Water Management to Water Sensitive Planning-

A contemporary approach for sustainable urban development

Dr. Somnath Sen, Architect Planner

Associate Professor,

Architecture & Planning,

IIT Kharagpur, INDIA

Introduction

WATER – its importance

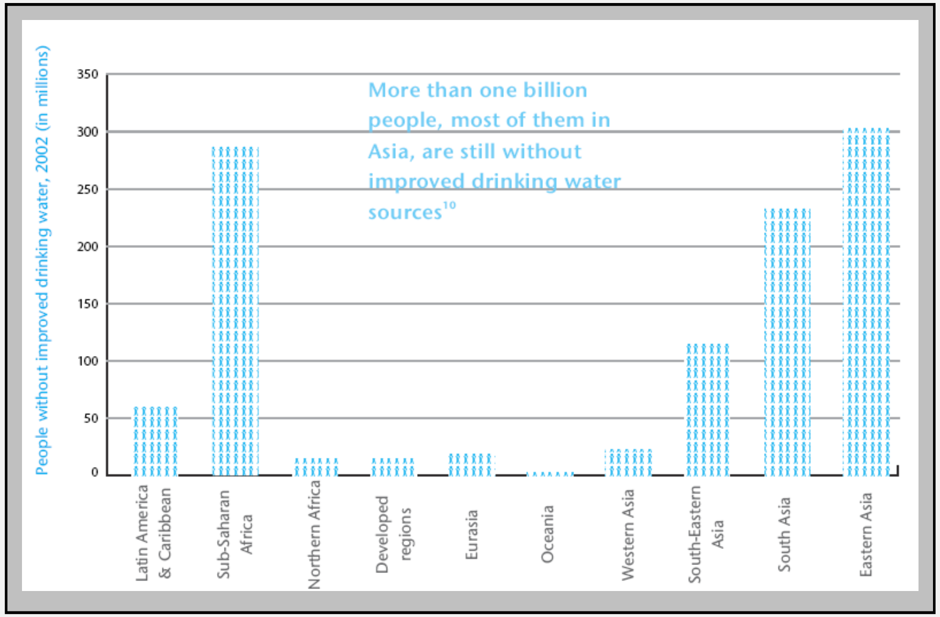
"Water is probably the only natural resource to touch all aspects of human civilization —from agricultural and industrial development to the cultural and religious values embedded in society."- Koichiro Matsuura, Director-General, UNESCO

Global water crisis -

•1.1 billion People lack access to safe water, roughly **one-sixth of the world's population.**

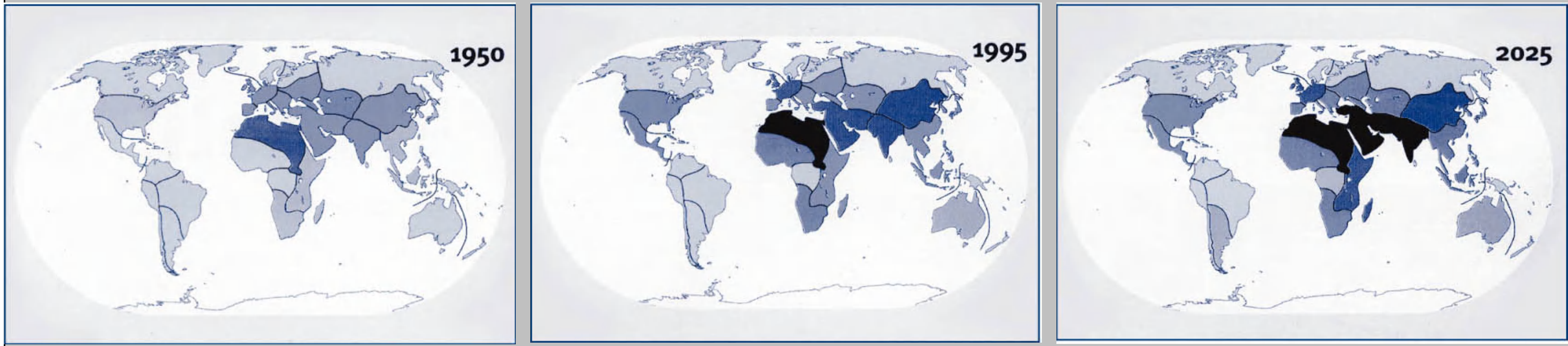
•**Water use has grown at twice the rate of population during the past century**

•By 2050, water scarcity will affect 2 to 7 billion people out of total 9.3 billion.



(Source: 2006 United Nations Human Development Report)

Global Water Availability



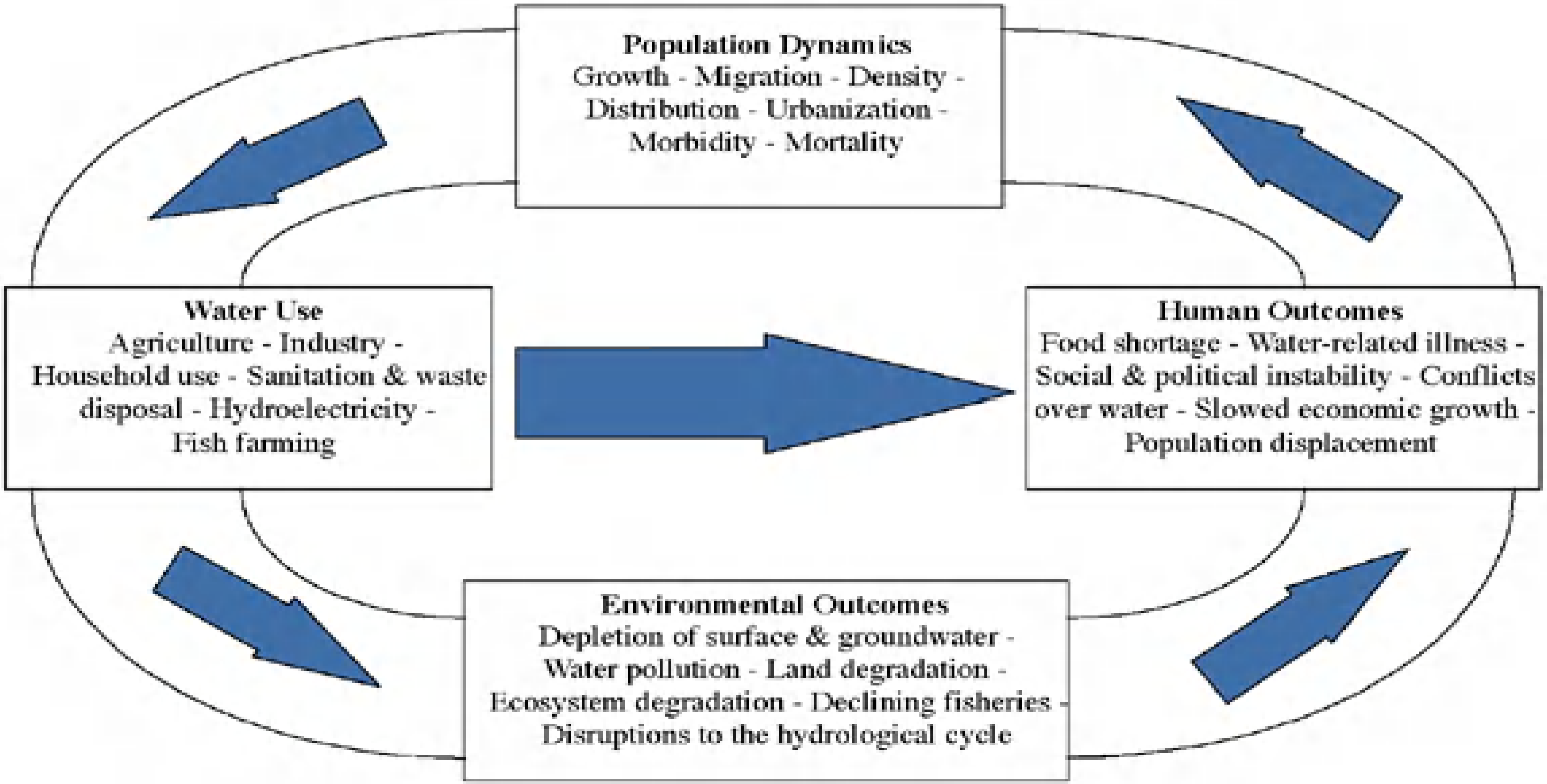
Cubic metres per person per year (in thousands)

- < 1.0 = catastrophically low
- 1.1 - 2 = very low
- 2.1 - 5 = low
- 5.1 - 10 = middle
- 10.1 - 20 = high
- > 20 = very high

In 2020, 60% of the world population will be urban, a concentration that makes urban water infrastructure development an extremely urgent issue.

Source: UN World Water Development Report

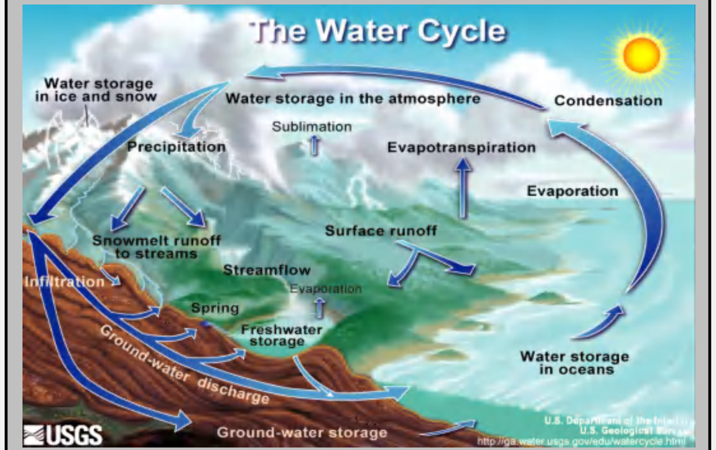
Link between Population and Fresh Water



Source: IUCN et al. 1996 (199)

URBAN HYDROLOGY

Urban hydrology is defined as the interdisciplinary science of water and its interrelationships with urban people

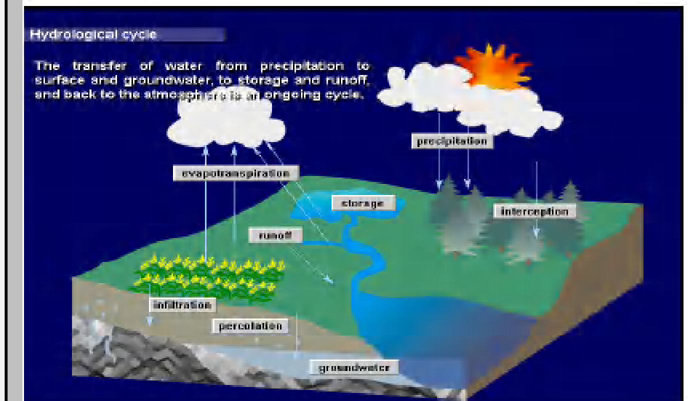


Water cycle –hydrological cycle

Evaporation: from oceans and other water bodies into the air and transpiration from land plants and animals into air.
Precipitation: from water vapor condensing from the air and falling to earth or ocean.
Runoff: from the land usually reaching the sea.

Natural water balance

Water evaporates from lakes, rivers and oceans. It then becomes water vapour and forms clouds. It falls to the earth as precipitation, and then it evaporates again. This **'hydrological cycle' never stops.**



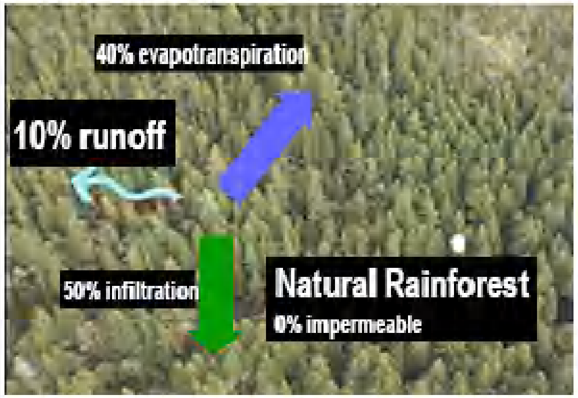
Components of the Natural Water Balance

Changes to Natural water balances

Runoff volume increases in proportion to **impervious area** (hard, non-absorbent surfaces).

Land uses with extensive roof and paving areas create more runoff than land uses with extensive areas of absorbent soils and forest cover

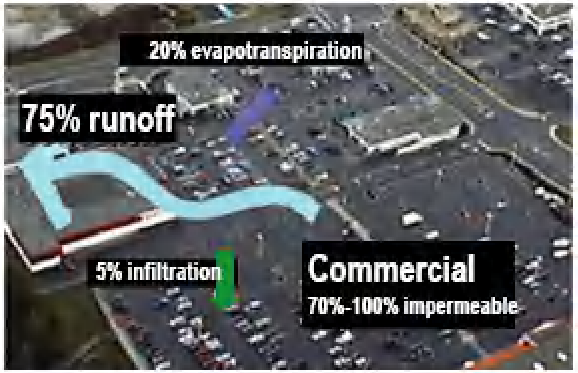
Traditional ditch and pipe systems have been designed to remove runoff from impervious surfaces as quickly as possible and deliver it to receiving waters.



Natural Rainforest

Single Family Development

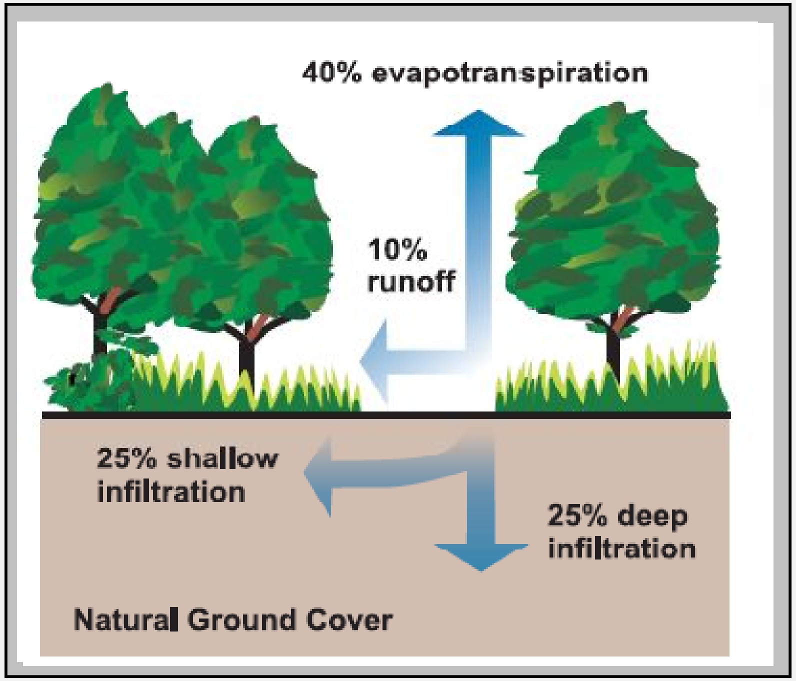

Flooding in the Urban Environment

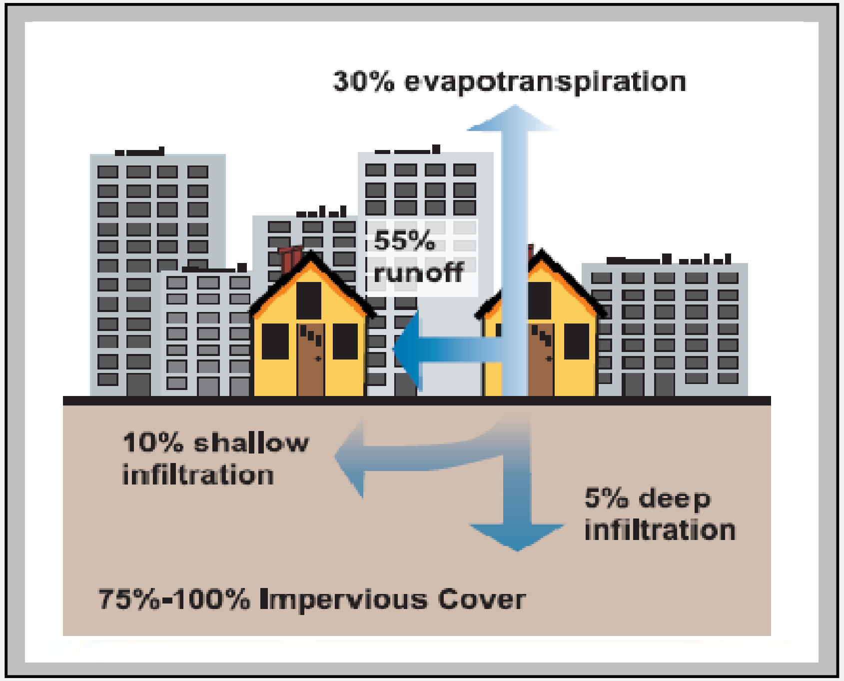


Commercial Development

Effect of urbanization on storm runoff

Urbanization increases surface storm water runoff and modifies its quality.





- Population density
- Building density

- Modification of the land surface
- Impervious surfaces

Impervious surfaces and urbanization affect runoff characteristics in the metro Atlanta, Georgia area.

THREATS OF URBAN SPRAWL

- **Hydrological Front**

  Drop in Ground water levels and loss in water quality.
- **Ecological Front**

  Erosion of land, loss of aquatic resources and vegetation.
- **Physical Front**

  Flooding, loss of property, loss of open space.
- **Climatology Front**

  Increased temperature, increased rainfall, decreased wind speed.
- **Socio-economic Front**

  Loss of health, loss of man-days and loss of employment.

Urban development will not be halted for water considerations. Hence, there is an urgent need to manage urban development with minimal damage to groundwater resources.

Traditional water management techniques:

19th CENTURY SOLUTIONS TO URBAN WATER MANAGEMENT

WATER SUPPLY	STORMWATER	SEWAGE
➢Large scale water supply from a few large sources	➢Collect it all and discharge to receiving waters. ➢Engineer water courses and drains	➢Collect it all and discharge after some treatment to receiving waters i.e. based on dilution

i.e. "BIG PIPES IN – BIG PIPES OUT"

TOWARDS A NEW APPROACH- SUSTAINABLE WATER MANAGEMENT

Characteristics of ‘old’ and ‘emerging’ paradigms of urban water systems:

The Old Paradigm	The Emerging Paradigm
Storm water is a nuisance..	**Storm water is a resource.**
Demand is a matter of quantity.	**Demand is multi-faceted.**
One use. Water follows one-way path from supply, to a single use, to treatment and disposal to the environment.	**Reuse and reclamation**. Water can be used multiple times, by cascading from higher to lower quality needs, and reclamation treatment for return to the supply side of infrastructure.
Gray infrastructure.	**Green infrastructure**.
Bigger/centralized is better	**Small/decentralized is possible**
Limit complexity and employ standard solutions.	**Allow diverse solutions..**
Integration by accident..	**Physical and institutional integration by design.**

WHAT HAS NOT BEEN RESEARCHED SO FAR ?

- **How Urban Development might be planned and executed in a manner so as to lower the hydrological impact of urbanisation and present opportunities for improved water management.**

- **To what extent rainwater available in an area could be effectively utilised with appropriate technology and environmental safeguard so as to partially meet the domestic as well as non-domestic water demand in local areas.**

- **What could be the appropriate technique for an effective flood control management in urban catchment under emergency situation.**

WSUD

Concept

Water sensitive urban design- WSUD

Urban design involves multi-disciplinary inputs including town planning, landscape architecture, building design, ecology and infrastructure engineering. WSUD has no scale constraints and is equally applicable from individual houses to whole catchments,

What is water sensitive urban design?

WSUD aims **to minimize the impact of urbanization on the natural water cycle** and its principles can be applied to the design of a single building or to a whole subdivision.

Why implement WSUD?

•Trying to more closely **match the pre-development storm water runoff regime** – both quantity and quality

•**Optimizing the use of rainwater** that falls on our urban areas

•**Reducing the amount of water we transport between catchments**, both in water supply import and wastewater export.

CURRENT RESEARCHES AROUND THE WORLD

In Australia –

Australia has adopted **Water sensitive urban design** (WSUD) in a holistic manner and is to establish a National Water Initiative that, among other aspects, will encourage water conservation in the cities including better use of storm water and recycled water.

In Israel –

Water sensitive urban planning is gradually being introduced into some localities in Israel in light of the results of research studies pointing to the loss of as much as 70 million cubic meters of water due to surface runoff in urban areas.

In U.S.A –

Water Sensitive Urban Design (WSUD) (also known as **Low Impact Development, LID in the USA)** recognizes the need to incorporate all aspects of water into urban development and planning from the earliest stages.

Planning and feasibility

Water-sensitive urban design concepts and technologies, if planned and implemented correctly, offer an opportunity for not only elements of the water cycle complementing the development, but the **development to complement the water cycle.**

In order to achieve the **best possible results of implementation**, the pre-planning and design phase must:

- identify the **land use capabilities and existing conditions** or constraints of the site
- consider the **intended design and function of the proposed development**
- identify the **likely impacts of the development on the existing environment**

- match these factors with the most appropriate water-sensitive urban design technologies designed **to achieve a sustainable balance between development and environment.**

Water-sensitive urban design techniques

▪**Grassed or vegetated swales** – primary treatment and conveyance function; can provide secondary treatment benefits

▪**Filtration trenches** – primary treatment and conveyance and detention options; can provide secondary treatment benefits

▪**Bio-retention systems** – secondary treatment, conveyance, detention and retention functions (through infiltration); can provide tertiary treatment benefits

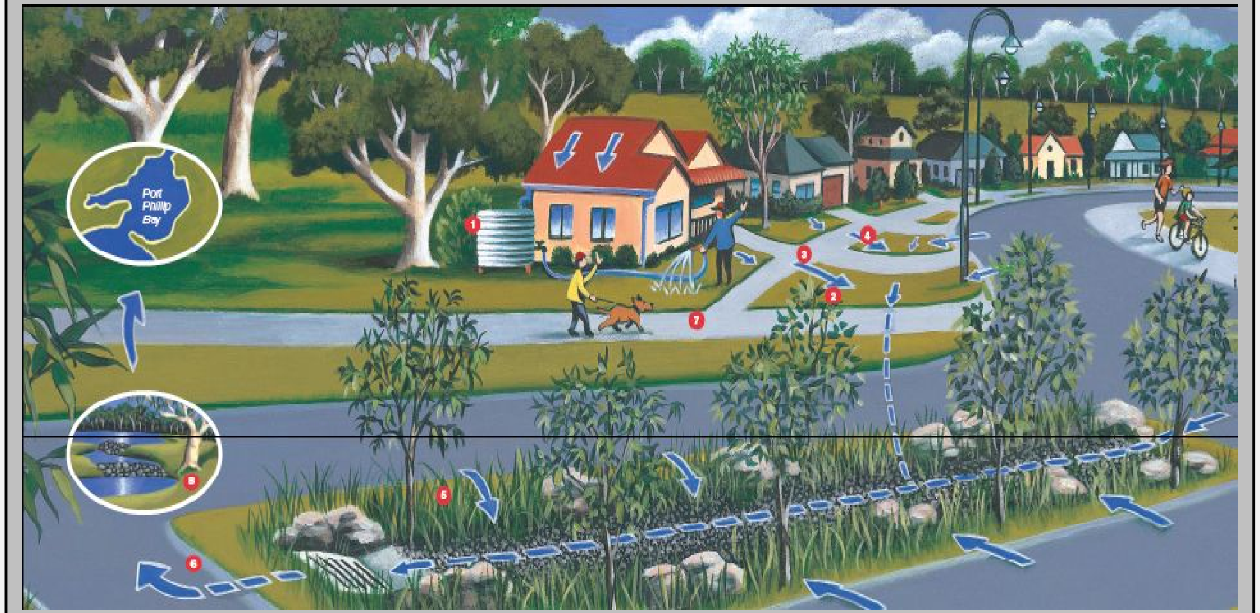
▪**Wetlands** – tertiary treatment system, storage, detention, possible reuse options
▪**Rainwater tanks** – using storm water as a resource – detention, retention, a substitute for drinking water in garden irrigation, car washing, toilet flushing, etc

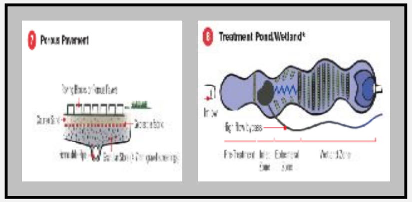
▪**Grey water reuse** – collect from households, primary treatment on site, reuse for external irrigation or internal toilet flushing options

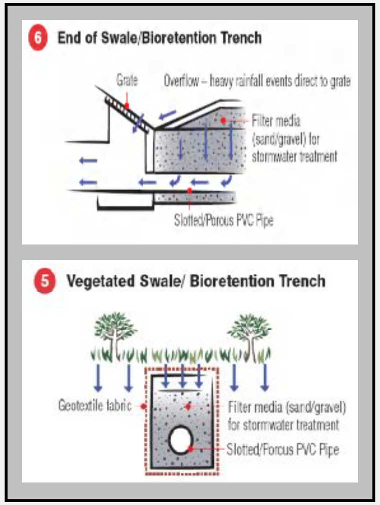
▪**Rain gardens, rooftop greening, urban forests** – provide natural vegetated features of aesthetic value and provide treatment function by filtering storm water

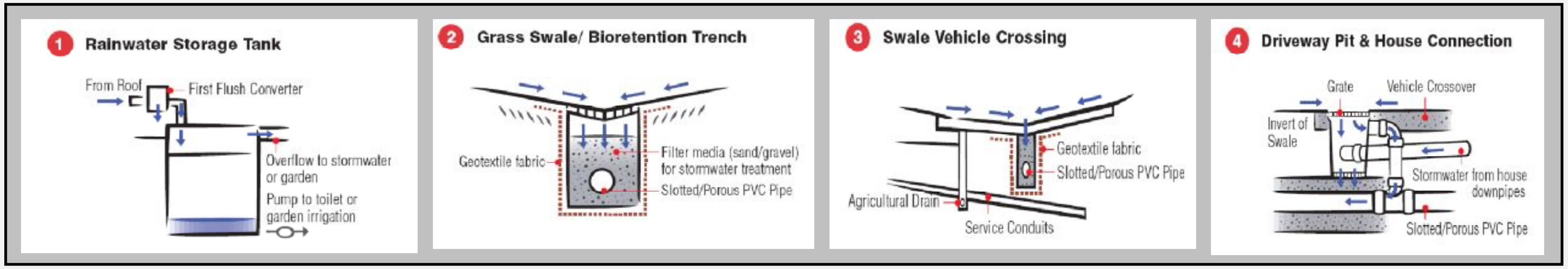
▪**Porous pavements**
▪Any combination of these and other techniques for the best possible outcome.

Water-sensitive urban design techniques









Case study

Lynbrook Estate- Melbourne

A demonstration project in Water Sensitive Urban Design

Green field residential development that incorporates Water Sensitive Urban Design (WSUD) **principles at the streetscape and sub-catchments scale**.

Technical Facts

▪Size of WSUD Site - <55 ha
▪Average Lot Size - 600 m2 (271 Lots)
•**Rainfall:** 600mm/a.

▪Drainage System - Roof and street runoff is directed towards WSUD treatment systems. Standard 16m road reserves applied.

- 'Treatment train' approach
- Runoff directed to vegetated swales, bioretention systems and constructed wetland

Bio-Retention System as part of Treatment Train

Case study

FIG TREE PLACE- Hamilton

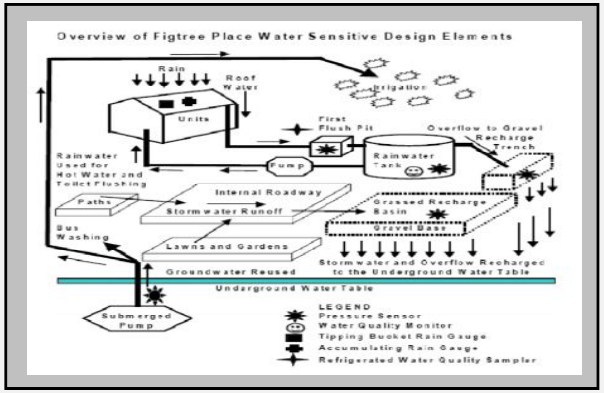
Water sensitive design saves money for a new development.

Fig tree Place is a 0.6 Ha development consisting of 27 townhouses in Hamilton, an inner suburb of Newcastle.
Rainfall: 930mm/a.

The project showed capital savings from using storm water on-site rather than the building of traditional drainage.

Objectives :

- Collecting rainwater.
- Conserving potable water.
- Minimizing storm water discharge.
- Minimizing development cost.



•Overall **potable water use is reduced by 60%**

•**Capital cost savings** prove all innovations cost **20 percent less than traditional storm water** infrastructure for the site.

Case study

HEALTHY HOME, Gold Coast

An advanced water system for a new house

The healthy home is an innovative ecologically designed house on a **460m2** urban site on the Gold Coast. **Rainfall:** 1460mm/a.

The advanced water system includes rainwater harvesting for potable use, grey water collection and treatment, and solar water heating.

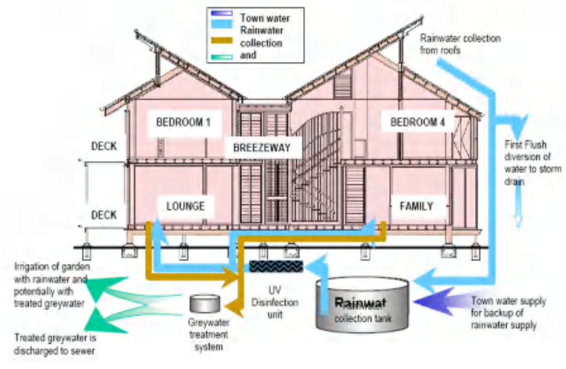


Figure 1. Schematic of the rainwater and grey water systems in the Healthy Home.

Objectives:
- Collecting rainwater.
- Reusing indoor grey water
- Conserving potable water
- Minimizing wastewater discharge.

Analysis of water usage estimated that an **80 percent reduction in potable water use** could be expected from the combined rain tank and grey water system if fully installed

Significant reductions in potable water usage and stormwater runoff from the site have been shown.

Case study

KOGARAH TOWN SQUARE, Sydney

The Kogarah Town Square project was developed to be a **best practice example of urban water collection, treatment and reuse**

-Collection and treatment of storm water
-Reuse of collected storm water in toilet flushing, car washing
-And water features Use of AAA-rated water saving facilities

STATISTICS

Area: 1 ha
Rainfall- 1175mm/a
Mixed use residential
•194 apartments
•2500sqm retail
•2500sqm commercial
•224 space public carpark
•240sqm Civic exhibition space

WATER

- 42% reduction in potable water use
- 85% of rainwater & storm water collected and reused on site for low quality water uses such as toilet flushing, irrigation and carwashing
- Treatment of stormwater collected from streets

Case study

Indian Institute of Management, Kozhikode (IIM-K)

Area: 96 acres campus
Population :400 residents
Rainfall:
The average **daily water consumption** exceeds one lakh litres.The campus is dependant **entirely on stored rain water.**
Capital cost: 80 lakh rupees

Topography :It occupies 2steep hillocks. The topography is such that some portion of the runoff goes from the back of 2 hillocks, but a major portion of run-off gets down to the front Side. At the foot of the hillock, there is a huge pond of 1.5 acres dug only to catch rain water. It is fed by the slopes on which the buildings stand.

Water from the main pond is treated and pumped to an overhead tank at the hilltop using a massive pumpset. From here, it is distributed to the necessary domestic use, including drinking, at the institution and staff quarters.

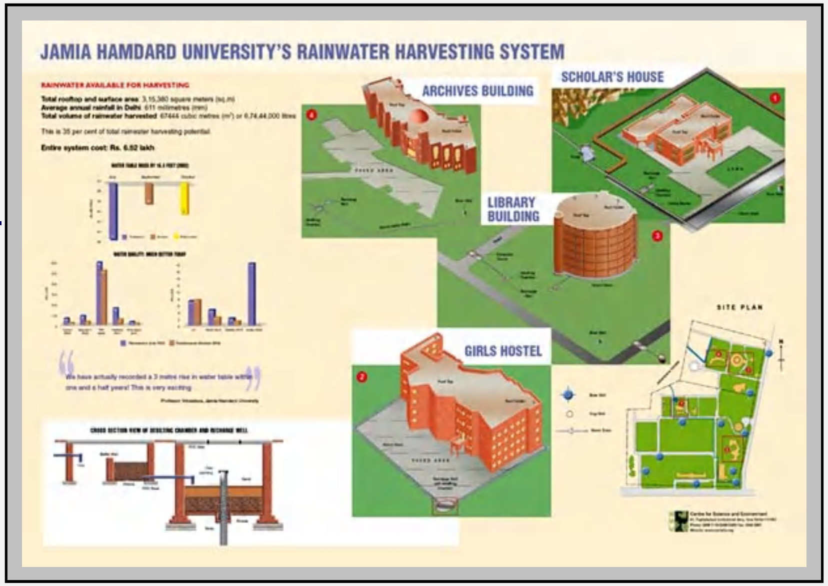
The large pond that stores rainwater for the campus.(30 million litres capacity)

It is a model for other educational institutions and corporate houses

Case study

JAMIA HAMDARD UNIVERSITY, DELHI

Total rooftop and surface area: 3,15,380 sq. m
Average annual rainfall in Delhi : 611mm
Total volume of rainwater harvested: 67444 cu. m.
35 per cent of total rainwater harvesting potential



WATER SUPPLY SOURCE

The daily water requirement :6 lakh litres, extracted from 6 borewells.
The remaining requirement is met through private water tankers.

RAINWATER HARVESTING SYSTEM

Rainwater from various catchments, such as rooftop, surface runoff from open areas and runoff from the Jahanpanah Reserve Forest are harvested. Rooftop rainwater harvesting at the library and hostel buildings **desilting chamber ->filtering chamber-> recharge well.**

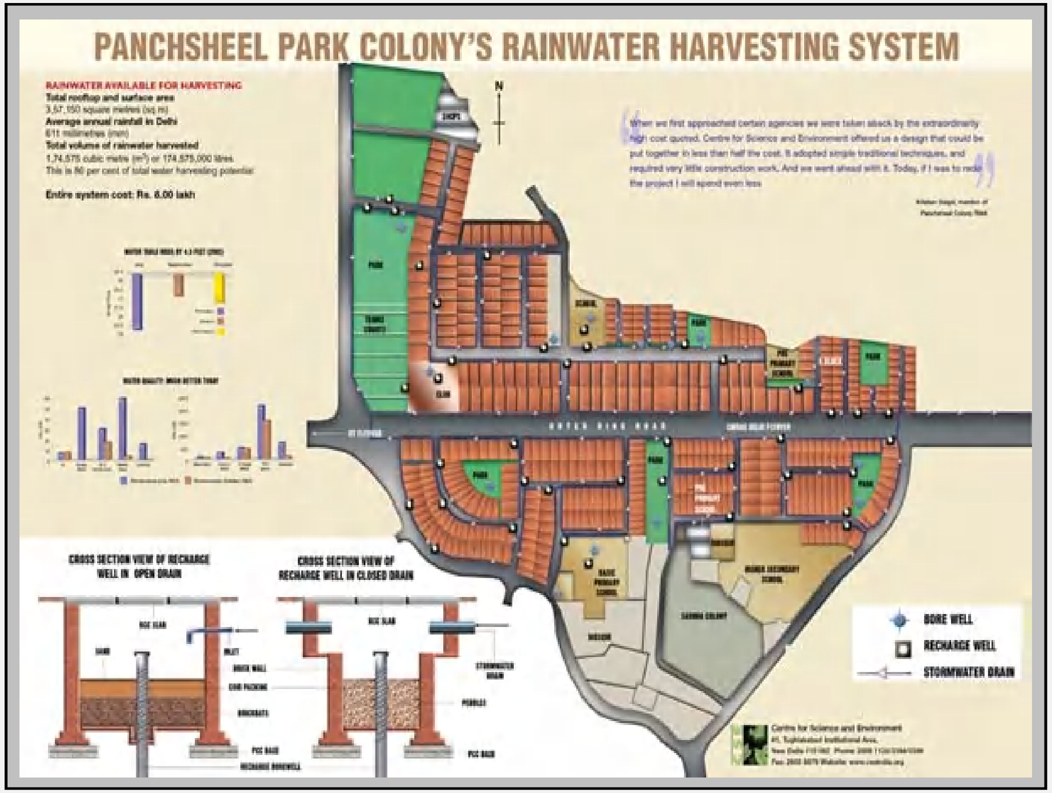
SURFACE RUNOFF HARVESTING near library building and Jahanpanah Reserve Forest
Trenches or ponds->stormwater drain->desilting chamber->recharge wells

Total cost of implementation - Rs. 6.52 lakhs.
Impact -There was significant improvement in water table and quality of water. Within one year there was a rise in 3m.

Case study

PANCHSHEEL PARK COLONY, DELHI

Total rooftop and surface area
3,57,150 (sq m)
Average annual rainfall in Delhi
611 (mm)
Total volume of rainwater harvested: 1,74,575 cu.m
80 per cent of the total water harvesting potential.



WATER SUPPLY SOURCE

The water supply is mainly through six borewells.

Recharge wells measuring 1m x 1m x 2m are constructed in the stormwater drain for facilitating groundwater recharge. The quality of runoff, which passes through a 15m borewell installed inside the recharge well, is ensured through a filter bed of pebbles

Lessons

Inferences:

Sl.No	Case studies	Area	Development Type	Average annual Rainfall (mm/a)	WSUD components	Outcomes
1	Fig tree Place, Newcastle	0.6 ha	Residential	930	-On-site storm water harvesting and storage - Infiltration of runoff from impervious surfaces -Reuse of storm water for irrigation, hot water supply and bus washing	-Quality of storm water-the supplied hot water compiles with Australian Drinking Water standards -Demand on mains water supply reduced by 60%
2	Lynbrook Estate, Melbourne	<55 ha	Residential	600	'Treatment train' approach -Runoff directed to vegetated swales, bio retention systems and constructed wetland	-Significant pollutant reductions - Only a small extra expense for WSUD
3	Kogarah Town Square, Sydney NSW	1 ha	Mixed use residential	1175	-Collection and treatment of storm water -Reuse of collected storm water in toilet flushing, car washing -And water features Use of AAA-rated water saving facilities	-85% of storm water captured -42%reduction in potable water
4	Lismore retrofit ,NSW	0.125 ha	Individual home retrofit	1343	On-site waste water management	Significant reduction in potable water use and the waste water generated
5	Healthy home, Gold Coast, Queensland	460m^2	Ecologically designed house	1460	-Collection and treatment of roof water -Reuse of collected roof water for all internal and external uses -Use of AAA-rated water saving facilities -Grey water treatment	-Significant reduction in potable water use and the waste water generated -High quality water supplied to the premises from the rainwater tank collection treatment system
6	60L Green Building, Carlton, Melbourne	<1 ha	Commercial	600	-Collection and treatment of roof water -Reuse of collected roof water for all internal and external uses -Use of AAA-rated water saving facilities -Grey water treatment	Potable water use reduced by 90%

lessons

Inferences:

Sl. No	Case studies	Area	Development Type	Average annual Rainfall (mm/a)	Water conservation Technique used	Outcomes
1	IIM- Kozhikode	96 acre	Institutional	3266	Large scale rain water harvesting On-site sweage treatment plant	-Self sufficient with no external water supply source -Zero-runoff
2	Jamia Hamdard University, Delhi	31.54 ha	Institutional	611	Surface runoff and roof top rainwater harvesting	-35%of the total rainwater harvested -Significant rise in ground water levels
3	Panchsheel park colony, Delhi	35.7 ha	Residential	611	Surface runoff and roof top rainwater harvesting	-80%of the total rainwater harvested -Significant rise in ground water levels

MAJOR EMERGING POINTS

1. Should WSUD measures be specified that are appropriate at the house, neighbourhood, and sub-catchment levels?

2. Do the model planning provisions fully reflect hydrological relationships between the subcatchment, estate, street and building allotment levels?

3. Is a ' star rating' system be appropriate for assessing such development ?

4. What is the best way to provide scenarios for implementing WSUD at different levels?

5. What time frame is realistically required for implementation and public acceptance?

RATING PARAMETERS

No.	Parameters of Runoff	SET -A	SET-B	SET -C
1	Peak Daily Rainfall	< 80 mm.	80-120mm.	> 120 mm.
2	Ground Water Table	< 6.0 m.	6.0 – 9.0 m.	> 9.0 m.
3	Average Slope of Terrain	<1:100	1:100-200	>1:400
4	Soil Condn. (hydrology grp.)	A	B	C
5	Water Consumption pattern	<100 lpcd	100-250	>250 lpcd
6	Density of Dwelling Unit	<80 du/ac.	80-125	>125du/ac.
7	Ground Coverage	45%	55%	65%
8	Impervious/ Pervious ratio	2.5	3.0	3.0
9	Roof/ Pervious ratio	1.5	2.2	2.5
10	Ave. Size of Drain	<0.15 sq.m.	0.15 – 0.2	>0.25 sq.m.

MAJOR EMERGING POINTS

6. How will implementation of WSUD requirements affect the planning of water supply head works?

7. What are the public safety and 'duty of care' implications?

8. What mechanisms are required to ensure effective installation and maintenance?

9. How implementation of the model provisions should be complemented by education programs?

10. Is it possible to link the model planning provisions with financial incentives?

Scope for further study

- "Water Sensitive Urban Planning" is a relatively new approach that addresses a series of simple control measures such as land cover control, rainwater retention control, conveyance control of storm water through infiltration and ultimately discharge controls through proper drainage systems for a sustainable catchment development right from residential cluster level.
- Spatial decision support system for urban water management.
- Re-use potential of stormwater for recharging groundwater in urban areas.
- Modelling infiltration through various forms of absorbent landscaping in urban areas.
- Design strategies for sullage and waste water network
- Efficiency modelling in water sensitive street design.
- Modelling social acceptability for use of rainwater for non-consumptive purpose at household level in urban areas.
- Economic & environmental benefits of source control strategies in Urban Water Cycle management.

DR. SOMNATH SEN, ASSOCIATE PROFESSOR, DEPARTMENT OF ARCHITECTURE AND REGIONAL PLANNING, IIT KHARAGPUR

WATER PLANNERS MOTTO

- *"Catch Water, Where-ever It Falls"*

- ***"Control Imperviousness,"------ Where-ever You Can"***

REFERENCES:

BOOKS

AGARWAL, A., NARAIN, S. and SEN, S. (1997) Eds. *Dying Wisdom: State of India's Environment,* Centre for Science & Environment, New Delhi

AGARWAL, A., NARAIN, S. and KHURANA, I. (2001) Eds., *Making Water Everybody's Business*, Centre for Science & Environment, New Delhi

CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY, (2007), *Second Master Plan for Chennai metropolitan area -2026*, Chennai

MOTT MAC DONALD, (1995), *Madras metro flood relief/ storm water drainage master plan study*, Cambridge, UK

ROBERT L. FRANCE, (2002), *Handbook of Water Sensitive Planning and Design,* Harvard University, Cambridge, Massachusetts, USA

PUBLISHED PAPERS:

GUMBO,B., (2000), *Mass balancing as a tool for assessing integrated urban water management,* Department of Civil Engineering, University of Zimbabwe.

NIEMCZYNOWICZ . J, (1999), *Urban hydrology and water management –present and future challenges,* Department of Water Resources Engineering, University of Lund, Sweden

PAULEIT,S.,DUHME,F., (2000), *Assessing the environmental performance of land cover types for urban planning*, In: Journal of landscape and Urban planning

THESIS BOOKS:

RAJESH, G., (2002), *Planning guidelines for Rainwater Harvesting in residential areas of Chennai,* Department of Architecture and Regional Planning, IIT- Kharagpur.

SABHERWAL , P., (2006), *Planning for water supply management, Nagpur* , Department of Architecture and Regional Planning, IIT- Kharagpur.

SEN , S., (2005), *Water sensitive urban development- Planning provisions at residential cluster level, Medinipur, West Bengal,* Department of Architecture and Regional Planning, IITKharagpur.

WEBSITES:

www.wsud.org
www.wsud.melbournewater.com.au/
www.urbanwater.info
www.environment.nsw.gov.au/
www.technion.ac.il/technion/civil/
www.lid-stormwater.net/

THANK YOU