Water Supply Engineering

Chapter 3

Quantity of Water

Lecture 3 (Week 3)

Quantity of Water ,Per capita demand of water ,Design and base periods ,Typical design and base periods ,Selection basis ,Design and base years, Types of water demand and Total water demand

Lecturer: Asst. Prof. Sunil Rakhal

Learning Objectives

By the end of this lesson, students will be able to:

- Understand and appreciate the per capita water demand and the determinants
- Comprehend design and base periods, their selection criteria, and significance.
- Identify and differentiate various categories of water demand
- Assess the impact of losses and wastage on overall water demand.

3. Quantity of Water

Quantity of water refers to the amount of water required for various uses, including domestic, industrial, commercial, municipal, and emergency purposes. The measurement of water demand must be exact while designing an efficient water supply system.

Importance of Determining the Quantity of Water

When designing a water supply system, accurately determining the required quantity of water is crucial for ensuring an efficient, reliable, and sustainable supply. Below are the key reasons why this is important:

1. Meeting Consumer Demand

- A well-planned system ensures that all users receive an adequate water supply for domestic, industrial, commercial, agricultural, and municipal needs.
- Helps avoid shortages that could disrupt daily life and business activities.
- Ensures future demand is accounted for as populations and industries grow.

2. Proper Infrastructure Planning

- The size of pipelines, storage reservoirs, pumping stations, and treatment plants depends on the estimated water demand.

- Prevents oversized systems (which are costly to build and maintain) or undersized systems (which fail to meet demand).
- Ensures proper pressure and flow rates throughout the distribution network.

3. Sustainable Management of Water Resources

- Prevents excessive withdrawal of natural water sources such as rivers, lakes, and groundwater, which can lead to depletion and damage to the environment.
- Fosters efficient utilization of water, and conserves water usage.
- Helps in planning alternative sources of water, if required.

4. Readiness in Case of Emergency and Fire

- Maintains sufficient water reserve for protection against fires.
- Helps design systems that can handle peak demand periods, such as hot summer months when usage increases.
- Aids in planning for droughts and emergency situations, ensuring a resilient water supply.

5. Cost Efficiency and Economic Planning

- Reduces wasteful water loss by optimizing supply based on demand.
- Helps determine fair pricing and tariffs for consumers, ensuring an economically viable water supply system.
- Avoids unnecessary investment in oversized infrastructure, reducing operational costs.

6. Wastewater Management and Treatment Planning

- A proper estimation of water usage helps in designing efficient sewage and wastewater treatment plants.
- Prevents overloading of treatment plants, ensuring effective water recycling and reuse.
- Reduces environmental pollution by ensuring proper handling of wastewater.

Conclusion

Right water quantity in a water supply system is a vital factor to make it efficient, sustainable, and reliable. This will also enable proper design for infrastructure, save resources, minimize costs, and prepare for emergencies. The correct estimation of quantity ensures the safe and sufficient availability of water to the present and future generations.

3.1 Per capita demand of water

Per capita demand is the amount of water required per person per day. It is usually expressed in **liters per capita per day (LPCD)**.

Factors Affecting Per Capita Demand:

1. **Climate:** Hot and dry regions have higher water consumption.
2. **Standard of Living:** Urban areas with modern amenities require more water.
3. **Availability of Water:** Easy access leads to higher consumption.
4. **Industrialization:** More industries increase overall water demand.
5. **Fire Protection Requirements:** Cities with fire hydrants need additional water.
6. **Water Wastage:** Poor plumbing and leakage increase demand.

3.2 Design and base periods

Design Period:

- The number of years for which a provision is made to meet the demand while planning and designing a water supply project is called design period.
- Low design period is adopted if population growth rate of a community is high.
- Design period must neither be low nor high.

Base period:

- The period required for the survey, design and construction of a water supply system is known as base period.
- The base period of 2 to 3 years is normally adopted for a water supply system.

3.2.1 TYPICAL BASE AND DESIGN PERIODS

COMMUNITY	BASE PERIOD YEARS	DESIGN PERIOD YEARS
Rural water supply system with low population growth rate	2-3	20
Rural water supply system with high population growth rate	2-3	15
Urban water supply system	2-3	up to 30

3.2.2 Base Year

- The year in which water is delivered to the community by a water supply system after the completion of its construction is known as base year.

- The base year depends on the year in which survey work of the water supply system is carried out and the base period.
- Base year is expressed as:

Base year= survey year+ base period

3.2.3 Design Year

- The year for which water supply is designed is known as design year.
- The sizes and capacities of all the water supply system components will be calculated for the design year.
- Design year is expressed as:

Design year= base year+ design period

3.2.4 Selection Basis For Design Period

1. Population Growth Rate

- depends not only on natural birth and death but also migration of people from other areas. The shorter design period should be considered if population growth rate is high and vice versa

2. Development of community

- Rapid development leads to high population growth hence shorter design period must be selected.

3. Useful life of component structures

- depends on the type and quality of the materials used in the construction. Designed period should not be greater than life of the component

4. Availability of funds

- If the fund available is limited, then system with less capacity should be designed and constructed. Consequently, shorter design period will be the selection. But if fund is sufficiently available, then longer design period should be preferred.

5. Rate of interest on borrowings

- If the money to be borrowed is available at a very low rate of interest, then a longer design period should be justified.

6. **Availability of water at source**

- If the water available at the source is limited, then design period should be shorter and vice-versa.

Conclusion

The selection of the design period for a water supply system is a balance between technical durability, economic feasibility, population growth, and environmental considerations. A well-chosen design period ensures that the system remains efficient, cost-effective, and sustainable for future generations.

3.3 Types of water demand

3.3.1 Domestic Demand

- Water used in private residence for drinking, cooking, bathing, washing, gardening etc.
- Domestic Demand of Water usually relies on the living condition of the consumer.

The domestic water demand in Nepal is generally taken as:

- 112 lpcd for fully plumbed houses;(urban area)
- 65 lpcd for partly plumbed houses;(semi urban)

- 45 lpcd for rural areas served by public stand posts; (Kansakar, 2015)

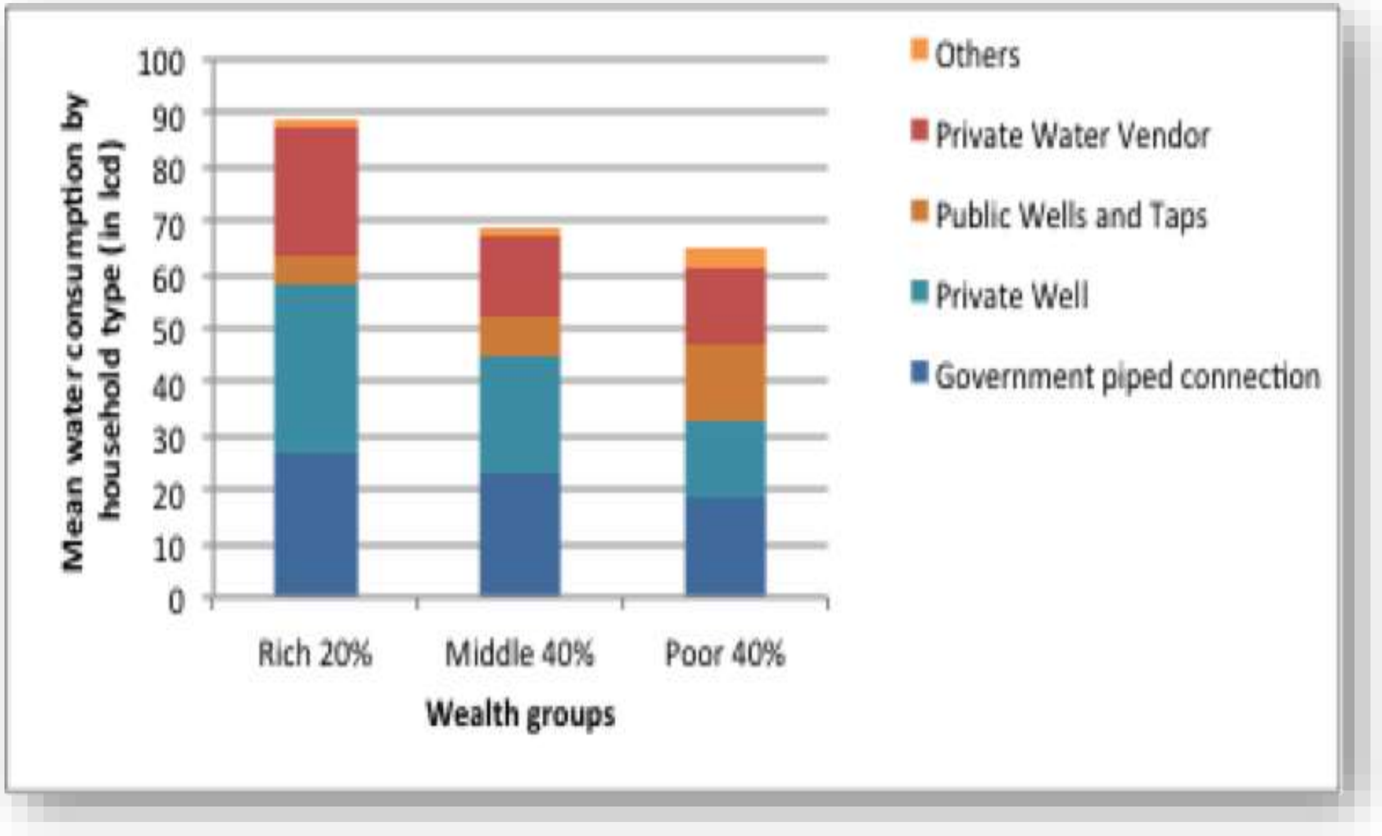

Figure 1:Water Consumption vs Wealth groups

(Source: globalwaterforum.org)

High Consumption Countries

These countries have a high per capita water consumption, often due to larger homes, extensive irrigation, industrial use, and higher living standards.

1. **United States** – The average person uses **80-100 gallons per day**, equivalent to approximately **302-378 liters per person per day (l/p/d)**. High usage is attributed to household appliances, agricultural needs, and industrial demands.
2. **Japan** – Average consumption stands at **400 l/p/d**, with significant usage in hygiene and industrial applications.
3. **Australia** – Australians consume about **340 l/p/d**, primarily due to a hot climate, water-intensive lifestyles, and extensive agricultural activities.
4. **Canada** – Canadians use an average of **250 l/p/d**, with large amounts directed toward heating, sanitation, and industrial purposes.

Source:(urbananalysis.wordpress.com, 2013)

Moderate Consumption Countries

These nations have moderate water usage, often balancing resource availability with efficiency measures.

1. **European Union** – The average water consumption is around **121 l/p/d**, with some variation between member states.
2. **Sweden** – Average consumption is **200 l/p/d**, reflecting a balance between conservation policies and comfortable living standards.
3. **China** – The world's most populous country uses **170 l/p/d**, influenced by rapid urbanization and industrialization.
4. **Brazil** – Brazilians consume around **200 l/p/d**, with agricultural irrigation contributing to overall demand.
5. **Germany** – Average consumption is **122 l/p/d**, reflecting strong water conservation measures.

6. **United Kingdom** – Residents use an average of **150 l/p/d**, with significant efforts to reduce household water waste.
7. **Singapore** – With limited freshwater resources, Singaporeans consume **151 l/p/d**, relying heavily on water reclamation and desalination.
8. **France** – Average consumption is **137 l/p/d**, with efficient public water management.
9. **Italy** – The average Italian uses **238 l/p/d**, influenced by domestic and agricultural usage.

Lower Consumption Countries

Lower consumption countries tend to have smaller economies, limited water infrastructure, or efficient conservation strategies.

1. **India** – Average water consumption is **135 l/p/d**, affected by regional disparities and limited access to clean water in rural areas.
2. **Lithuania** – Residents use **85 l/p/d**, benefiting from conservation practices.
3. **Poland** – Average water use stands at **98 l/p/d**, reflecting government conservation efforts.
4. **Hungary** – Consumption is **101 l/p/d**, indicating efficient water management.
5. **Czech Republic** – Czech citizens use **95 l/p/d**, showcasing strong sustainability policies.

Source:*(worldpopulationreview.com, 2025)*

Conclusion

- High consumption countries generally have **higher living standards, greater industrial use, and extensive agriculture.**
- Moderate consumption countries **balance availability and sustainability** through policies and public awareness.
- Lower consumption countries often have **restricted access to water or efficient conservation policies**.

Water is a finite resource, and global efforts should focus on **sustainable water management, conservation, and reducing wastage** to ensure equitable access for future generations.

3.3.2 Livestock demand

- It includes water consumed by domesticated animals.
- The livestock water demand depends on the type of domesticated animals.

(www.agric.wa.gov.au, n.d.)

Figure 2: Fullfilling the water demand by livestock

The livestock water demand in Nepal is generally taken as:

animals such as cows,buffalo, horses, etc.;	**45 litres/animal/day**
medium sized animals such as sheep, pigs, goats, dog,rabbit etc.;	20 litres/animal/day
birds such as chickens, ducks, etc.;	for 20 litres/100 birds/day

3.3.3 Commercial demand

- Includes the water demands for commercial establishments such as educational institutions, restaurants, offices, hospitals, etc.

Purpose	Quantity required
Day-scholar in educational institutions	10 liters/pupil/day
Boarders in educational institutions	65 liters/pupil/day
Offices	500-1000 liters/day
Hospitals with bed	500 liters/day/bed
Hospitals without bed and health clinics	2500 liters/day
Hotels with bed	200 liters/day/day /bed
For hotels without bed and resteraurents etc	500-1000 liters/day

- The demand for commercial purpose also depends entirely on the nature and purpose of the institutions. (Kansakar, 2015)

3.3.4 Public/municipal demand

- This includes the quantity of water that is required for public or municipal utility such as watering of public parks, cleaning of roads, cleaning sewers, etc.

(www.thehimalayntimes.com, 2018)

Figure 3: Water demand for Public Road

- A provision of 5-10% of the total consumption is made for this demand.
- This demand is considered for water supply system in urban communities only.

3.3.5 Industrial demand

- This includes the quantity of water that is required for the industrial purposes.
- A provision of 20-25% of total consumption is made for this purpose.

Figure 4: Water used by industries (source: (www.usgs.gov, n.d.)

3.3.6 Firefighting demand

- It is the quantity of water used for fire fighting purpose.
- It is mathematically determined using an empirical formula.
- It has been expressed as a function of population.

Some of the empirical formulae has been mentioned below:

1. **Indian Water Supply Manual and Treatment Formula**

where, Q = Quantity of Water required to meet fire demand in kilolitres/day

P = Population in thousands

$$Q = 100 \sqrt{P}$$

2. **Buston's Formula**

$$Q = 5663\sqrt{P}$$

where, Q = Quantity of Water required to meet fire demand in litres/min

P = Population in thousands

3. **Kuichling's Formula**

$$Q = 3182\sqrt{P}$$

where, Q = Quantity of Water required to meet fire demand in litres/min

P = Population in thousands

4. **Freeman's Formula**

$$Q = 1136\left(P/5 + 10\right)$$

where, Q = Quantity of Water required to meet fire demand in litres/min

P = Population in thousands

5. **National Board of Fire Underwriters' Formula**

$$Q = 4637\sqrt{P}\left(1-0.01\sqrt{P}\right)$$

where, Q = Quantity of Water required to meet fire demand in litres/min

P = Population in thousands

3.3.7 Loss and Wastage

- Includes water lost due to leakage in mains, valves, and other fittings, damaged water meters, unauthorized water connections, etc.
- The quantity of water lost cannot be precisely determined however proper maintenance and supervision is to be done to minimize this effect.
- While doing so, the losses may hardly exceed 15% of the total water supply.

3.3.8 Total water Demand

It is the sum of all water demands.

$$DD + LD + CD + PD + ID + FD + LW = TWD$$

where, TWD = Total water Demand,

DD = Domestic Demand,

LD = Livestock Demand,

CD = Commercial Demand,

PD = Public Demand, ID = Industrial Demand,

FD = Fire Demand, LW = Loss and Wastage.

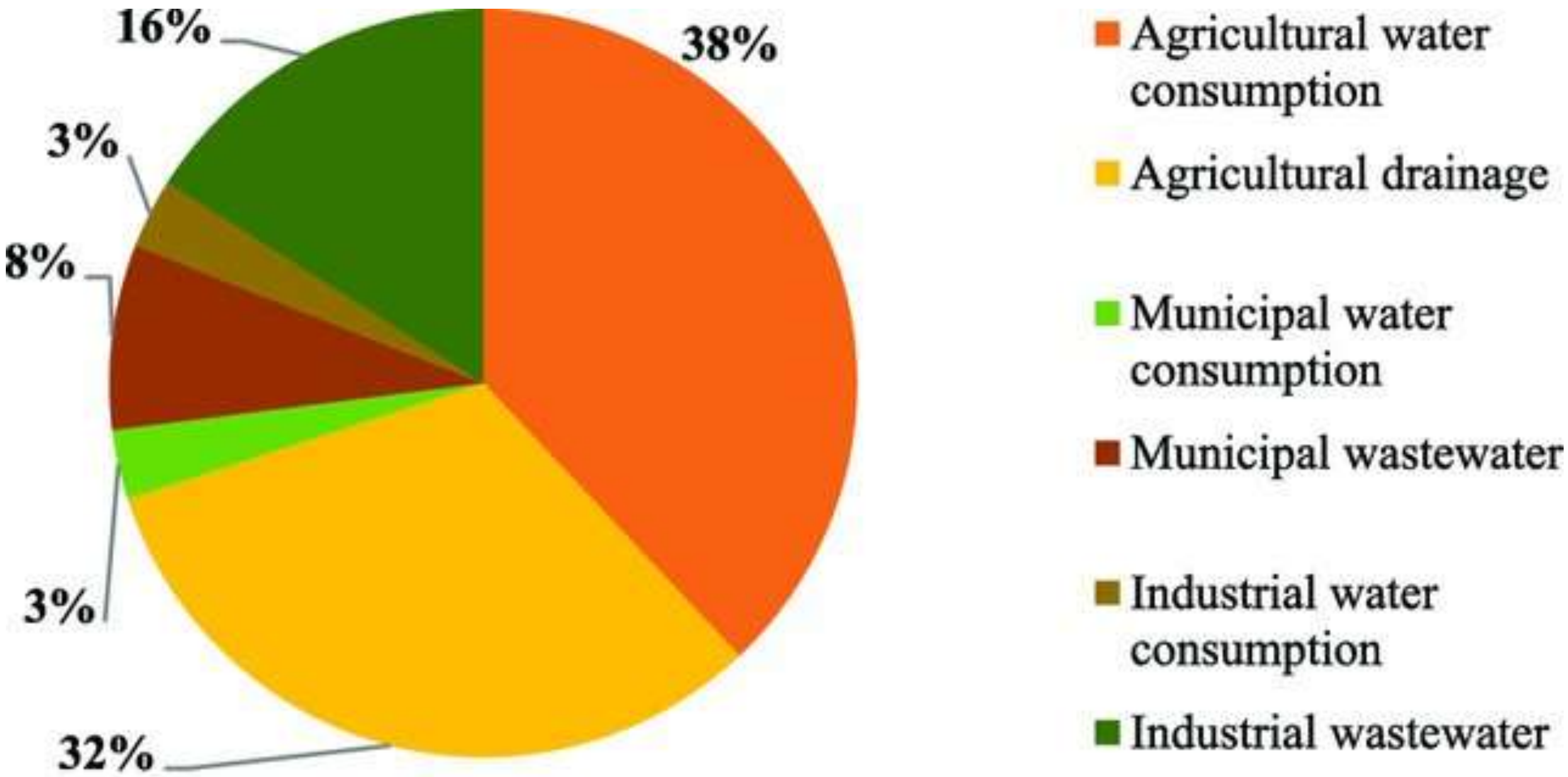

Figure 5: Total water consumption in sector wise

(Research gate , n.d.)

Works Cited

1. (n.d.). Retrieved from globalwaterforum.org.
2. (n.d.). Retrieved from www.agric.wa.gov.au: https://www.agric.wa.gov.au/small-landholders-western-australia/calculating-livestock-water-requirements-small-landholders
3. (2025,0402).Retrieved from worldpopulationreview.com: https://worldpopulationreview.com/country-rankings/water-consumption-by-country
4. Kansakar, D. B. (2015). *water supply engineering*. kathmandu: Prakash Man Shakya.
5. *Research gate* . (n.d.). Retrieved from www.researchgate.com
6. *urbananalysis.wordpress.com*. (2013, 12 22). Retrieved from www.urbananalysis.wordpress.com/: https://urbananalysis.wordpress.com/water-2/1-3-per-capita-water-consumption/

Thank You!!!