RAINWATER HARVESTING (B22EDO601)

OPEN ELECTIVE- SEMESTER-VI

MINAKSHI MISHRA
SCHOOL OF CIVIL ENGINEERING

Course Title	Rainwater Harvesting				Course Type		OE	
Course Code	B22EDO601	Credits	3		Class		Semester-VI	
	TLP	Credits	Contact Hours	Work Load	Total Number of Classes Per Semester		Assessment in Weightage	
	Theory	3	3	3				
	Practice	-	-	-	Theory	Practical	CIE	SEE
	Tutorial	-	-	-				
	Total	3	3	3	48	-	50	50

Course Overview

Course Overview

- Rainwater harvesting (RWH) is the technique of **capturing, conserving, and utilizing** rainwater for various purposes to ensure sustainable water management.
- The course provides an understanding of traditional and modern RWH methods, emphasizing the **design, implementation, and maintenance** of RWH systems.

Course Outcomes

Course Outcomes

1. Recognize the importance and **benefits** of rainwater harvesting and water conservation techniques.
2. Understand the **design and components of RWH systems** for urban and rural applications.
3. Analyze water conservation and **recycling techniques** for sustainable water management.
4. Evaluate the **effectiveness of RWH systems** through case studies and practical applications.

Course Outcomes

5. Apply advanced RWH technologies such as **IoT-based monitoring and smart systems**.
6. Interpret **government policies**, guidelines, and case studies to develop sustainable RWH solutions.

Course Content

Unit -1

- **Global and Indian Scenario for Water Resources:** Surface Water and Groundwater Global and Indian Scenario-Quality of water resources. Usable water resources by continent and Country-Water footprint.
- Water use and Sustainable Reuse Methods.
- **Introduction:** Concept and Necessity of Rainwater Harvesting, Benefits of Rainwater Harvesting (Social, Environmental, and Economic), Rainwater Harvesting in ancient India and worldwide.

Unit -2

- **Introduction:** Advantages of Rainwater Harvesting, Natural Water Resources.
- **Agricultural Practices**, integrated farming, Soil erosion and conservation techniques.
- Concept of Arid and Semiarid Regions. **Drought Management-** introduction, Drought assessment and classification, drought mitigation planning, Concept of watershed, introduction to watershed management.

Unit -3

- **Rainwater Harvesting:** Types of Rainwater Harvesting, Components of domestic Rainwater Harvesting system, Principles of design of roof top Rainwater Harvesting System. Conveyance Systems- Material selection and installation.
- **Water Conservation and Recycling:** Perspective on recycle and reuse, Wastewater reclamation, Rainwater Harvesting Techniques- in Urban areas and Rural areas, a case study of both techniques, maintenance and monitoring of Rainwater Harvesting Structures.

Unit -4

- **Advancement and Policies of RWH:** Government policies and schemes for RWH in India, guidelines and regulations (e.g., building codes, municipal policies), Incentives and subsidies for RWH.
- **Smart RWH systems**, Integration with IOT for monitoring and management. Role of RWH in achieving water sustainability, Case Studies in Urban and Industrial.

Textbooks

Textbooks

- **Rainwater Harvesting for Drylands and Beyond**, Volume 1: Guiding Principles to Welcome Rain into Your Life and Landscape by Brad Lancaster, Rainsource Press, 2019.
- **Rainwater Harvesting: Principles and Practices** by H.S. Ramesh, New India Publishing Agency, New Delhi, India, 2020.
- **Rainwater Harvesting and Utilisation**: Blue Drop Series, United Nations Environment Programme, UNEP and IETC, 2009.

Important Dates

Important Dates

S. No.	Description	Tentative Dates	No. of Contact Hours
1	Unit 1	03/02/25 to 20/02/25	08
2	Unit 2	20/02/25 to 11/03/25	08
3	**Assignment 1 Submission by**	**07/03/25**	
4	**IA 1**	**17/03/25 to 20/03/25**	
5	Unit 3	25/03/25 to 17/04/25	09
6	Unit 4	17/04/25 to 08/05/25	08
7	**Assignment 2 Submission by**	**05/05/25**	
8	**IA 2**	**12/05/25 to 15/05/25**	
9	SEE	26/05/25 to 06/06/25	

Unit -3

- **Rainwater Harvesting:** Types of Rainwater Harvesting, Components of domestic Rainwater Harvesting system, Principles of design of roof top Rainwater Harvesting System. Conveyance Systems- Material selection and installation.
- **Water Conservation and Recycling:** Perspective on recycle and reuse, Wastewater reclamation, Rainwater Harvesting Techniques- in Urban areas and Rural areas, a case study of both techniques, maintenance and monitoring of Rainwater Harvesting Structures.

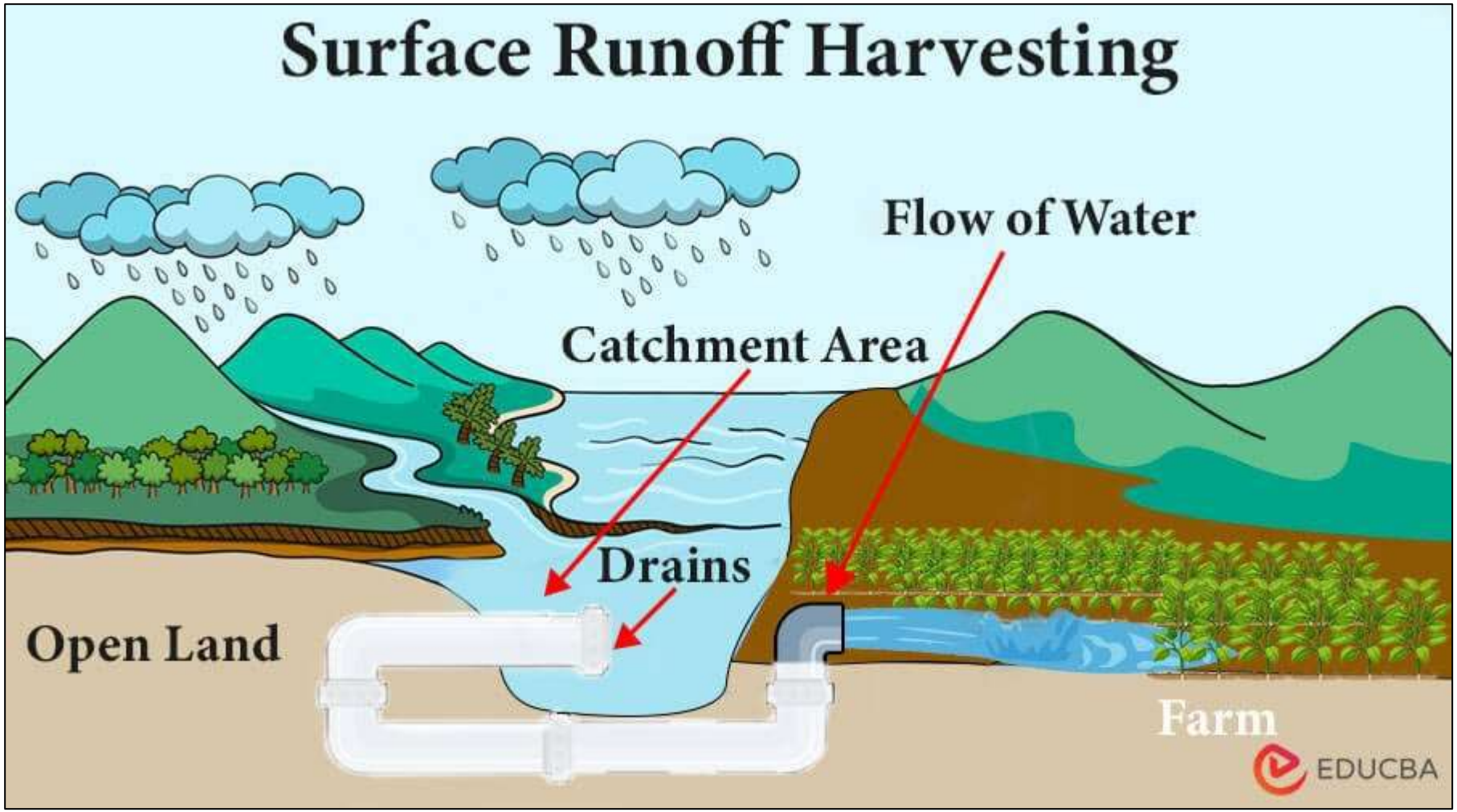
Types of Rainwater Harvesting

Types of Rainwater Harvesting

1. Surface Runoff Harvesting

- Collects rainwater from **roads, open spaces, and catchment areas**.
- The water is directed to storage tanks, reservoirs, or recharging structures.
- Often used in **urban areas** to
  - Reduce waterlogging and
  - Replenish groundwater.

Types of Rainwater Harvesting

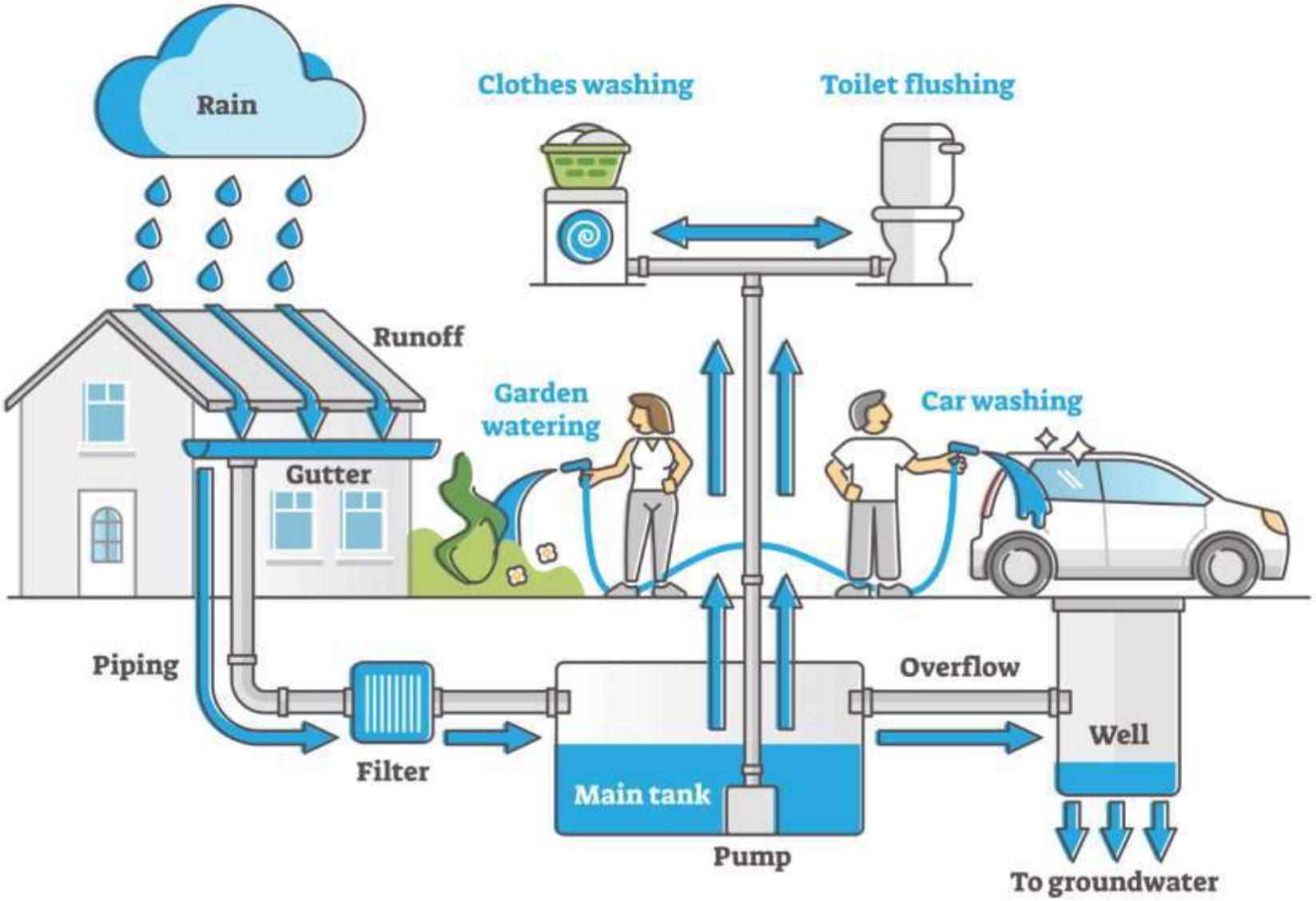


Types of Rainwater Harvesting

2. Rooftop Rainwater Harvesting (RRWH)

- Collects rainwater from **rooftops of buildings** and directs it to storage or recharge systems.
- Can be done using gutters, pipes, filters, and storage tanks.
- Suitable for domestic, commercial, and institutional buildings.

RAINWATER HARVESTING



ROOFTOP RAINWATER HARVESTING

Components

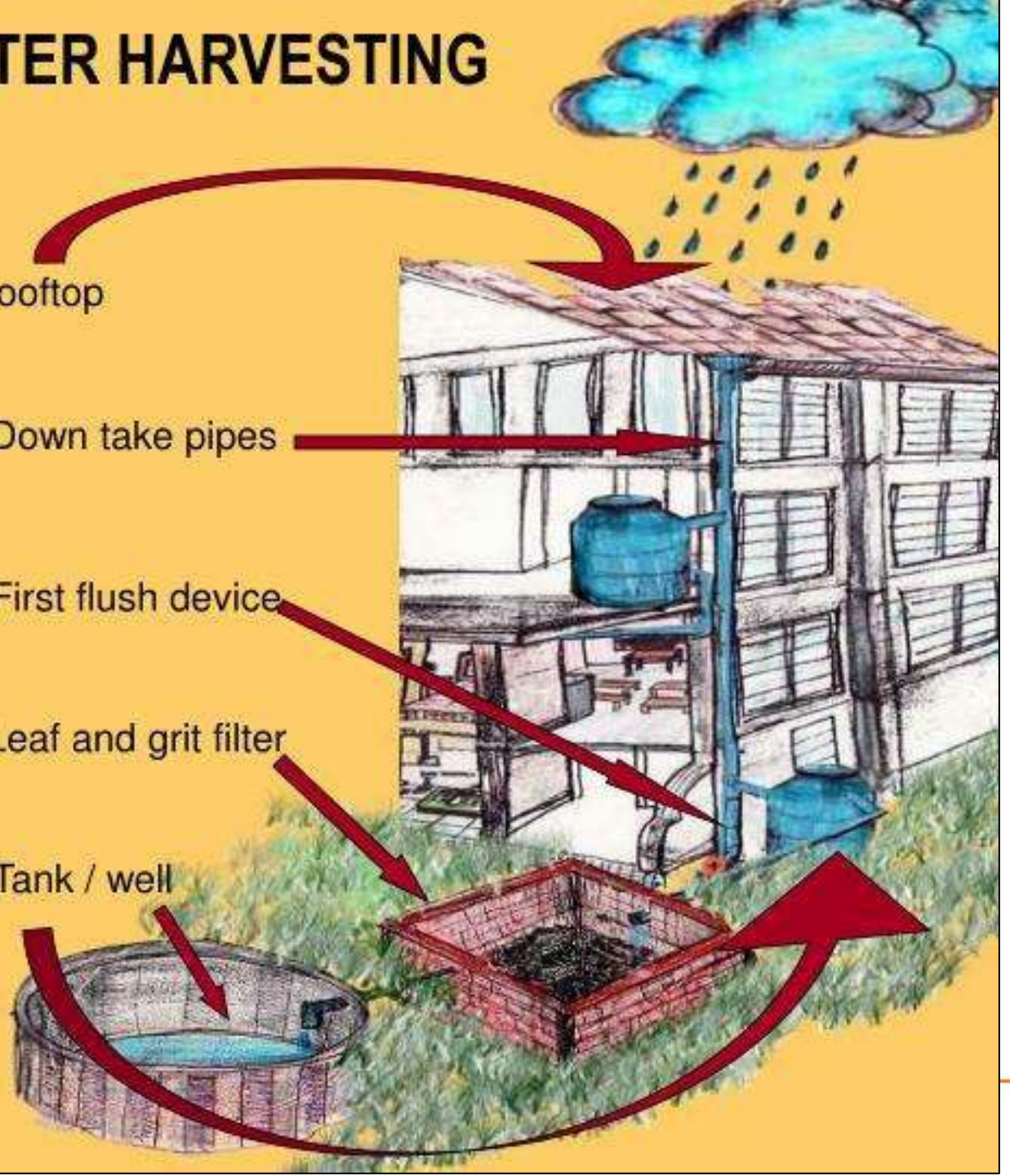
Catchment – rooftop

Transportation – Down take pipes

Filters – First flush device

Leaf and grit filter

Storage – Tank / well



Types of Rainwater Harvesting

3. Check Dams & Nala Bunds

- Constructed across **small streams or rivers** to store rainwater.
- Helps in groundwater recharge and prevents soil erosion.
- Commonly used in **rural areas** for water conservation.

Types of Rainwater Harvesting

i) Badgaon check dam

iii) Hinta check dam

ii) Dharta check dam

iv) Sunderpura check dam

https://youtu.be/hWOulL1FQnM?si=1qwnh8Phb1zfXF2L

Types of Rainwater Harvesting

4. Percolation Pits & Recharge Wells

- Designed to allow rainwater to percolate into the ground and **recharge groundwater.**
- Pits are filled with gravel, sand, and pebbles to facilitate infiltration.
- Suitable for **areas with low groundwater levels**.

Types of Rainwater Harvesting

https://youtu.be/n-0DnwyGa7A?si=bQpCKO3s8cWNIKDd

Types of Rainwater Harvesting

5. Rainwater Storage Tanks & Cisterns

- Directs rainwater into **storage tanks for later use**.
- Tanks can be above ground or underground.
- Used for **drinking, irrigation, and other household purposes**.

Types of Rainwater Harvesting

Rainwater Storage Tanks & Cisterns

Types of Rainwater Harvesting

6. Farm Ponds & Percolation Tanks

- Small ponds or tanks created to store rainwater for **irrigation and livestock.**
- Helps in **soil moisture retention and groundwater recharge**.

Types of Rainwater Harvesting

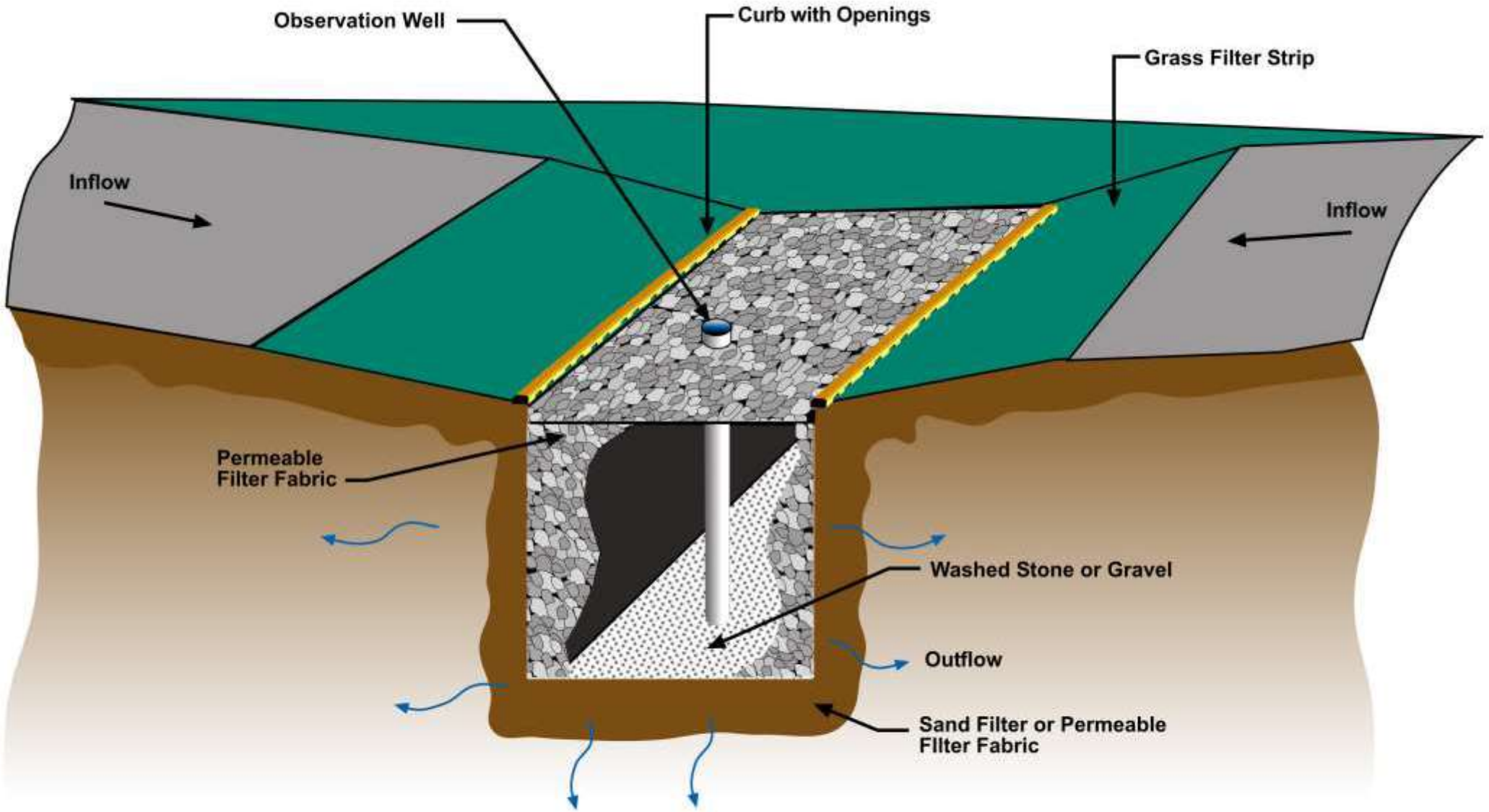
Farm Ponds

Percolation Tanks

Types of Rainwater Harvesting

7. Infiltration Trenches

- Shallow ditches filled with gravel or porous material that help **infiltrate rainwater into the ground.**
- Used in **urban areas** to manage **stormwater and recharge aquifers.**



INFILTRATION TRENCH

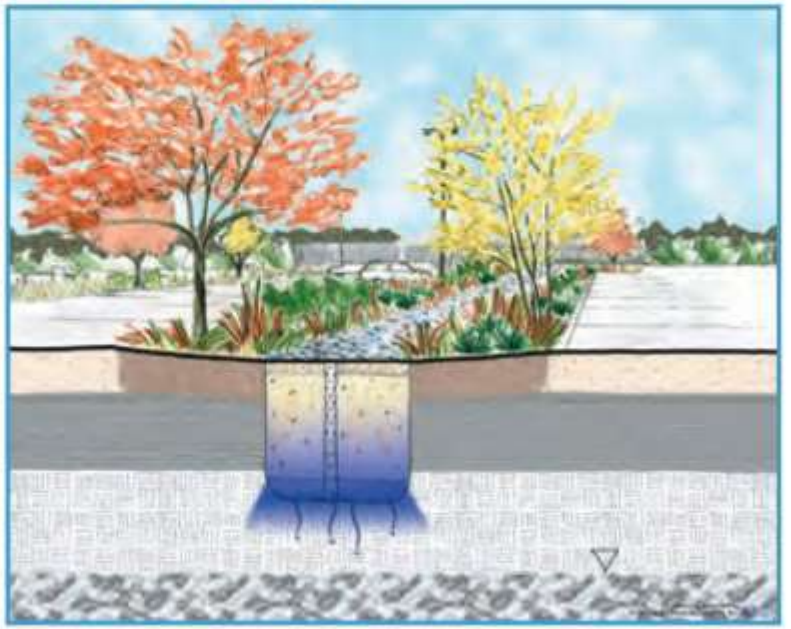
Types of Rainwater Harvesting

INFILTRATION TRENCH

RAINFALL

STORAGE

INFILTRATION

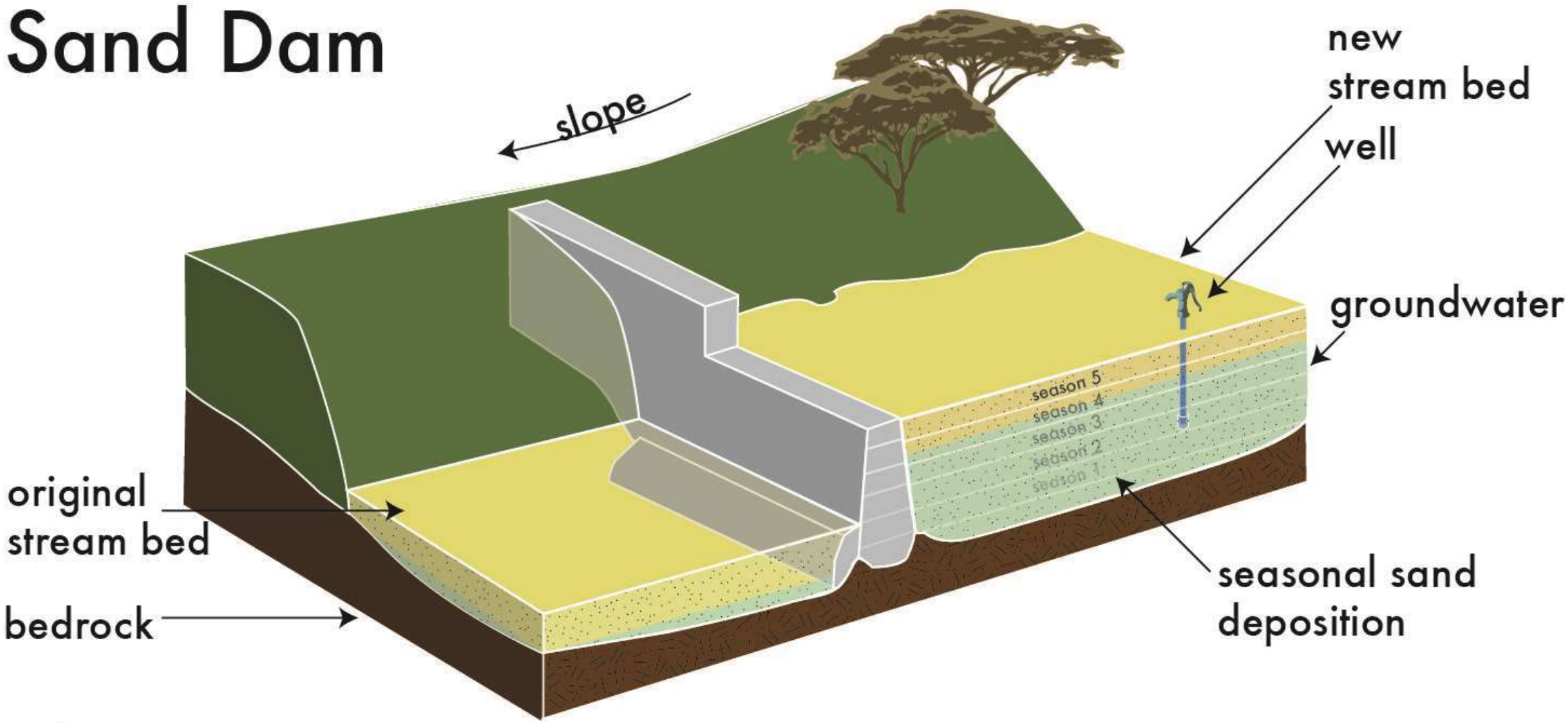


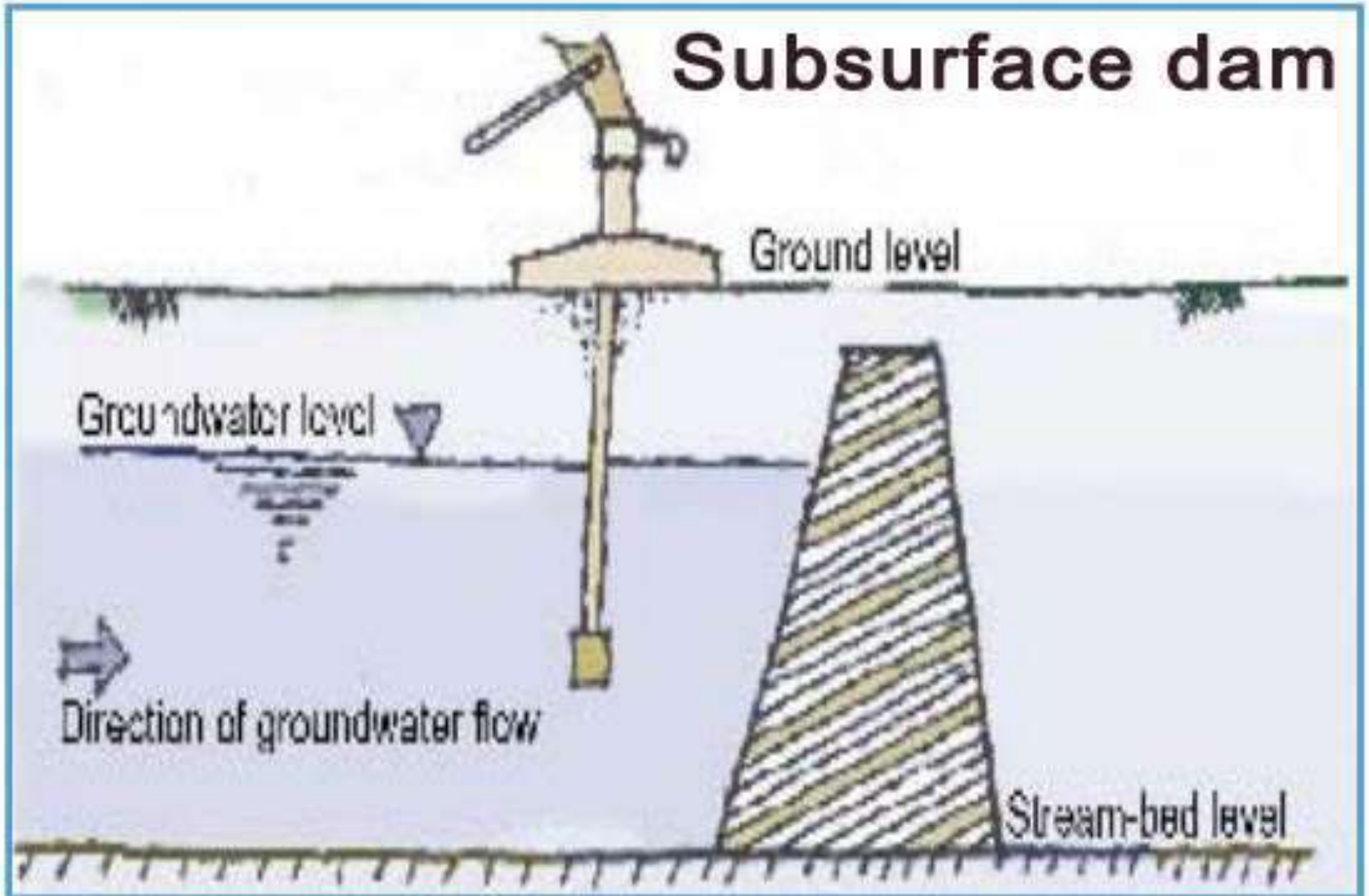
Types of Rainwater Harvesting

8. Sand Dams & Subsurface Dams

- Built in seasonal **riverbeds** to store rainwater beneath the sand layer.
- Water can be extracted using wells or pumps.
- Common in arid and semi-arid regions.

Types of Rainwater Harvesting

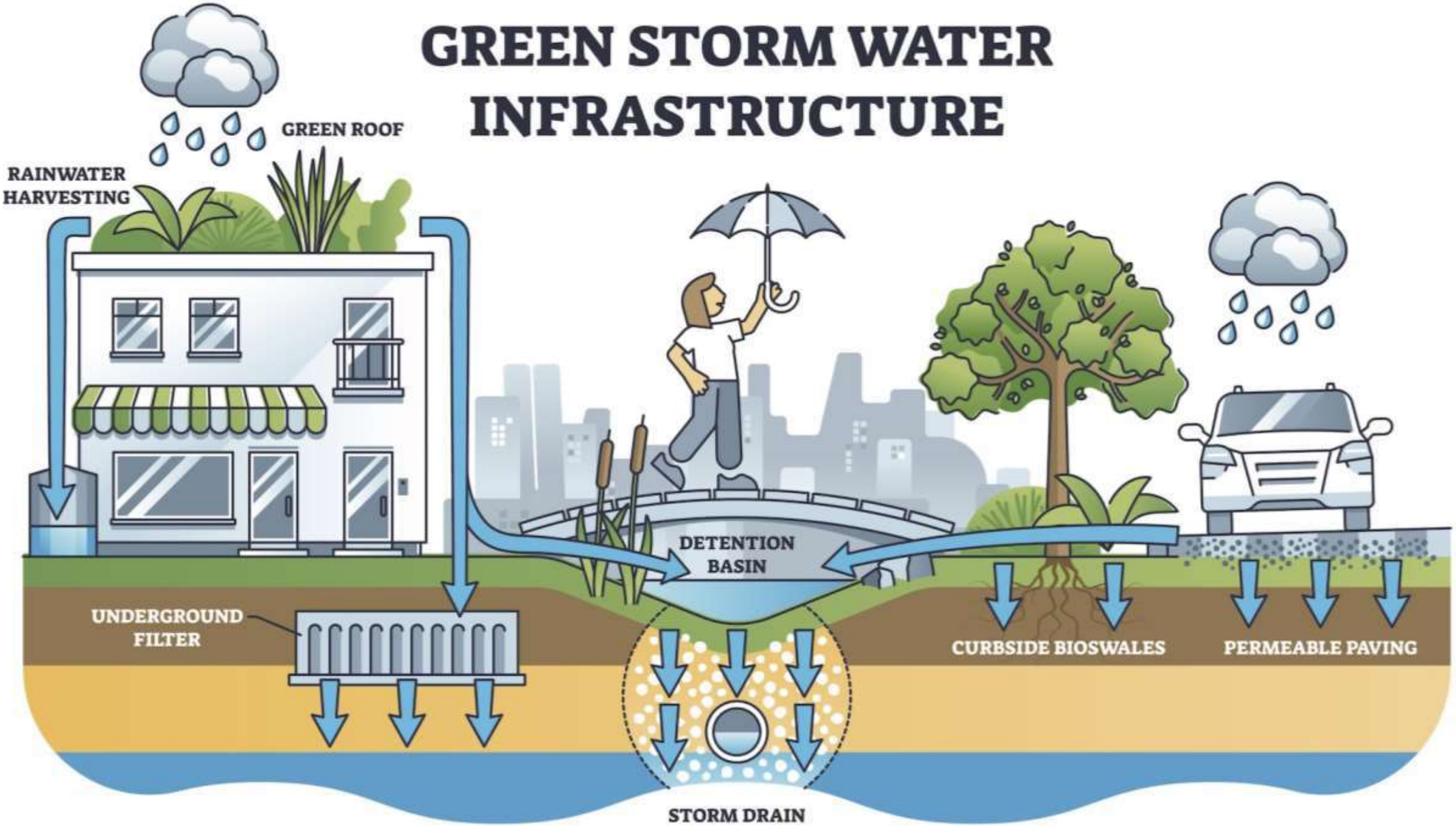



Subsurface dam
Ground level
Groundwater level
Direction of groundwater flow
Stream-bed level

Types of Rainwater Harvesting

9. Stormwater Harvesting

- Captures and stores **stormwater** from drains, roads, and open spaces.
- Used **in urban planning** to reduce flooding and replenish groundwater.


GREEN STORM WATER INFRASTRUCTURE
GREEN ROOF
RAINWATER HARVESTING
DETENTION BASIN
UNDERGROUND FILTER
CURBSIDE BIOSWALES
PERMEABLE PAVING
STORM DRAIN

Components of Domestic Rainwater Harvesting System

Components of domestic Rainwater Harvesting System

A domestic rainwater harvesting system consists of several **key components** that work together to **collect, store, and utilize** rainwater efficiently. Below are the main components:

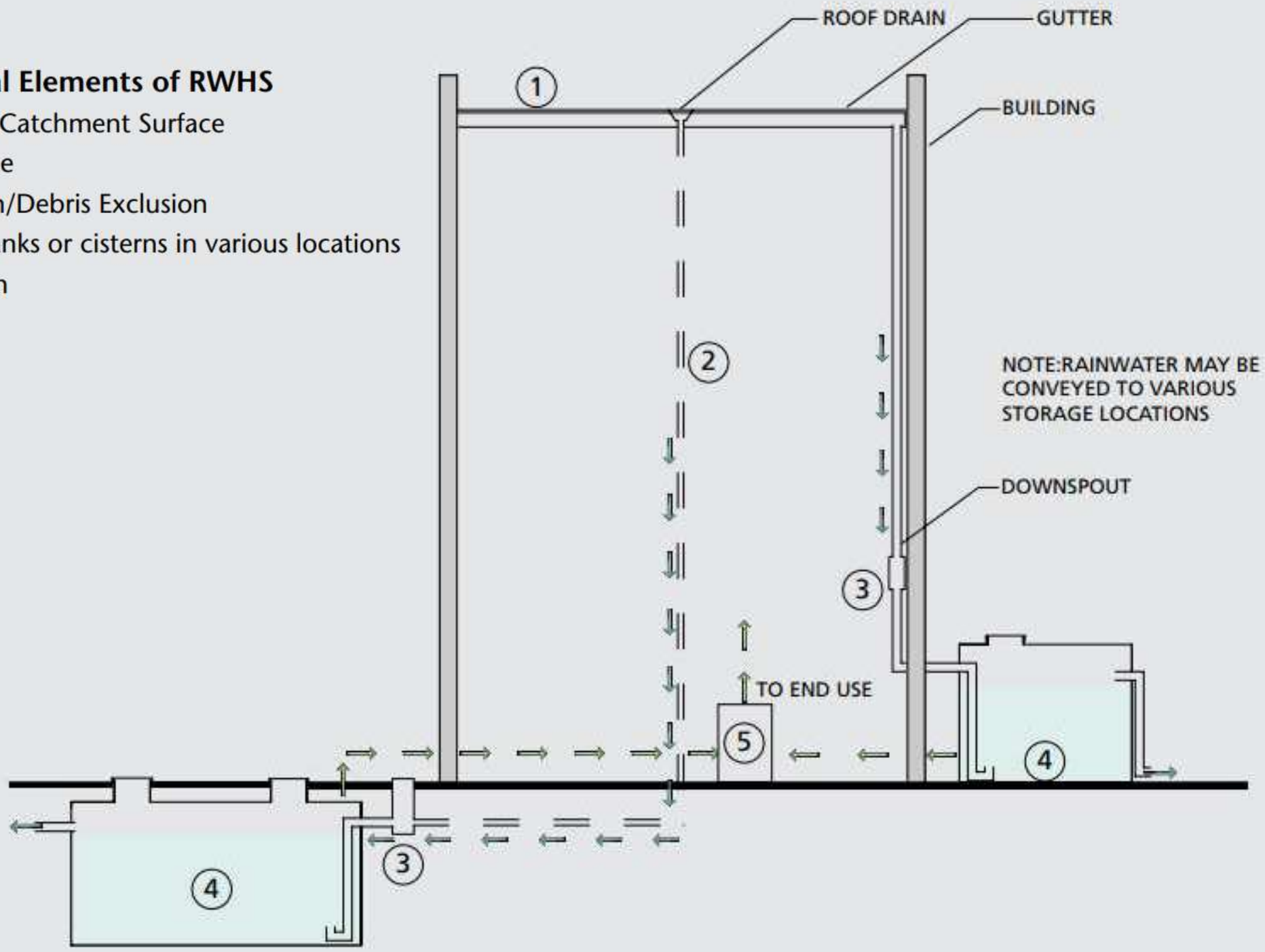
- Catchment Area (Roof Surface)
- Gutters & Downpipes
- Leaf Screens & First Flush Diverters
- Filtration Unit
- Storage Tank (Above-Ground or Underground)

Components of domestic Rainwater Harvesting System

- Overflow System & Soak Pit
- Pumping System
- Distribution System

Fundamental Elements of RWHS

1. Collection/Catchment Surface
2. Conveyance
3. Prefiltration/Debris Exclusion
4. Storage: Tanks or cisterns in various locations
5. Distribution



Components of domestic Rainwater Harvesting System

1. **Catchment Area**

- The **surface where rainwater is collected**, usually a rooftop of a house or building.
- Made of materials like concrete, tiles, metal sheets, or thatched roofs.
- The **quality** of harvested **water** depends on the **cleanliness of the catchment.**

Components of domestic Rainwater Harvesting System

Components of domestic Rainwater Harvesting System

2. Gutters & Downpipes

1. **Gutters collect** rainwater from the roof and direct it into downpipes.
2. **Downpipes transport** water from the roof to the storage or filtration system.
3. Made of PVC, metal, or concrete.

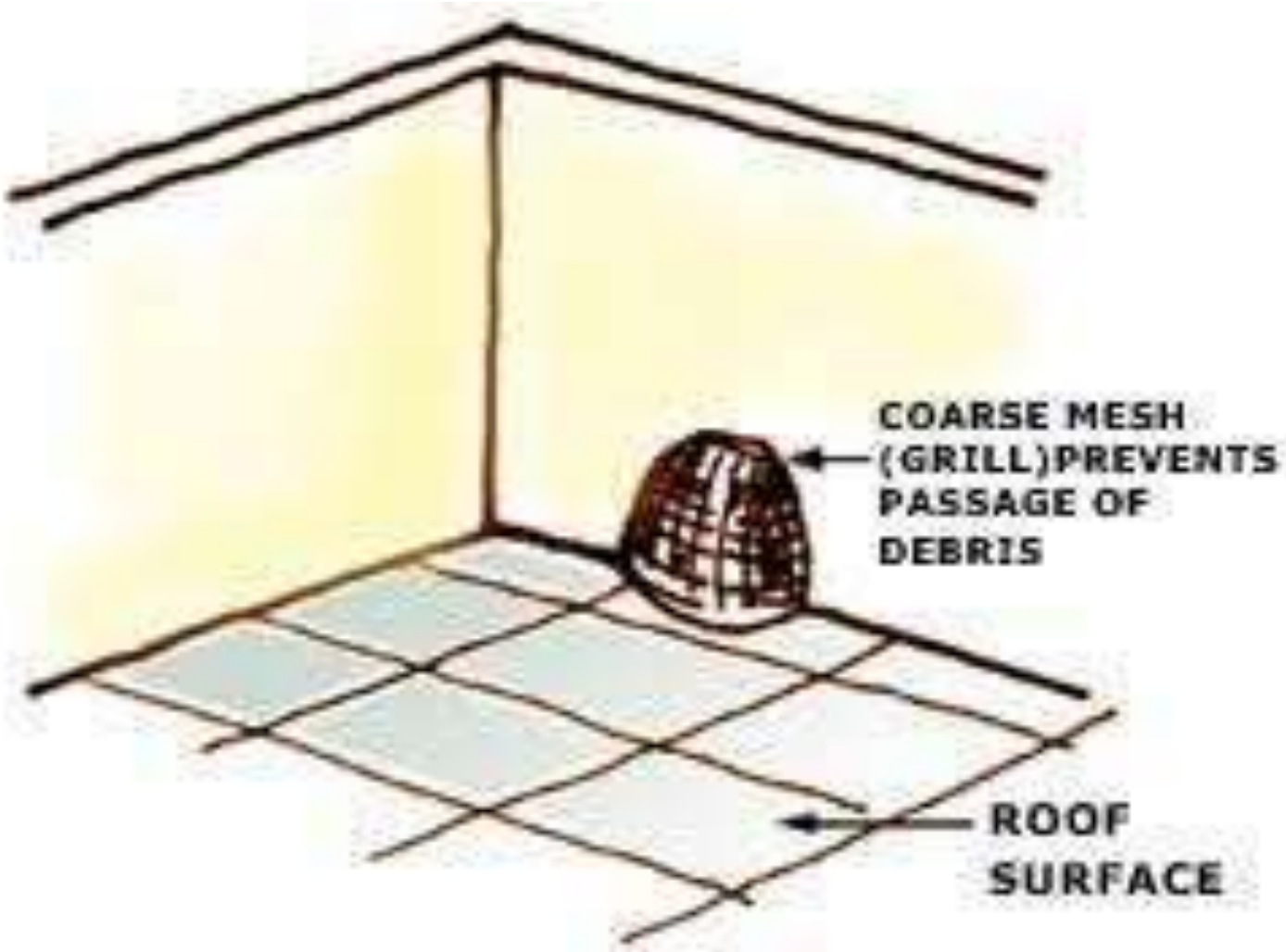
Components of domestic Rainwater Harvesting System

Components of domestic Rainwater Harvesting System

3. Leaf Screens & First Flush Diverters

- **Leaf Screens:** Filters out leaves, debris, and dirt before water enters the system.
- **First Flush Diverter:** Ensures the first few millimeters of rain, which may contain dust and contaminants, are discarded.

Components of domestic Rainwater Harvesting System



Components of domestic Rainwater Harvesting System

Components of domestic Rainwater Harvesting System

Components of domestic Rainwater Harvesting System

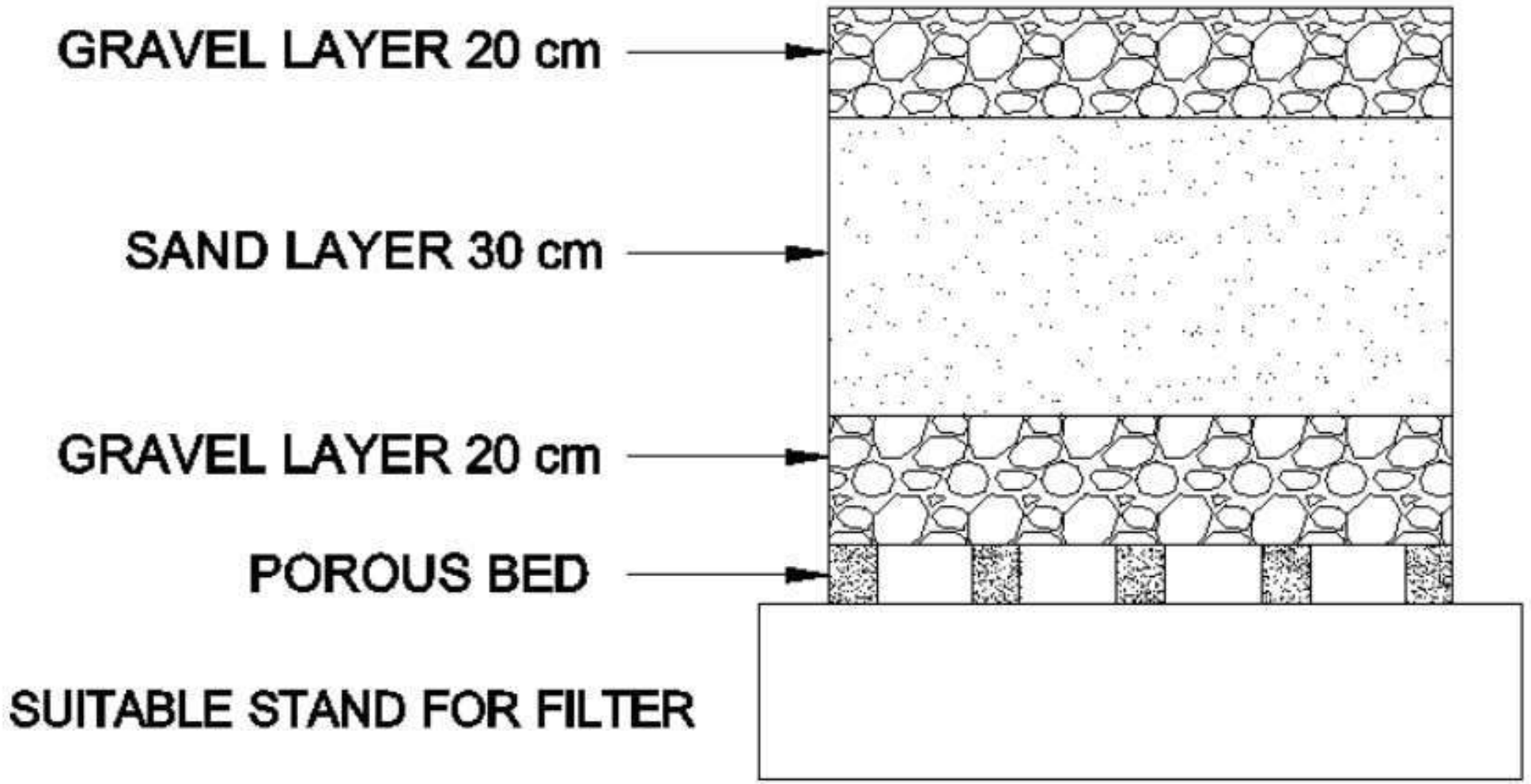
4. Filtration Unit

- Cleans collected water before storage.
- Uses **gravel, sand, charcoal, or mesh filters** to remove sediments, dust, and organic matter.
- Essential for maintaining water quality, especially for drinking purposes.

4. Filtration Unit-Sand filter

- In the sand filters, the main filtering media is commonly available **sand sandwiched between two layers of gravels**.
- The filter can be constructed in a galvanized iron or ferro cement tank.
- The sand fillers are very effective **in removing turbidity, colour and microorganism.**

Components of domestic Rainwater Harvesting System



4. Filtration Unit-Charcoal water filter

- This is almost similar to sand filter except that a **10-15 cm thick charcoal layer placed above the sand layer**.
- Charcoal layer inside the filter result into **better filtration** and purification of water.

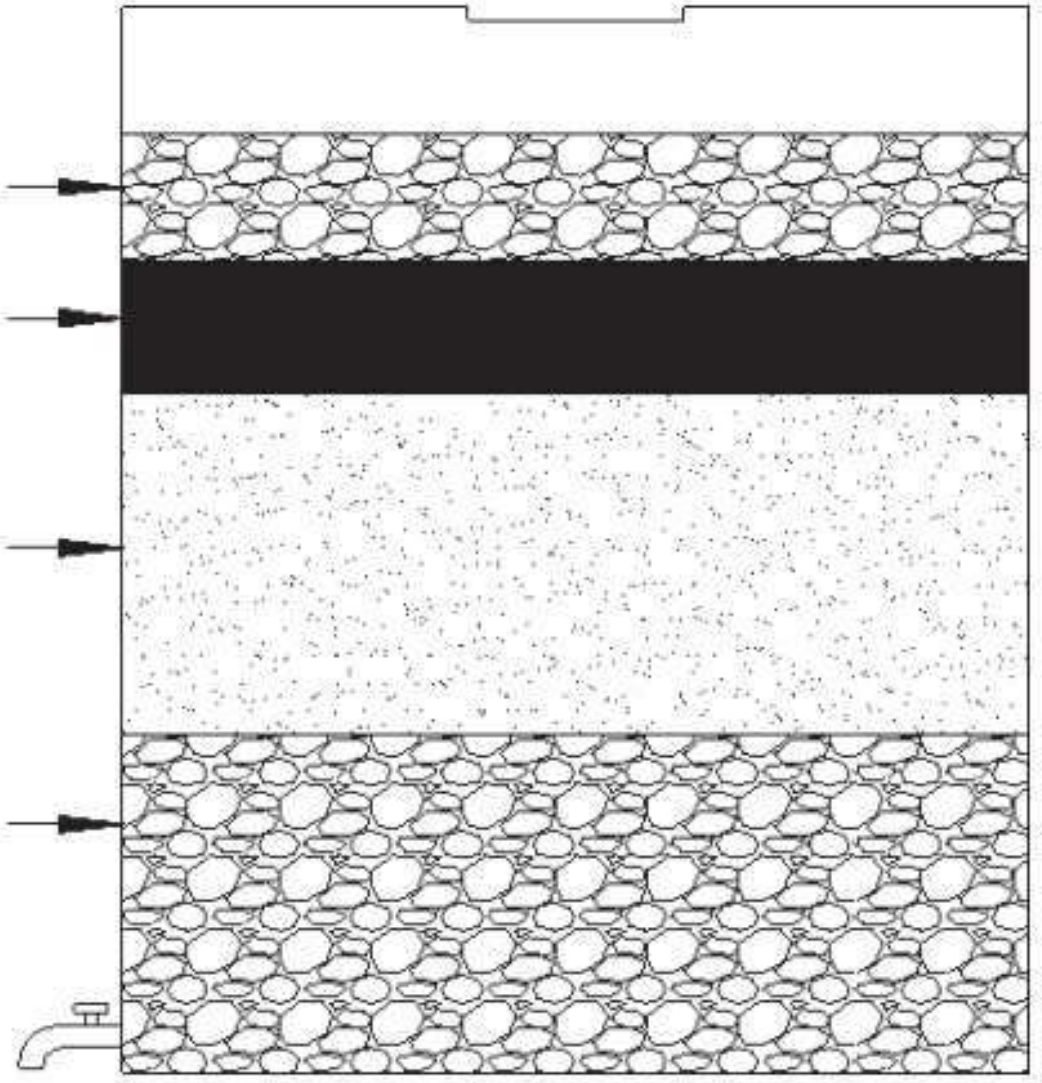
Components of domestic Rainwater Harvesting System

GRAVEL LAYER 10

CHARCOAL LAYER 10 cm

SAND LAYER 25 cm

GRAVEL LAYER 25 cm



Components of domestic Rainwater Harvesting System

5. Storage Tank (Above-Ground or Underground)

- Stores the filtered rainwater for future use.
- Made of **plastic, concrete, fiberglass, or metal**.
- Equipped with an **overflow system** to prevent flooding.

Components of domestic Rainwater Harvesting System

Components of domestic Rainwater Harvesting System

- The **capacity** of storage tank is dependent on many factors like
- **Number of persons** in the household – The greater the number of persons, more will be requirement of water.
- **Per capita requirement** – **varies from household to household**, based on standard of living. The requirement also **varies with season**. In summer the requirement is more in comparison to winter. Similarly, the per capita requirement is more in urban areas in comparison to rural areas.

Components of domestic Rainwater Harvesting System

- **Average annual rainfall**
- **Rainfall pattern** – It has a significant impact on capacity of storage tank. If the rainfall is **uniformly** spread throughout the year, the **requirement** of storage capacity will be **less**. But if the rainfall is **concentrated to a limited period** in a year, the storage tanks of **higher** capacity will be required.

Components of domestic Rainwater Harvesting System

- **Type and size of catchment** – Depending upon the **type of roofing material, the runoff coefficient** varies which affect the effective yield from a catchment area. The size of the catchment also has a bearing on tank size. The **more the catchment area, larger the size** of storage tank.

Components of domestic Rainwater Harvesting System

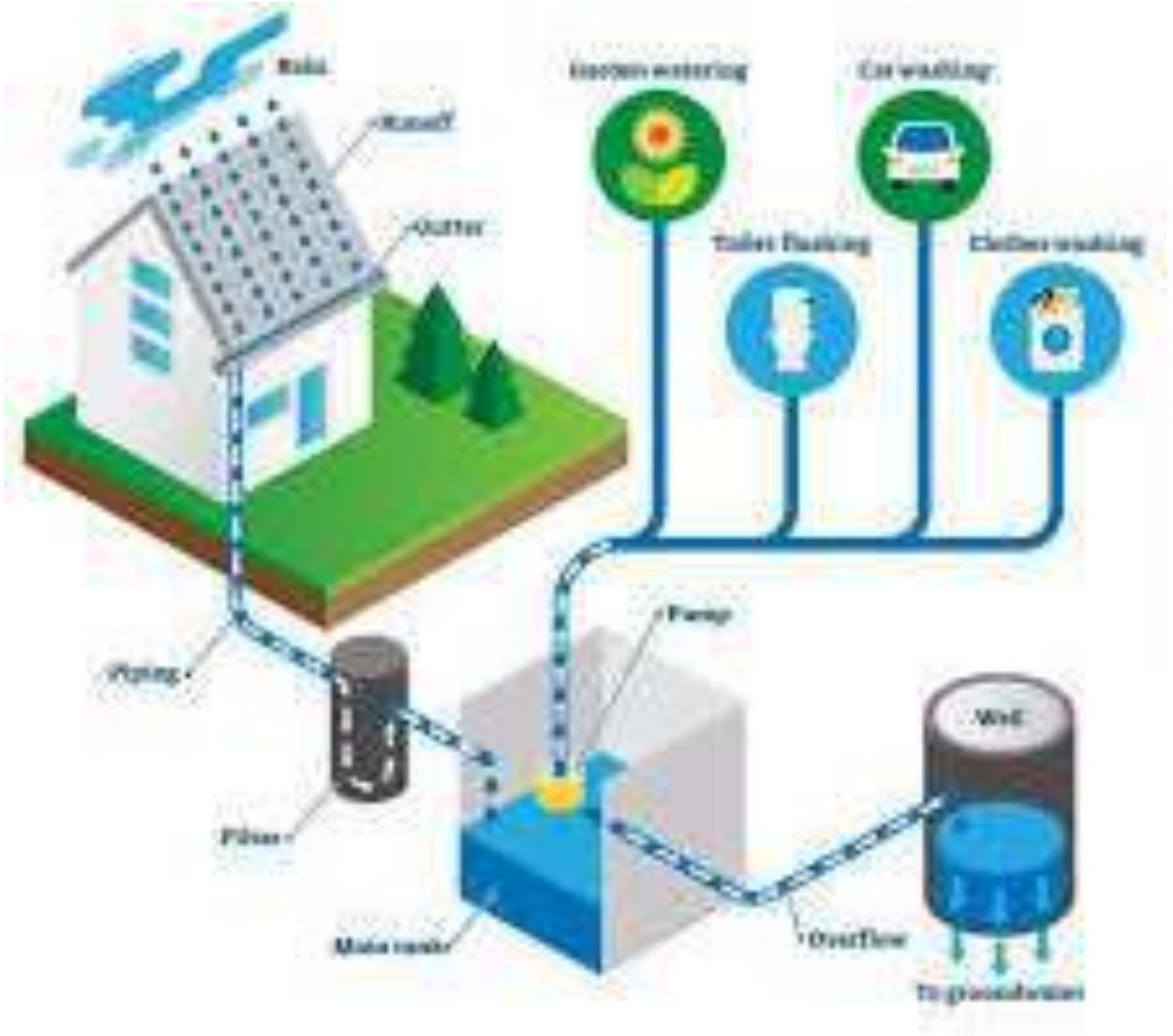
- The design of the storage tank, can be done using following three
- approaches:
  - Matching the capacity of the tank to the **area of the roof**.
  - Matching the capacity of the tank to the **quantity of water required** by its **users**.
  - Choosing a tank size that is appropriate **in terms of costs, resources and construction methods**.

Components of domestic Rainwater Harvesting System

6. Overflow System & Soak Pit

- **Overflow System:** Directs excess water away when the storage tank is full. An overflow mechanism ensures your tank doesn’t overfill and potentially damage itself during heavy rainfall.
- **Soak Pit:** Allows surplus water to percolate into the ground, recharging groundwater.

Components of domestic Rainwater Harvesting System

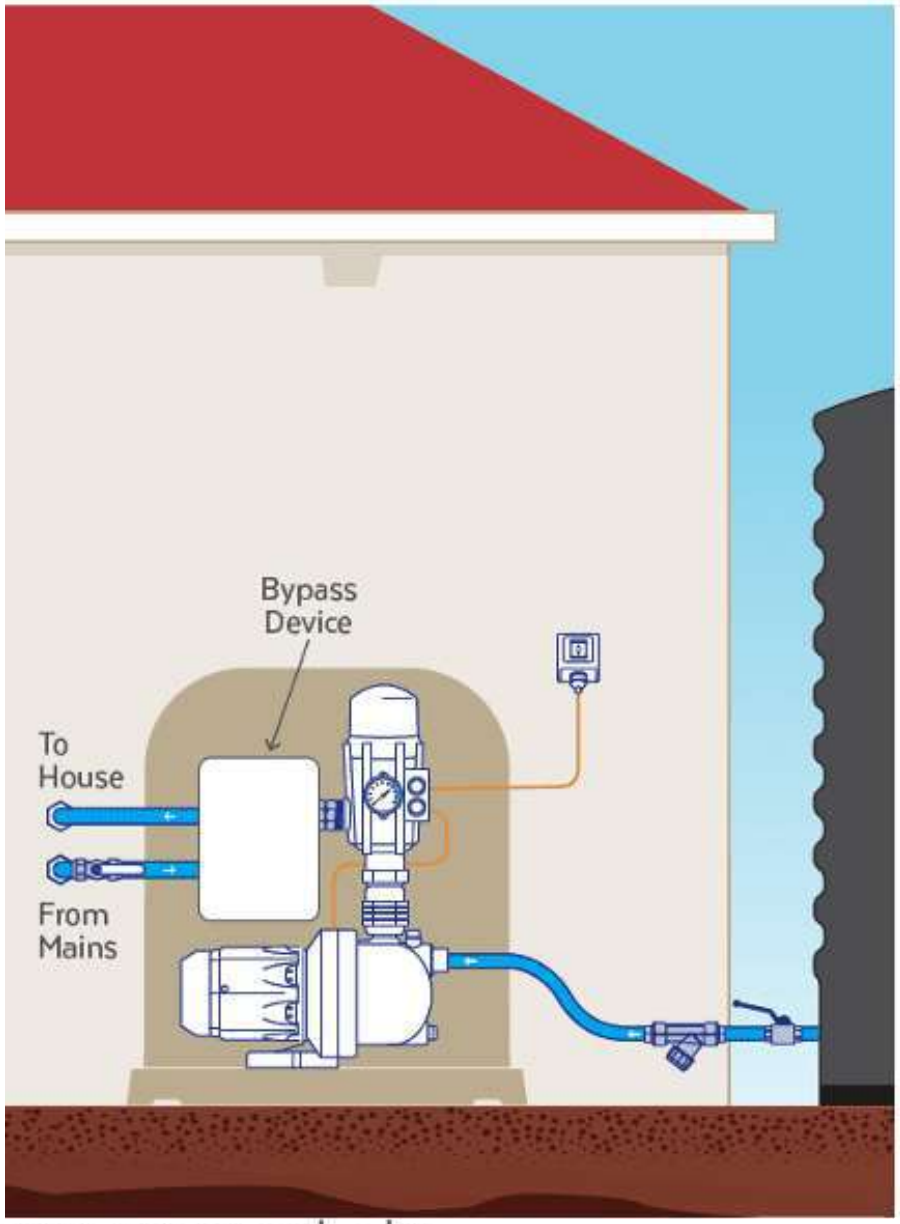


Components of domestic Rainwater Harvesting System

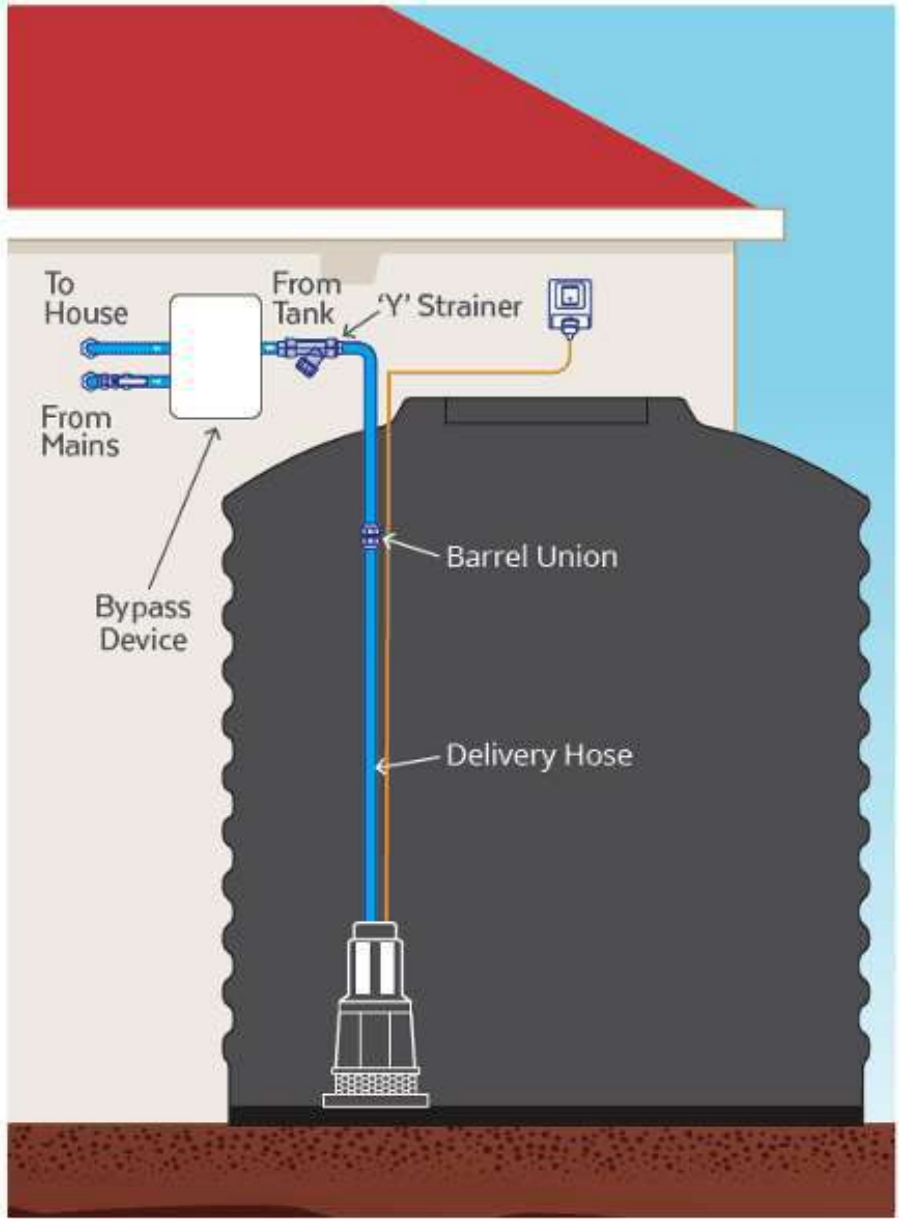
7. Pumping System

- If the storage tank is underground, a **pump** may be required to lift water for usage.
- Can be **manual, electric, or solar-powered**.

EXTERNAL OPTION



IN TANK OPTION

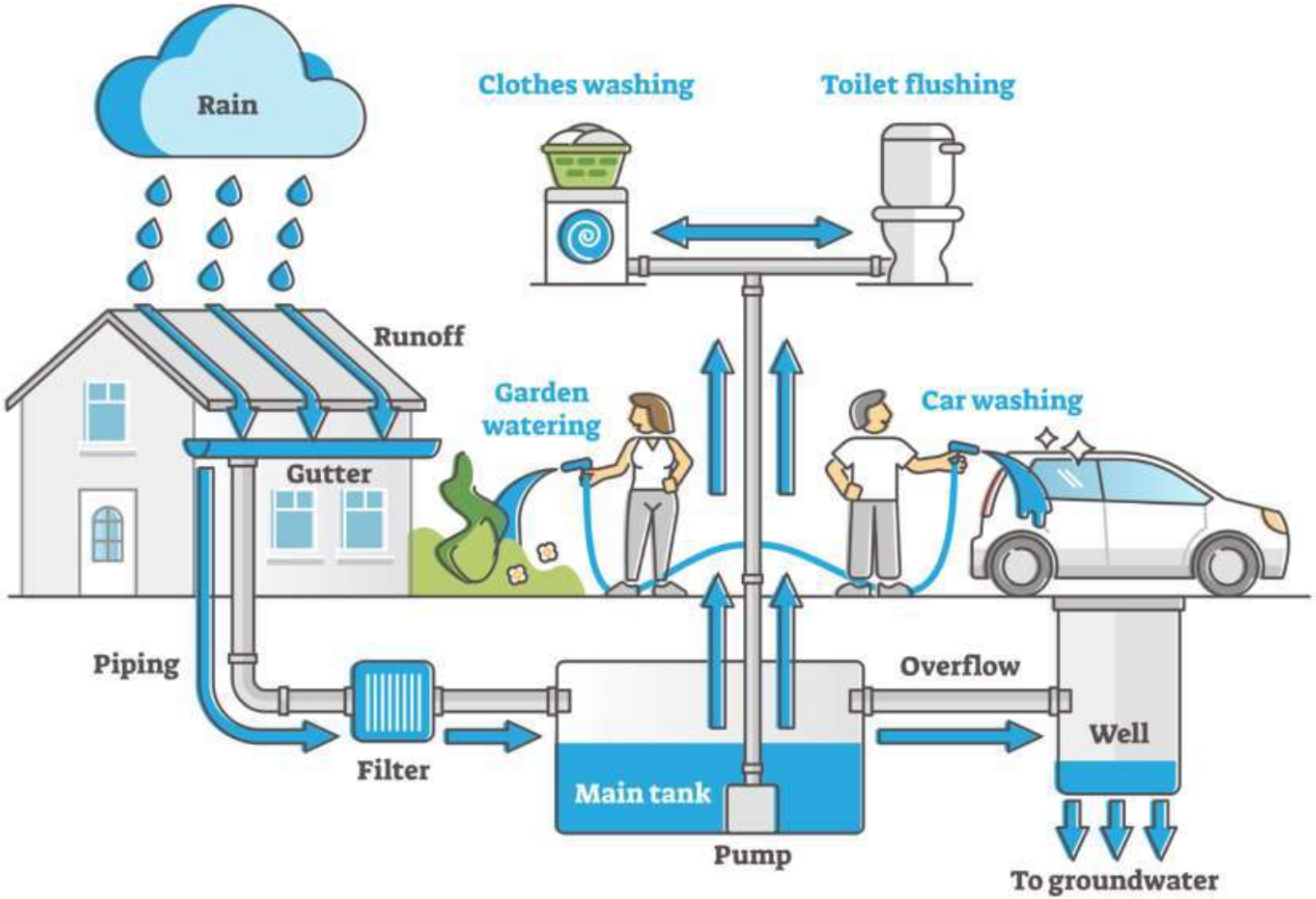


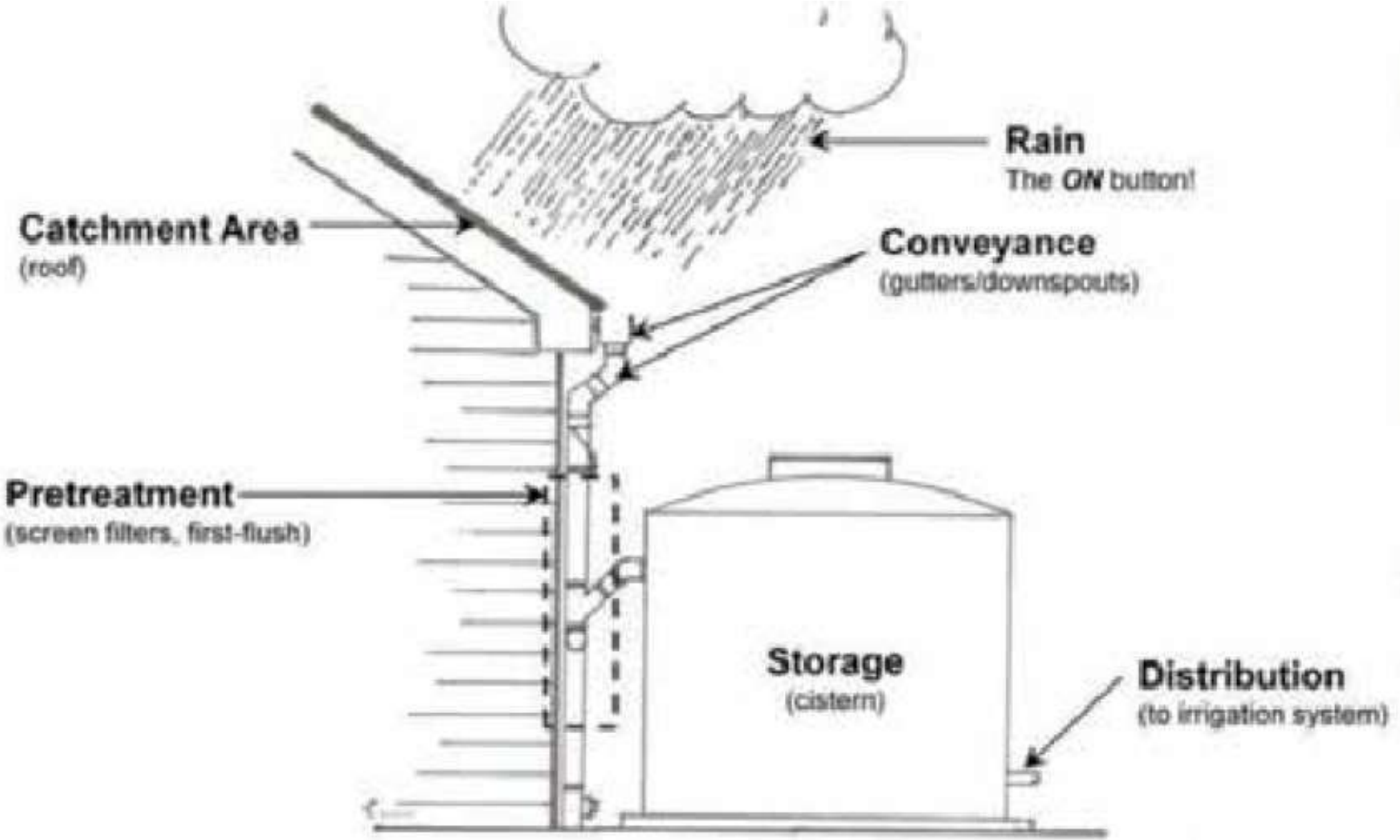
Components of domestic Rainwater Harvesting System

8. Distribution System

- Network of **pipes, taps, and valves** to deliver stored water to households for domestic use (toilets, washing, irrigation, etc.).
- Can be connected to **existing plumbing** or used separately.

RAINWATER HARVESTING




Rain
The ON button!
Catchment Area
(roof)
Conveyance
(gutters/downspouts)
Pretreatment
(screen filters, first-flush)
Storage
(cistern)
Distribution
(to irrigation system)

Principles of Design of Rooftop Rainwater Harvesting System

Principles of Design of Rooftop Rainwater Harvesting System

1. **Catchment Area Selection**

- The **roof surface** should be clean, smooth, and non-toxic.
- Materials like **concrete, tiles, metal sheets, and slates** are preferred.
- Avoid **asbestos and lead-based materials** to prevent contamination.

Principles of Design of Rooftop Rainwater Harvesting System

2. Rainfall Estimation & Water Demand Calculation

- **Average annual rainfall data** should be considered.
- **Total rainwater harvested (R) = Catchment Area (A) × Rainfall (P) × Runoff Coefficient (C)**
- Storage capacity should meet **household water demand**.

Principles of Design of Rooftop Rainwater Harvesting System

3. **Efficient Collection & Conveyance System**

- Gutters and downpipes should be properly designed to handle peak rainfall.
- Use slope (at least 1:100) for easy water flow.
- Install leaf screens and mesh filters to prevent debris entry.

4. First Flush System

- Essential to **divert the first rainwater** (which may carry dust, bird droppings, and pollutants).
- Can be **automated or manual first flush diverters**.

Principles of Design of Rooftop Rainwater Harvesting System

5. Filtration System

- A **multi-layer filter** (gravel, sand, and charcoal) should be used before storage.
- Removes **sediments, bacteria, and organic matter**.
- Regular maintenance is required to ensure efficiency.

Principles of Design of Rooftop Rainwater Harvesting System

6. Storage Tank Design

- Tanks can be **above-ground or underground**.
- Should be **leak-proof, algae-resistant, and properly ventilated**.
- Overflow mechanism should be connected to a **soak pit or recharge structure**.

Principles of Design of Rooftop Rainwater Harvesting System

7. Water Quality & Maintenance

- **Regular cleaning** of catchment areas, filters, and tanks is necessary.
- **Disinfection (chlorination/UV treatment)** may be required if used for drinking.
- Prevent **stagnant water** to avoid mosquito breeding.

Principles of Design of Rooftop Rainwater Harvesting System

8. Groundwater Recharge (Optional)

- Excess water can be directed to **percolation pits, recharge wells, or borewells**.
- Helps in **aquifer recharge and sustainability**.

Conveyance Systems

Conveyance Systems- Material selection and installation

The conveyance system transports rainwater from the **catchment area (roof)** to the **storage tank or recharge structure**.

- It includes **gutters, downpipes, first flush diverters and filters** that ensure efficient water flow.

2. Material Selection for Conveyance Systems

(A) Gutters & Downpipes Common Materials:

I. PVC (Polyvinyl Chloride) Pipes

- **Pros:** Lightweight, corrosion-resistant, easy to install, cost-
- **Cons:** Can become brittle over time due to UV exposure.
- **Best Use:** Residential and small-scale systems.

Conveyance Systems- Material selection and installation

II. Galvanized Iron (GI) Pipes & Gutters

- **Pros:** Strong, durable, resistant to UV damage.
- **Cons:** Prone to rusting; needs protective coatings.
- **Best Use:** Industrial and commercial applications.

III. Stainless Steel Pipes & Gutters

- **Pros:** Corrosion-resistant, durable, hygienic.
- **Cons:** Expensive and heavy.
- **Best Use:** High-end residential and commercial systems.

Conveyance Systems- Material selection and installation

IV. Aluminum Gutters

- **Pros:** Lightweight, rust-proof, long-lasting.
- **Cons:** Can be dented or damaged easily.
- **Best Use:** Urban areas and homes with aesthetic considerations.

V. Concrete Channels (for large-scale systems)

- **Pros:** Strong, long lifespan, suitable for heavy rainfall areas.
- **Cons:** Costly, difficult to modify after installation.
- **Best Use:** Large buildings, public institutions, and industrial setups.

Conveyance Systems- Material selection and installation

(B) First Flush Diverters & Filters

I. Material Choices:

- **Plastic (PVC):** Affordable and easy to install.
- **Metal:** More durable but prone to rust (use coated metal).
- **Ceramic:** Used for fine filtration.

II. Key Features:

- Should be non-toxic and **free from lead or asbestos**.
- Should have **UV resistance** to prevent degradation.

3. Installation Guidelines for Conveyance Systems

(A) Gutters Installation

Slope: Maintain a slight slope (1:100) towards the downpipe to prevent water stagnation.

Support Brackets: Install brackets every **1-1.5 meters** for stability.

Leaf Guards & Mesh Screens: Prevent debris from entering the system.

3. Installation Guidelines for Conveyance Systems

(B) Downpipe Installation

Connection to Storage Tank: Ensure a smooth connection with no leaks.

Diameter Selection: Typically **50mm to 110mm**, depending on roof size and rainfall intensity.

Secure Fastening: Use wall brackets every **1-2 meters** for pipe stability.

(C) First Flush & Filtration System

- **Placement:** Install **before the storage tank** to remove initial contaminants.
- **Easy Maintenance:** Design with an accessible cleaning mechanism.

4. Maintenance Considerations

- **Regular Cleaning:** Clean gutters and downpipes **every 3-6 months**.
- **Inspect for Leaks & Cracks:** Repair any damages promptly to prevent water loss.
- **Replace Old Pipes:** Especially if made of materials prone to corrosion or cracking.
- **Check for Blockages:** Ensure water flows smoothly without obstructions.

Water Conservation and Recycling

Perspective on recycle and reuse

- Water recycling and reuse play a crucial role in **sustainable water management**, especially in the face of increasing water scarcity and climate change. Adopting these strategies helps **conserve freshwater, reduce wastewater discharge, and promote environmental sustainability.**
- Recycling and reusing water are essential steps toward a sustainable future. By **embracing innovative technologies, improving infrastructure, and raising awareness,** we can significantly reduce freshwater consumption and ensure water security for future generations.

Perspective on recycle and reuse

Why Recycle and Reuse Water?

- **Water Scarcity:** Growing populations and climate change are straining freshwater resources.
- **Environmental Protection:** Reduces pollution by limiting wastewater discharge into natural water bodies.
- **Cost Savings:** Lowers water bills by using treated wastewater for non-potable applications.
- **Energy Conservation:** Reduces the energy required for water extraction, treatment, and distribution.

Perspective on recycle and reuse

Challenges in Water Recycling & Reuse

- **Public Perception:** Many people are hesitant about using recycled water, especially for drinking.
- **High Initial Costs:** Advanced treatment systems require significant investment.
- **Regulatory Barriers:** Strict guidelines and permits may be required for water reuse projects.
- **Infrastructure Needs:** Existing water systems may not be designed for dual water supply networks.

Perspective on recycle and reuse

Types of Water Recycling and Reuse

Greywater Reuse

- **Sources:** Bathing, washing machines, sinks (excluding kitchen sinks and toilets).
- **Uses:** Garden irrigation, toilet flushing, cleaning, and cooling systems.
- **Treatment Needed:** Basic filtration and disinfection

Perspective on recycle and reuse

Blackwater Recycling

- **Sources:** Toilet wastewater, kitchen sinks, and industrial sewage.
- **Uses:** After advanced treatment, can be reused for irrigation, industrial cooling, or even potable water in some cases.
- **Treatment Needed:** Biological treatment, filtration, and disinfection.

Perspective on recycle and reuse

Industrial Water Recycling

- **Sources:** Factories, power plants, and manufacturing industries.
- **Uses:** Cooling processes, cleaning, and industrial operations.
- **Treatment Needed:** Advanced filtration, chemical treatment, and desalination if needed.

Perspective on recycle and reuse

Rainwater Harvesting & Reuse

- Sources: Collected rainwater from rooftops and open areas.
- Uses: Drinking (with filtration), irrigation, toilet flushing, and industrial use.
- Treatment Needed: Filtration and disinfection (depending on end use).

Waste water reclamation

- **Wastewater reclamation** is the process of treating and repurposing wastewater for beneficial uses, such as irrigation, industrial processes, and even drinking water.
- **Purpose:** Reduces water scarcity, minimizes pollution, and promotes sustainable water management.

Perspective on recycle and reuse

Methods of Water Recycling & Treatment

- Filtration Systems – Removes sediments and impurities.
- Biological Treatment – Uses bacteria to break down organic matter.
- Reverse Osmosis (RO) – Removes dissolved salts and contaminants.
- UV & Chlorination Disinfection – Kills harmful microorganisms.

Sources of Wastewater for Reclamation

- **Municipal Wastewater:** From households, offices, and commercial buildings.
- **Industrial Wastewater:** From factories, power plants, and production facilities.
- **Stormwater Runoff:** Collected from urban areas and treated for reuse.
- **Agricultural Wastewater:** Runoff from farms that contains fertilizers, pesticides, and organic matter.

Waste water reclamation

Wastewater Reclamation Process

Primary Treatment (Physical)

- **Screening & Grit Removal:** Removes large debris, sand, and grease.
- **Sedimentation:** Settles heavier solids at the bottom for removal.

Secondary Treatment (Biological)

- **Activated Sludge Process:** Uses microorganisms to break down organic matter.
- **Trickling Filters & Biofilters:** Uses bacteria to further purify water.

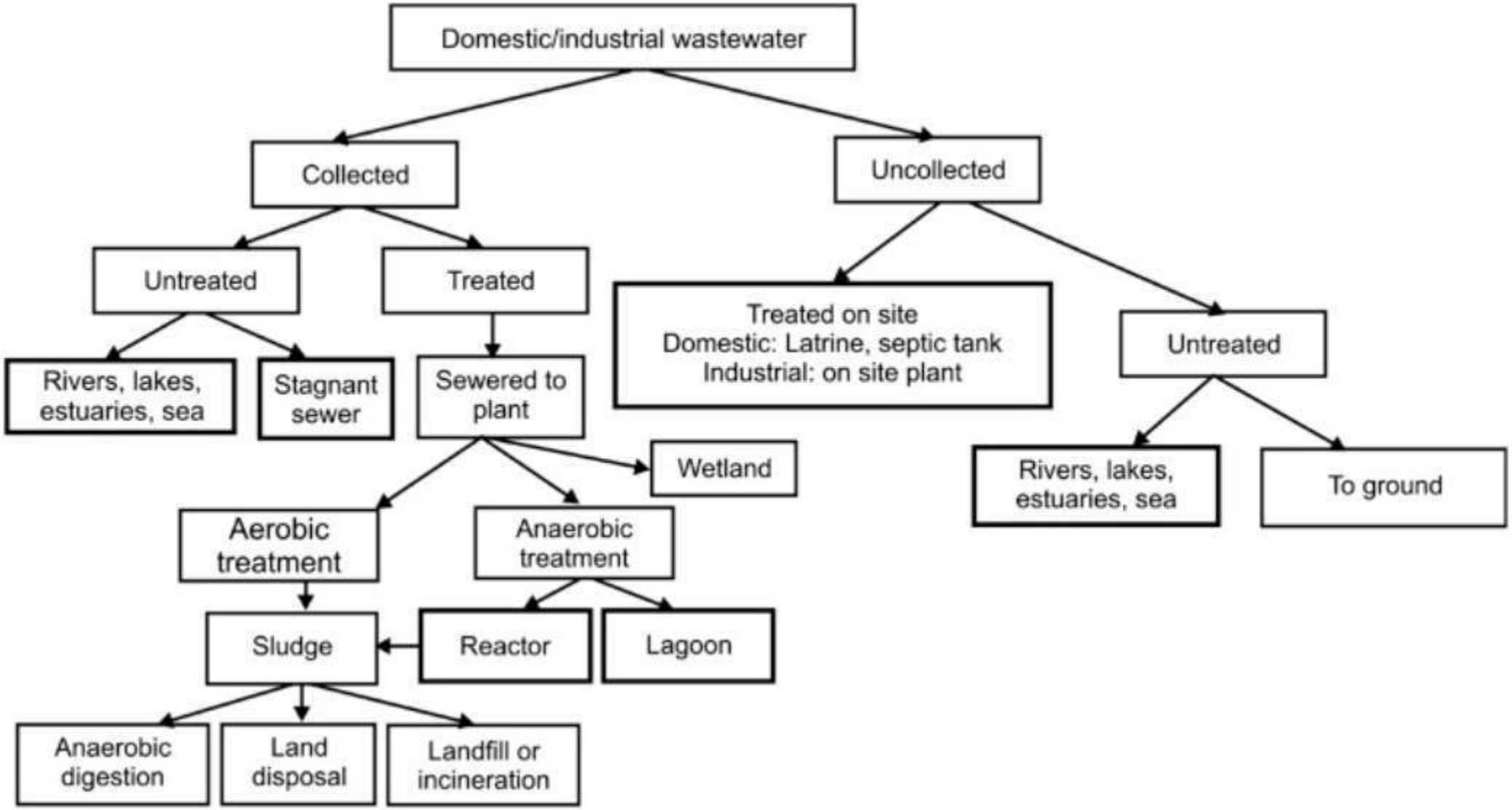
Waste water reclamation

Tertiary Treatment (Advanced)

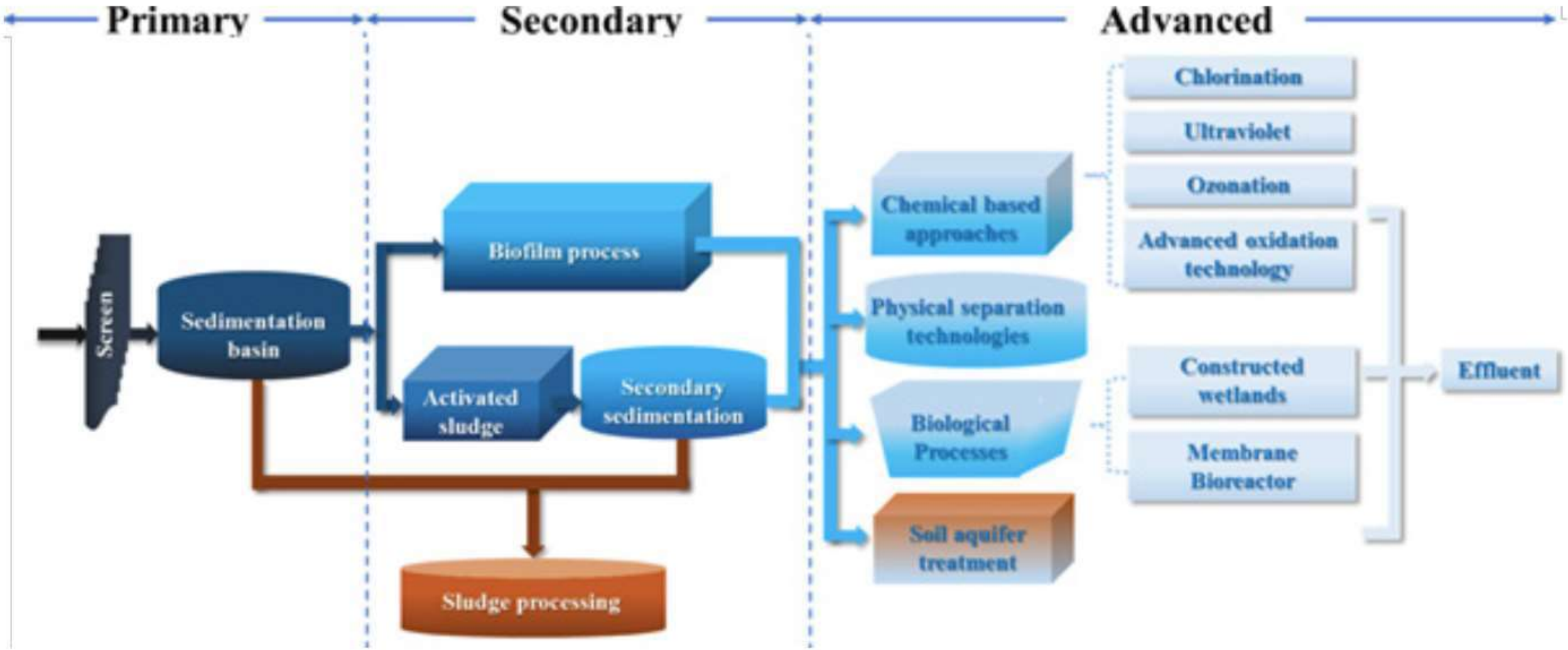
- **Filtration:** Removes fine particles using sand or membrane filters.
- **Disinfection:** Kills bacteria and viruses using chlorine, UV light, or ozone.
- **Reverse Osmosis (RO):** Removes dissolved salts and contaminants for high-purity water.

Applications of Reclaimed Water

- **Agricultural Irrigation:** Used for watering crops and landscapes.
- **Industrial Processes:** Used in cooling systems, boiler feedwater, and cleaning.
- **Potable Water Supply:** Advanced treatment allows safe drinking water production.
- **Environmental Restoration:** Enhances wetland ecosystems and groundwater recharge.

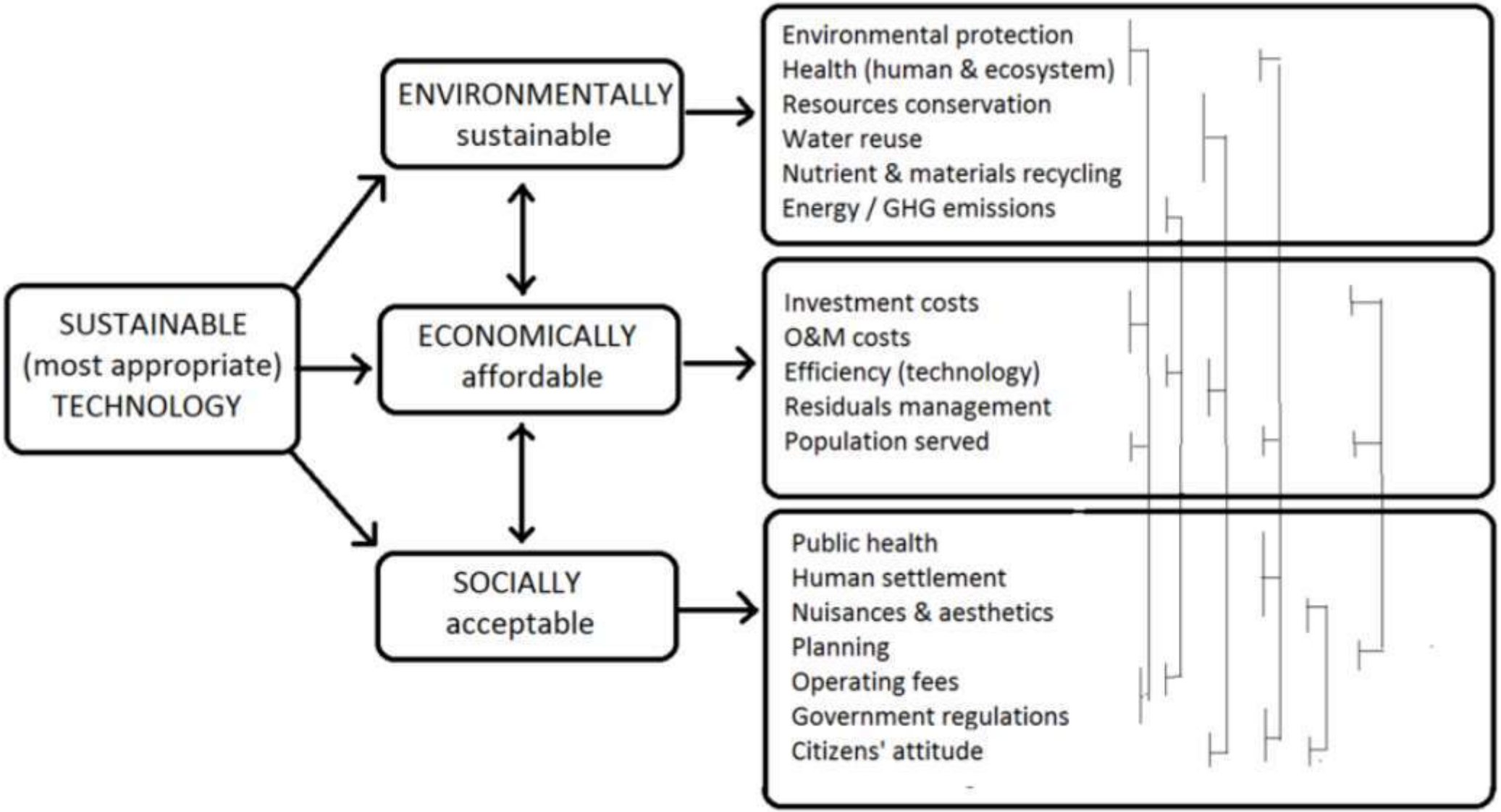


A typical flowchart of wastewater treatment process



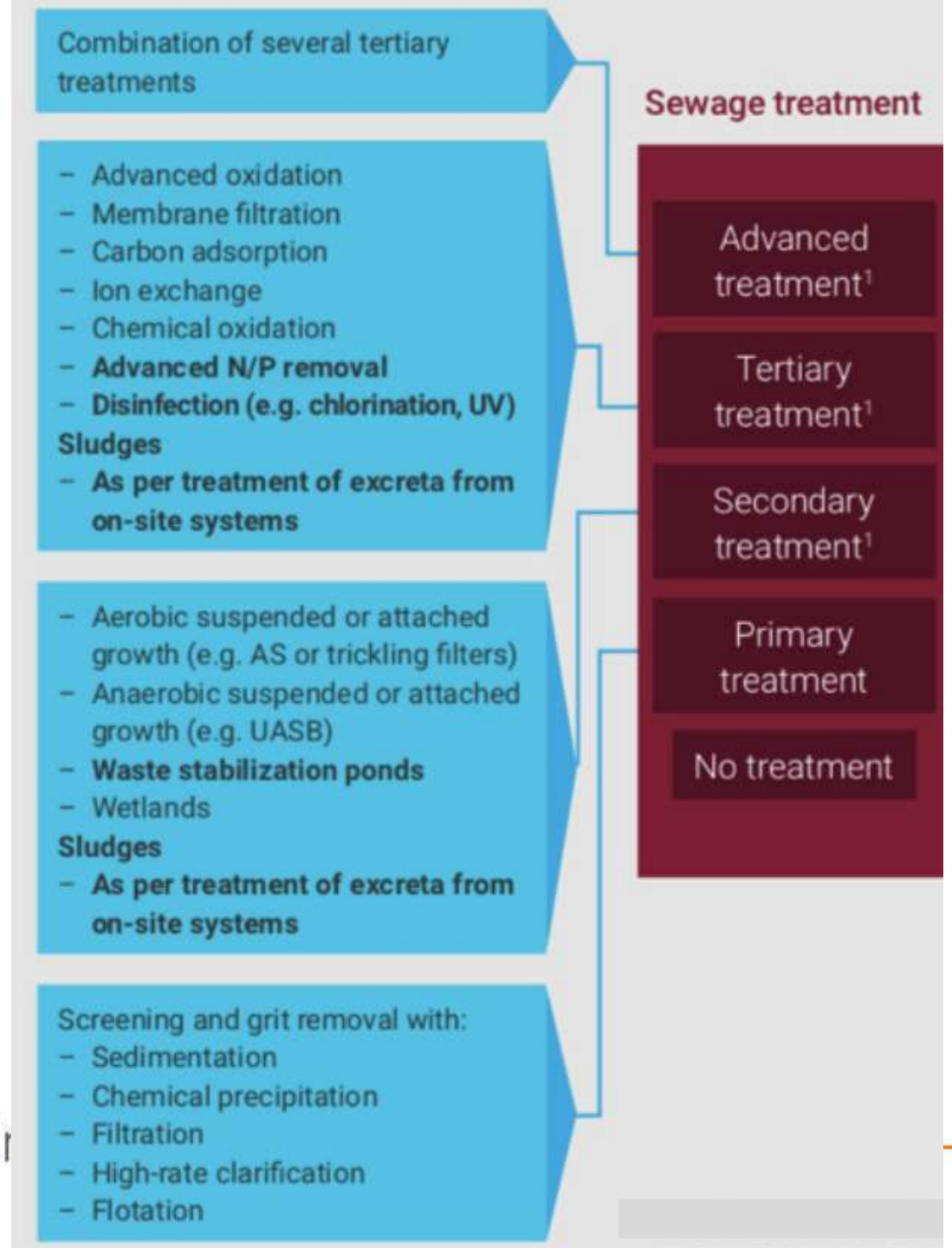
Primary, Secondary and Tertiary Treatment of Wastewater

Broad parameters for planning and design of wastewater infrastructure

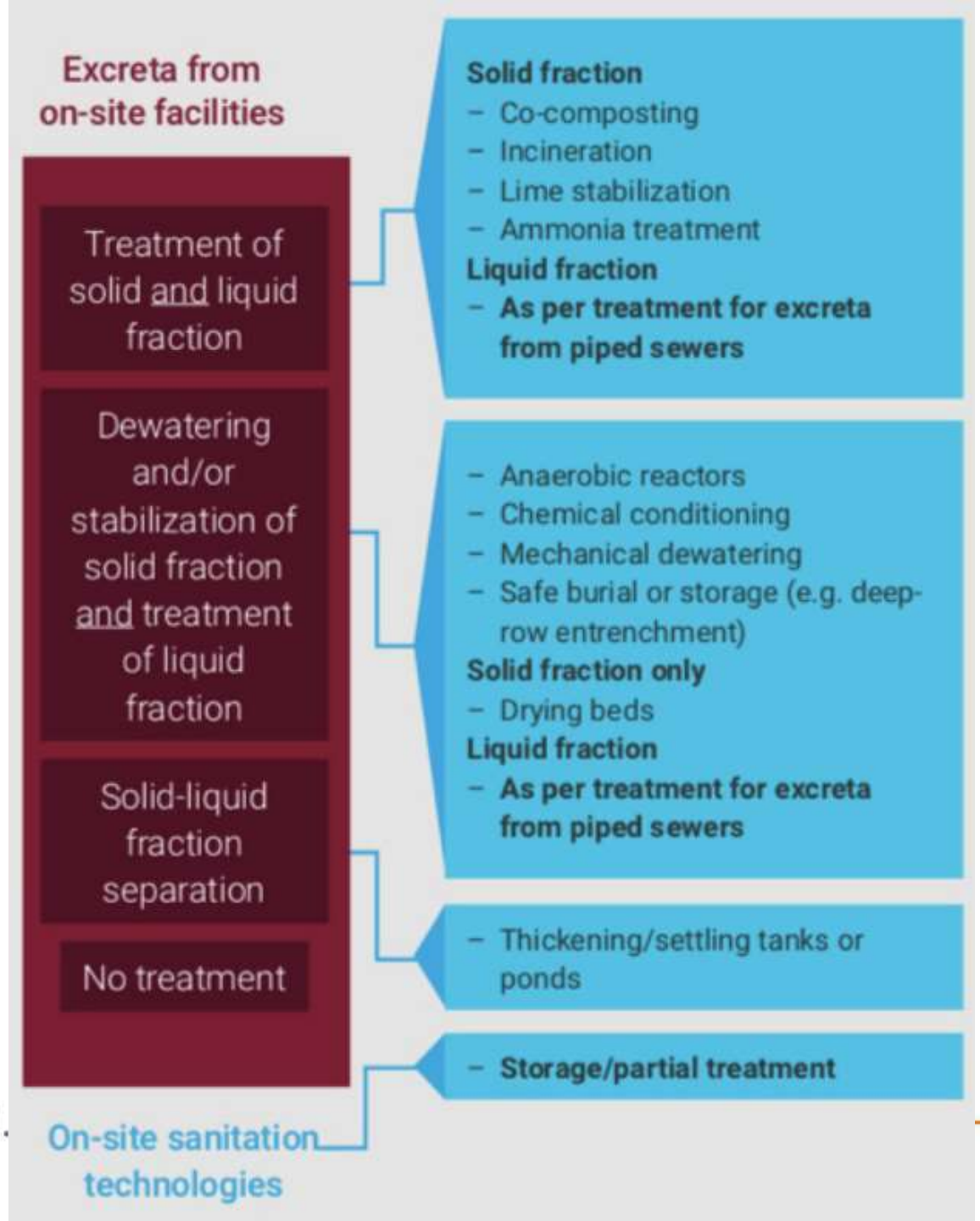


Parameters for selection of appropriate technology for wastewater treatment

Different type of technologies for wastewater treatment



Different type of technologies for wastewater treatment



Perspective on recycle and reuse

Future of Water Recycling & Reuse

- **Smart Water Systems:** AI-driven monitoring and automated filtration for efficient reuse.
- **Decentralized Treatment Plants:** On-site recycling systems for buildings and communities.
- **Innovative Technologies:** Membrane bioreactors, nanotechnology, and advanced desalination.
- **Policy & Awareness:** Government incentives and public education to promote reuse practices.

RWH Techniques- in Rural Areas

Check Dams & Percolation Tanks

- **Method:** Small dams built across streams to slow water flow and increase percolation.
- **Uses:** Supports agriculture and enhances groundwater recharge.

Farm Ponds & Tanks

- **Method:** Large pits dug in fields to store rainwater for irrigation and livestock use.
- **Uses:** Provides water security for farmers during dry periods.

Borewell & Dug Well Recharge

- **Method:** Directing rainwater into abandoned or functional borewells to replenish underground reserves.
- **Uses:** Maintains well water levels for drinking and irrigation.

Contour Bunding & Trenches

- **Method:** Constructing small embankments along land contours to capture rainwater.
- **Uses:** Prevents soil erosion, improves soil moisture, and aids crop growth.

RWH Techniques- in Urban Areas

RWH Techniques- in Urban areas

RWH in urban areas focus on **storage and flood control**, while rural areas emphasize **groundwater recharge and irrigation support**.

Rooftop Rainwater Harvesting (RRWH)

- **Method:** Collecting rainwater from rooftops through pipes and directing it to storage tanks or recharge pits.
- **Uses:** Drinking (after treatment), domestic use, toilet flushing, and irrigation.

Recharge Wells & Pits

- **Method:** Excess rainwater is diverted into recharge wells or percolation pits to replenish groundwater.
- **Uses:** Reduces urban water shortages and enhances groundwater levels.

RWH Techniques- in Urban areas

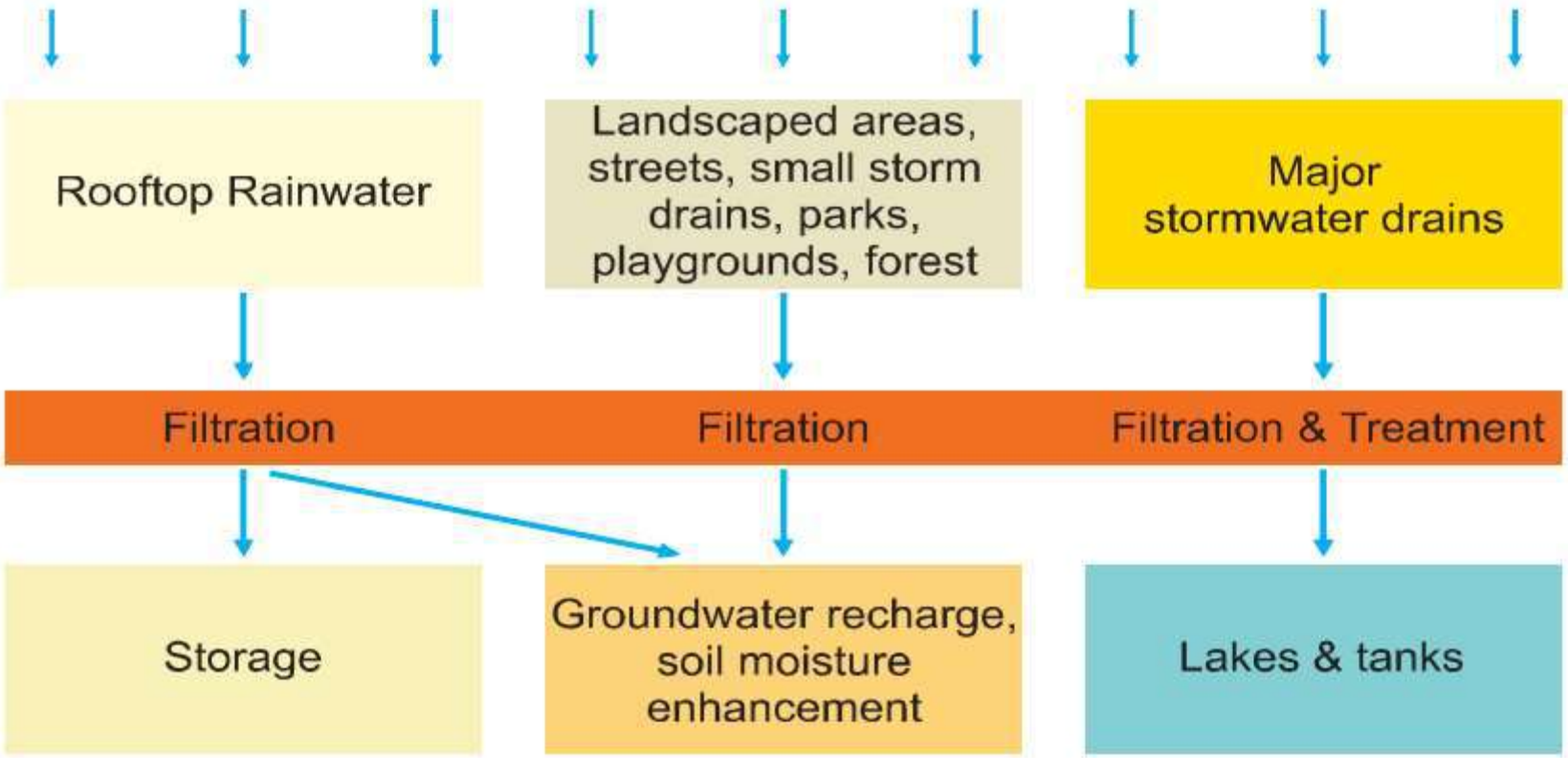
Stormwater Harvesting

- **Method:** Capturing runoff from roads, pavements, and open spaces, and directing it to treatment and storage systems.
- **Uses:** Reduces urban flooding, supports landscaping, and recharges aquifers.

Rain Gardens & Permeable Pavements

- **Method:** Specially designed landscapes and pavements that allow rainwater infiltration instead of surface runoff.
- **Uses:** Enhances urban greenery, reduces flooding, and improves groundwater recharge.

RWH Techniques- in Urban areas



Schematic representation of a RWH system in an urban area.

Case Studies on Rainwater Harvesting

Urban Case Study: Chennai, India

Chennai, the capital of Tamil Nadu, is one of India’s largest metropolitan cities. It has faced severe **water shortages** due to rapid urbanization, over-extraction of groundwater, and inconsistent rainfall.

To combat this crisis, the **government made rooftop rainwater harvesting (RRWH) mandatory** in 2003, leading to significant improvements in the city's water security.

Urban Case Study: Chennai, India

Challenges Faced by Chennai

- **Depleting Groundwater Levels** – Over-extraction led to drying wells and saltwater intrusion.
- **Urban Water Crisis** – Dependence on external water sources like tankers and desalination plants.
- **Flooding & Water Wastage** – Heavy rainfall often resulted in urban flooding due to poor drainage.
- **Growing Population & Water Demand** – Increased demand strained existing resources.

Rainwater Harvesting Initiative

I. Government Policy (2003 Mandate)

- **Mandatory RWH in All Buildings:** Every household, apartment, and commercial building had to install a rainwater harvesting system.
- **Financial Support & Awareness:** Public awareness campaigns and financial incentives encouraged adoption.
- **Strict Monitoring & Enforcement:** The Chennai Municipal Corporation ensured compliance through inspections.

Urban Case Study: Chennai, India

II. Rainwater Harvesting Techniques Used in Chennai

1. Rooftop Rainwater Harvesting (RRWH)

- Collected rainwater from rooftops and directed it to underground sumps or recharge pits.

2. Recharge Wells & Percolation Pits

- Allowed excess water to percolate into the ground, increasing groundwater levels.

3. Stormwater Drain Diversion

- Rainwater from streets was redirected to recharge structures instead of draining into the sea.

4. Temple & Public Building RWH Systems

- Historic temple tanks were revived to store rainwater and recharge groundwater.

4. Impact of Rainwater Harvesting in Chennai

- **Increase in Groundwater Levels:** Post-implementation, groundwater **levels rose by 50%** in some areas.
- **Reduced Urban Water Crisis:** Dependence on external water sources reduced significantly.
- **Better Flood Management:** Excess rainwater was captured, reducing urban flooding.
- **Improved Public Participation:** Citizens became more aware of water conservation methods.

Future Improvements

- **Mandatory RWH policies** can effectively tackle urban water shortages.
- Public awareness and **government support** are crucial for **large-scale adoption.**
- Regular **maintenance of RWH systems** is necessary for long-term efficiency.
- **Integration with modern technologies** (smart water meters, IoT sensors) can further optimize water management.

Rural Case Study: Ralegan Siddhi, Maharashtra, India

- Ralegan Siddhi, a small drought-prone village in Maharashtra, transformed itself from **water scarcity and poverty** to a model of **sustainable water management** through community-led rainwater harvesting and watershed development.
- Led by **Anna Hazare**, the village adopted water conservation techniques that restored groundwater levels and improved agriculture.

Challenges Faced by Ralegan Siddhi

- **Severe Water Shortages** – The village faced frequent droughts and drying wells.
- **Degraded Land & Soil Erosion** – Uncontrolled runoff led to poor soil fertility and low agricultural yield.
- **Groundwater Depletion** – Over-extraction and lack of recharge systems reduced groundwater levels.
- **Poverty & Migration** – Lack of water resulted in poor farming conditions, forcing migration to cities.

Rainwater Harvesting & Watershed Development Initiatives

Check Dams & Percolation Tanks

- Constructed small earthen and cement dams across streams to slow water flow and increase percolation.
- Helped store monsoon runoff, allowing gradual groundwater recharge.

Contour Bunding & Trenching

- Built small embankments along land contours to trap rainwater.
- Prevented soil erosion, improved soil moisture, and enhanced crop growth.

Farm Ponds & Well Recharge Systems

- Dug ponds on farmlands to collect rainwater for irrigation and livestock use.
- Abandoned wells were revived by directing rainwater into them for groundwater recharge.

Afforestation & Sustainable Agriculture

- Planted thousands of trees to restore the ecological balance.
- Encouraged organic farming and water-efficient irrigation methods.

Impact of Rainwater Harvesting in Ralegan Siddhi

- **Groundwater levels** increased significantly, making wells functional year-round.
- **Agriculture flourished**, with farmers growing multiple crops instead of relying only on rain-fed farming.
- **Soil fertility improved**, reducing dependency on chemical fertilizers.
- **Livelihoods improved**, and migration to cities decreased.
- **The village** became self-sufficient in water and food production.

Rural Case Study: Ralegan Siddhi, Maharashtra, India

Lessons Learned & Future Scope

- **Community participation** is essential for successful rural water conservation projects.
- **Low-cost, traditional rainwater harvesting** methods can be highly effective.
- **Watershed management** should be integrated with afforestation for long-term sustainability.
- **Other drought-prone** villages can replicate this model to achieve water security.

Maintenance and monitoring of Rainwater Harvesting Structures

Maintenance and monitoring of Rainwater Harvesting Structures

- Proper **maintenance and monitoring** of Rainwater Harvesting (RWH) systems ensure **efficient operation, water quality, and long-term sustainability**.
- Neglecting maintenance can lead to contamination, clogging, and system failure.

Maintenance of Rainwater Harvesting Structures

Key Components Requiring Maintenance

- Catchment Area (Rooftops, Pavements, etc.)
- Conveyance System (Pipes, Gutters, Filters)
- Storage Tanks & Sumps
- Recharge Wells & Pits
- Filtration & Treatment Systems

Maintenance of Rainwater Harvesting Structures

Catchment Area Maintenance

- **Cleaning:** Regular removal of dirt, leaves, and bird droppings.
- **Roof Inspection:** Check for cracks, leaks, or contaminants.

Conveyance System Maintenance

- **Gutter & Pipe Cleaning:** Remove debris, algae, and blockages.
- **Leak Detection:** Check for cracks or leaks in pipes.

Maintenance of Rainwater Harvesting Structures

Storage Tank Maintenance

- **Cleaning & Desilting:** Remove sediment buildup at least once a year.
- **Algae & Biofilm Prevention:** Ensure tanks are covered and shaded.
- **Overflow System Check:** Ensure proper drainage to prevent overflow damage.

Maintenance of Rainwater Harvesting Structures

Filtration System Maintenance

- **Screen & Mesh Cleaning:** Clean first-flush diverters and inlet screens.
- **Filter Replacement:** Change activated carbon or sand filters regularly.

Recharge Structure Maintenance

- **Desilting of Recharge Pits:** Prevents clogging and maintains infiltration efficiency.
- **Regular Water Flow Checks:** Ensure proper percolation into groundwater.

Monitoring of Rainwater Harvesting Structures

4. Monitoring of RWH Systems

Water Quality Monitoring

- **Physical Tests:** Check for colour, odour, and turbidity.
- **Chemical Tests:** Monitor pH, hardness, and contamination levels.
- **Microbiological Tests:** Periodically test for bacteria (E. coli, coliforms).

Monitoring of Rainwater Harvesting Structures

Structural Integrity Checks

- Inspect tanks, wells, and pipes for cracks and leaks.
- Ensure no stagnation or waterlogging occurs.
- Confirm first-flush systems function correctly to divert initial dirty rainwater.

C. Data Logging & Smart Monitoring

- Install water meters to track usage and recharge efficiency.
- Use IoT-based sensors for real-time monitoring of water levels and quality.
- Keep a logbook of maintenance activities and test results.

Monitoring of Rainwater Harvesting Structures

Common Issues & Troubleshooting

Issue	Cause	Solution
Water contamination	Unclean roof/tank, algae growth	Regular cleaning, install UV filters
Low water collection	Clogged gutters or pipes	Clean and check for blockages
Tank overflow	Poor drainage system	Ensure proper overflow outlet
Recharge pit clogging	Excess silt and debris accumulation	Regular desilting and maintenance

Thank You