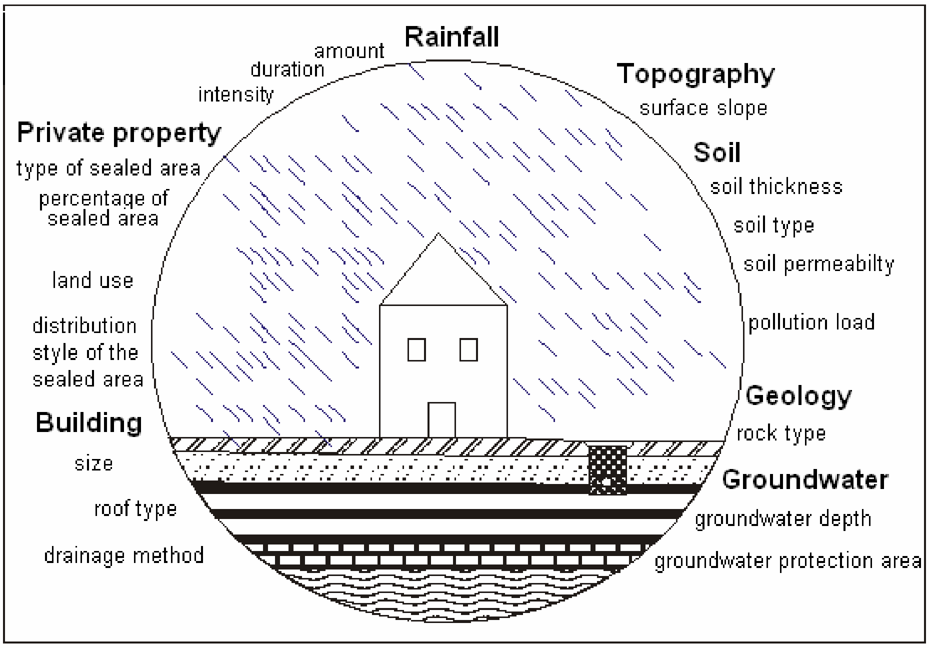
Among on-site stormwater management measures, rainwater utilization is a relatively simple concept. Its application is rather limited to household water use or garden irrigation, etc. The boundary conditions on installation of a rainwater utilization system depend mainly on the integration of the system (for example, a storage tank) with the local environment and the construction and operation cost.

A decentralized rainwater retention basin functions much like a central retention basin, but functions on a reduced scale and inside a drainage catchment. The effects of decentralized retention basins include: Relieving the hydraulic overloading of the sewer system, relaying the concentration of runoff into the receiving water and reducing the combined overflow (when the system is the combined sewer system). Whether a decentralized retention basin should be constructed to relieve the overloading of sewer pipes mainly depends on the available natural area, the management of the retention basin, cost and construction issues.

On-site rainwater infiltration tries to make the best use of the storage capacity of local soil. The rainwater from a local impervious area is collected and drained into an infiltration structure. The collected water will either immediately infiltrate into the surrounding soil or infiltrate after temporary storage. In this way, constructed areas suitable for this type of treatment can be disconnected from the sewer system and drained on-site.

Obviously, on-site rainwater infiltration is more often applicable than rainwater utilization for its suitability to disconnect more types of built-up areas and it is more flexibly installed than a decentralized retention basin considering its requirement for natural area and its integration into the surrounding environment. The foremost advantages that make infiltration measures desirable are:

- Reducing inflow to the existing sewer system, hence reducing flooding inside the city or contributing to flood control in rivers in or near cities.
- Contributing to the cleanliness of the rainwater by filtering rainwater through vegetated shallow ponds and/or active soil layers.
- Increasing groundwater recharge and to some extent also evapotranspiration. In this regard, on-site rainwater infiltration manages rainwater in a near-natural way.

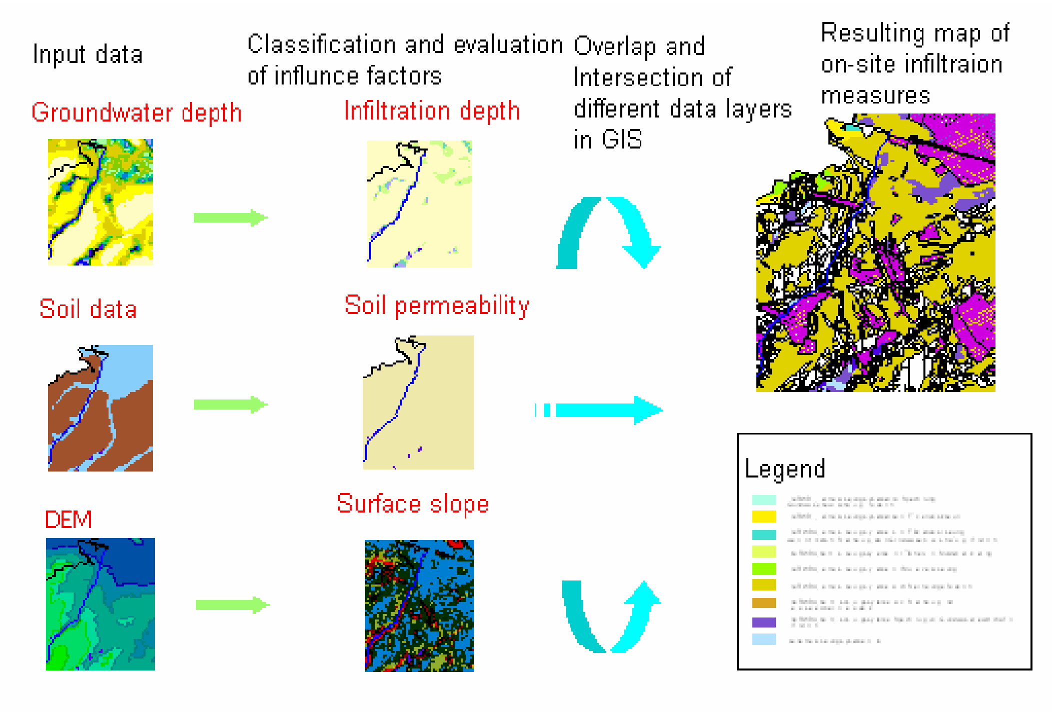


(Source: S. Bandermann)

Figure 3. Different influence factors on selection of on-site storm water infiltration measures

However, compared to the other two types of decentralized rainwater management, the application of on-site infiltration measures depends on not only factors related to construction and cost, but also influencing factors such as soil type, soil permeability, groundwater depth, storm water pollution load etc. (Figure. 3). The decision on whether on-site storm water infiltration is suitable for a given area and if yes, which type of infiltration measure is the optimal one for that area involves relatively complicated, multi-disciplinary and rather experienced judgment.

The complexity of this decision or selection will be especially remarkable if one considered the complicate decision has to be made individually for numerous small areas (such as a single lot of a villa or an apartment) during an integrated planning of the storm water drainage for a whole urban catchment. Moreover, such decisions need usually repeated under the change of the planning constraints, because a planning needs normally the comparison of the hydrologic and hydraulic effects of many different scenarios.



(Source: S. Bandermann)

Figure 4. A schematic demonstration of the procedure of planning of on-site infiltration measures

A schematic presentation (Figure. 4) of the general procedure of a planning of on-site infiltration measures for an urban catchment could demonstrate the complexity of the process. First, the different digital input data (GIS data), such as groundwater depth, soil permeability, etc. are first processed and classified according to their individual boundary conditions on each of stormwater infiltration measures. Some factors may not be directly available and hence must be derived from other original data, for example the surface slope data is usually derived from digital elevation model (DEM). The classified spatial data are normally distributed in different style and hence hold in different layers in a GIS project file. Therefore they must then be spatially overlapped and intersected with each other to obtain a new spatial distribution (i.e. a layer), in which data of all factors are enclosed and consistent (that is, values of each factor keep consistent in every object of the layer).

Because of the spatial intersection of many layers, the number of objects in the resulting layer could be hundreds of thousands. This means there must be hundreds of thousands decisions to be made for one planning scenario. Moreover, each decision process is dynamic because effects of some factors on the decision of the infiltration measure may depend on what other parameters have currently affected the decision. For example, when the groundwater depth is relative high, then the on-site infiltration structures with underground storage facilities (such as a trench) are usually ruled out. And hence the further evaluation of permeability of deep soil layer is not necessary. Such dynamic unstructured analysis is difficult to carry out through macro operations in a database record set or Excel sheets, which could be the way dealing with the massive decisions. Therefore the selection of a suitable on-site infiltration measure needs then to be analyzed manually for one object after another. This is actually not practicable.

Decentralized water management planning aiming to preventive flood control in river basin

Similarly to on-site stormwater management in urban area, the preventive decentralized measures in a river catchment scale aims to reduce as much on-site surface runoff in the whole river catchment as possible during rain events. One of the decentralized management concepts is the increase of natural water infiltration in agricultural lands, forest area, etc. This concept tries to make best use of the water-retention capacity of soil in the whole catchment and concerns every patch of land where potential exists for storing rainwater during rain events. Comparing to conventional river engineering, such as canalization, this preventive decentralized measures on one hand mitigate potential floods to some extent, and on other hand increase base flow as well as soil moisture after flood. The special characteristics of this kind of preventive decentralized measure is that it makes contribution to flood control without just shifting the problem from upper reaches to lower reaches of a river basin, which could be so by conventional river engineering measures, like canalization (Sieker, 2002).

However, the planning of the decentralized measures is based on appropriate evaluation of soil water-retention potentials of the widely diversified situation in whole catchment. The evaluation involves not only the soil properties, surface slope, etc, as in the evaluation for urban area, but also the land use, such as agricultural lands or forest area, natural protection area, etc. Different land uses require different evaluation regulations. Therefore, one of such planning task involves already different domain knowledge. Similarly, this planning involves also massive evaluations of small areas distributed in a whole river basin.

Flext (Decision Support System) -> GIS

The concept of integration of an Expert System into GIS

The decision support system FLEXT was developed for automated processing of GIS data in preparation of Storm water master planning. This system runs with GeoMedia Professional (Intergraph) or other GIS system like ArcGIS (ESRI) and enables the user to specify their decision rule system and use basic data for creating solution maps like storm water measurement maps.

Running procedure of the integrated model

With a knowledge base formulator from GeoMedia Professional it is possible to edit one's problem-specific knowledge base, which usually consists of a rules system and maybe external professional models and expertise databases referenced in the rules system. The necessary expertise database can be prepared by using MS Access.

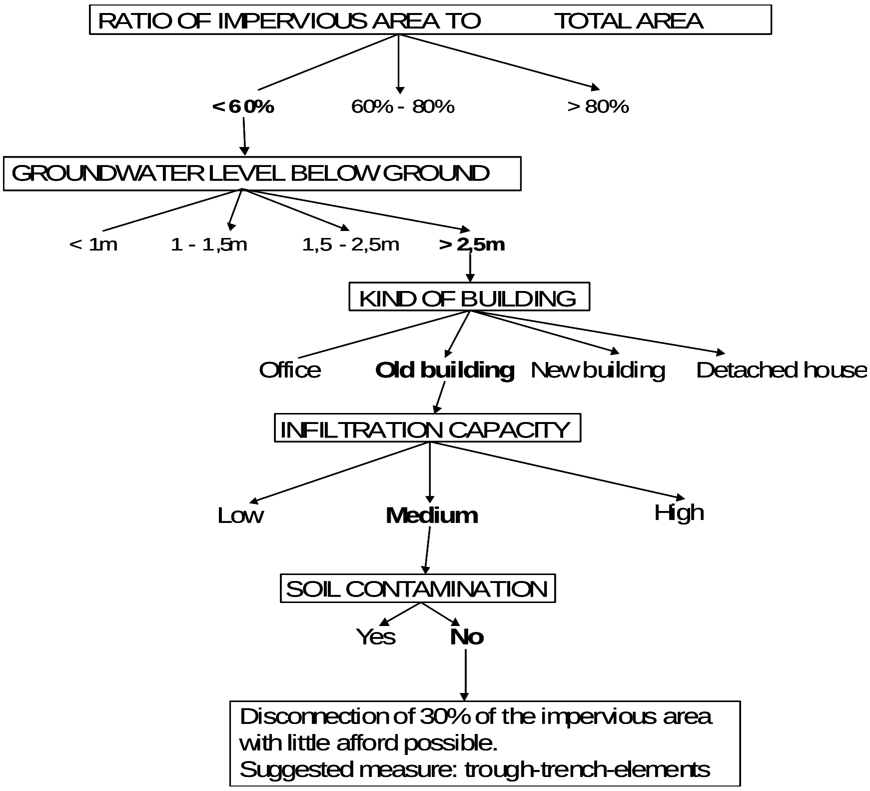


Figure 5. setting up a decision tree for defining decision procedures

The formulated knowledge base and the Flext Runtime modular (inference engine and interface) form a problem-specific expert system or knowledge-based decision support system. This system can be activated though menu commands of GeoMedia Professional (user commands) to process for all objects of a selected feature. Clicking on an object of a spatially distributed feature can also trigger the runtime module. For example, in reacting to a mouse click, the integrated knowledge-based system is executed with the necessary inputs read from the pre-matched fields of the record related to the clicked object. The results or decisions for this object are then displayed in a docking window.

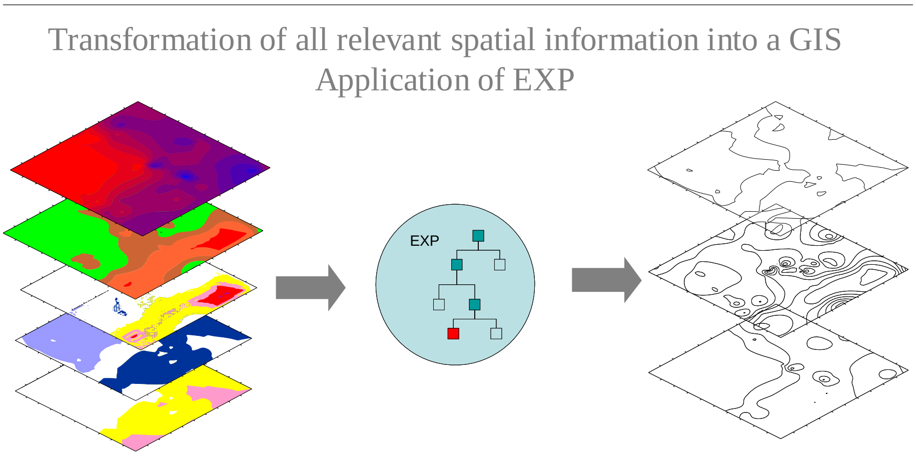


Figure 6. Schematic presentation of the application of a GIS integrated expert system for the planning of on-site stormwater management

Development of A transparent spatial decision support systems for on-site USWM planning

For the development of a transparent spatial decision support system on the planning of the on-site stormwater infiltration measures, the necessary case-specific knowledge was first analyzed and clearly formulated in natural contexts. The transformation of the human knowledge into a knowledge base for Flext and the application of the developed system was then tested on on-site SWM planning in the River basin of the Wupper.

Of decentralized rainwater management measures, the on-site rainwater infiltration measures, which serve as making good use of the water storage capacity of local soil, are of special interest in this study. Among on-site rainwater infiltration measures, some are designed such that the runoff from the connected catchment (local sealed area) can be totally infiltrated underground and later either percolated further into groundwater bodies or evapotranspired before the next rain event. However, these so-called complete infiltration measures are sometimes not justified in soil with very low permeability. In such situations, measures aimed at partial infiltration are then considered.

Classification of affecting factors of decentralized SWM

Although the main constraints of some on-site infiltration structures are already described in previous section, in following factors which concerns an overall decision or selection of a stormwater infiltration measure for a given area are classified and explains in detail.

Factors affecting on-site water retention

On-site water retention is the essential pre-condition for decentralized stormwater management. Therefore, these factors will be investigated and evaluated first. Water retention means in this case immediate on-site rainwater infiltration or infiltration after temporary storage. It is principally influenced by the following factors:

- Permeability (Kf) of the surrounding soil: a parameter that indicates how fast the infiltrated water will be transported underground. The following table shows the Kf criteria on each infiltration measure according to German practice.

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Table 1 Criteria of permeability on different on-site stormwater infiltration measures

Decentralised rainwater infiltration measures	Permeability (m/s)
Surface infiltration	$K_f \exists 2*10^{-5}$
Swale infiltration	$K_f \exists 5*10^{-6}$ Can be smaller when large pervious area available
Swale-trench element without drainage	$K_f \exists 1*10^{-6}$
Swale-trench-system with throttled drainage	No limitation

- Porosity (n) of the soil layer: indicates the extent of the void space of soil.
- Groundwater table: reflects the thickness of the unsaturated layer, and hence the local water retention capacity, and therefore is essential to on-site infiltration measures.
- Thickness of soil: indicates the distance to hard rocks.

Factors concerning pollution dispersion

The infiltration of collected rainwater will inevitably transport pollutants underground at meantime, even though there are vegetated filtering processes in the swale and the active soil layer at the bottom of the swale, so the infiltration measures should be avoided for such environments as:

- Well zones where groundwater is pumped for drinking water, because the demand on water quality is very high.
- Highly polluted areas such as old industrial areas, industry deposits, roadways with high traffic volumes, etc., because the high pollution loads are expected in the stormwater runoff from such area.

Factors affecting the construction of on-site infiltration measures:

- Surface slope concerns both the installation of the infiltration basin and the inlet of the stormwater runoff from connected sealed area to the basin. The steeper the slope, the higher the cost of the construction of the infiltration basin is.
- Thickness of soil layers: described already in the first class, influences also the construction of the infiltration structures, for example, the underground trenches.
- Available natural area: for swale and swale-trench system, an existing natural area (at least 10 percent of the planned connected sealed area) is a pre-condition of installing these measures.

Factors concerning other utilisation of the site or aesthetics

When planning on-site infiltration measures, it should be considered whether the local original utilization or function is affected by the installation of the stormwater infiltration measures, such as the basement, foundation of buildings, railways or highways, etc. The main indicating factor to evaluate these effects is the local groundwater table (described already in first class). According to DWA (German Water Association, Germany), the critical distance between the bottom of the infiltration structure and the groundwater surface is 1 m.

The effects on aesthetics depend on mainly whether there is enough green space available. Ideally, the design of the infiltration swale or swale-trench system should be integrated into local landscape planning to create pleasant scenery. However, this factor is hardly demonstrable.

Social and economic factors

Social acceptance and costs are the final important factors to consider in selecting on-site infiltration measures.

In the above factors, the factors in the first three classes concern spatially distributed information on the planning area and are available in most of cases. They can also be evaluated quantifiably or decisively. Factors in last classes are relevant only by concrete design and construction of the measures. In the planning stage, only factors in the first three classes are relevant.

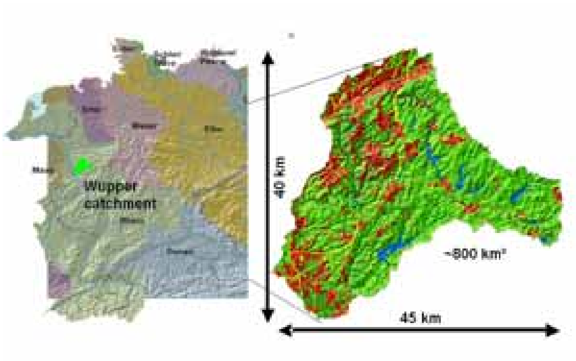

Figure 7. Catchment of the River Wupper

The assessed part of the Wupper river basin covers an area of 40,100 hectares and consists of six WWTP catchments. For each of these urban catchments a rainfall-runoff model was set up with the application STORM. On the basis of the output, decisions would be made concerning SWM measures to reduce or eliminate negative environmental effects of CSOs by possible use of decentralize BMPs. Since the area is covering more than 40,000 hectares a knowledge-based decision support tool for a first screening of the potential for on-site SWM measures was indispensable. Therefore the Flext Spatial Decision Support Tool was applied to the River Basin.

Case Study: River basin of the Wupper

As an End-User within the DayWater Project, the Water Board of the River Wupper (Wupperverband) in Germany is responsible for the River Basin Management in this area. Therefore the knowledge about quantitative and qualitative processes in the water cycle is essential. To manage the interaction between catchments, sewer treatment plant and water bodies, an integrated approach to water management in the river basin of the Wupper is important. For this purpose, an extensive assessment of rainfall-runoff-processes in the urban sub catchments of the chosen river basin was needed, but as important is a useful system to assess potentials for decentralize SWM in the catchment area as a whole.

Application of the ES in combination with GIS

The expert knowledge had to be put into the expert system, whereas at the same time relevant information for the area was put into a GIS Application. The expert system was applied to the GIS Application, after which maps were generated, showing potentials for suitable BMPs. The decision rules applicable for the Wupper Catchment, were based on information for: Hydrology, Urban drainage, Economy, Agriculture and Environmental protection.

The results of the testing on the River Basin of the River Wupper can be seen in figureures 8. and 9 below.

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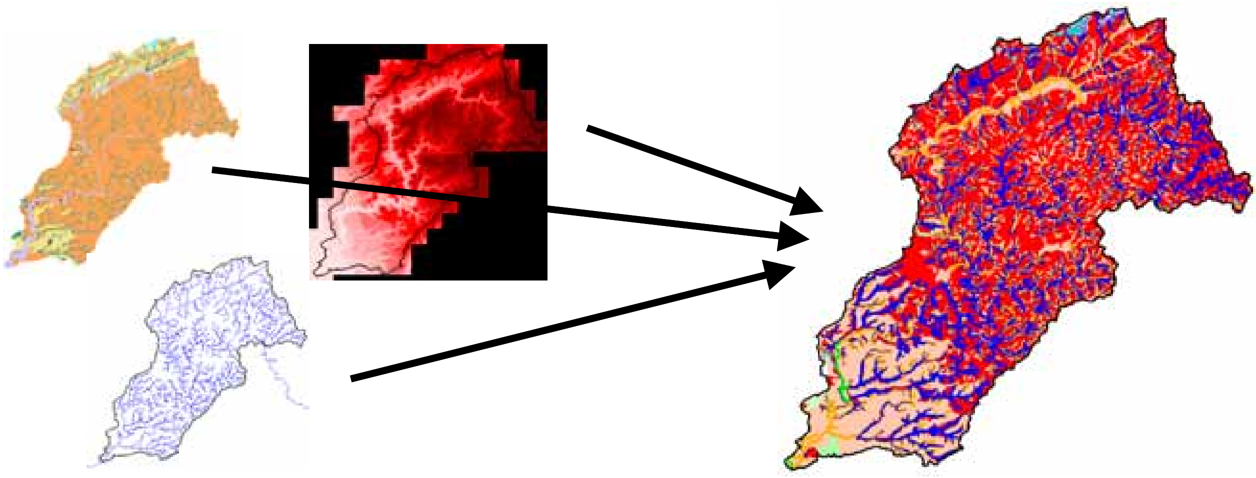

Figure 8. Application of ES and GIS to the River Basin of the River Wupper

For further preparation the land use of the urban and rural areas were identified and evaluated. Urban areas are classified in residential areas, industrial areas, traffic areas, special use, sports use and dumps. Rural areas are classified as parks, horticulture, forests, heath, pasture, farmland, more, swamp, vegetation less and surface waters. This step is important for the setup of runoff parameter and local water balances.

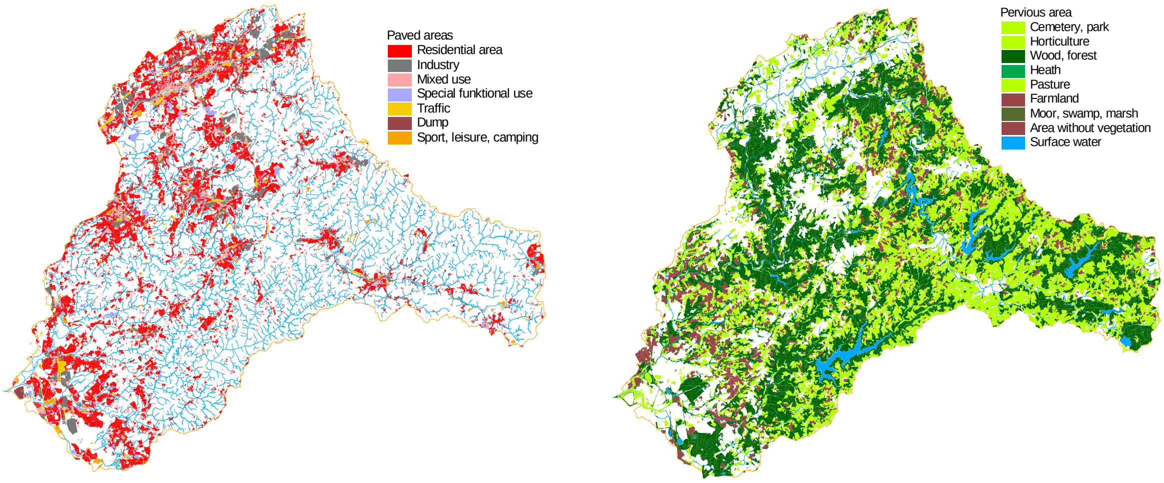

Figure 9. Urban and Rural land use in the Wupper river basin

In addition the sewer systems in the urban areas and the water system in the overall area were. Sewer system were divided in separate and combined sewers. The catchment areas regarding all outlets to the receiving water were assigned. This includes combined sewers overflows, the outlets from separate sewers and waste water treatment plants.

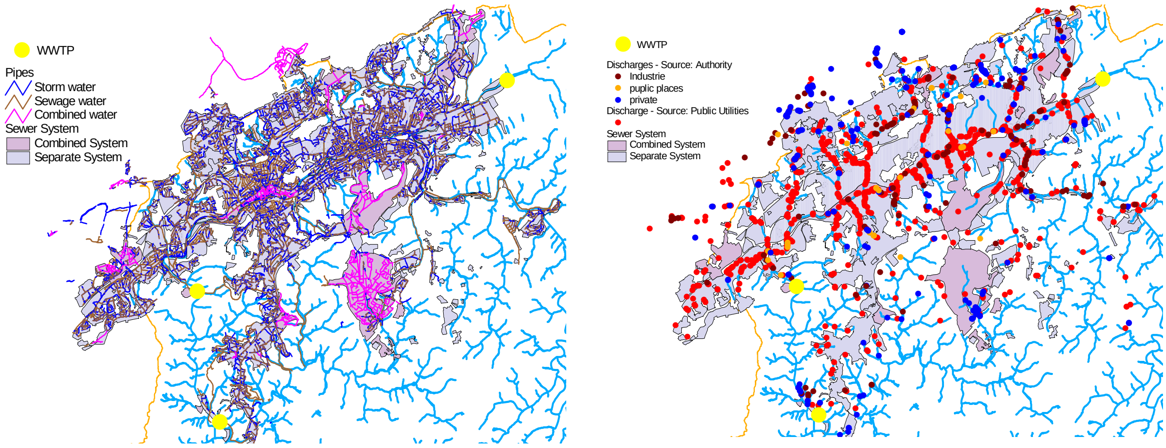

Figure 10. Sewer network structure and outlets to the Wupper in the area of the City of Wuppertal

On the base of the input data storm water management maps were established which identify possible storm water management measures in the single catchment areas for the complete river basin. The following figure shows storm water management measures assigned to surface water strip. This is the result an intersection of all basic data from groundwater, land use, soil conditions, slope etc.

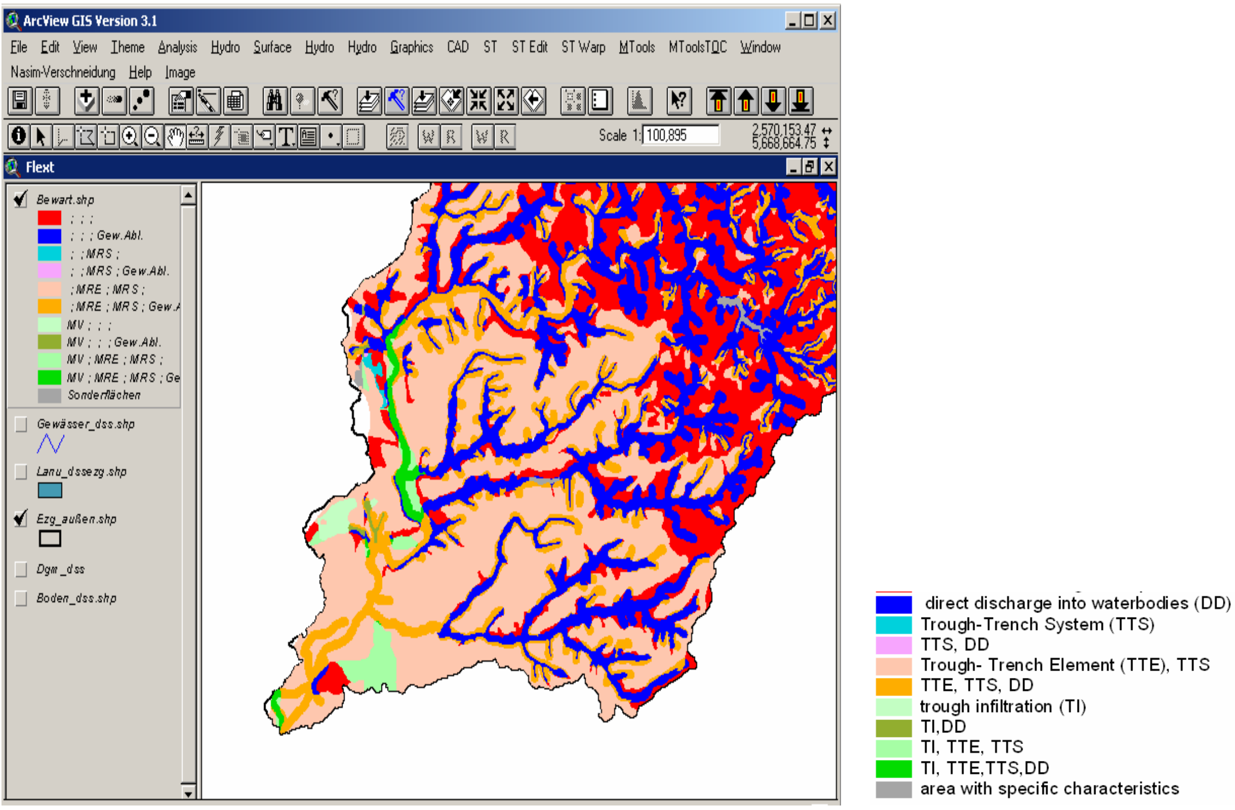

Figure 11. Specification of the assessed on-site BMP potentials near Leverkusen

For the calculation of different scenarios models were established for the hydrological simulation program STORM (IPS, 2008). These simulations included runoff processes from urban and non urban areas with the whole variety of processes on the surfaces and in the soil.

Discussion and Conclusions

The developed problem-specific expert systems can be applied as a decision support system in other projects of planning of the on-site storm water infiltration. The pre-defined knowledge may be necessary to be slightly modified to meet the projects specific demands, such as due to lack of data in certain factors, introducing new factors or simply the change of the different critical values of some constraints on certain measures. However, the possibility of modification of the pre-defined knowledge is just the characteristics of this transparent and opened system. In fact, this tools is to applied by respective researcher fellows to building expert systems or decision support systems for the analyses of decentralised water management measures on agricultural land and measures with considerations for environmental protection and preventive flood control. In general, the integrated model (Flext + GIS) can be used for developing GIS-based rules systems for totally different problem domain.

A simple important application may be the development of an intelligent end of a decision support system in which the complicated decision-making procedure can be formulated as decision trees or networks of nodes and the different professional models or functions necessary in relevant steps can be activated in the corresponding rules of a formulated knowledge base. The advantages of using Flext in this case are:

- Complicated decision-making procedures can be clearly formulated as structured trees or networks.
- For the dialog in each decision-making procedure, an informative graphic interface can be designed.
- Easy integration into a GIS platform, if necessary.

Acknowledgement

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