UNIT 4  WATER: COMPETITIVE USES

Structure

4.0 Introduction
4.1 Objectives
4.2 Water Resources and Economic Development: Challenges
4.3 Water: Availability vs. Demand
   4.3.1 Availability
   4.3.2 Competitive Uses and Increasing Demand
   4.3.3 Water Scarcity Scenario
4.4 Dynamics of Water Use: Spatial and Temporal
4.5 Sharing of Water Resources between Communities and Nations
   4.5.1 Equitable Access and Partnership to Conserve Shared Water
   4.5.2 Conflicts Arising due to Water Resource Sharing
4.6 Climate Change and Water Resources of the World
4.7 International Efforts to Conserve Water and to Protect its Quality
4.8 Individual and Community Level Efforts Required to Conserve Water
4.9 Water Resources of India: Status, Use and Management
4.10 Let Us Sum Up
4.11 Key Words
4.12 References and Suggested Further Readings
4.13 Key to Check Your Progressive

4.0 INTRODUCTION

Earth is composed largely of water, but freshwater comprises only 3% of the total water available to us, of that, only 0.06% is easily accessible. As human populations continue to expand and an increasing number of people use finite resources, future availability of adequate supplies of freshwater for human and agricultural needs may become critical in many regions. According to the United Nations Population Fund (UNFPA, 2005), while the global population tripled over the past 70 years, the water use has grown six fold, a result of industrial development and expansion of irrigation. Even as demand for water by all users grows, groundwater is being depleted, other water ecosystems are becoming polluted and degraded, and developing new sources of water is becoming more costly.

So all that needs to be addressed by the water sector today in order to promote sustainable and equitable water management. Many of these challenges are interconnected, requiring integrated and holistic solutions.

4.1 OBJECTIVES

After reading this unit, you will be able to:

• describe the impact of economic development on global water resources;
• underline the individual, national and international efforts and conflicts regarding water sharing and conservation throughout the world;
• recognise the impacts of climate change on water resources; and
• discuss the conservation methods options from our ancient civilizations till today for water conservation.

4.2 WATER RESOURCES AND ECONOMIC DEVELOPMENT: CHALLENGES

There have been three major drivers to the enormous expansion of water resources infrastructure in the past century: (1) population growth; (2) changing standards of living and (3) expansion of irrigated agriculture. All these factors have increased dramatically. Between 1900 and 2000, the population of the world has grown from 1.600 million to 6.000 million people. Land under irrigation increased from around 50 million hectares at the turn of the century to over 267 million hectares today. These factors other factors have led to a nearly seven fold increase in freshwater withdrawals. Rapid population growth and increased water consumption are quickly depleting the available water and also degrading water quality. Demand for water will surpass accessible water by 2014 (at around 10,000 cubic Km/yr). It is said that actual consumption is lower than demand because water sources may be inaccessible to population centers. Consumption will be forced to level off by 2030 due to limits on accessible water (refer to Fig 4.1). Many factors significantly impact the increasing water demand, including population growth, economic growth, technological development, land use and urbanization, rate of environmental degradation, government programs, climate change, and others. In 1990, 43.5% of the world’s population lived in urban areas by 2000 the proportion had grown to 47%. Simultaneously business activity ranging from industrialization to services such as tourism and entertainment continues to expand rapidly. This expansion requires increased water services including both supply and sanitation, which can lead to more pressure on water resources and natural ecosystems.

Fig.4.1: Estimated global water demand and consumption
4.3 WATER: AVAILABILITY VS. DEMAND

Water availability, as well as the amount of water used, is a significant factor for social (and economic) activities. Various countries in the world are at different levels of demographic and economic development which may determine a region’s (country’s) vulnerability to water resources.

4.3.1 Availability

Water resource availability in different parts of the world varies significantly, in part due to the size of the country and in part as a result of differences in the natural conditions. Of all of the countries in the world, only 13 countries have water resources exceeding 500 km³. Most of these countries also have a large surface area. Many countries, particularly in Europe, Africa, and Middle East Asia, have a relatively small amount of water resources; the annual availability of water is less than 100 km³. Water supply in a country (region) consists of internal surface water, net inflow of surface water, and annual recharge of groundwater in its aquifers. On average, for the world as a whole, groundwater contributes roughly 29 percent to the total world water supply.

Per capita water availability

On a per capita basis, the availability of water resources is different from the availability of total water resources. On average, we have 7,824 m³ of water for every individual inhabitant in the world. This water is available in plentiful quantities in the other Pacific region, the Southwest Pacific, Northern South America, and Southern South America.

However, the situation in Northern Africa, the Middle East region of Asia, and the Eastern Asian region is remarkably different. In these regions the availability of water on a per capita basis is less than 800 m³ per annum (Fig. 4.2).

![Fig.4.2: Per Capita Water Use, 2000 (cubic meters per year), Source: EarthTrends, 2007](image)
4.3.2 Competitive Uses and Increasing Demand

Recent estimates of water stocks and flows through the world’s hydrologic cycle and their spatiotemporal variability illustrate the nature of current and projected water disparities throughout the world (Fig. 4.3). Water is used for three major purposes - domestic, industrial, and agricultural. On average, in the world, we use almost 3,609 km³ of water annually or 9,888 m³ of water every day.

![Global Water Withdrawal and Consumption](image_url)

*Fig. 4.4: Water consumption pattern throughout the world*
4.3.3 Water Scarcity Scenario

One of the most pressing global issues currently facing mankind is the increase in world population and its impact on the availability of freshwater. Water resources are under increasing stress due to patterns of over exploitation, conflicts over rights, and broader anthropogenic environmental change. The quality and quantity of regional water resources are under stress due to increasing variability and scarcity, compounded by pressure on ground and surface water resources to meet intensified agricultural outputs and industrial needs. The water crisis would lead to a breakdown in domestic water service for hundreds of millions of people, a devastating loss of wetlands, serious reductions in food production and skyrocketing food prices, that would force declining per capita food consumption in much of the world.

While the world’s population tripled in the 20th century, the use of renewable water resources has grown six-fold. Within the next fifty years, the world population will increase by another 40 to 50%. This population growth coupled with industrialization and urbanization will result in an increasing demand for water and will have serious consequences on the environment. By 2025, 1.8 billion people will live in countries or regions with absolute water scarcity (Fig. 4.4). Most countries in the Middle East and North Africa can be classified as having absolute water scarcity today. By 2025, these countries will be joined by Pakistan, South Africa, and large parts of India and China. This means that they will not have sufficient water resources to maintain their current level of per capita food production from irrigated agriculture even at high levels of irrigation efficiency and also to meet reasonable water needs for domestic, industrial, and environmental purposes. To sustain their needs, water will have to be transferred out of agriculture into other sectors, making these countries or regions increasingly dependent on imported food. Many African countries, with a population of nearly 200 million people, are facing serious water shortages. By the year 2025, it is estimated that nearly 230 million Africans will be facing water scarcity, and 460 million will live in water-stressed countries.

Fig. 4.5: Global water scarcity scenario
4.4 DYNAMICS OF WATER USE: SPATIAL AND TEMPORAL

Knowledge about spatial dynamics of land use and its irrigation water use, under changing water availabilities helps in the determination of suitable solutions in finding the best way to allocate the scarce and strongly varying amount of available water. To get more knowledge about the spatial dynamics of agricultural land use and irrigation water use under different situations of water availability around strategic water reservoirs in the semi-arid regions of the world could be done by analyzing the aspects in a spatial way, using GIS and Remote Sensing-techniques, for a research area during a time frame.

1) Firstly a downscaling has to be carried out to areas of interest each mainly supplied by one source of water availability. Four aspects of water availability could be distinguished in the research area: rainfall, river discharges/reservoir releases, reservoir volumes and locally stored runoff. Each type of water availability is quantified for each area of interest.

2) Secondly the agricultural land use, as largest water user, has to be determined by applying a land cover classification to satellite images of each year.

3) Thirdly the irrigation water use of each area of interest in each dry season within the research period has to be estimated by using the Cropwat model, a model able to calculate crop irrigation requirements.

The results of these three components could be analyzed in an inter annual way (how are the components evolving during the research period in a particular area of interest) and in a spatial way (how do the components of different areas of interest influence each other during the research period. The analysis of the result will show that the different types of water sources have different spatial and temporal ranges and different water availabilities.

Check Your Progress 1

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) Write a note on the relation between economic development and water scarcity scenario.

........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
........................................................................................................................................
4.5 SHARING OF WATER RESOURCES BETWEEN COMMUNITIES AND NATIONS

More than 260 river basins, covering almost 50% of the earth’s land area are shared by at least two countries, making many countries dependent on the use of common water resources for national development. Unilateral action by any one country concerning international basins is often ineffective (fish ladders in an upstream country only), inefficient (hydropower development in a flat downstream country), or impossible (many developments on boundary stretches).

However, cooperation in managing transboundary water resources is the most effective way to harness this mammoth resource of fresh water. ‘Benefit sharing’ has been proposed as one approach to bypass the contentious issue of property rights. The idea is that, if the focus is switched from physical volumes of water to the various values derived from water use in multiple spheres, including economic, social, political, and environmental, riparians will correctly view the problem as one of positive outcomes associated with optimising benefits, rather than the zero outcomes associated with dividing water.

4.5.1 Equitable Access and Partnership to Conserve Shared Water

The case for sharing benefits is a compelling one. A river basin is a common pool resource, meaning that use of it by one riparian (or indeed individual) will necessarily diminish the benefits available to others. In other words, water use in one part of the basin creates external effects in other parts. If these externalities are not ‘internalised’, the overall benefits are reduced and the outcome is suboptimal. Thus, both hydrology and economics concur that a river basin should be treated as a single unit to maintain the physical integrity of the system and to internalise externalities. In the last decades of the past century, in global level, are registered phenomenon of violence between states regarding with transboundary waters. However, at the same time are recorded over 200 bilateral and multilateral agreements related to transboundary waters. Due to the importance of transboundary waters, the United Nations World Water Day (March 22nd, 2009) focused cross border waters topic entitled “Shared Water, Shared Opportunities.

4.5.2 Conflicts Arising due to Water Resource Sharing

Water is our right, but it is not a secured right. It is fraudulent for anyone to claim legitimate ownership of the air, the sea, or space itself. Yet we can see from historical events that these claims are inevitable. Water conflict is a term describing
a conflict between countries, states, or groups over an access to water resources. A wide range of water conflicts appear throughout history, though rarely are traditional wars waged over water alone. Instead, water has historically been a source of tension and a factor in conflicts that start for other reasons. However, water conflicts arise for several reasons, including territorial disputes, a fight for resources, and strategic advantage.

Water’s viability as a commercial resource, which includes fishing, agriculture, manufacturing, recreation and tourism, among other possibilities, can create dispute even, when access to potable water is not necessarily an issue.

Historically, fisheries have been the main sources of question, as nations expanded and claimed portions of oceans and seas as territory for ‘domestic’ commercial fishing. Certain lucrative areas, such as the Bering Sea, have a history of dispute; in 1886 Great Britain and the United States clashed over sealing fisheries, and today Russia surrounds a pocket of international water known as the Bering Sea Donut Hole.

Corporate interest often crosses opposing commercial interest, as well as environmental concerns, leading to another form of dispute. Water pollution poses a significant health risk, especially in heavily industrialized, heavily populated areas like China. The possibility of polluted water making it way across international boundaries, as well as unrecognized water pollution within a poorer country brings up questions of human rights, allowing for international input on water pollution. There is no single framework for dealing with pollution disputes local to a nation

4.6 CLIMATE CHANGE AND WATER RESOURCES OF THE WORLD

The effect of changing climate on water resources is one of the most difficult global environmental changes to assess. Problems arise because:

1) A changing climate may affect both availability and use.

2) A changing level of water availability would have an impact on water quality.

3) The distribution of climate induced impacts would differ significantly from region to region.

4) The available results of climate models are not consistent with their predictions.

Four attributes of climate change are particularly relevant in the context of regional vulnerability:

1) Changes in atmospheric variables, such as temperature, precipitation, and wind speed.

2) Inter year variability in precipitation and temperature, leading to extreme events such as droughts and floods.

3) Intra year variability in precipitation and temperature.

4) A rise in sea level.
The change in the atmospheric variables would affect the relationships that govern water needs, as well as river flow. Occurrences of droughts and floods can also alter a region’s water availability and demands. The IPCC, in cooperation with new partners, has begun to address this issue in addition to their more traditional focus on greenhouse gases and temperature changes. IPCC expert meeting (IPCC, 2004, p. 27) identified two issues related to water and the impacts from global warming: one related to impacts and the other to knowledge gaps. These two issues, as taken from the IPCC report, are as follows:

- The extreme event frequency and magnitude will increase even with a small increase in temperature and will become greater at higher temperatures.
- The impacts of such events are often large locally and could strongly affect specific sectors and regions. Increased extreme events can cause critical design values or natural thresholds to be exceeded, beyond which the impacts magnitudes increase rapidly.

Although climate change may be perceived as a long-term problem, it needs to be addressed now because decisions today will affect society’s ability to adapt to increasing variability in tomorrow’s climate. If we are to balance freshwater supply with demand, and also protect the integrity of aquatic ecosystems, a fundamental change in current wasteful patterns of production and consumption is needed. Recognition of the links between rapidly growing populations and shrinking freshwater supplies is the essential first step in making water use sustainable.

### 4.7 INTERNATIONAL EFFORTS TO CONSERVE WATER AND TO PROTECT ITS QUALITY

Authority for managing the world’s fresh water resources is fragmented amongst the world’s nations, hundreds of thousands of local governments, and countless non-governmental and private organizations, as well as a large number of international bodies. Management issues have been subjected to numerous studies and debates in the international arena to promote awareness, build political commitment and trigger action on critical water issues at all levels, including the highest decision-making level, to facilitate the efficient management and use of water in all its dimensions and on an environmentally sustainable basis.

In 1977, The Mar del Plata United Nations Conference on Water was the first and only intergovernmental conference devoted exclusively to water—a milestone in the history of water development. In 1980, it led the UN General Assembly to proclaim the Declaration of the International Drinking Water Supply and Sanitation Decade. In 1992, the idea of forming a world water council was first proposed in 1992 at the UN’s International Conference on Environment and Development in Dublin and at the Rio de Janeiro Earth Summit. Later on in 1994, The International Water Resources Association (IWRA) organized a special session on the topic in its Eighth World Water Congress held in Cairo in November 1994, which resulted in a resolution to create the World Water Council and a committee to accomplish the preparatory work for this task. Consensus was established around the need for the creation of a common umbrella organisation to unite the disparate, fragmented, and ineffectual efforts in global water management. In 1995, the Founding Committee of the World Water Council
was formed and convened its first meeting in Montreal, Canada, in March 1995, and again in Bari, Italy in September, 1995. These two meetings defined the mission and objectives of the World Water Council. Again in June 1996, the World Water Council was legally incorporated and its headquarters established in Marseille, France. In July 1996, the First Interim Board of Governors met in Grenada, Spain. In March 1997, the success of the First World Water Forum in Marrakech, Morocco, and the issuing of the Marrakech Declaration firmly established the leadership of the Council in water affairs. The World Water Council received the mandate to develop the World Water Vision for Life and Environment for the 21st Century. In September 1997, the First Meeting of the General Assembly of members of the World Water Council was held in Montreal, during the Ninth World Water Congress of the IWRA. The Constitution of the Council was approved and the members of the first Board of Governors were elected. Again in March 1998, the World Water Council, in cooperation with the Government of France, participated in organizing the International Conference on Water and Sustainable Development in Paris. In March 2000, the Second World Water Forum, was successfully held in the Netherlands. The results of the Vision were presented to some 5,700 participants from all parts of the world. The Ministerial Conference gathered 120 Ministers and resulted in the Declaration of the Hague on Water Security in the 21st Century. In March 2003, the Third World Water Forum took place in Kyoto, Shiga and Osaka, Japan. Following up on its commitments from the 2nd Forum, the WWC launched the World Water Actions report, an inventory of over 3,000 local water actions. This Forum was the largest water conference in history, gathering 24,000 participants. A Ministerial Conference was held in parallel and brought together 130 Ministers. Participants made hundreds of commitments to action, and each session organizer was asked to state, what concrete output would follow his or her respective session. In March 2006, the Fourth World Water Forum was held in Mexico City, gathering some 20,000 people from throughout the world who participated in 206 working sessions, under the theme “local actions for a global challenge”. In December 2010, the United Nations General Assembly declared the year 2013 as the United Nations International Year of Water Cooperation. As rapid urbanization, climate change and growing food needs put ever-increasing pressure on freshwater resources, the objective of the Year was to draw attention to the benefits of cooperation in water management.

4.8 INDIVIDUAL AND COMMUNITY LEVEL EFFORTS REQUIRED TO CONSERVE WATER

The daily action or inaction of each individual across the globe, has a continual and exponential effect on the earth’s ability to remain sustainable. The excess consumption of valuable natural resources occurring in developed countries has a direct impact on the growth and sustainability of underdeveloped countries. “Sustainable development encourages us to conserve and enhance our resource base, by gradually changing the ways in which we develop and use technologies. In developed nations the necessary effort that each of us puts forth to conserve water and prevent unnecessary waste can have immense financial and environmental impacts across the globe. Water is essential for everyone. We are sharing this precious water with all life on Earth. So we have to share the responsibility of keeping the water clean. A little bit of environmentally friendly behavior can make a difference. We must all keep Earth safe and clean for
everyone in the world and for our future generations. At community level Water conservation programs are typically initiated at the local level, by either municipal water utilities or regional governments.

4.9 WATER RESOURCES OF INDIA: STATUS, USE AND MANAGEMENT

Although India occupies only 3.29 million km² geographical area, which forms 2.4% of the world’s land area, it supports over 15% of the world’s population. The total utilizable water resources of the country are assessed as 1122 km³ (Fig. 4.5).

Precipitation pattern

India receives annual precipitation of about 4000 km³, including snowfall. Out of this, monsoon rainfall is of the order of 3000 km³. Rainfall in India is dependent on the south-west and north-east monsoons, on shallow cyclonic depressions and disturbances and on local storms. Most of it takes place under the influence of south-west monsoon between June and September except in Tamil Nadu, where it is under the influence of north-east monsoon during October and November. The annual potential natural groundwater recharge from rainfall in India is about 342.43 km³, which is 8.56% of total annual rainfall of the country.

Surface and Groundwater

India is gifted with a river system comprising more than 20 major rivers with several tributaries. Many of these rivers are perennial and some of these are seasonal. The rivers like Ganges, Brahmaputra and Indus originate from the Himalayas and carry water throughout the year. The snow and ice melt of the Himalayas and the base flow contribute the flows during the lean season.

Apart from the water available in the various rivers of the country, the groundwater is also an important source of water for drinking, irrigation, industrial uses, etc. The annual potential groundwater recharge augmentation from canal irrigation system is about 89.46 km³. Thus, total replenishable groundwater resource of the country is assessed as 431.89%. Thus, the available groundwater resource for irrigation is 361 km³, of which utilizable quantity (90%) is 325 km³. It accounts for about 80% of domestic water requirement and more than 45% of the total irrigation in the country.

Table 4.1: Water Resources of India

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Items</th>
<th>Quantity (Cu.Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Annual Precipitation Volume (Including snowfall)</td>
<td>4000</td>
</tr>
<tr>
<td>2</td>
<td>Average Annual Potential flow in Rivers</td>
<td>1869</td>
</tr>
<tr>
<td>3</td>
<td>Per Capita Water Availability (2001) in cubic meter</td>
<td>1820</td>
</tr>
<tr>
<td>4</td>
<td>Estimated Utilizable Water Resources</td>
<td>1122</td>
</tr>
<tr>
<td>i)</td>
<td>Surface Water Resources</td>
<td>690</td>
</tr>
<tr>
<td>ii)</td>
<td>Ground Water Resources</td>
<td>432</td>
</tr>
</tbody>
</table>
Land and Water Resources

![Pie chart showing water resources distribution in India](image)

**Fig. 4.6:** Water resources of India (Source: Ministry of water resources, GoI, *Down to Earth Mag.*)

**Water use in India**

Community water supply is the most important requirement and it is about 5% of the total water use. About 7 km³ of surface water and 18 km³ of groundwater are being used for community water supply in urban and rural areas. Along with the increase in population, it is expected that nearly 61% of the population will be living in urban areas by the year 2050, in high growth scenario as against 48% in low growth scenario.

Sectoral consumption pattern of water in India indicates an all time highest consumption in agriculture from 1980 to 2010, followed by municipal and industrial consumption (Fig.4.6). In India per capita surface water availability in the years 1991 and 2001 were 2309 and 1902 m³ and these are projected to reduce to 1401 and 1191 m³ by the years 2025 and 2050 respectively. Hence, there is a need for proper planning, development and management of water resources for raising the standards of living of the millions of people, particularly in the rural areas.

![Bar chart showing sectoral water consumption](image)

**Fig.4.7:** Sectoral water consumption pattern of India

---

*Source: USDA, FAO, Government of India, FAO*
Some ancient Indian methods of water conservation

The Indus Valley Civilization, that flourished along the banks of the river Indus and other parts of western and northern India about 5,000 years ago, had one of the most sophisticated urban water supply and sewage systems in the world. Another very good example is the well planned city of Dholavira, on Khadir Bet, a low plateau in the Rann in Gujarat.

Rainwater harvesting

In urban areas, the construction of houses, footpaths and roads has left little exposed earth for water to soak in. In parts of the rural areas of India, floodwater quickly flows to the rivers, which then dry up soon after the rains stop. If this water can be held back, it can seep into the ground and recharge the groundwater supply.

This has become a very popular method of conserving water, especially in the urban areas. Rainwater harvesting essentially means collecting rainwater on the roofs of building and storing it underground for later use. Not only does this recharging arrest groundwater depletion, it also raises the declining water table and can help augment water supply. Rainwater harvesting and artificial recharging are becoming very important issues. It is essential to stop the decline in groundwater levels, arrest sea-water ingress, i.e. prevent sea-water from moving landward, and conserve surface water run-off during the rainy season.

Realizing the importance of recharging groundwater, the CGWB (Central Ground Water Board) is taking steps to encourage it through rainwater harvesting in the capital and elsewhere. A number of government buildings have been asked to go in for water harvesting in Delhi and other cities of India.

Typically, rain is collected on rooftops and other surfaces, and the water is carried down to where it can be used immediately or stored. You can direct water run-off from this surface to plants, trees or lawns or even to the aquifer.

Some of the benefits of rainwater harvesting are as follows

- Increases water availability
- Checks the declining water table
- Is environmentally friendly
- Improves the quality of groundwater through the dilution of fluoride, nitrate, and salinity
- Prevents soil erosion and flooding especially in urban areas

Agriculture

Conservation of water in the agricultural sector is essential since water is necessary for the growth of plants and crops. A depleting water table and a rise in salinity due to overuse of chemical fertilizers and pesticides has made matters serious. Various methods of water harvesting and recharging have been and are being applied all over the world to tackle the problem. In areas where rainfall is low and water is scarce, the local people have used simple techniques that are suited to their region and reduce the demand for water.
In India's arid and semi-arid areas, the ‘tank’ system is traditionally the backbone of agricultural production. Tanks are constructed either by bunding or by excavating the ground and collecting rainwater.

Rajasthan, located in the Great Indian Desert, receives hardly any rainfall, but people have adapted to the harsh conditions by collecting whatever rain falls. Large bunds to create reservoirs known as khadin, dams called johads, tanks, and other methods were applied to check water flow and accumulate run-off. At the end of the monsoon season, water from these structures was used to cultivate crops. Similar systems were developed in other parts of the country. These are known by various local names jal talais in Uttar Pradesh, the haveli system in Madhya Pradesh, ahar in Bihar, and so on.

Reducing water demand

Simple techniques can be used to reduce the demand for water. The underlying principle is that only part of the rainfall or irrigation water is taken up by plants, the rest percolates into the deep groundwater, or is lost by evaporation from the surface. Therefore, by improving the efficiency of water use, and by reducing its loss due to evaporation, we can reduce water demand. There are numerous methods to reduce such losses and to improve soil moisture. Some of them are listed below.

- Mulching i.e., the application of organic or inorganic material such as plant debris, compost, etc., slows down the surface run-off, improves the soil moisture, reduces evaporation losses and improves soil fertility.
- Soil covered by crops, slows down run-off and minimizes evaporation losses. Hence, fields should not be left bare for long periods of time.
- Ploughing helps to move the soil around. As a consequence it retains more water thereby reducing evaporation.
- Shelter belts of trees and bushes along the edge of agricultural fields slow down the wind speed and reduce evaporation and erosion.
- Planting of trees, grass, and bushes breaks the force of rain and helps rainwater penetrate the soil.
- Fog and dew contain substantial amounts of water that can be used directly by adapted plant species. Artificial surfaces such as netting-surfaced traps or polyethylene sheets can be exposed to fog and dew. The resulting water can be used for crops.
- Contour farming is adopted in hilly areas and in lowland areas for paddy fields. Farmers recognize the efficiency of contour-based systems for conserving soil and water.
- Salt resistant varieties of crops have also been developed recently. Because these grow in saline areas, overall agricultural productivity is increased without making additional demands on freshwater sources. Thus, this is a good water conservation strategy.
- Transfer of water from surplus areas to deficit areas by inter-linking water systems through canals, etc.
- Desalination technologies such as distillation, electrodialysis and reverse osmosis are available.
Check Your Progress 2

Note: a) Use the space given below for your answer.
   b) Compare your answers with those given at the end of the unit.

1) Comment on opportunities and conflicts from Trans boundary water sharing.

2) Discuss the water distribution, consumption, scarcity and management options of water resources in India.

4.10 LET US SUM UP

- Demand for the world’s increasingly scarce water supply is rising rapidly, challenging its availability for food production and putting global food security at risk. Therefore one of the most pressing global issues currently facing mankind is the increase in world population and its impact on the availability of freshwater.

- Water resources are under increasing stress due to patterns of over-exploitation, conflicts over rights, and broader anthropogenic environmental change. The quality and quantity of regional water resources are under stress due to increasing variability and scarcity, compounded by pressure on ground and surface water resources to meet intensified agricultural outputs and industrial needs.

- Knowledge about spatial dynamics of land use and its irrigation water use under changing water availabilities helps in the determination of suitable solutions in finding the best way to allocate the scarce and strongly varying amount of available water.
Land and Water Resources

- The effect of changing climate on water resources is one of the most difficult global environmental changes to assess.
- The solution remains in cooperation in managing transboundary water resources is the most effective way without conflicts.
- Like international efforts, even community based and individual efforts are also required and for that prior to any management strategy, what is required is the change in vision towards water resources and developing attitude for conserving them.

4.11 KEY WORDS

**Water scarcity** : Water scarcity involves water stress, water shortage or deficits, and water crisis

**Water conservation** : Water conservation encompasses the policies, strategies and activities to manage fresh water as a sustainable resource to protect the water environment and to meet current and future human demand.

**Transboundary Water issues** : International waters (the open seas of the world outside the territorial waters of any nation

**Climate Change** : A change in the world’s climate

4.12 REFERENCES AND SUGGESTED FURTHER READINGS

- Central Ground Water Authority, Government of India “Ground Water Management in India” New Delhi.
- Sampath, A., Kedarnath, Chandrika Ramanujam, Haidery, HozeFa, Rao, Arunachalam, Govindaraju, Thirumalavan and Jeet, Vishv 2003. Water Privatization and Implications in India, Association for India’s Development, Austin, TX, USA

Relevant Websites:
4.13 KEY TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Your answer must include the following points:
   • Rapid urbanisation, Population growth
   • Per capita water availability and demand
2) Your answer must include the following points:
   • Spatial and temporal water consumption variability
   • Monitoring methods

Check Your Progress 2

1) Your answer must include the following points:
   • Water sharing
   • Equitable access
   • Conflicts
2) Your answer must include the following points:
   • Water distribution statistics
   • Consumption pattern
   • Conservation strategies in tune to the primitive eco friendly methods