Chapter 1
Introduction

Abstract The present study tried to achieve three objectives. The first objective is to develop an indicator to represent the real situation of water availability in different locations as a function of urbanization, climate and water quality. The indicator will consider the temporal variation of its input parameters and water quality parameters. The second objective was to identify the priority values of the input parameters to differentiate the input variables with respect to its sensitivity to the amount of consumable fresh water. The last aim of the investigation was to find the impact of urbanization on water availability under different climatic scenarios. To achieve all three objectives, Multi Criteria Decision Making (MCDM) and Artificial Neural Network (ANN) was used to develop the index after the input parameters were identified with the help of literature, expert and stakeholders survey. ANN was selected for its predictive ability under non-linear and complex situations. A new MCDM method, Ensemble Analytical Hierarchy Process and Fuzzy Logic was utilized for decision making about the importance of selected parameters and determination of the priority values. Three study areas having three different densities of urban population was selected. Climate change scenarios A2 and B2 as proposed by Inter-Governmental Panel on Climate Change (IPCC) was considered to represent the climatic situations where the values of the climatic parameters was predicted by Climate Models. For each scenario, the index value was estimated for three different time slabs (2010–2030, 2031–2070 and 2071–2100).

Keywords Decision making in water resources · Multi criteria decision making · Artificial neural networks · Climate change · Urbanization impact · Water shortage indicator

1.1 Definition of Water Shortage

According to the Ecology Dictionary (ED 2014), Water shortage is defined as "The situation within all or part of the District when insufficient water is available to meet the present and anticipated needs of the permit system, or when conditions are such

M. Majumder, *Impact of Urbanization on Water Shortage in Face of Climatic Aberrations*, SpringerBriefs in Water Science and Technology,
DOI 10.1007/978-981-4560-73-3_1

as to require temporary reduction in total use within a particular area to protect water resources from serious harm". In general terms, water shortage is defined as the lack of sufficient available water resources to meet the demands of water usage within a region. According to RWL (Paulson 2013), "Water shortage can be defined as a condition in which people lack sufficient water or else do not have access to safe water supplies".

Water shortage is also referred as water scarcity. In conclusion, *the definition of water shortage or scarcity can be defined as lack of water available both in quantity and quality for the use of the local population of a region.*

1.2 Causes

The main causes of water shortage may be attributed to:

1. Urbanization
2. Water Pollution
3. Climate Change
4. Mismanagement of Available Water Resources

1.2.1 Urbanization

In the urbanization process rural population metamorphose to a part of urban population.

In order to carry on the sustenance of the excess population addition of more roads, houses, and commercial and industrial buildings is necessary.

The additional development has its own impact on the urban ecology and eco-systems. The addition of road, buildings and industry step-up the amount of impervious area in a region. This decrease the accessibility of water as amount of surface runoff also increases due to the reduction of infilterable area.

In addition to this, overgrowth in density of population and change in land use and land cover is two other impact of urbanization. Both of this changes will increase stress on natural resources of the region and will also change the nature of stakeholders.

The accumulative impact of all the above will be on water availability.

As population increases so will be the demand for water. One of the ill effects of increasing concentration of industries is the toxic discharges from them which will pollute the surface water resources.

Again to sustain the livelihood and satisfy the demand of the population the conversion of forest land to agriculture and/or industrial lands will take place. To provide shelters or space for the commercial enterprises vast area of forest cover will also be uprooted.

Thus, the amount of water flowing out of the region will increase due to the reduction of infiltration capacity of the region. Thus availability of water will reduce both in quality and quantity as an impact of urbanization.

The urbanization impacts on water availability can be grouped into following four classes.

1. Population Overgrowth
2. Landuse Change
3. Stress on available Resources
4. Change in Nature of Stakeholders

1.2.1.1 Population Overgrowth

The water balance equation as proposed by United Nation For Climate Change clearly indicates that the volumes of water that can be stored in the basin depend on climatic as well as geo-physical properties of the catchment. The available volume of water in a catchment is a direct function of climatic factors like Precipitation and inverse function of Evapo-transpiration. The geophysical properties along with the soil characteristics influences the amount of water that can be infiltrated, flows out of the catchment as surface runoff or get retained due to the depressions available in the basin.

The amount of water that can be consumed for different purposes like domestic, agricultural and industrial uses depends not only in the volumes of water available but also on the quality of water. The rate of population growth is found to be 80 million per year. As a consequence, the demand for both water and energy has increased. As energy potential also depend upon the volume of water available, demand for water has aggravated rapidly.

The abjuration of freshwater worldwide has tripled in the last 50 years. The postulation for freshwater has inflated by 64 billion cubic meters a year. The industrial sector was found to engross 70 % of the World's available freshwater followed by agriculture sector (20 %) and 10 % is consumed by the domestic sector. In industrialized nations, however, industries consume more than half of the water available for human utilisation. Belgium, for instance, uses 80 % of the water for industry.

According to the interpretations of Water.org, which is an international organization working to solve the global water crisis:

- Nearly 780 million people in the world lack access to clean water.
- Each year 60 million people is added to different cities of the World.
- Within the following 40 years, there will be 2–3 billion people living in the World. As a result expected increase of food demand will be about 70 % by 2050.
- About half of the global population lives in metropolis areas, and the concentration of urban population is accretive each day.

Although, urban areas are superior than rural areas, but due to the burgeoning growth in urban settlements, giving provision to the rising demand is becoming problematic (UNICEF 2010).

1.2.1.2 Landuse Change

"Land use is characterised by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it" (FAO 2014a, b). Land use refers to the human utilisation of the land (Modi 2013).

Land can be utilized for residential, agricultural or industrial purposes. Land can be utilized to make roads, water bodies and other supports to provide obligatory requirements to continue livelihood.

Whenever a land is transformed from the earlier use, it modifies among others, the water quality and hydrologic regime of the region (Kiersch 2002).

According to Kiersch (2002), the "impacts of land use on water resources depend on a host of natural and socio-economic factors". "Natural factors" include climate, geography and soil composition. "Socio-economic factors" consist the economic susceptibility and consciousness of a farmer and developmental works which have absolute or allusive impact on land use change.

The land use change can alter the hydrologic regime and quality of water.

Impact on Hydrologic Regime

Land use alteration can cause the overall water availability or the mean annual runoff, and the year-around distribution of water availability by influencing the following parameters. Each of the following parameters has its own impact on water availability.

1. Mean Surface Runoff
2. Peak Flow
3. Dry Season flow
4. Groundwater Recharge

Mean Surface Runoff

The impact of land use on the mean runoff is a function of numerous factors, the most important of them are:

- the water regime of the flora cover in terms of evapotranspiration (ET)
- the cognition of the soil to hold water (infiltration capacity)
- the capacity of the plant cover to intercept moisture. An exclusion to this rule are cloud forests, which can tap more moisture than consumption by ET, and very old forests, which, depending on the species, may adsorb less water than the new vegetations, that substantiate itself after clear-cutting (Calder 1998).

The increment in discharge or surface runoff diminishes over time, with formation of new plant cover, but time scales can change greatly.

In wet and warm areas, the impact of clear-cutting is shorter lived than in less humid areas, due to fast maturation of floral population (Falkenmark and Chapman 1989).

Increasing water yield from changing plant canopy does not, inevitably increase water availability downstream, the runoff may lessen because of water intake by riverside vegetation or by channel infiltration (Brooks et al. 1991).

Peak Flow

Peak flows can increase as a consequence of a change in land use if the infiltration capacity of the soil is attenuated, for example, through soil compaction or erosion, or due to increase of drainage capability. Peak flow may aggrevate after cutting of trees (Bruijnzeel 1990).

Relative increases in storm flow after tree removal are smallest for large events and largest for small events. As the volume of precipitation increases, impact on storm flow of soil and plant cover diminishes (Bruijnzeel 1990).

A gain of peak flows may also result from the building of roads and infrastructure.

Studies in the north-western USA have shown that the construction of forest roads can intensify peak runoff from forested areas significantly. Integration of smaller plots to large fields can lead to higher runoff rates, due to drainage systems and asphalt access roads (Falkenmark and Chapin 1989).

Conversely, peak flows may decrease as a result of an increased soil infiltration capacity.

Dry Season Flow

The impact of land use change on dry-season flow depends on the following competing processes:

- changes in ET
- changes in infiltration capacity.
- The net impact is highly location specific (Calder 1998).

In tropical areas, afforestation can lead to decreased dry-season flows due to increased evapotranspiration.

The most of the literary study evidenced in rainfall-dominated regimes suggests that uprootal of forest cover or conversion from water filic to water phobic plants may increases dry season flows (Brooks et al. 1991).

The dry-season flows from deforested land may decrease if the soil infiltration capacity is reduced for utilization of heavy machinery for agricultural practices (Bruijnzeel 1990).

Lean flow developed from enlarged arid periods or droughts may not change substantially due to the changes in vegetative cover (Brooks et al. 1991).

Groundwater Recharge

The groundwater recharge may be increased or decreased as a result of changing land use practices. The major factors are the ET of the vegetative cover and the infiltration capacity of the soil. Groundwater recharge is influenced by dry-season flows as during that time groundwater feeds the river discharge.

The water table may rise as a result of decreased evapotranspiration as for example:

Recharge may increase due to logging or conversion of forest to grassland for grazing.
Recharge may also increase due to an increased infiltration rate, e.g. through afforestation of degraded areas (Tejwani 1993). In contrast, the water table may fall as a result of decreased soil infiltration, e.g. through non-conservation farming techniques and compaction (Tejwani 1993).

Impact on Water Quality
The landuse change can influence the water quality in the following manner:

- Erosion and Sediment Load
- Nutrients and organic matter
- Pathogens
- Pesticides and other persistent organic pollutants
- Salinity
- Heavy metals
- Changes in thermal regime

Erosion and Sediment Load Properties
Amount and type of forest are factors which can control soil erosion. The understorey vegetation and litter, and the stabilization effect of the root network protects the soil cover and prevents from being eroded. Afforestation has no effect on soil erosion. Splash erosion may increase substantially when litter is cleared from the forest floor (Bruijnzeel 1990). Deforestation may aggrevate erosion. In Malaysia, streams from logged areas carry 8–17 times more sediment load than before logging (Falkenmark and Chapman 1989). Sediment can act both as a physical and a chemical pollutant.

Physical contamination by sediments mainly includes:

- increase in turbidity (limited penetration of sunlight)
- sedimentation (loss of downstream reservoir capacity, destruction of coral reefs, loss of spawning grounds for certain fish).

Chemical pollution of sediment includes:

- adsorbed metals and phosphorous
- contamination of hydrophobic organic chemicals (FAO 1996).

Nutrients and Organic Matter
A land use change can deviate the nutrient concentration of surface and groundwater specially the concentration of nitrogen (N) and phosphorus (P). The reason can be attributed to:

- Deforestation
- Agricultural Activities
- Freshwater Aquaculture

Due to Deforestation
Deforestation can lead to high nitrate (NO3) concentrations in water due to decomposition of plant material and a reduced nutrient uptake by the vegetation. The concentration of Nitrate in runoff from deforested catchments can be 50 times higher than in a forested control catchment over several years (Falkenmark and Chapman 1989; Brooks et al. 1991).

Due to Agricultural Activities
Agricultural activities can lead to an increased influx of nitrogen into water bodies as a consequence of:

- fertiliser application
- manure from livestock production
- sludge from municipal sewage treatment plants
- aeration of the soil.

Phosphate contaminated sediments can produce a nutrient pool in the bottom of eutrophic lakes, which can be extinguished into the water under anaerobic conditions. This makes it difficult to control eutrophication in the short term through limitation of P inflow. Eutrophication can be mitigated by dredging sediment or oxidising the hypolimnion, but these options are expensive (FAO 1996).

Due to Freshwater Aquaculture
Freshwater aquaculture can also contaminate surface water through:

- waste feed that is not consumed by the fish
- the fish's faecal production

Pathogens
The density of pathogenic bacteria in surface waters may increase as a result of riparian grazing activities or waste influx from livestock production. A reduction of stream flow as a consequence of upstream diversion for irrigation, may lead to ponding in riverbeds, which in turn may provide breeding grounds for vectors of waterborne diseases, such as malaria. The low flow of the rivers in estuaries can spread vectors breeding in brackish water.

Pesticides and other persistent organic pollutants
As pesticide compounds are toxic and persistent mixing of such compounds into surface and groundwater sources can be fatal. Pesticide can contaminate groundwater based on their chemical's persistence and mobility, as well as the soil structure.

In humans and animals, pesticides can have both acute and chronic toxic effects.

Pesticide contamination occurs due to their use in agriculture, forestry and aquaculture. "Furthermore, unsafe stockpiling and dumping of old and obsolete pesticides can cause severe ground and surface water contamination" (FAO 1996).

Salinity
Agricultural activities can lead to increased salinity of surface and groundwater due to the evaporation and the leaching of salts from soils.

A high application rate of potassium chloride fertiliser can lead to an increased leaching of chloride into groundwater.

In coastal areas, groundwater extraction for irrigation, domestic and industrial purposes can induce the intrusion of seawater into the aquifer, and consequently a salinization of the groundwater resources will take place.

A decrease in river discharge due to upstream new reservoirs, can also lead to an inland intrusion of brackish water in the estuarine zone.

Heavy metals
The release of organic waste in the runoff can create a direct pathway for heavy metals to contaminate the surface water or groundwater sources. Pig manure contains high concentrations of copper (FAO 1996). When such wastes are mixed with the streams it becomes contaminated. Many local inhabitants earn their livelihood by culturing pigs. When a certain land is converted as a residential place for such kind of people then chance of contamination gets increased.

The land use change also impacts the mobility of heavy metals. The heavy metals can be transferred by erosive processes, acidification of soil or excessive application of water on soil. The increase in application of water from ground water or surface water sources can increase the soil solubility and which can imbibe mixing of heavy metals in soil particles.

Changes in thermal regime
In mini channel flow, uprootal of riparian vegetation can imbibe rise in the temperature of the water (thermal pollution). Also, rise in temperature can be observed in streams receiving agricultural runoff. As temperature rise is inversely proportional to oxygen solubility of streams, increase in temperature will always degrades the self-cleaning ability and biological activity of the rivers.

1.2.1.3 Stress on Available Resources

As the century begins, natural resources are under increasing pressure, threatening public health and development. Water shortages, soil exhaustion, loss of forests, air and water pollution, and degradation of coastlines afflict many areas. As the world's population grows, improving living standards without destroying the environment is a global challenge.

Most developed economies currently consume resources much faster than they can regenerate. Most developing countries with rapid population growth face the urgent need to improve living standards. As the century begins, natural resources are under increasing pressure, threatening public health and development. Water shortages, soil exhaustion, loss of forests, air and water pollution, and degradation of coastlines afflict many areas. As the world's population grows, improving living standards without destroying the environment is a global challenge.

Most developed economies currently consume resources much faster than they can regenerate. Most developing countries with rapid population growth face the urgent need to improve living standards (Hinrichsen and Robey 2000).

As the population and their requirement to sustain their livelihood is increasing at a steady rate the stress on natural resources like land, water and energy is also increasing steadily.

> When population growth is combined with extortionate consumption of natural resources, problems amplify. At present, 20 percent of the world's people in the highest-income countries account for 86 percent of the full private consumption expenditures, while the poorest 20 percent consume only 1.3 percent. The anisometric distribution of wealth and resources leads to unmindful waste and excess in the wealthy nations, and suffering in the resource-starved regions. (CWAC 2014)

This inequality can be seen in the consumption of water in America when compared to the other parts of the world. The world's population is continuously growing, so the demand of water is also, but we have a limited water supply. It is important that industrialized nations realize the demand for water globally and therefore practice conserving the current water supply.

When the population increases so does the consumption of water; it is estimated that by 2025 2–3 billion people will be living in countries experiencing conditions that are water-stressed. In the 20th century the world's population has tripled, but the consumption of the water resources has grown sixfold. It is also estimated that in the next 50 years the world's population will again grow 40–50 % and if we continuously use the amount of water that we are currently using the water supply will significantly diminish.

An increase to the population would also bring industrialization and urbanization which causes environmental problems which directly affects the quality of the water supply and creates conditions of water shortage. Presently we are globally enduring 1.1 billion people not having access to safe drinking water and 2.6 billion people not having sufficient sanitation supplies leading to the loss of life of 3900 children every day from waterborne diseases. Even in America the reality that is harsh of population increase and its affects on our water supply. About 218 million American citizens live at least 10 miles from a impure water source, giving the estimate of 40 % of water in America is unsafe for fishing, swimming, or aquatic life.

Scarce Water

Around 1.2 billion people, or almost one-fifth of the world's population, live in areas of physical scarcity, and 500 million people are approaching this situation. Another 1.6 billion people, or almost one quarter of the world's population, face economic water shortage. Depending on future rates of population growth, between 2.6 and 3.1 billion people may be living in either water-scarce or water-stressed conditions by 2025.

Scarce Cropland

Increasing soil and land degradation is damaging harvest and crop land all through the world, with more than 10 million hectares of effective crop land so severely debased they have to be deserted each year. In addition, salinization is loss that is causing of

10 million hectares per year. Due to the fact of the deficits, approximately 30 % of the world's cropland has been discontinued during the past 50 years. The number of people surviving in countries where cultivated land is significantly scarce is projected to increase in between 600 million and 986 million around 2025.

Fisheries

Most of the world's ocean fisheries are already being fished to their maximum capacities or are in decline. Our appetite for fish is exceeding the ocean's ecological limits with devastating impacts on marine ecosystems.

Forests

According to the U.N. Food and Agriculture Organization Global Forest Resources Assessment 2005, the net loss in forest area at the global level during the 1990s was an estimated 94 million hectare—an area larger than Venezuela and equivalent to 2.4 % of the world's total forests. Throughout the 1990s many countries with high rates of deforestation also had rapid population growth. In 1995, close to 1.7 billion people lived in 40 forest-scarce countries, those with less than one-tenth of a hectare of forest per capita. By 2025, 4.6 billion people will live in forest-scarce countries. By then watersheds in China, Nepal, Thailand, and Vietnam are projected to be critically degraded as a result of the loss of forest cover.

1.2.1.4 Change in Nature of Stakeholders

When transformation of land use takes place, the character of the people also evolves. For example people living encompassing an farming zone will be imposed to change their livelihood and income possibilities when the land will be translated into industrial land. The same agriculture labours will become industrial workforce. It is observed in all parts of the world that people adjust and adapts to change inland type so that they can sustain the new form to their livelihood of opportunities.

Land-cover change has been identified as one of the most important drivers of change in ecosystems and their services. However, information on the consequences of land cover change for ecosystem services and human well-being at local scales is largely absent.

Where information does exist, the traditional methods used to collate and communicate this information represent a significant obstacle to sustainable ecosystem management. Embedding science in a social process and solving problems together with stakeholders are necessary elements in ensuring that new knowledge results in desired actions, behavior changes, and decisions.

An effort has been made to deal with this identified information gap, as well as the way information is gathered, by quantifying the localized consequences of land-cover change for ecosystem services in the Little Karoo region, a semiarid biodiversity hotspot in South Africa. The entire region was mapped and quantified based on the potential supply of, and changes in, five ecosystem services: generation of forage, carbon retention, erosion management, water flow control, and tourism. The outcomes exhibited considerable (20–50 %) declines throughout ecosystem services as a result of land-cover change in the Little Karoo (Reyers et al. 2009).

1.2.2 Water Pollution

The effects of water pollution are varied and depend on what chemicals are dumped and in which locations. Many water bodies near urban areas (cities and towns) are highly polluted. This is the result of both garbage dumped by individuals and dangerous chemicals legally or illegally dumped by manufacturing industries, health centers, schools and market places. The causes of water pollution can be contributed by:

1. Water and Energy Demand
2. Increase in Concentration of Industries
3. Increase in Agriculture Activities
4. Increase in Amount of Urban Domestic Waste
5. Increase in Power Plants

1.2.2.1 Water and Energy Demand

Fossil fuels like coal and oil when burnt produce substantial amount of ash in the atmosphere. The particles which contain toxic chemicals when mixed with water vapor result in acid rain. Also, carbon dioxide is released from burning of fossil fuels which result in global warming.

According to the US Energy Information Administration (EIA), fossil fuels meet around 82 % of U.S. energy demand.

Fossil fuels make modern life possible. These huge sources of energy work to generate steam, electricity and power transportation systems. They make the manufacturing of tens of thousands of commercial goods possible. And although fossil fuels have become synonymous with modern industrial society, their potential to solve some of the challenges of everyday existence has been understood throughout history.

Scattered records of the use of coal date to at least 1100 BC. By the Middle Ages, small mining operations began to spread in Europe, where coal was used for forges, smithies, lime-burners, and breweries. The invention of fire bricks in the 1400s made chimneys cheap to build and helped create a home heating market for coal. Coal was firmly established as a domestic fuel in much of Europe by the 1570s, and represented the major heating source for buildings, especially in cities located far from easy access to less energy-dense biomass forms.

Despite concerted global efforts to reduce carbon emissions through the expansion of clean and renewable energy resources, fossil fuels continued to dominate the global energy sector in 2012, according to new figures released yesterday by the Worldwatch Institute.

Coal, natural gas and oil accounted for 87 % of the world's primary energy consumption last year, the group reported in a new "Vital Signs Online" report.

"The relative weight of these energy sources keeps shifting, although only slightly," states the report by researchers Milena Gonzalez and Matt Lucky, members of the Worldwatch Institute's climate and energy team.

While the U.S. boom in shale gas helped push the fossil fuel's share of total global energy consumption from 23.8 to 23.9 %, coal also increased its share, from 29.7 to 29.9 %, as demand for coal-fired electricity remained strong across much of the developing world, including China and India, and parts of Europe.

As such, coal is expected to surpass oil as the most consumed primary energy source in the world, the report said. In 2012, China alone accounted for more than half the world's total coal consumption, mostly for electric power generation.

But natural gas is also seeing significant gains, both in the United States and in countries like Japan, which are shifting their energy portfolios away from nuclear power. "With increasing shale gas fracking and many countries' interest in displacing coal generation with natural gas due to the lower greenhouse gas emissions, natural gas use seems well poised to grow," the report states (Cusick 2013).

1.2.2.2 Increase in Concentration of Industries

Industries produce huge amount of waste which contains toxic chemicals and pollutants which can cause air pollution and damage to us and our environment. They contain pollutants such as lead, mercury, sulfur, asbestos, nitrates and many other harmful chemicals. Many industries do not have proper waste management system and drain the waste in the fresh water which goes into rivers, canals and later into sea. The toxic chemicals have the capability to change the color of water, increase the amount of minerals, also known as Eutrophication, change the temperature of water and pose serious hazard to water organisms.

Mining is the process of crushing the rock and extracting coal and other minerals from underground. These elements when extracted in the raw form contain harmful chemicals and can increase the amount of toxic elements when mixed up with water which may result in health problems. Mining activities emit several metal waste and sulphides from the rocks and is harmful for the water.

Allthough World GDP is has decreased from 2010 to 2013 (from 4.1 to 2.2) (World Bank 2014). But the global volume of international virtual water flows in relation to trade in agricultural and industrial products averaged 2320 billion m^3 per year during the period 1996–2005 (Mekonnen and Hoekstra 2011). The major gross virtual water exporters were the USA, China, India, Brazil, Argentina, Canada, Australia, Indonesia, France and Germany and the major gross virtual water importers were the USA, Japan, Germany, China, Italy, Mexico, France, the UK and the Netherlands. The biggest net exporters of virtual water are found in North and South America (the US, Canada, Brazil and Argentina), Southern Asia (India, Pakistan, Indonesia, Thailand) and Australia. The biggest net virtual water importers are North Africa and the Middle East, Mexico, Europe, Japan and South Korea.

For water-scarce countries it can sometimes be attractive to import virtual water (through import of water-intensive products), thus relieving the pressure on the domestic water resources. This happens for example in Mediterranean countries, the Middle East and Mexico. Also Northern European countries import a lot of water in virtual form (more than they export), but this is not driven by water scarcity. International trade patterns can only be understood from a multitude of factors; water scarcity is merely one of them.

Virtual Water

Virtual water is defined as the total volume of water needed to produce and process a commodity or service.

The global footprint of water resources is 1385 m^3/year per capita (Mekonnen and Hoekstra 2011).

Water Footprint

Where the Water Footprint is defined as an indicator of freshwater use that looks at both direct and indirect water use of a consumer or producer.

The water footprint of an individual, community or business is defined as the total volume of freshwater used to produce the goods and services consumed by the individual or community or produced by the business. Water use is measured in terms of water volumes consumed (evaporated or incorporated into a product) and/or polluted per unit of time.

A water footprint can be calculated for a particular product, for any well-defined group of consumers (for example, an individual, family, village, city, province, state or nation) or producers (for example, a public organization, private enterprise or economic sector).

The water footprint is a geographically explicit indicator, showing not only volumes of water use and pollution, but also the locations like:

1. India
2. USA
3. Germany

India

The water footprint of Indian consumption was 987 billion m^3/year in the period 1997–2001, which means 980 m^3/year per capita (Hoekstra and Chapagain 2008). Nearly this entire footprint was within the country. Only 2 % of the water footprint of Indian consumers lies outside the country.

Considerations about the need to augment domestic food production to fulfill the needs of a large and rapidly growing population has encouraged the Government of India to recommend an estimated US$ 120 billion National River Linking Programme envisaging to grid 37 Himalayan and Peninsular rivers. This enormous south Asian water grid will annually handle 178 billion m^3/year of inter-basin water exchange; have water transported through 12,500 km of new canals; generate 34 GW of hydro-power; add 35 million ha to India's irrigated areas and generate inland navigation benefits. Alternatives suggested to this grand project include the use of inter-state virtual water trade instead of physical water transfers to tackle the high spatial variation in water availability across the country.

The existing pattern of inter-state virtual water trade is exacerbating scarcities in already water scarce states, with virtual water flows moving from water scarce to water rich regions and running in the opposite direction to the proposed physical transfers (Kampman et al. 2008; Verma et al. 2008, 2009). Rather than being dictated by water endowments, virtual water flows are influenced by many other factors such as per capita availability of arable land and more importantly by biases in food and agriculture policies of the Government of India as indicated by the Food Corporation of India's procurement patterns. In order to have a comprehensive understanding of virtual water trade, non-water factors of production need to be taken into consideration.

United States of America

The Average water footprint of United States of America is 2842 m^3/year per capita and the part of footprint falling outside of the country is found to be 20.2 %.

Germany

In the past years, the water use in German households as well as in the industrial sector has declined constantly. This trend is very welcome and has to be encouraged in the future. But this amount of water only represents a small portion of the total water the Germans consume on a daily basis. A considerably higher portion is hidden in the food, clothes and other products that citizens use or consume in everyday life. Since many of the products consumed come from abroad, Germany has a significant external water footprint.

The total water footprint of German consumers is 159.5 cubic kilometres of water per year. With a population of currently 82.2 million, each citizen consumes 5288 l of water each day, and only a small portion of it for drinking, cooking or other household activities.

The biggest amount of this water is hidden in the food or products that are consumed each day. About half of the German agricultural water footprint is made up by imported products or food. That means that by importing those goods, water in virtual form was also imported from the producing countries. Germany has thereby left its water footprint in those countries. The imported goods with the highest water footprint are—in descending order—coffee, cocoa, oilseeds, cotton, pork, soybeans, beef, milk, nuts and sunflowers.

The biggest water footprint of Germany is left in Brazil, Ivory Coast, France, the Netherlands, the USA, Indonesia, in Ghana, India, Turkey and Denmark respectively, also in descending order (Sonnenberg et al. 2009).

By observing the status represented by Water Footprint the increased density of industries in these countries can be assumed all though recent GDP of all the countries has decreased.

1.2.2.3 Increase in Agriculture Activities

According to FAO, the percentage use of water for Agriculture, Industries and domestic purposes is respectively 70, 19, 11 % (FAO 2014c).

Agriculture is the world's largest industry. It employs more than one billion people and generates over $1.3 trillion dollars worth of food annually. Pasture and cropland occupy around 50 % of the Earth's habitable land and provide habitat and food for a multitude of species.

Agriculture, and especially irrigated agriculture, is the sector with by far the largest consumptive water use and water withdrawal.

When agricultural operations are sustainably managed, they can preserve and restore critical habitats, help protect watersheds, and improve soil health and water quality. But unsustainable practices have serious impacts on people and the environment.

The need for sustainable resource management is increasingly urgent. Demand for agricultural commodities is rising rapidly as the world's population grows. Agriculture's deep connections to the world economy, human societies and biodiversity make it one of the most important frontiers for conservation around the globe.

The priority agriculture commodity was found to be Beef, Soy, Palm Oil, Sugarcane, Dairy and Cotton (WWF 2014).

Beef

Beef is raised in many of the most sensitive environmental areas around the world. Most of the world's beef is produced in Australia, Brazil, Southern Africa and the United States. Unlike many other agricultural commodities, cattle have significant impacts on a wide range of ecosystems.

With the United Nations forecasting that global population will exceed 10 billion by the end of the century and income levels rising, demand for beef is increasing and only expected to get higher. It is thus essential to improve the sustainability of beef production globally.

Palm Oil

Grown only in the tropics, the oil palm tree produces high-quality oil used primarily for cooking in developing countries. It is also used in food products, detergents, cosmetics and, to a small extent, biofuel. Palm oil is a small ingredient in the U.S. diet, but more than half of all packaged products Americans consume contain palm oil—it's found in lipstick, soaps, detergents and even ice cream.

Palm oil is a very productive crop. It offers a far greater yield at a lower cost of production than other vegetable oils. Global production of and demand for palm oil is increasing rapidly. Plantations are spreading across Asia, Africa and Latin America. But such expansion comes at the expense of tropical forests—which form critical habitats for many endangered species and a lifeline for some human communities.

Soy

Around the world, there is a surging demand for soy—the "king of beans." Soy is a globally traded commodity produced in both temperate and tropical regions and serves as a key source of protein and vegetable oils. Since the 1950s, global soybean production has increased 15 times over. The United States, Brazil, and Argentina together produce about 80 % of the world's soy. China imports the most soy and is expected to significantly increase its import of the commodity.

Soy is pervasive in our lives. Not only are soybeans made into food products like tofu, soy sauce, and meat substitutes, but we also eat them in the form of soybean oil and soybean meal. Soybean meal is widely used as animal feed, so we humans consume much of it indirectly via our meat and dairy.

Without proper safeguards, the soybean industry is causing widespread deforestation and displacement of small farmers and indigenous peoples around the globe.

Sugarcane

Sugarcane is a water-intensive crop that remains in the soil all year long. As one of the world's thirstiest crops, sugarcane has a significant impact on many environmentally sensitive regions, like the Mekong Delta and the Atlantic Forest. Historic planting of sugarcane around the world has led to significant impacts on biodiversity.

A vast global market for sugarcane derivatives keeps the industry booming. Sugar is prevalent in the modern diet and increasingly a source of biofuels and bioplastics. As prices of petroleum rise, there is a growing market for ethanol from sugarcane.

Managing social and environmental risks is important for sugarcane growers, processors and food companies due to regulatory pressures as well as shareholder and consumer expectations for sustainably produced goods.

Dairy

The dairy industry impacts some of the world's most sensitive environmental areas covering a wide range of ecosystems. As milk is not usually shipped internationally and is instead distributed and consumed in its country of origin, the impact of dairy in a given place is primarily a local issue. Dairy farms are often family-owned and seen as essential for rural employment.

Despite its local focus, dairy is indeed a large, global industry—there are approximately 250 million dairy cows in the world. Production systems and practices vary widely across countries. With demand for dairy rising as the world's population grows, it is essential to improve the sustainability of dairy production globally.

The dairy industry poses a number of challenges to the health of the environment. Methane emitted from cows' digestions process—called enteric fermentation—and their manure is the most critical potential impact of dairy production. Water pollution is another major concern, as manure and nutrients run into waterways. The dairy industry is also responsible for land conversion, particularly in the tropics, to grow the feed required by dairy herds.

Cotton

Cotton is the most widespread profitable non-food crop in the world. Its production provides income for more than 250 million people worldwide and employs almost 7 % of all labor in developing countries. Approximately half of all textiles are made of cotton.

The global reach of cotton is wide, but current cotton production methods are environmentally unsustainable—ultimately undermining the industry's ability to maintain future production.

Bringing cotton production in line with even minimally acceptable environmental standards is a challenging task.

It may take 2700 L to produce the cotton needed to make a single t-shirt.

1.2.2.4 Increase in Amount of Urban Domestic Waste

> Water which is of no further immediate value to the purpose for which it was used or in the pursuit of which it was produced because of its quality, quantity or time of occurrence. However, wastewater from one user can be a potential supply to another user elsewhere. Cooling water is not considered to be wastewater (FAO 2014d).

Wastewater can be contaminated by degradable and non-degradable Volatile Suspended Solid (VSS), Colloids and Sorbable and Non-Sorbable Soluble Organics.

In Vietnam the daily production of sewage sludge amounts to 2000 m^3 per day whereas same for Thailand is found to be 36.5 m^3/day. South Africa produces about 50,00,000–70,00,000 m^3/day of sewage of which 57 % are anaerobically digested sludge. The sewage treatment facility of Ghana is very limited and covers only 4.5 % of total sewage sludge generated (Spinosa 2011).

The Figs. 1.1, 1.2 and 1.3 shows the waste water released from different types of consumers.

1.2.2.5 Increase in Power Plants

In recent years due to the increase in urban population and technological developments demand for energy has raised manifold. That is why to satisfy the demand in recent years there is an increase in density of both coal, natural gas and nuclear power plants. As there is an increase in number of power plants the waste from the plants will also increase and so will be the level of contamination.

Nuclear Waste

Nuclear energy is produced using nuclear fission or fusion. The element that is used in production of nuclear energy is Uranium which is highly toxic chemical. The nuclear waste that is produced by radioactive material needs to be disposed off to prevent any nuclear accident. Nuclear waste can have serious environmental

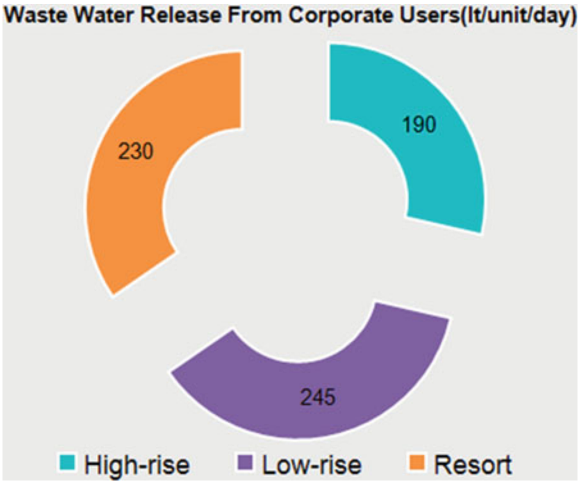

Fig. 1.1 Waste water release from corporate users

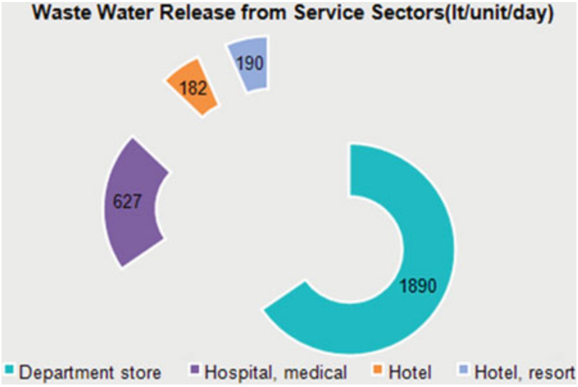

Fig. 1.2 Waste water release from service sectors

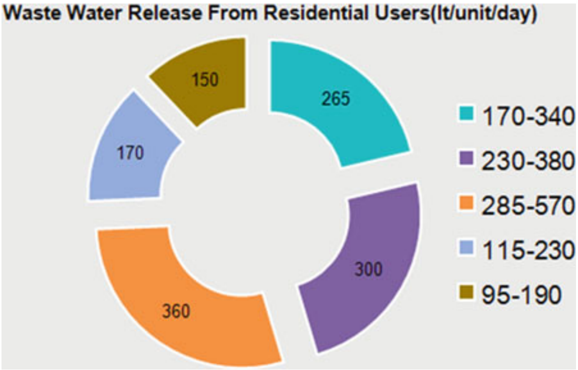

Fig. 1.3 Waste water release from residential users

hazards if not disposed off properly. Few major accidents have already taken place in Russia and Japan.

Coal

Coal is one of the most-water intensive methods of generating electricity. A typical coal plant withdraws enough water to fill an Olympic-sized swimming pool every three and a half minutes. The International Energy Agency says that global water consumption for power generation and fuel production is expected to more than double from 66 billion cubic meters (bcm) in 2010, to 135 bcm by 2035. Coal accounts for 50 % of this growth.

Despite the looming water scarcity crisis, today there are more than 1200 new coal plants proposed around the world. Much of proposed coal expansion is in water stressed regions—regions which already have limited available water for sanitation, health and livelihoods.

China

In China, a coal chemical project in the dry Inner Mongolia region, part of a new mega coal power base, had extracted so much water in 8 years of operation that caused the local water table to drop by up to 100 m, and the local lake to shrink by 62 %. The drastic ecological impacts forced thousands of local residents to become 'ecological migrants'. This is just the tip of the iceberg—by 2015, China's current plan of 16 such mega coal power bases will consume 10 billion m^3 of water annually, equivalent to 1/6 of Yellow River annual flow.

India

In India, the energy-water conflict is even starker. According to analysis by HSBC and the World Resources Institute, a staggering 79 % of new energy capacity will be built in areas that are already water scarce or stressed, but coal is still the energy of choice despite the clear water constraint (Greenpeace 2014). A case in point is the plan to build a cluster of 71 coal plants in the highly water stressed Vidarbha region in Central Maharashtra, where there had been over 6000 documented farmer suicides in the last decade due to lack of water for irrigation.

South Africa

In South Africa, the main utility, Eskom, admits that there is no unallocated water available in the catchments that supply its power stations, and argues that, as it is classified as a strategic water user, "water would have to be given up by other users most notably irrigation farmers". Moreover, Eskom also argues that their coal plants should be exempt from Minimum Emissions Standards because there isn't enough water to operate the scrubber (Metcalf and Eddy 1991). The excess emissions of sulfur and nitrous oxides and mercury from their coal fleet are projected to cause approximately 20,000 pre-mature deaths.

1.2.3 Climate Change

The uncontrolled extraction of natural resources, non-moderated growth in industrial activities, destruction of natural forest and water bodies followed by the rising demand for water and energy from the ever growing population to sustain their livelihood as well as luxury and the recent technological advancements has increased the stress on water resources of most of the countries in the World. The use of fossil fuel has increased many fold compared to the earlier decades and as a result amount of green house gas in the atmosphere has increased. Major impact of climate change is:

1. Rise in Average Temperature
2. Increase in number of Extreme Events
3. Increase in Occurrence of Floods and Droughts
4. Early Onset of Season
5. Stress on Water Resources

1.2.3.1 Rise in Average Temperature

The five hottest years on record have all occurred since 1997.

Heat-trapping gases emitted by power plants, automobiles, deforestation and other sources are warming up the planet. In fact, the five hottest years on record have all occurred since 1997 and the 10 hottest since 1990, including the warmest years on record—2005 and 2010.

High temperatures are to blame for an increase in heat-related deaths and illness, rising seas, increased storm intensity, and many of the other dangerous consequences of climate change.

During the 20th century, the Earth's average temperature rose one degree Fahrenheit to its highest level in the past four centuries—believed to be the fastest rise in a thousand years.

Scientists project that if emissions of heat-trapping carbon emissions aren't reduced, average surface temperatures could increase by 3–10 degrees Fahrenheit by the end of the century.

Don't let average temperatures fool you: A one-degree increase may be found in one place, a 12-degree increase in another place, and yet other areas may become much colder.

The planet's oceans are also warming, which is causing dangerous consequences such as stronger storms, coral bleaching and rising seas.

Climate change brings health risks to the world's most vulnerable communities.

As temperatures rise, so do the risks of heat-related illness and even death for the most vulnerable human populations.

In 2003, for example, extreme heat waves caused more than 20,000 deaths in Europe and more than 1500 deaths in India. Scientists have linked the deadly heat waves to climate change and warn of more to come.

1.2.3.2 Increase in Number of Extreme Events

Climate change will cause storms, hurricanes and tropical storms to become more intense.

Scientific research indicates that climate change will cause hurricanes and tropical storms to become more intense—lasting longer, unleashing stronger winds, and causing more damage to coastal ecosystems and communities.

Scientists point to higher ocean temperatures as the main culprit, since hurricanes and tropical storms get their energy from warm water. As sea surface temperatures rise, developing storms will contain more energy.

1.2.3.3 Increase in Occurence of Floods and Droughts

Climate change is making floods, fires and droughts more frequent and severe.

Climate change is intensifying the circulation of water on, above and below the surface of the Earth—causing drought and floods to be more frequent, severe and widespread.

Higher temperatures increase the amount of moisture that evaporates from land and water, leading to drought in many areas. Lands affected by drought are more vulnerable to flooding once rain falls.

As temperatures rise globally, droughts will become more frequent and more severe, with potentially devastating consequences for agriculture, water supply and human health. This phenomenon has already been observed in some parts of Asia and Africa, where droughts have become longer and more intense.

Hot temperatures and dry conditions also increase the likelihood of forest fires. In the conifer forests of the western United States, earlier snowmelts, longer summers and an increase in spring and summer temperatures have increased fire frequency by 400 % and have increased the amount of land burned by 650 % since 1970.

1.2.3.4 Early Onset of Season

The timely onset of the monsoon bodes well for the economy. Indeed, the monsoon was making rapid progress and was ahead of its schedule over the west coast at the time of going to press. The rainfall (until June 12, 2013) has been 17 % higher than normal and augurs well for the sowing of the kharif crop, according to Laxman Singh Rathore, Director General of the India Meteorological Department. “The arrival in the territories covered so far has been either ahead of the normal date or around the normal date. The timely onset is a positive development. Even in those areas where the monsoon has not set in, pre-monsoon showers are taking place," he says.

The south-west monsoon spread over June to September is the primary rainy season in India. Most of the country—except southern peninsula, Jammu and Kashmir and Assam—receives more than 75 % of its annual rainfall during this period. The monsoon rainfall has a direct bearing on crops across the country. Agriculture and allied sectors such as forestry and fishing account for 14 % of gross domestic product (GDP) but employ more than half of the Indian workforce.

1.2.3.5 Stress on Water Resources

The relationship between water, energy, agriculture and climate is a significant one. More and more, that relationship is falling out of balance jeopardizing food, water and energy security. Climate change is a phenomenon we can no longer deny as its effects have become increasingly evident worldwide. On the list of warmest years on record, almost every year since 1992 is included and, according to NASA and NOAA data, 2012 was the hottest.

As the earth's temperature continues to rise, we can expect a significant impact on our fresh water supplies with the potential for devastating effects on these resources. As temperatures increase, evaporation increases, sometimes resulting in droughts. As of 2013, the U.S. has been experiencing one of the most severe, multi-state, multi-year droughts in decades.

In addition, rising temperatures are melting glacial ice at an unprecedented rate. Glaciers are an important source of freshwater worldwide, and some, like those at Glacier National Park, are in danger of disappearing within the 21st century. Once these glaciers have melted away, they can't be restored. Areas that previously depended on glaciers for freshwater will then have to seek other sources.

Complicating this potential outcome is the prediction that in a warmer environment, more precipitation will occur as rain rather than snow. Although more rain than snow may seem like a plus, it could mean more frequent water shortages. When snow and ice collect on mountaintops, water is released slowly into reservoirs as it melts throughout the spring and summer. When rain falls, reservoirs fill quickly to capacity in the winter, which can also result in excess water runoff that can't be stored. Because rain flows faster than melting snow, higher levels of soil moisture and groundwater recharge are less likely to occur. Areas that rely on snowmelt as their primary freshwater source could increasingly experience water shortages, like having low water supplies by summer's end (GRACE 2014).

The greenhouse gases or GHG is responsible for raising atmospheric temperature. It also prevents the escape of heat from the earth crust. Thus increase in GHG concentration can cause global warming or cooling. The warming or cooling of atmosphere will certainly influence the regular climatic pattern. The change in climatic pattern will induce abnormality in the precipitation as well as evaporation patterns of any region which will again impose variations in the available volumes of freshwater. The reason for this increase in GHG is:

1. Increase in Industries
2. Decrease in Forest Cover
3. Decrease in Water Body
4. Increase in Number of Automobiles

Increase in Industries

Five companies in Britain produce more carbon dioxide pollution together than all the motorists on UK roads combined, according to new figures which reveal heavy industry's contribution to climate change.

A league table compiled by the Guardian identifies EON UK, the electricity generator that owns Powergen, as Britain's biggest corporate emitter of greenhouse gases. It produced 26.4 m tonnes of carbon dioxide last year—slightly more than Croatia did.

The uncontrolled extraction of natural resources, non-moderated growth in industrial activities, destruction of natural forest and water bodies followed by the rising demand for water and energy from the ever growing population to sustain their livelihood as well as luxury and the recent technological advancements has increased the stress on water resources of most of the countries in the World. The use of fossil fuel has increased many fold compared to the earlier decades and as a result amount of green house gas in the atmosphere has increased.

Germany negotiated to produce 495 m tonnes of carbon dioxide, but its companies emitted only 474 m. France produced 131 m tonnes, but had permits for 151 m (Adams and Evans 2014).

Decrease in Forest Cover

Deforestation, clearance or clearing is the removal of a forest or stand of trees where the land is thereafter converted to a non-forest use. Examples of deforestation include conversion of forestland to farms, ranches, or urban use.

Deforestation is clearing Earth's forests on a massive scale, often resulting in damage to the quality of the land. Forests still cover about 30 % of the world's land area, but swaths the size of Panama are lost each and every year.

The world's rain forests could completely vanish in a hundred years at the current rate of deforestation.

Forests are cut down for many reasons, but most of them are related to money or to people's need to provide for their families. The biggest driver of deforestation is agriculture. Farmers cut forests to provide more room for planting crops or grazing livestock. Often many small farmers will each clear a few acres to feed their families by cutting down trees and burning them in a process known as "slash and burn" agriculture.

Logging operations, which provide the world's wood and paper products, also cut countless trees each year. Loggers, some of them acting illegally, also build roads to access more and more remote forests—which leads to further deforestation. Forests are also cut as a result of growing urban sprawl.

Not all deforestation is intentional. Some is caused by a combination of human and natural factors like wildfires and subsequent overgrazing, which may prevent the growth of young trees.

Deforestation has many negative effects on the environment. The most dramatic impact is a loss of habitat for millions of species. Seventy percent of Earth's land animals and plants live in forests, and many cannot survive the deforestation that destroys their homes.

Deforestation also drives climate change. Forest soils are moist, but without protection from sun-blocking tree cover they quickly dry out. Trees also help perpetuate the water cycle by returning water vapor back into the atmosphere. Without trees to fill these roles, many former forest lands can quickly become barren deserts.

Removing trees deprives the forest of portions of its canopy, which blocks the sun's rays during the day and holds in heat at night. This disruption leads to more extreme temperatures swings that can be harmful to plants and animals.

Trees also play a critical role in absorbing the greenhouse gases that fuel global warming. Fewer forests means larger amounts of greenhouse gases entering the atmosphere—and increased speed and severity of global warming.

The quickest solution to deforestation would be to simply stop cutting down trees. Though deforestation rates have slowed a bit in recent years, financial realities make this unlikely to occur.

A more workable solution is to carefully manage forest resources by eliminating clear-cutting to make sure that forest environments remain intact. The cutting that does occur should be balanced by the planting of enough young trees to replace the older ones felled in any given forest. The number of new tree plantations is growing each year, but their total still equals a tiny fraction of the Earth's forested land (NG 2014).

Forests cover 31 % of the land area on our planet. They produce vital oxygen and provide homes for people and wildlife. Many of the world's most threatened and endangered animals live in forests, and 1.6 billion people rely on benefits forests offer, including food, fresh water, clothing, traditional medicine and shelter.

But forests around the world are under threat from deforestation, jeopardizing these benefits. Deforestation comes in many forms, including fires, clear-cutting for agriculture, ranching and development, unsustainable logging for timber, and degradation due to climate change. This impacts people's livelihoods and threatens a wide range of plant and animal species. Some 46–58 thousand square miles of forest are lost each year—equivalent to 36 football fields every minute.

Forests play a critical role in mitigating climate change because they act as a carbon sink—soaking up carbon dioxide that would otherwise be free in the atmosphere and contribute to ongoing changes in climate patterns. Deforestation undermines this important carbon sink function. It is estimated that 15 % of all greenhouse gas emissions are the result of deforestation.

Deforestation is a particular concern in tropical rainforests because these forests are home to much of the world's biodiversity. For example, in the Amazon around 17 % of the forest has been lost in the last 50 years, mostly due to forest conversion for cattle ranching. Deforestation in this region is particularly rampant near more populated areas, roads and rivers, but even remote areas have been encroached upon when valuable mahogany, gold and oil are discovered (WWF 2014).

Decrease in Water Body

In the 1600s, over 220 million acres of wetlands are thought to have existed in the lower 48 states. Since then, extensive losses have occurred, and over half of our original wetlands in the lower 48 have been drained and converted to other uses. The years from the mid-1950s to the mid-1970s were a time of major wetland loss, but since then the rate of loss has decreased.

Between 2004 and 2009, an estimated 62,300 acres of wetlands were lost in the conterminous United States. Various factors have contributed to the decline in the loss rate including implementation and enforcement of wetland protection measures and elimination of some incentives for wetland drainage. Public education and outreach about the value and functions of wetlands, private land initiatives, coastal monitoring and protection programs, and wetland restoration and creation actions have also helped reduce overall wetland losses (USEPA 2014).

The main causes of Wetland Impairment:

Hydrologic Alteration;
Urbanization (including development);
Marinas/Boats;
Industry (including industrial development);
Agriculture;
Silviculture/Timber Harvest;
Mining;
Atmospheric Deposition

Increase in Number of Automobiles

In 2012, for the first time in history, over 60 million cars passenger cars will be produced in a single year (or 165,000 new cars produced every day).

After a 9 % decline in 2009 (due to the 2008 global financial crisis), global car production immediately jumped back the following year with a 22 % increase in 2010, to then consolidate at the current 3 % yearly growth rate.

Going back in history, in 2006 there were less than 50 million passenger cars produced in the world, with an increase of 6.45 % over the previous year. The increase for 2007 was more modest, and 2008 showed a decline. Analysts from various institutes had in fact pegged the year 2007 as the year which would end the 5-year cycle (2002, 2003, 2004, 2005, 2006) of record global auto sales worldwide.

1 out of 4 cars produced in the world comes from China. China was the world's third-largest car market in 2006, as car sales in China soared by nearly 40 % to 4.1 million units. Soon thereafter, China took the lead and became the world's first-largest car market, as low vehicle penetration, rising incomes, greater credit availability and falling car prices lift sales past those of Japan. Furthermore, vehicle penetration in China still stands at only about 40 vehicles per 1000 people,

compared with approximately 700 vehicles per 1000 people in the mature markets of the G7.

More than half of the cars are produced in Asia and Oceania, whereas Europe produces almost a third.

It is estimated that over 1 billion passenger cars travel the streets and roads of the world today. The 1 billion-unit mark was reached in 2010 for the first time ever.

In the United States alone, 250,272,812 "highway" registered vehicles were counted in 2010, of which 190,202,782 passenger cars.

In 2013 the percentage of passenger and commercial car produced is maximum than the last 15 years (Statista 2014).

The Figs. 1.4, 1.5 and 1.6 depicts the automobile production from top five countries in the year 2013, 2011 and 2000 respectively (WM 2014). The increase in rate of production can be visible if the three images were compared.

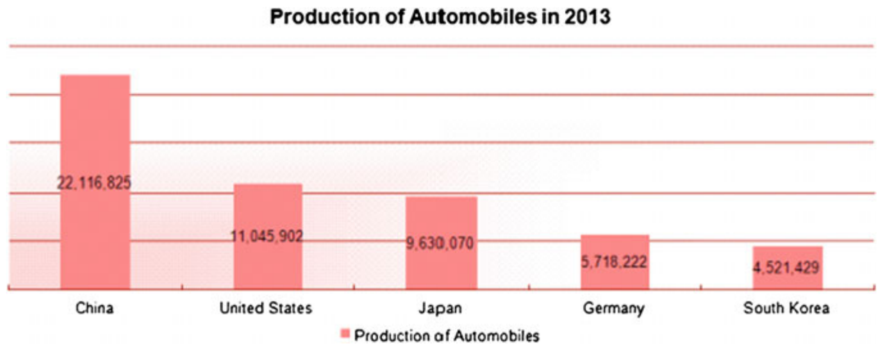

Fig. 1.4 Production of automobiles in 2013

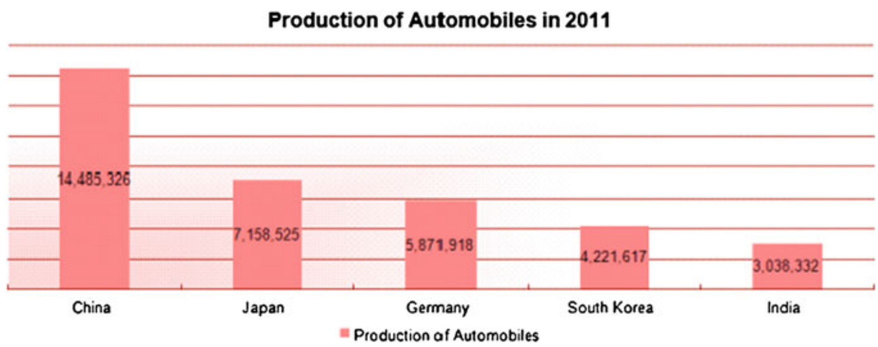

Fig. 1.5 Production of automobiles in 2011

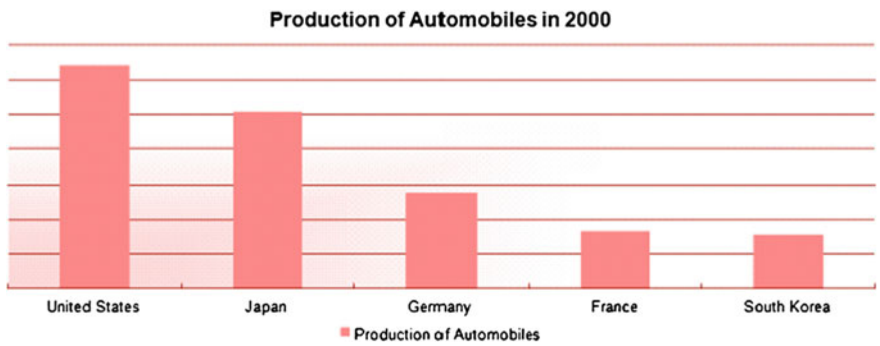

Fig. 1.6 Production of automobiles in 2000

1.2.4 Mismanagement of Available Water Resources

While the amount of freshwater on the planet has remained fairly constant over time—continually recycled through the atmosphere and back into our cups—the population has exploded.

This means that every year competition for a clean, copious supply of water for drinking, cooking, bathing, and sustaining life intensifies.

Freshwater makes up a very small fraction of all water on the planet. While nearly 70 % of the world is covered by water, only 2.5 % of it is fresh. The rest is saline and ocean-based. Even then, just 1 % of our freshwater is easily accessible, with much of it trapped in glaciers and snowfields. In essence, only 0.007 % of the planet's water is available to fuel and feed its 6.8 billion people.

Keeping in view of the above scenario, the question is will it be possible to provide enough water to the ever-growing population (predicted to be at least 9 billion by 2050 (UN Medium Hypothesis) using a volume which will be roughly the same as it is now?

The impact of climate change, urbanization and water pollution is raising stress on fresh water resources of the World.

Even after the impact of the above causes there are some amount of water available in every country of the World. But that amount is also non-optimally utilize. There is no specific methods for allocation of water resources to different kind of consumers. Still monetory and political gains are considered before allocation of the scarce resources. In some places uniform allocation of water is followed. In few places water metering concept is adopted but charge taken from the consumers is nominal and often nature of consumers are not considered before fixing of tariff.

Thus due to the non-optimal allocation of the scarce resource a sufficient amount of water available for use is also wasted. The reason for this mismanagement is:

1. Non-Optimal Allocation of Water Resources
2. Drawback with the Indicators

1.2.4.1 Non-optimal Allocation of Water Resources

A major concern of non optimal allocation of water resources is there are no specific methodology adopted for allocation of the resources. All though their are some indicators available to track and monitor the status of the availability of water. But in most of them the effect is given more importance than the causes.

1.2.4.2 Drawback with the Indicators

The major drawback of the indicators explained above is most of them have not explicitly considered spatial and temporal variability of the related parameters (e.g. Index of Water scarcity, Falkenmar's Water Availability Indicators). Also they have not considered the water quality while calculating the availability of water resources which can be consumed for different purposes (e.g. WAI). Moreover the indicators has the following limitations:

1. The input parameters are uniformly weighted or the importance of all the input parameters are taken as equal. But in reality different parameters has different level of sensitivity towards the determination of availability of usable water.
2. Even if there are more than one indicator and the result of which is aggregated to find the final output all the indicators are treated equally (e.g. WPI).

1.3 Objective of the Present Study

The drawback of the available indicators and the present situation of availability of water resources all over the world encouraged the author to develope an indicator which will consider both spatial and temporal variability, quality of water as well as the different types of uses while estimating the severity of water scarcity in a region.

All the parameters are not equally weighted in this indicator. The weights of importance for each of the selected parameters are determined in directly proportional manner to their capability to influence the availability of usable fresh water. The major objective of the present investigation is:

1. To develop a Weighted Cognitive Indicator for Representing Status of the Water Shortage
2. To identify the priorities of the related parameters of water availability

1.3.1 To Develop a Weighted Cognitive Indicator for Representing Status of the Water Shortage

The indicator is developed to represent the status of the water shortage as a function of urbanization, climatic parameter and water quality.

Advanced techniques like Multi Criteria Decision Making (MCDM) was utilized to determine the importance of each of the parameters.

The indicator was induced a cognitive capability by the introduction of Artificial Neural Networks (ANN).

The index was validated by sensitivity and scenario analysis where three cases having different levels of urbanization was analyzed with the help of the indicator under six different climate change scenarios as proposed by Inter-Governmental Panel of Climate change (IPCC). Further the new indicator is developed in such a manner that it becomes:

1. a function of Urbanization
2. a function of Climatic Parameters
3. a function of Water Pollution

1.3.1.1 To Develop the Indicator as a Function of Urbanization

The following parameters are selected to make the indicator a function of urbanization. The inclusion of the parameters enabled the index to represent the impact of change in urbanization. As amplitude of the curve representing the temporal variability of the parameters the indicator was able to indicate the impact of temporal change in urbanization also:

1. Frequency of Peaks in Annual Water Demand curve for Domestic Consumers (Dd)
2. Frequency of Peaks in Annual Water Demand curve for Agriculture Consumers (Da)
3. Frequency of Peaks in Annual Water Demand curve for Industrial Consumers (Di)
4. Percentage Impervious Area (last 10 year) (A)
5. Annual Average Area of Canopy (Ac)

1.3.1.2 To Develop the Indicator as a Function of Climatic Parameters

The next few parameters are considered to develop the indicator a function of climatic parameter and to provide the index a capability to represent the impact of climate change. The inclusion of the amplitudes rather than discrete data of the input parameters enabled the indicator to depict the impact of temporal variability of climatic parameters.:

1. Frequency of Troughs in Annual Hyetograph (P)
2. Frequency of Peak in Annual Hydrograph (Q)

1.3.1.3 To Develop the Indicator as a Function of Water Pollution

Water Quality Index (WQI) is an indicator proposed by National Sanitation Foundation (NSF) to represent the overall quality of water. The values of WQI is determined for different purposes and uses of water. In the present study WQI was determined to represent the usability of available water for industrial purposes. If the water is required to be used in agriculture and domestic purposes it is taken that necessary treatment arrangements can be provided so that the quality of the water can be upgraded for agriculture or domestic consumption. Here also to represent the temporal variability the amplitudes rather than discrete data was considered to calculate the value of the indicators.

1. Frequency of Troughs in Annual Water Quality Index curve (WQI)

1.3.2 To Identify the Priorities of the Related Parameters of Water Availability

The priority values or the weights of importance of all the parameters were calculated first before the estimation of the indicator value to represent the status of water shortage.

The reason for determination of priority values can be contributed to the fact that in case of mitigative action to prevent further degradations and reversal of the situations the developers can concentrate on the most important parameters only and can compromise on the least important factors within the selected parameters.

This can save lot of money and manpower and can provide an opportunity for optimally tackling the situation of water shortage.

1.4 Brief Methodology

1. Identification of most influential parameters which can impact on availability of water by Expert survey, Literature survey and Stakeholder survey
2. Assigning weight vectors to the identified parameters according to their importance in controlling the intensity of shortage water.

3. The weight vector of the selected parameter is determined with the help of aggregation methods like: Analytical Hierarchy Process and Fuzzy Logic Decision Making.
4. The index was formulated as per the weight function concept where the weight vectors are taken as the weights and the factors are taken as the variable. This index is developed in such a manner that it became coherent with the severity of water shortage.
5. An ANN model was also developed for prediction of the value of the index with respect to different real life situations that may exist in various regions of the World.
6. Once the index is developed the sensitivity of the same will be carried out.
7. A scenario analysis will be conducted with respect to climate change on three different locations having various level of urbanization.

1.4.1 MCDM

The advantage of MCDM technology is applied in the present study. The MCDM techniques like Analytical Hierarchy Process (AHP) and Fuzzy Logic Decision Making (FLDM) was applied after the parameters are selected by literature, expert and stakeholder's survey.

In the present study; Expert Survey, Stakeholders Survey, Literature Review, Sponsors Preference and Data Availability are taken as the Criteria of the decision making process.

The alternative of the MCDM was the parameters selected by the Expert, Literature and Stakeholder Survey. The parameters which have been considered as the Alternatives are given below:

Fquency of Troughs in Annual Hyetograph (P)
Frequency of Peak in Annual Hydrograph (Q)
Frequncy of Peaks in Annual Water Demand curve for Domestic Consumers (Dd)
Frequency of Peaks in Annual Water Demand curve for Agriculture Consumers (Da)
Frequency of Peaks in Annual Water Demand curve for Industrial Consumers (Di)
Percentage Impervious Area (last 10 year) (A)
Annual Average Area of Canopy (Ac)
Frequency of Troughs in Annual Water Quality Index curve (WQI)

1.4.2 Artificial Neural Network

After the priority values of the selected parameters were determined a neural network model was prepared to estimate the indicator for all type of situations that can be represented by the selected parameters. The input of the model are the selected parameters of the indicator and the output is the weight function of the parameters. This addition will remove the need of applying MCDM again and again once a new location is required to be analyzed if the locations are considered as the Sub-Alternatives.

1.4.3 Validation of the Indicators by Sensitivity Analysis

The index was validated with the help of sensitivity analysis where the sensitivity of the selected parameters were analyzed and compared with the priority values of the parameters. For successful validation the priority values and sensitivity of the parameter has to be directly correlated.

1.4.4 Application and Validation of the Indicator with Respect to Climate Change Scenarios in Three Different Study Areas

Three areas were at first selected for calculation of the value of the indicator. The areas were selected in such a manner that all three have different level of urban population.

Three selected regions are:

1. Farakka Barrage on River ganges: Medium Level of Urban Population
2. Mahi River Dam on Mahi River: High Level of Urban Population
3. Vaigai Dam in River Periyar: Low Level of Urban Population

Next according to the IPCC proposed climate change scenario A2 and B2 the value of the indicator was calculated for three time slabs under both of the scenarios.

The value of the indicator will represent the impact of climate change on three regions having different level of population density.

References

Adams D, Evans R (2014) New figures reveal scale of industry's impact on climate. http://www.theguardian.com/environment/2006/may/16/pollution.uk

Brooks KN, Ffolliott PF, Gregersen HM, Thames JL (1991) Hydrology and the management of watersheds. Iowa State University Press, Ames

Bruijnzeel LA (1990) Hydrology of moist tropical forests and effects of conversion: a state-of-knowledge review. UNESCO International Hydrological Programme, Paris

Calder IR (1998) Water-resource and land use issues. SWIM Paper 3. Colombo: IIMI. http://www.fao.org/docrep/004/y3618e/y3618e07.htm

Clean Water Action Council (2014) Population facts the future. http://www.cleanwateractioncouncil.org/issues/resource-issues/population/

Cusick D (2013) Global demand for fossil fuels continues to rise. http://www.eenews.net/stories/1059989393

ED (2014) Water shortage: ecology dictionery definition. http://www.ecologydictionary.org/WATER_SHORTAGE

Falkenmark M, Chapman T (eds) (1989) Comparative hydrology: an ecological approach to land and water resources. UNESCO, Paris

FAO (1996) Control of water pollution from agriculture. Written by Ongley ED. FAO Irrigation and Drainage Paper, No. 55. http://www.fao.org/docrep/004/y3618e/y3618e07.htm

FAO (2014a) Population and water resources (contrib. by FAO). http://www.un.org/popin/fao/water.html

FAO (2014b) Land use definition. https://www.fao.org/nr/land/use/en

FAO (2014c) Water uses. http://www.fao.org/nr/water/aquastat/water_use_agr/index.stm

FAO (2014d) AQUASTAT definitions. http://www.fao.org/nr/water/aquastat/data/glossary/search.html?lang=en&_p=100&submitBtn=-1&keywords=Wastewater&subjectId=-1&termId=-1&submit=Search

GRACE (2014) The impact of climate change on water resources. http://www.gracelinks.org/2380/the-impact-of-climate-change-on-water-resources

Greenpeace (2014) Coal impacts on water. http://www.greenpeace.org/international/en/campaigns/climate-change/coal/Water-impacts/

Hinrichsen D, Robey B (2000) Population and the environment: the global challenge. http://www.actionbioscience.org/environment/hinrichsen_robey.html

Hoekstra AY, Ashok KC (2007) Water footprints of nations: water use by people as a function of their consumption pattern. Water Resour Manage 21(1):35–48

Kampman DA, Hoekstra AY, Krol MS (2008) The water footprint of India. http://www.waterfootprint.org/?page=files/India

Kiersch (2002) Land use impacts on water resources: a literature review. http://www.fao.org/docrep/004/y3618e/y3618e07.htm

Ma J, Hoekstra AY, Wang H, Chapagain AK, Wang D (2006) Virtual versus real water transfers within China, Phil. Trans R Soc Lond B 361(1469):835–842

Mekonnen MM, Hoekstra AY (2011) National water footprint accounts: the green, blue and grey water footprint of production and consumption, Value of Water Research Report Series No. 50, UNESCO-IHE, Delft, the Netherlands

Metcalf and Eddy (1991) Wastewater engineering. In: Tchobanoglous G, Burton FL (eds) Treatment disposal reuse. McGraw-Hill, New York, 1820 pp. http://www.eolss.net/eolsssamplechapters/c06/e6-13-04-05/E6-13-04-05-TXT-05.aspx#4._Wastewater_Quantities_

Modi A (2013) Still early days. http://businesstoday.intoday.in/story/impact-of-monsoon-on-agriculture/1/195941.html

National Geographic (2014) Deforestation. http://environment.nationalgeographic.com/environment/global-warming/deforestation-overview/

Paulson LD (2013) What is water scarcity, Retrieved from RWL Water. http://www.rwlwater.com/what-is-water-scarcity/

Reyers B, O'Farrell PJ, Cowling RM, Egoh BN, Le Maitre DC, Vlok JHJ (2009) Ecosystem services, land-cover change, and stakeholders: finding a sustainable foothold for a semiarid biodiversity hotspot. Ecol Soc 14(1):38. http://www.ecologyandsociety.org/vol14/iss1/art38/

Sonnenberg A, Chapagain A, Geiger M, August D (2009) Der Wasser-Fußabdruck Deutschlands: Woher stammt das Wasser, das in unseren Lebensmitteln steckt? WWF Deutschland, Frankfurt. http://www.waterfootprint.org/Reports/Sonnenberg-et-al-2009-Wasser-Fussabdruck-Deutschlands.pdf

Spinosa L (2011) Wastewater sludge: a global overview of the current status and future prospects. IWA Publishing, London. http://books.google.co.in/url?client=ca-print-pub-6951585976377766&format=googleprint&num=0&id=JTsPuhoLh1cC&q=http://www.iwapublishing.com/template.cfm%3Fname%3Disbn9781843393887&usg=AFQjCNGbz2jxBPlwdfvOtS1sU74oVOcQsg&source=gbs_buy_r

Statista (2014) Worldwide automobile production from 2000 to 2013 (in million vehicles). http://www.statista.com/statistics/262747/worldwide-automobile-production-since-2000/

Tejwani KG (1993) Water management issues: population, agriculture and forests—a focus on watershed management. In: Bonell M, Hufschmidt MM, Gladwell JS (eds) Hydrology and water management in the humid tropics. UNESCO, Paris, pp 496–525

United States Environment Protection Agency (2014) Wetlands—status and trends. http://water.epa.gov/type/wetlands/vital_status.cfm

Verma S, Kampman DA, Van der Zaag P, Hoekstra AY (2008) Going against the flow: a critical analysis of virtual water trade in the context of India's National River Linking Programme. http://www.waterfootprint.org/Reports/Report31-India.pdf

Verma S, Kampman DA, Van der Zaag P, Hoekstra AY (2009) Going against the flow: a critical analysis of inter-state virtual water trade in the context of India's National River Linking Programme. Phys Chem Earth 34:261–269

WM (2014) Cars produced in the world—sources and methods. http://www.worldometers.info/cars/

World Bank (2014) GDP growth(annual %). http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG/countries?display=graph

World Wildlife Federation (2014) Deforestation threats. http://www.worldwildlife.org/threats/deforestation

WWF (2014) Sustainable agriculture. http://www.worldwildlife.org/industries/sustainable-agriculture