Sustainable Water Integrated Management - Support Mechanism (SWIM- SM)

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CSEI Catania
Centro Studi di Economia applicata all'Ingegneria

STUDY TOUR ON WASTEWATER MANAGEMENT USING NATURAL TREATMENT SYSTEMS (NTS) IN RURAL AREAS

Importance and impact of sewage treatment in rural areas

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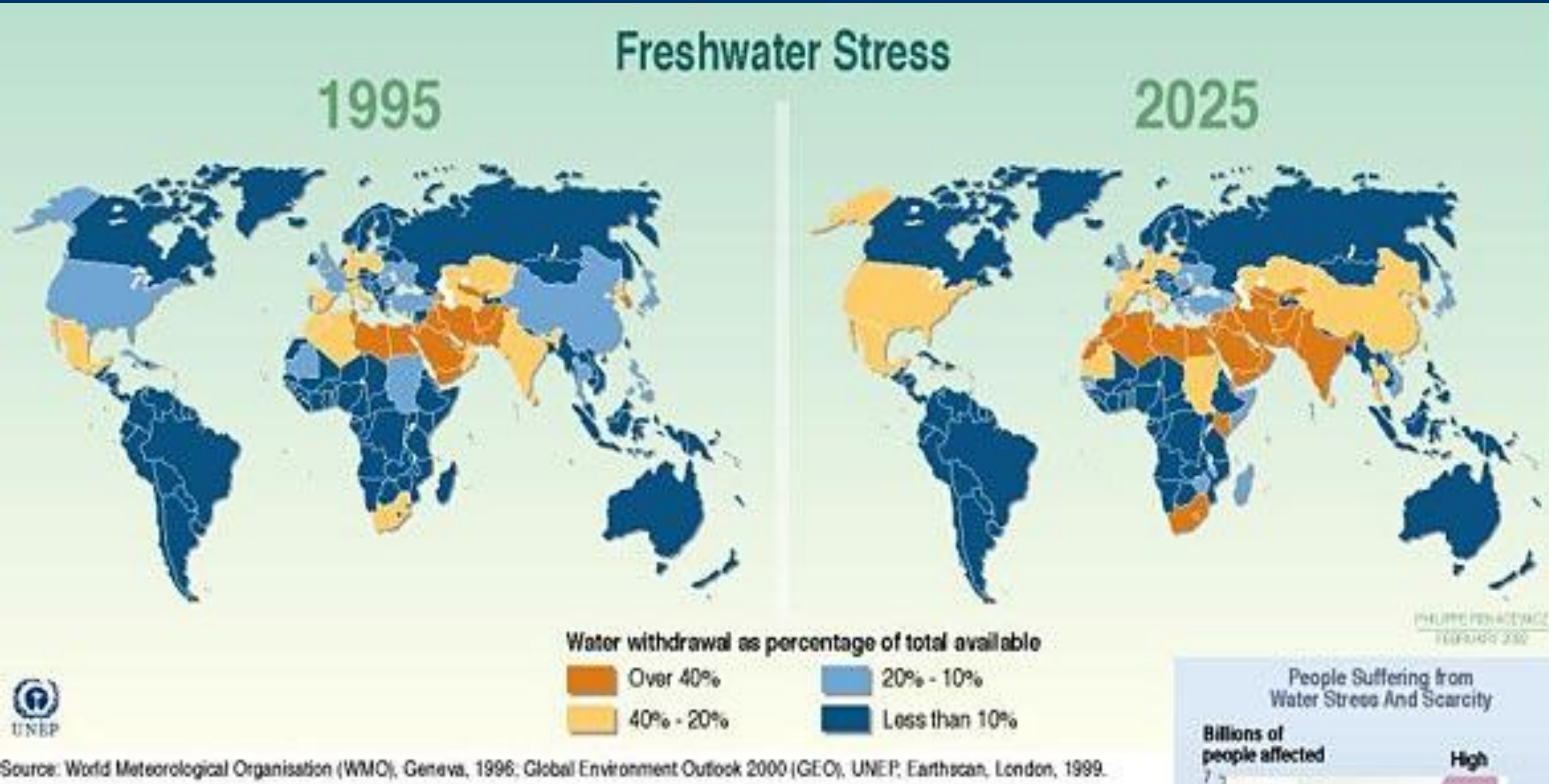
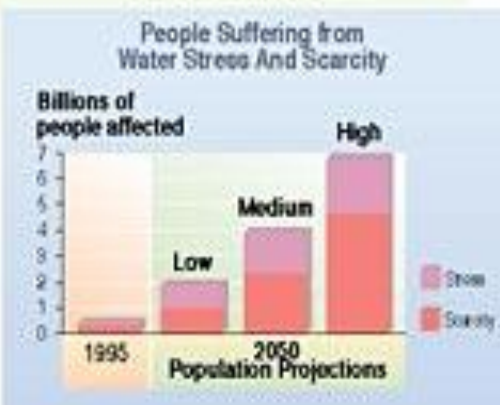
Introduction

- Growing water scarcity, rapid increase in population, rapid urbanization and megacity development, increasing competition among water users and growing concerns for health and environmental protections : these are just some of the main issues of water management .
- Notwithstanding the increase in water use efficiency in developed countries, the water demand has continued to climb as the world's population and economic activity have expanded.
- By 2025 (IWMI, 2000), 1.8 billion people will live in regions with absolute water scarcity (< 100 m^3/inhabitant /year). This water availability level is not sufficient to maintain current level of per capita food production from irrigated agriculture.
- Most of the countries in Middle East and North Africa can be classified as having absolute water scarcity (Lazarova and Asano, 2005). By 2025, these countries will be joined by Pakistan, South Africa, large part of China and India, and a number of other regions.
- Many countries will have to manage water resources more efficiently than they do now to meet their future needs.


Freshwater Stress
1995
2025
Water withdrawal as percentage of total available
Over 40%
40% - 20%
20% - 10%
Less than 10%
UNEP
Source: World Meteorological Organisation (WMO), Geneva, 1996; Global Environment Outlook 2000 (GEO), UNEP, Earthscan, London, 1999.


People Suffering from
Water Stress And Scarcity
Billions of
people affected
7
6
5
4
3
2
1
0
Low
Medium
High
1995
2050
Population Projections

Water consumption

- The situation has drastically changed during recent decades: variations in the quantitative and qualitative characteristics of renewable water resources have been greatly affected by many anthropogenic factors.

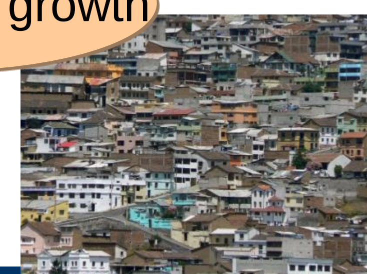
industrialization

intensive irrigation

Increase
water consumption

Population growth

Urbanization growth



Domestic Water Use (UNESCO, 2000)

Source: *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI) Washington DC, 2000.

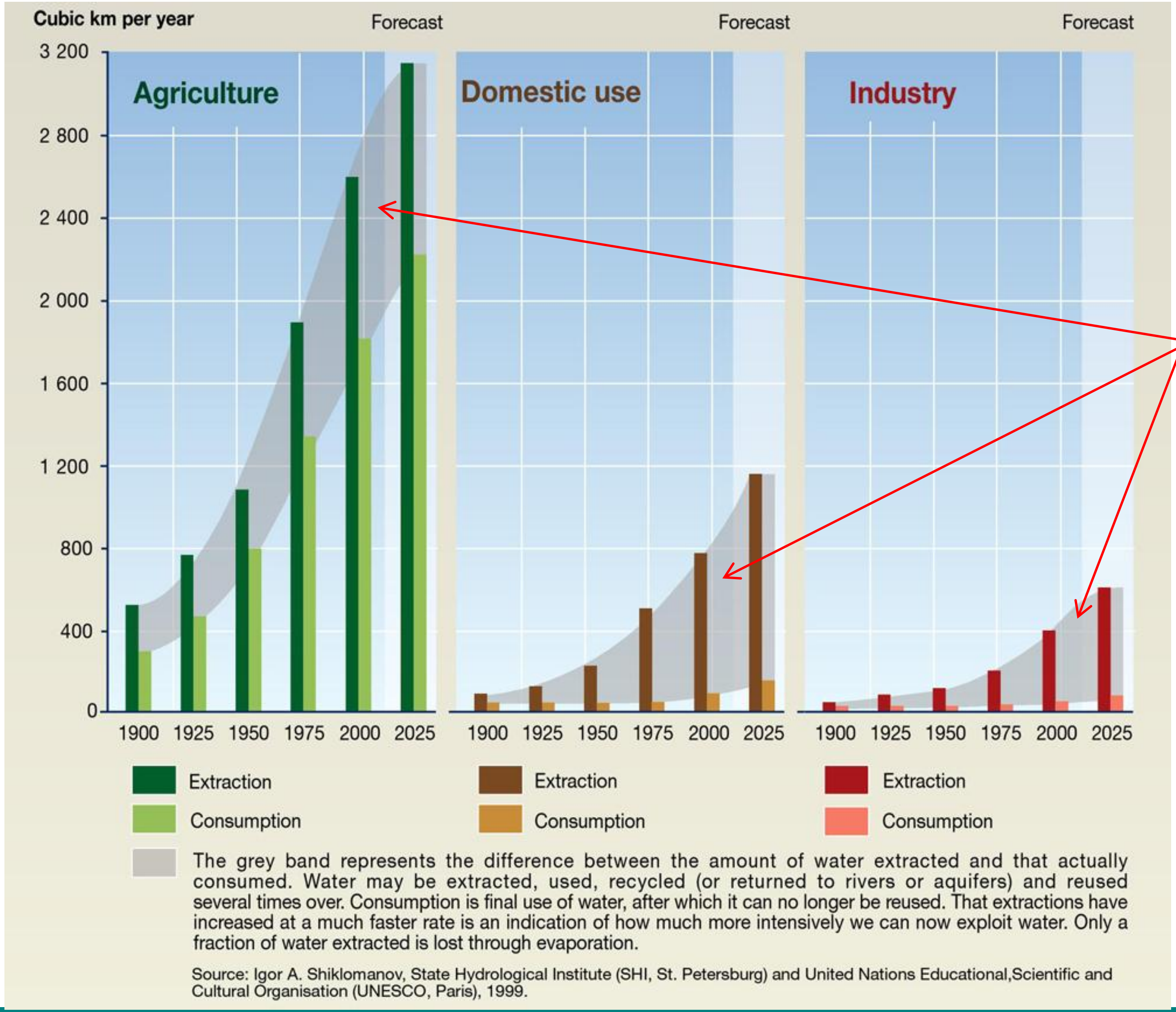
Water Use in Agriculture (UNESCO, 2000)

Source: *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000.

Water Use in Industry (UNESCO, 2000)

Source: *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI) Washington DC, 2000.

Evolution of global water use (UNESCO, 1999)

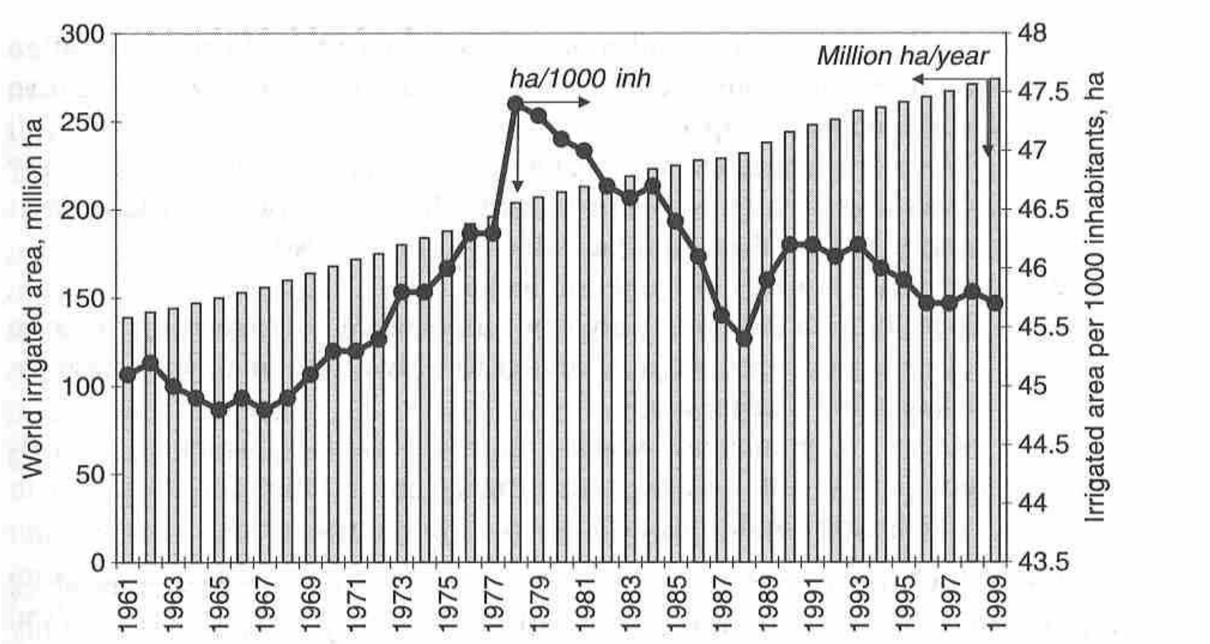


The grey band represents the differences between the amount of water extracted and that actually consumed

Water for agriculture

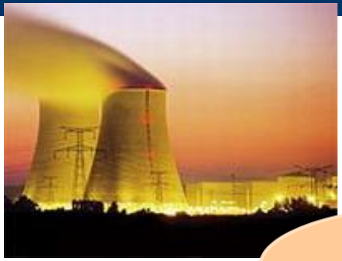
- Water for agriculture is a critical issue for food security. About 70-80% of the world’s freshwater consumption is used in agriculture. In some areas until 90%.
- About 30-40% of food production comes from irrigated land that is only about the 17% of the total cultivated land (FAO, 2003).
- Between 1961-1999, it was observed about 100% increase in total irrigated area in the world

Irrigated area per 1000 inhabitant (ha/ 1000 inh)



The demand and pressure for irrigation are increasing to satisfy the required growth of food production, because there is a little increase in cultivated total irrigated area (0,1%/year).

Wastewater production



industry

intensive irrigation

Increase
water consumption

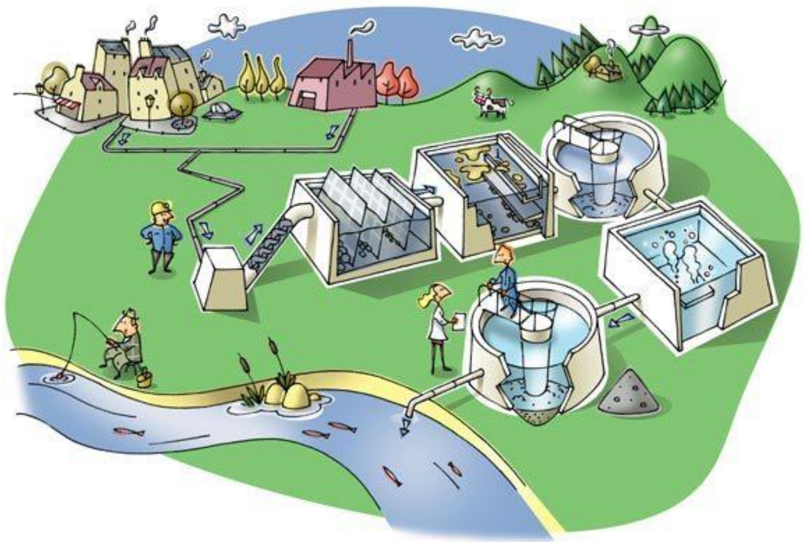
population

urbanization

Increase
Wastewater production

Untreated wastewater discharge effects

Importance to treat wastewater



Organic matter	→	Their biological decomposition can lead to depletion of oxygen
Nutrients (N, P, K)	→	When discharged into the aquatic environment they lead to eutrophication
Stable organics (pesticides)	→	Some are toxic in the environment, accumulation processes in the soil
Heavy metals	→	Accumulation processes in the soil, toxicity for plants.
Pathogenic organisms	→	have to be removed to make water safe

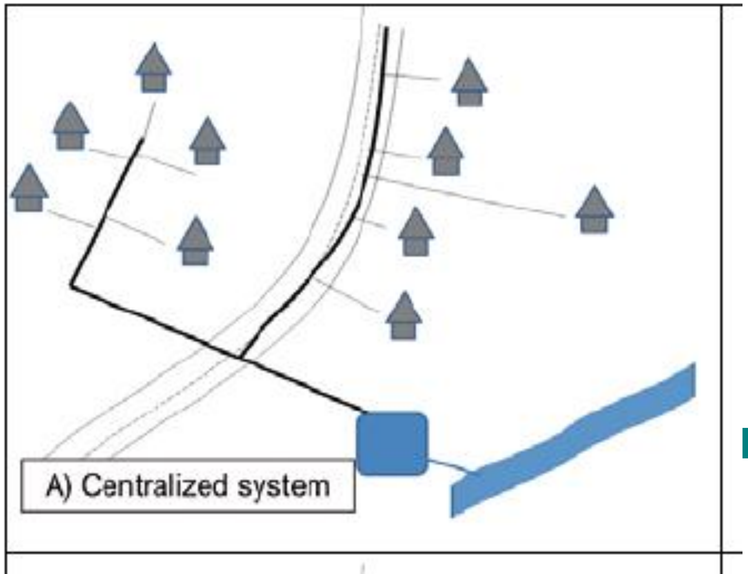
Wastewater management

- Wastewater management consists of of wastewater collection, treatment, and reuse or disposal of effluent and sludge. It is essential for several reasons:
  - (1) protecting public health and the well-being of the communities;
  - (2) protecting the water resources and the environment;
  - and (3) in water-scarce regions for reuse purposes in order to reduce the pressure on the potable resources.
- Two main problems pose constrains on adequate wastewater treatment:
  - high costs and institutional low performance.
- These constraints are likely to be more sever in the smaller settlements, as their ability to cope with wastewater management is lower due to financial and institutional weakness. This increases the challenge of promoting solutions for these communities.
- It is important to know that wastewater collection conventionally accounts for 60 – 80% of the total costs for wastewater disposal. As wastewater management and infrastructure generally benefit from economies of scale, the *per capita cost* in small communities is much higher than in urban areas.

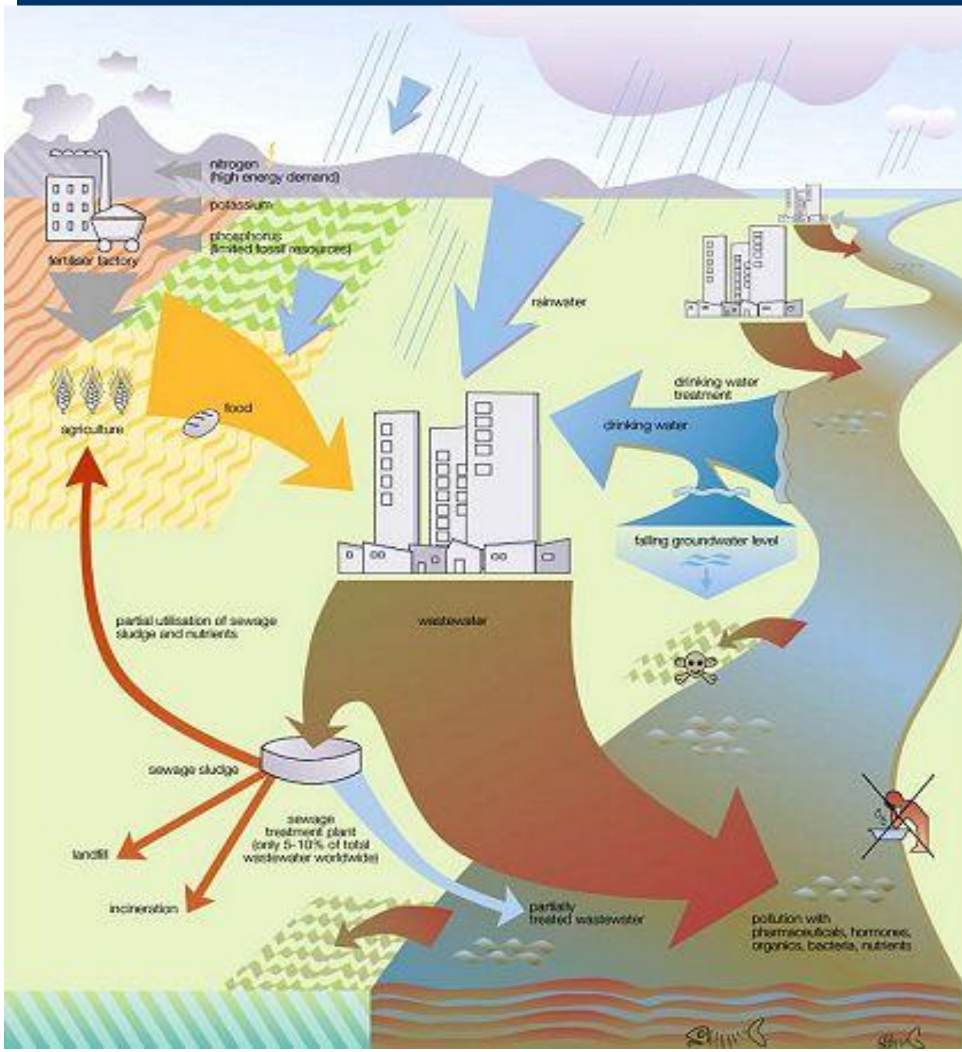
Centralized wastewater management

- *Centralized wastewater* management represents the conventional approach in many countries.
- Centralized wastewater management consists of:
  - (1) **centralized collection system** (sewers) that collects wastewater from many wastewater producers: households, commercial areas, industrial plants and institutions, and transports it to (2) **centralized wastewater treatment plant** in an off-site location outside the settlement, and (3) **disposal/reuse of the treated effluent**, usually **far from the point of origin**

The overall advantages of this management concept are perceived to be the lower investment and operational costs incurred by a single large treatment plant as compared to several small-scale plants as well as a more effective control of quality standards and plant operation procedures.



Conventional sanitation



- High water consumption
- Small amount of fecal matter are mixed with high volumes of potable water (diffusion of environmental risks)

↓

- High costs of treatment and disinfection
- High costs of reuse

Centralized wastewater management

- *Is centralized wastewater management option as the universally applicable solution especially in less densely populated areas?* Several disadvantages are entailed with this management concept:
  - The costs/benefits ratio of central systems may be less favourable if the high and long-term construction and maintenance costs of the sewerage system are taken into account.
  - If not adequately maintained, an extensive sewerage system may leak and cause contamination of soil and groundwater.
  - Centralized treatment systems require (multiple) pumping stations which must be properly operated and maintained as well.
  - centralized municipal treatment plants reduce opportunities for water, nutrients and sludge re-use in local cycles, due to their high load of harmful substances, such as chemicals, heavy metals, and pathogens
  - collection system and the intensive treatment technologies, require high skilled labor, large amounts of capital, and steady socio-economic conditions.
- **All this makes it difficult and in many cases not advantageous, especially in low population density areas, to apply this strategy for wastewater treatment. A viable alternative in these cases, can be the decentralized management.**

Decentralized wastewater management

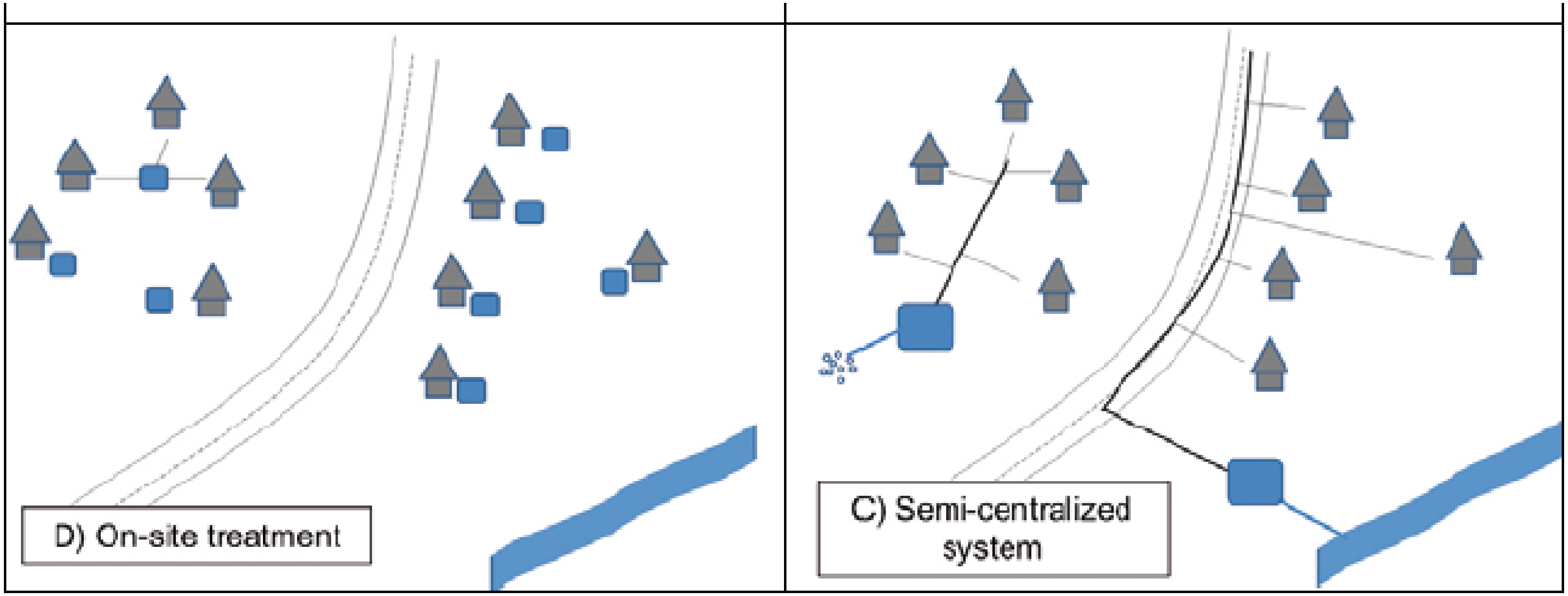
- In recent years, increasing attention has been given to modern onsite, *decentralized* or *semi-centralized* wastewater management concepts that are already applied in many countries, particularly in rural and peri-urban areas

"Fred, I really don't think this is what they meant by a centralized collection system!"

eas

Decentralized wastewater management

- These concepts comprise **collection, treatment and disposal/reuse** of wastewater from small communities (from individual homes to portions of existing communities) **as close as practical** to where it is generated and to where its potential beneficial reuse is located. (US EPA, 2005).
- Decentralized systems maintain both the solid and liquid fractions of the wastewater at or near the point of origin and, hence, minimize the wastewater collection network. This approach offers a high degree of flexibility, allowing modifying the design and operation of the system to fit to various site conditions and scenarios



Sustainable sanitation

- Water saving
- Wastewater reuse (nutrients recovery)
- Fecal matter is separaterd at the “source point” (reducing the pollution of water bodies and soil)
- Flexible solutions according different economical and social contest
- Low cost technologies (O&M) with low environmental impact (less “concrete and iron” !!!!)

Decentralized wastewater management

- The USEPA developed cost estimates of centralized and decentralized approaches to wastewater management for a hypothetical rural community (USEPA, 1997). <u>The study revealed that decentralized systems (cluster or onsite) are generally more cost effective for managing wastewater in rural areas than the centralized systems</u>

Technology	Total capital cost	Annual operation and maintenance cost	Total annual cost
Centralized system	2,321,840–3,750,530	29,740–40,260	216,850–342,500
Alternative small-diameter gravity sewers	598,100	7290	55,500
Collection and small cluster systems			
On-site systems	510,000	13,400	54,500

Assumptions:
All technology options presented are assumed to have a 30-year life span.
All of the options considered are capable of achieving the secondary treatment level.
The rural community consists of 450 people in 135 homes.

Wastewater Reuse

- Wastewater Reuse needs to be perceived as a measure towards three fundamental objectives within a perspective of integrated water resources management:
  - 1.Environmental sustainability – reduction of emission of pollutants and their discharge into receiving water bodies, and the improve ment of the quantitative and qualitative status of those water bodies (surface-water, groundwater and coastal waters) and the soils.
  - 2. Economic efficiency – alleviating scarcity by promoting water efficiency, improving conservation, reducing wastage and balancing long term water demand and water supply.
  - 3. For some countries, contribution to food security – growing more food and reducing the need for chemical fertilisers through treated wastewater reuse.
- In addition to these objectives, the public health perspective should be considered

Type of wastewater reclamation and reuse

- The major types of reuse have been developed and practiced throughout the world are:
  - agriculture irrigation
  - landscape irrigation (parks, public places of forestry, golf courses)
  - aquaculture
  - groundwater recharge (indirect water reuse)
  - reuse in industry (es: cooling towers) and in a house (es: for toilet flushing, watering of gardens)

Problems associated wastewater reuse

- Costs of the water vs traditional sources: the cost of water has to be acceptable for farmers.

- **Social acceptance** (farmers, retailers and consumers): This is the most sensitive area of this topic. Farmers are not going to reuse water, if their product cannot be sold. Consumers will not buy products where reuse water was used unless it is proven to be safe.

- **Social issues** play a significant role in water reuse initiatives and should be adequately addressed. With adequate political will accompanied by awareness programmes these cultural, religious and social objections can be overcome.

Benefits and Risks of Wastewater Use

- Hussain et al. (2001) developed an overview of the potential benefits and risks arising from the use of wastewater in agriculture.
- **RISKS**
  - **Public health**: Wastewater has the potential to cause diseases because it contains bacteria, viruses and parasites. Also, the inclusion of heavy metals in wastewater can be very dangerous for human health. Wastewater use in agriculture creates risks for the population living within and outside the wastewater irrigation zone.
  - **Crops:** Wastewater is attractive and economically valuable for farmers because it contains important nutrients for crop growth. However, a high concentration of chemical pollutants in wastewater may be toxic to plants.
  - **Soil resources:** Accumulation of nitrogen, phosphorus, dissolved solids and other constituents such as heavy metals in the soil affect its productivity and the sustainability of land use for agriculture. Salt accumulation in the root zone may have harmful impacts on crop yields.
  - **Groundwater resources:** Leaching of nutrients and salts included in wastewater has the potential to affect the quality of groundwater. The degree of impact depends on several factors, including the quality of groundwater, the depth of the water table, soil drainage and the amount of wastewater applied for irrigation.

Benefits and Risks of Wastewater Use

- **BENEFITS**
  - components found in wastewater can contain useful and valuable nutrients that are required by plants. These nutrients and fertilizers can reduce the input of artificial fertilizers.
  - wastewater lies in its availability. In urban areas where alternative water supplies are lacking, wastewater is an advantageous resource because it is available all year round
  - Reuse increases the total available water supply and decreases demand on potable water
  - Water not discharged to receiving waters