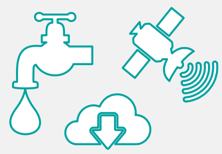
Water Management Sector: Identification of Green Business Potential in India

HIGHLIGHTS

Growth Forecast for Water Management Sector in India



Job Potential for Water Management Sector

Occupational Map for Water Management Sector

April 2017

Preamble

Cities have become the place where development challenges and opportunities increasingly come face to face. In 2014, 3.9 billion people, or 54% of the global population, lived in cities, and by 2050, two-thirds of the global population will be living in cities (UNDESA, 2014). Furthermore, most of this growth is happening in developing countries, which have limited capacity to deal with this rapid change. Cities impact the hydrological cycle in several ways by: extracting significant amounts of water from surface and groundwater sources; extending impervious surfaces thus preventing recharge of groundwater and exacerbating flood risks; and polluting water bodies through the discharge of untreated wastewater. Since much of the water consumed by cities generally comes from outside the city limits, and the pollution they generate also tends to flow downstream, the impact of cities on water resources goes beyond their boundaries.

Water is at the core of sustainable development. Water resources, and the range of services they provide, underpin poverty reduction, economic growth and environmental sustainability. From food and energy security to human and environmental health, water contributes to improvements in social well-being and inclusive growth, affecting the livelihoods of billions. Inter-linkages between water and sustainable development reach far beyond its social, economic and environmental dimensions. In-fact water is associated with four different facets viz. social, economic, political and environmental however, human health, food and energy security, urbanization and industrial growth, as well as climate change are critical challenge areas where policies and actions at the core of sustainable development can be strengthened (or weakened) through water. Lack of water supply, sanitation and hygiene (WASH) takes a huge toll on health and well-being and comes at a large financial cost, including a sizable loss of economic activity.

Illustrative Examples of Various Water Facets

Social Facet	Economic Facet	Environmental Facet	Political Facet
Communities in Churu district in Rajasthan offer camel's milk to visiting guests & a glass of water to a visiting VIP. *In the Andes mountain the community collects every drop of water by hanging a vertical net over a trough, for harnessing dew drops in the night, which is collected & distributed equitably, as per age old customs. They know the scarcity value of water. Similarly, in few districts of Rajasthan, the local community has harvested water innovatively & drought proofed their villages, as opposed to surrounding regions.*	*In Germany which has abundant water the homes have 2 meters : inlet & outlet hence people use water with care as it is expensive & have to pay for the out flow too.* *Such enlightened practices need to be brought in well of areas of cities to begin with & become part of all gated colonies & new towns & ultimately building code.*	*Aral Sea mistake made by the former Soviet Union. Diversion of the rivers Amu Darya and Syr Darya rivers, to grow cotton, lead to reduction of the Aral Sea area by two thirds*	*Need for drip, root & controlled irrigation (early morning / late evening to reduce evaporation loss) has to be scaled up by capacity building via panchayats , electronic & social media. There has to be consensus built up to change crop pattern (with less water intensive crops) in water stressed regions*

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Executive Summary

Accelerated urbanization and rising living standards have contributed to increase in freshwater withdrawals globally by about 1% per year since the 1980s (*UN; WDR, 2016*). Higher population growth rates contribute to higher water demand which further result in increased water stress in overpopulated cities. The water scarcity which results is not just associated with environmental aspects but has three other dimensional facets *viz.,* social, economic and political.

Cities witnessing rapid urban growth need to create efficient water utilization infrastructure and devise innovative solutions to meet the water requirements of future. Both water-use efficiency and water productivity can contribute to improving socio-economic development and create opportunities for employment and decent jobs in water-dependent sectors, especially under conditions of water scarcity (where inadequate water supplies may impede development). New resource-efficient technologies as well as enhanced competitiveness and innovation are also generating shifts in employment and changes in the workforce worldwide. (UN; WDR, 2016).

Sustainable water management, water infrastructure and access to a safe, reliable and affordable supply of water and adequate sanitation services improve living standards, expand local economies and lead to the creation of more decent jobs and greater social inclusion. Sustainable water management is also an essential driver of green growth and sustainable development. Unsustainable management of water and other natural resources can cause severe damages to economies and to society, thus reversing many poverty reduction, job creation and hard-won development gains.

International studies of water management sector have primarily classified jobs in three functional categories: *(i)* water resources management, including integrated water resources management (IWRM) and ecosystem restoration and remediation; *(ii)* building, operating and maintaining water infrastructure; and *(iii)* the provision of water related services including water supply, sanitation and wastewater management. These jobs serve as the building blocks for a wide array of water-dependent job opportunities in several sectors. This report specifically focus on growth projections, job numbers and key job roles associated with urban rainwater harvesting, sewage treatment and watershed management.

Rainwater harvesting defined as "the gathering and storage of water running off surfaces on which rain has directly fallen", could be a potential alternative in small communities that cannot be served by more centralized water supply schemes. Although RWH has been practiced for several years, it is only in recent years that countries have given it a serious thought with several passing legislations and offering incentives to promote the concept.

Untreated sewage is one of the biggest environmental nuisances associated with unplanned sprawling growth of urban communities and clusters. As per the census 2011 data, the urban population has increased from 286 million in the year 2001 to 377 million in the year 2011 which translates to 31.82% increase in a decade. Considering the same percentage growth up to 2030 for urban sewage, the sewage generated from urban areas is expected to increase from 22630 million m^3/year to 36202 million m^3/year. Urban infrastructure for wastewater/ sewage treatment need to come to terms to enable and cope with increased stresses on rivers and water bodies polluted as a result of these untreated discharges which in itself present.

Integrated water management and conservation needed to be looked in a more elaborate manner. Government of India and several state governments such as state of Madhya Pradesh in India have implemented several successful watershed programmes. There have been cases and examples where efforts of a single person supplemented with participation of local communities have contributed to water positive futures for the entire villages. CGWB, 2012 Report on the status of Indian aquifers estimates that the total area of the country suitable for groundwater development stands at 1963791 km^2 and that 486573 km^2 area of the blocks is overexploited and 76201 km^2 area of the country is critical. The need is to have train and equip people with adequate sector specific skills to take this crisis head-on and contribute to water sustainable future.

Chapter 1: Introduction

- **Background**
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Background

Water is inextricably linked to the development of all societies and cultures. At the same time, this development also places considerable pressure on water resources — agriculture, energy and industry all have impacts on the use and governance of water. More than two decades after the first summit on sustainable development, many countries still face the challenges of eliminating poverty and promoting economic growth, ensuring health and sanitation, preventing land degradation and pollution, and advancing rural and urban development. Around 748 million people today still do not have access to an improved source of drinking water, and water demand for manufacturing is expected to increase by 400 per cent between 2000 and 2050 globally. Water is truly at the core of sustainable development. It is inextricably linked to climate change, agriculture, food security, health, equality, gender and education, and there is already international agreement that water and sanitation are essential to the achievement of many sustainable development goals (UNDESA, 2015).

The water availability, both in terms of quality and quantity, has declined to such an extent that many parts of India, rural and urban, today face a drought-like situation. And when drought actually sets in, as it did in many parts of the country since last 3 years, scarcity takes on a frightening visage. Water is becoming a cause for social conflicts: Protests, demonstrations, road-blockades, riots. City-dwellers against farmers. Villages against towns. Towns against cities. Citizens against the government. People against people. Increasingly, these (usually local) conflicts are taking on the general shape of a bitter war for water. As wells, ponds and taps dry up, women begin to walk the village streets and city roads with pots and pitchers looking for a water-point. As municipality water-tankers and government-run water trains begin to traverse the length and breadth of the country, people gather on street corners, village squares and in front of municipality offices.

The term 'water management' covers wide variety of activities and disciplines. These activities can be divided into three categories:

- Managing the resource,
- Managing water services,
- And managing the trade-offs needed to balance supply and demand.
- And taking care of the water needs of the ecosystems which is most often forgotten leading to many rivers not reaching the sea

The management of water is a mix of measures including changes in policies, prices and other incentives, as well as infrastructure and physical installations. Effective water management demands trans-boundary coordination in a context where international river basins cover almost half the earth's surface, and some identified trans-boundary aquifers underpin various national economies. Time is ripe for BWE- Bureau of Water Efficiency. This will lead to measuring every drop of water in the agri / industry & domestic domains and will empower the masses to purchase based on sustainability principles by understanding the embodied water of products & processes. Organizations which use excessive water will be forced to conform to competitive forces.

Hydro-politics

"The days of casual use of water must come to end through a visionary approach coupled with a deep understanding of the socio- economic -political & environment approach. Grossly underpricing water creates an illusion of plenty for all stakeholders. This disease needs to be rectified once again by leaders & I do not mean political leaders alone most of us are leaders in our families, in our enterprises. Lead by example in the use of water is the need of the hour. This is not going to happen by lofty thought but requires policy, cost driven awareness enhancing initiatives on a War footing, otherwise it will lead to war like situations as seen in the Tamil Nadu and Karnataka water crises /a bigger war in IWT –Indus water treaty which has loomed it ugly head currently.

The International Conference "Water conservation and water use efficiency", organized by the Network of Water Organizations from Eastern Europe, Caucasus and Central Asia (INBO-EECCA) took place on May 21, 2015 in Minsk. The conference addressed the following issues:

- Increasing water shortage as a challenge to water security: natural - climate change; anthropogenic - the growth of consumption, the future development, including hydropower;

- Implementing of high technologies in all types of water use (automation, water conservation, energy efficiency, etc.);
- Water accounting and improving of water service quality.

UN-Water's overarching goal is "Securing Sustainable Water for all". The water goal and targets directly address the development aims of societies, promote human dignity and ensure achievements are sustainable over the long term. India should suggest to the UN to start BWE protocol just as we have Montreal Kyoto protocol for all countries to adopt in their own self-interest after setting it up for India under National Water Mission. There are various best practices at global level in industries, municipalities, household societies which had been replicated by many, also implemented in India. Some of them are the following:

- Water balance
- Leak management
- Eliminate once-though cooling
- Cooling tower management
- Flow meters
- Low flow fixtures and flow resistors
- Rinse tank overflow
- Xeriscaping
- Recycle process wastewater
- Resource management through mind and lifestyle changes for conservation of water

Water Scarcity: Indian Context

The annual precipitation including snowfall in India is of the order of 4000 BCM and the natural runoff in the rivers is computed to be about 1869 BCM. The utilizable surface water and replenish able ground water resources are of the order of 690 BCM and 433 BCM respectively. Thus, the total water resources available for various uses, on an annual basis, are of the order of 1123 BCM. (Source: CGWB)

Significant reasons behind water scarcity in India are:

- Population growth and Food production (Agriculture) - inefficient, over use of water
- Increasing construction/ infrastructure development Activities- over use & no innovative recycling of water at project sites
- Massive urbanization and industrialization throughout the country- plan path ways for water to flow into aquifers or designed reservoirs to absorb heavy rain water in cities otherwise we are designing our cities for disasters as we are currently seeing in leading cities..
- Climatic change and variability- Depleting of natural resources due to changing climate conditions (Deforestation etc.) - compelling reasons to manage every drop & save in aquifers to drought proof the country-insurance cos. Give premium rebate to organizations which have good fire safety standards, similar inducement may be given for organizations which have comprehensive water best practices .
- Lack of implementation of effective water management systems – capacity building at multiple levels across country.

Water Management Approaches: A Snapshot

PHNOM PENH: WATER SUPPLY

The Phnom Penh Water Supply Authority (PPWSA), which has transformed itself from a near-bankrupt, demoralized and corrupt institution into one of the best water utilities in the world, can provide valuable experiences for other cities. Under the dynamic leadership of Ek Sonn Chan, PPWSA was able to turn around the performance of the utility within a decade to provide all people with continuous, good quality and affordable water supply, while consistently increasing its net profit. Due to its pro-poor policies, it has also increased its connections to poor households from 101 household connections in 1999 to 17,657 in 2008. The fact that Phnom Penh has been able to reduce its unaccounted-for water from over 60% in 1998 to just 6% by 2008, which is comparable to Singapore, demonstrates that state managed utilities in developing countries can be efficient, if they have good leadership and governance.

DEWATS IN INDONESIA:

The government of Indonesia is promoting community-managed decentralized wastewater treatment systems (DEWATS) and aims to reach 5% of the total urban population through DEWATS by the end of 2014. A review of almost 400 DEWATS units installed in different Indonesian cities between 2003 and 2007 found that over 80% of them were functioning well and complying with effluent discharge standards. The study found, however, that sustained use of the infrastructure over the long term requires some external monitoring and support, as community groups often lose enthusiasm and are reluctant to fund major repairs on their own. It concluded that "community managed DEWATS can be effective for serving poor communities where the appropriate type of system is built well in the right location, the number of users is optimized and sustained and there is shared responsibility with government for operation and maintenance" (WSP, 2013).

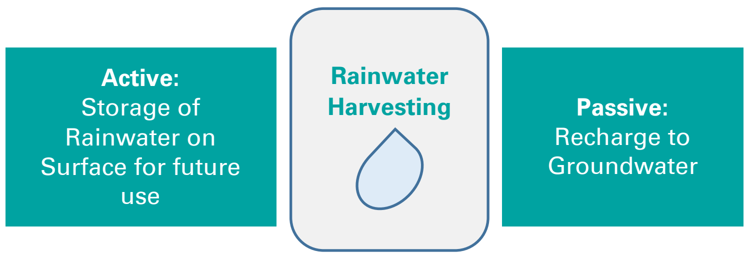
WATER MANAGEMENT-SINGAPORE

Water has become an issue of national security for most countries of the world, Singapore being one of them because of its dependence on imports of water from Malaysia. Public Utilities Board (PUB) currently manages the entire water cycle of Singapore. Earlier, PUB was responsible for managing potable water, electricity and gas. In 2001, the responsibilities for sewerage and drainage were transferred to PUB from the Ministry of the Environment. This transfer allowed PUB to develop and implement a holistic policy, which included protection and expansion of water sources, stormwater management, desalination, demand management, community-driven programmes, catchment management, outsourcing to private sector specific activities which are not within its core competence, and public education and awareness programmes. The country is now fully sewered to collect all wastewater, and has constructed separate drainage and sewerage systems to facilitate wastewater reuse on an extensive scale. PUB invariably comes to the top 5% of all the urban water utilities of the world in terms of its performance. Indicators are • 100% of population have access to drinking water and sanitation. • The entire water supply system, from water works to consumers, is 100% metered. • Monthly bill collection efficiency: 99% in 2004. • Monthly bill collection in terms of days of sales outstanding was 35 days in 2004.

Rainwater Harvesting in Urban India

Groundwater reservoirs get water as a result of recharge by infiltration from rainfall (Precipitation), rivers, canals, irrigation water etc. and loose water due to regeneration in surface water bodies, movement towards down slope of aquifer surface and manmade withdrawals. Such manmade withdrawals are very prominent in mining areas. Rapid industrial development, urbanization and increase in agricultural production have led to freshwater depletion in many parts of the country. Extensive use of advanced pumping techniques has made it possible to extract groundwater from greater depth, making the problem more acute. In this context, rooftop rainwater harvesting can become a popular technique to improve the storage and recharge of water.

Rain-water harvesting is a water management technique and practice of collecting rainwater falling on the rooftops. **Active Usage:** The collected water is either stored for continuous use/consumption by the users / occupants of the houses/buildings. **Passive recharge:** The water is used for recharging groundwater by pumping it through existing bores / hand pumps etc.



Rainwater Harvesting and Usage Techniques

The main goal of the rainwater harvesting is to minimize the flow of rainwater through drains to the rivers without making use of the same. The rainwater that is harvested through RWH can also be used to recharge aquifers through artificial recharge techniques which help to restore supplies from depleted aquifers due to excessive groundwater development.

India's Traditional Water Harvesting Practices

Table below gives the various traditional water harvesting practices in India.

Type	Description
Zings	*Zings* are water harvesting structures found in Ladakh. They are small tanks, in which collects melted glacier water
Ramtek Model	Ramtek Model after water harvesting structures in the town of Ramtek, Maharashtra. A scientific analysis revealed an intricate network of groundwater and surface water bodies, intrinsically connected through surface and underground canals. A fully evolved system, this model harvested runoff through tanks, supported by high yielding wells and structures like baories, kundis, and waterholes. This system, intelligently designed to utilize every raindrop falling in the watershed area is disintegrating due to neglect and ignorance.
Kere	Tanks, called kere in Kannada, were the predominant traditional method of irrigation in the Central Karnataka Plateau, and were fed either by channels branching off from *anicuts* (check dams) built across streams, or by streams in valleys. The outflow of one tank supplied the next all the way down the course of the stream

Phad	The community-managed phad irrigation system, prevalent in north western Maharashtra, probably came into existence some 300-400 years ago. The system operated on three rivers in the Tapi basin - Panjhra, Mosam and Aram - in Dhule and Nasik districts (still in use in some places here).
Bhandaras	These are check dams or diversion weirs built across rivers. A traditional system found in Maharashtra, their presence raises the water level of the rivers so that it begins to flow into channels. They are also used to impound water and form a large reservoir. Where a *bandhara* was built across a small stream, the water supply would usually last for a few months after the rains. They are built either by villagers or by private persons who received rent-free land in return for their Public Act.
Kohli Tanks	The Kohlis, a small group of cultivators, built some 43,381 water tanks in the district of Bhandara, Maharashtra, some 250-300 years ago. These tanks constituted the backbone of irrigation in the area until the government took them over in the 1950s. It is still crucial for sugar and rice irrigation. The tanks were of all sizes, often with provisions to bring water literally to the doorstep of villagers.
Cheruvu	*Cheruvu* are found in Chitoor and Cuddapah districts in Andhra Pradesh. They are reservoirs to store runoff. *Cheruvu* embankments are fitted with *thoomu* (sluices), *alugu* or *marva* or *kalju* (flood weir) and *kalava* (canal).
Dungs or Jampois	Dungs or Jampois are small irrigation channels linking rice fields to streams in the Jalpaiguri district of West Bengal.
Canal water management	Most canals are in poor condition, due to paucity of funds as water is given free, or there is negligible charge which leads to inefficiency & inequity. Often at the head of the canal, there is over use & the tail end farmer suffers with low availability of water. At times due to leakages soil salinity occurs in large areas of upstream farms.

State wise Rainwater Harvesting related provisions

Majority of the states in India have passed legislations making the installation of RWH systems in all buildings mandatory. The state of Tamil Nadu was among the first to take this initiative and has witnessed considerable success. Table below gives the rainwater harvesting related provisions as per the building bye laws prescribed under the various states.

State Building Byelaws	Rainwater harvesting related provisions
Delhi	▪ Mandatory Rainwater harvesting in all new buildings with a roof area of more than 100m$^{2.}$ and in all plots with an area of more than 1000 sq. m., that are being developed.
National Capital Region	▪ Mandatory Rainwater harvesting in all institutions and residential colonies by CGWA. CGWA has also banned drilling of tube wells in notified areas
Indore (MP)	▪ Mandatory Rainwater harvesting in all new buildings with an area of 250 m^2 or more. RWH has been made mandatory for G+3 Structures.

Kanpur (UP)	▪ Mandatory Rainwater harvesting in all new buildings with an area of 1000 m^2 or more.
Kerala	▪ Mandatory rooftop rainwater harvesting arrangements as an integral part of all new building constructions for the following occupancies, namely:- o Residential (with floor area of 100 m^2 or more and plot area of 200 m^2 or more), Educational Institutions, Medical/Hospital o Assembly, Office/Business o Industrial (only for workshops, assembly plants, laboratories, dry cleaning plants, power plants, Gas plants refineries, diaries food processing units and any other occupancies notified by the Government from time to time)
Hyderabad (Andhra Pradesh)	▪ Mandatory Rainwater harvesting in all new buildings with an area of 300 m^2 or more. All existing buildings in Municipalities/Municipal Corporations shall construct rain water harvesting structures within a period of one year from issue of this GO. Competent authority shall insist on implementation of RWH in all layouts and sub divisions for sanctioning the same.
Tamil Nadu	▪ Mandatory RWH in three storied buildings irrespective of the size of rooftop area and for all Government buildings.
Rajasthan	▪ Mandatory RWH for all public establishments and all properties in plots covering more than 500 m^2 in urban areas.
Mumbai	▪ Mandatory RWH for all buildings that are being constructed on plots that are more than 1,000 m^2 in size.
Gujarat	▪ Mandatory RWH for all buildings with area between 500 and 1500 m^2 in size. Mandatory percolation wells with rain water harvesting system @ one percolating well for every 4000 m^2 or part thereof of building unit for all buildings with area between 1500 to 4000 m^2 in size.
Himachal Pradesh	▪ For all existing or coming up commercial and institutional buildings, tourist and industrial complexes, hotels etc. ▪ Having area of more than 1000 square meters will have rain water storage facilities commensurate with the size of roof area. It has been recommended that the buildings will have rain water storage facility commensurate with the size of roof in the open and set back area of the plot at the rate of 0.24 cft. per m^2 of the roof area. ▪ No building plan without rainwater harvesting system can be approved. Toilet flush systems will have to be connected with the rainwater storage tank.
Haryana	▪ Mandatory RWH in all new buildings irrespective of roof area. CGWA has also banned drilling of tube wells in notified areas of the state.
Goa	▪ Mandatory RWH for all government buildings.
Bangalore (Karnataka)	▪ Mandatory RWH in newly constructed buildings. Mandatory RWH for Residential sites which exceed an area of 2400 ft^2 (40 x 60 ft).

New Approach for Building Design

- As use of led lights are being encouraged there is need to introduce innovative design in the kitchen, so that water used for washing fruits/vegetables is harnessed below the wash basin in a bucket for mopping. Similarly, water used for washing dal, rice is captured in another bucket for gardening or for potted plants in the balcony.
- In many states, Rain Water Harvesting (RWH) is mandatory for new buildings. RWH must be mandated for existing stock of old buildings. This would also help in generating numerous job opportunities.

Urban Sewage Treatment in India

As per World Urbanization Prospects, 2014, Indian urban population stands at 410 million which is expected to grow by 404 million people by 2050. Profound changes to the size and spatial distribution of the Indian population is bringing some key urban challenges and treatment and disposal of domestic sewage is one of them. A report on Indian wastewater treatment market indicated that the market size stands at 4 billion USD which is growing at a steady rate of 10-12 percent per year (Business Standard, 2015).

Disposal of domestic sewage from cities and towns is the biggest source of pollution of water bodies in India. As per CPCB 2015 estimates, about 62,000 million litres per day (MLD) of sewage is generated from urban areas. With an installed treatment capacity is about 23,277 MLD only about 37% of the total sewage generated is treated while the remaining sewage flows untreated into rivers. In urban areas, water is tapped from rivers, streams, wells and lakes for domestic and industrial uses. Almost 80% of the water supplied for domestic use, comes back as wastewater. In most of the cases untreated wastewater is let out which either sinks into the ground as a potential pollutant of ground water or is discharged into the natural drainage system causing pollution in downstream areas.

Sewage generation from States

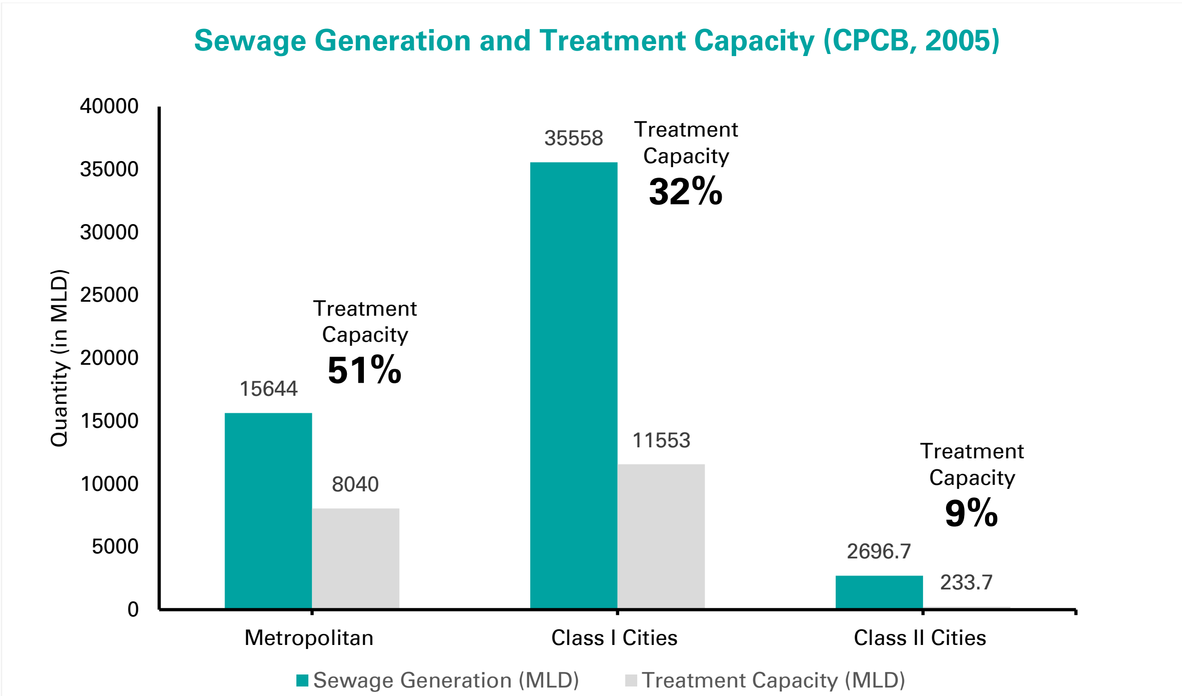
Central pollution control board (CPCB) has carried out a study on the status of municipal wastewater generation and treatment capacity in metropolitan cities, Class I cities and Class II towns of India. Metropolitan cities have a population of 10 lakhs or more; and as per the study, 15,644 million liters per day (MLD) sewage is generated from 35 metropolitan cities. Among the metropolitan cities, Delhi was having the highest capacity of sewage treatment (2330 MLD) which was 29% of the total treatment capacity of metropolitan cities). Among the Class-I cities (498 in total), nearly 52% cities were located in five States *viz.* Andhra Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal and the quantity of sewage generated from class-I cities was estimated at 35558.12 MLD. Out of 11553.68 MLD sewage treatment capacity from Class I Cities, 8040 MLD existed in 35 metropolitan cities *i.e.* 69% and the capacity of sewage treatment in remaining 463 Class-I cities was 31% only. Table below gives the sewage generation and treatment capacity from the 35 metropolitan cities in India (CPCB, 2005 Estimates).

Name of the City	Sewage generation (MLD)	Sewage Treatment Capacity (MLD)	Percent of Treatment Capacity
Hyderabad	426.21	593	100
Vishakhapatnam	134.99	-	-
Vijayawada	128.39	-	-
Patna	279.14	105	37
Delhi	3800	2330	61
Ahmedabad	472	488	100
Surat	432	202	46
Rajkot	108.8	44.5	40
Vadodara	180	206	100

Bangalore	771.75	-	-
Indore	204	78	38
Bhopal	334.75	22	6
Jabalpur	143.34	-	-
Mumbai	2671	2130	80
Pune	474	305	64
Nagpur	380	100	26
Nasik	227.84	107.5	47
Ludhiana	235.2	311	100
Amritsar	192	-	-
Jaipur	451.71	54	11
Chennai	158	264	100
Kanpur	417.35	171	41
Lucknow	363.81	42	11
Agra	260.36	88	33
Kolkata	705.86	172	24
Faridabad	164	65	39
Jamshedpur	199.43	-	-
Asansol	147	-	-
Coimbatore	120	-	-
Madurai	97.93	-	-
Meerut	177.05	-	-
Varanasi	230.17	102	44
Allahabad	176	60	34
Kochi	188.4	-	-
Dhanbad	192	-	-

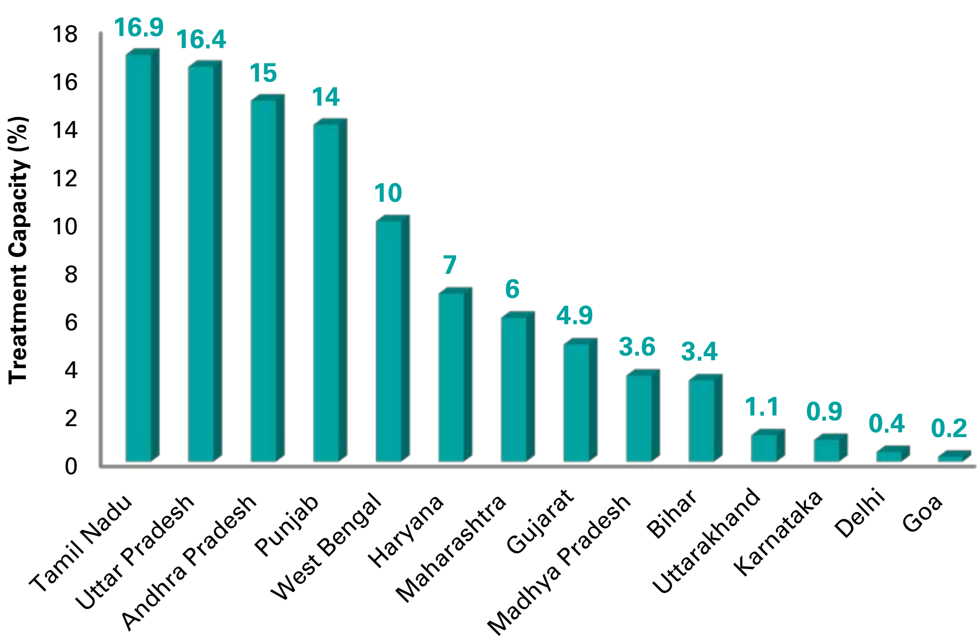
(Reference: Performance Evaluation of Sewage Treatment Plants under NRCD, CPCB, 2014)

Figure below gives the summary of sewage generation and treatment capacities for metropolitan, Class-I and Class-II cities in India (as per CPCB, 2005):



Installed Capacity for Sewage Treatment various States

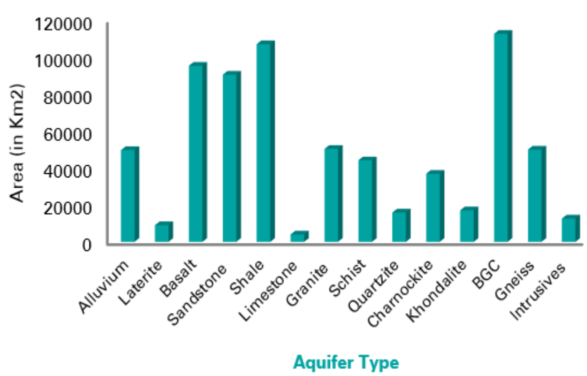
As per the CPCB, 2014 study on the status of sewage treatment plants (STP's) in the states, the maximum sewage treatment capacity exists in Tamil Nadu (16.9%). The installed sewage treatment capacity for other states is indicated in the figure below:



Watershed Management in India

Ground water is the most easily accessible and exploited fresh water resource. In India, groundwater provides for more than 80% of the rural drinking water and more than 50% of water used for agriculture. Demands for domestic, agricultural and industrial sectors are increasing along with socio economic development of the country. In order to meet this increasing demand, there is a need for sustainable management of the ground water resource. Due to the excessive withdrawal and poor management of watersheds across India the groundwater levels have depleted substantially. Central Ground Water Board (CGWB) has identified aquifer management plans for various types of aquifers in the country and as per 695457 km^2 of area has been delineated for water conservation and harvesting across the country (CGWB 2012 estimates). Table below gives an overview of delineated area for water conservation and harvesting across various states and under various aquifer types:

State	Total Area (in Km^2)	State	Total Area (in Km^2)
Andhra Pradesh	31854	Madhya Pradesh	84710
Arunachal Pradesh	52462	Maharashtra	65389
Assam	26033	Manipur	16441
Bihar	2240	Meghalaya	17695
Chandigarh	1	Mizoram	18225
Chhattisgarh	57516	Nagaland	13635
Dadra and Nagar Haveli	240	Orissa	63019
Daman and Diu	0	Puducherry	5
Delhi	0	Punjab	1270
Goa	685	Rajasthan	38482
Gujarat	18143	Sikkim	5340
Haryana	722	Tamil Nadu	23501
Himachal Pradesh	19102	Tripura	6711
Jammu and Kashmir	49821	Uttarakhand	3248
Jharkhand	15903	Uttar Pradesh	4384
Karnataka	34245	West Bengal	7202
Kerala	17232	**Total Area**	**695456**



Area delineated for water conservation under different aquifers
(Source: Aquifer Systems of India, CGWB, 2012)

Government Program on Watershed Development

Integrated Watershed Management Program (IWMP)

India has integrated Watershed Development Program for development of watersheds in India. Government of India started Integrated Watershed Development Program (IWDP), the revised guidelines for which is published in the year 2001.The main objectives of the IWMP is to restore the ecological balance by harnessing, conserving and developing degraded natural resources such as soil, vegetative cover and water. The outcomes are prevention of soil run-off, regeneration of natural vegetation, rain water harvesting and recharging of the ground water table. This enables multi-cropping and the introduction of diverse agro-based activities, which help to provide sustainable livelihoods to the people residing in the watershed area. In addition, there is a Scheme of Technology Development, Extension and Training (TDET) is also being implemented to promote development of cost effective and proven technologies to support watershed management.

Activities under IWDP

There are various activities which are prescribed under Watershed Development Program. The major activities taken-up under the scheme are:-

- In situ soil and moisture conservation measures like terracing, bunding, trenching, vegetative barriers and drainage line treatment.
- Planting and sowing of multi-purpose trees, shrubs, grasses, legumes and pasture land development.
- Encouraging natural regeneration.
- Promotion of agro-forestry & horticulture.
- Wood substitution and fuel wood conservation measures.
- Awareness raising, training & extension.
- Encouraging people's participation through community organization and capacity building.
- Drainage Line treatment by vegetative and engineering structures
- Development of small water Harvesting Structures.
- Afforestation of degraded forest and non-forest wasteland.

National Mission for Micro-irrigation (NMMI)

Ministry of Agriculture, Government of India has published guidelines on micro-irrigation. NMMI is a centrally sponsored scheme in which 40% of the cost of the micro-irrigation system will be borne by the central government, 10% by the state government and the remaining amount will be borne by the beneficiary either through his/her own resources of through financial institutions. 75% of the cost of drip and sprinkler demonstration for a maximum area of 0.5 hectare per demonstration will be borne by the Central Government. Under NMMI, assistance will be available for both sprinkler and drip irrigation and all categories of farmers are eligible to avail assistance under this scheme.

The objective of the scheme is "to achieve convergence of investment in irrigation at the field level, expand cultivable area under assured irrigation." The outlay for the five-year period has been slated as INR 50,000 crores (US$ 7.8 billion), with an outlay of INR 5,300 crores (US$ 826.6 million) set for 2015-16. Micro irrigation plays a key role for the future with the need to increase productivity whilst water saving. It is the frequent application of small quantities of water directly above and below the soil surface; usually as discrete drops, continuous drops or tiny streams through emitters placed along a water delivery line.

Challenges

- Lack of focus on micro irrigation
- Lack of dedicated team and IT-backed operations
- Subsidy disbursement process
- Absence of easy financing mechanisms for farmers

Benefits of Micro irrigation

- Increase in water efficiency
- Energy consumption savings
- Fertilizer consumption savings
- Productivity increase, Fruit/Crops
- Irrigation cost savings /New crop introduction
- Increase in Farmers' income
- Absence of easy financing mechanisms for farmers

Participatory Groundwater Management

Participatory Groundwater Management (PGWM) is a current practice which is used for the groundwater management in the rural areas. It is a program which is based on eight simple principles wherein, groundwater is recognized as a common pool resource. PRWM is a fresh paradigm of looking at groundwater wherein aquifer is identified as the unit of groundwater management. PGWM include supply augmentation, demand management and resource-based interventions instead of source-based approach which will attempt to bridge certain gaps within groundwater-related programs and allied projects such as watershed management and drinking water-sanitation. Figure below gives an overview of some of the principles of PGWM:

PARTICIPATORY GROUNDWATER MANAGEMENT PRINCIPLES

Groundwater is a common Pool Resource	Long Term Engagement (8-10 years)
Priority on Science, Local Knowledge and Education	Minimum unit of management can be 'Local Aquifer' and maximum unit is 'Watersheds'
Groundwater problem defined in terms of quantity, quality, equity of access and aquifer sustainability	Management processes must consider different uses like drinking water, irrigation etc.
Planning, management and Monitoring to be executed by community	Funding from external agencies viz., corporates, international agencies, government

National Bank for Agriculture and Rural Development (NABARD) and Watershed Development

NABARD was established on the recommendations of Shivaraman Committee, (by Act 61, 1981 of Parliament) on 12 July 1982 to implement the *National Bank for Agriculture and Rural Development Act 1981*. It replaced the Agricultural Credit Department (ACD) and Rural Planning and Credit Cell (RPCC) of Reserve Bank of India, and Agricultural Refinance and Development Corporation (ARDC). It is one of the premier agencies providing developmental credit in rural areas. NABARD is India's specialized bank for Agriculture and Rural Development in India.

NABARD has been instrumental in grounding rural, social innovations and social enterprises in the rural hinterlands. It has in the process partnered with about 4000 partner organizations in grounding many of the interventions be it, SHG-Bank Linkage program and tree-based tribal communities' livelihoods initiative, watershed approach in soil and water conservation, increasing crop productivity initiatives through lead crop initiative or dissemination of information flow to agrarian communities through Farmer clubs. Despite all this, it pays huge taxes too, to the exchequer – figuring in the top 50 tax payers consistently.

Watershed Development Projects implemented by NABARD has resulted in creation replicable models of participatory watershed development has helped in augmentation of natural resources and improvement in livelihood of watershed communities. Major impact of the watershed implementation in various program as observed based on impact evaluation studies are given below:

- Rise in ground water level;
- Drinking water scarcity in villages has been overcome;
- Local employment generation has improved, reducing off season migration;
- Increase in agricultural productivity and production - maize (28%), jowar / bajra (50%), ground nut (18%), pulses (36 to 42%);
- Dairy activity has received a fillip;
- Demand for credit has gone up (estimated potential ₹6420 crore);
- Women empowerment and reduction in drudgery; large number of women SHGs formed and credit linked (about 12840 SHGs); and
- Secondary impact – improved housing, health and education (schools).

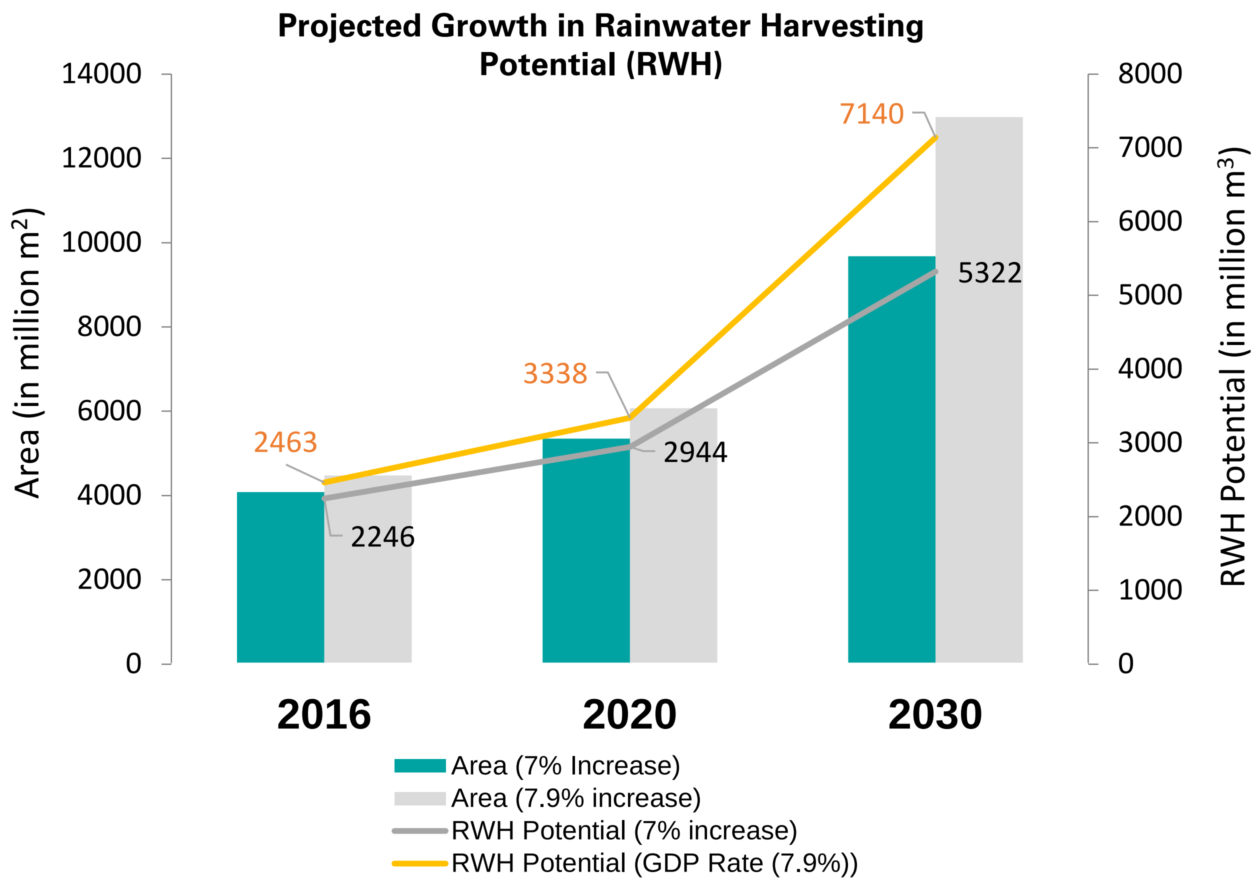
Chapter 2:
Growth Forecast

- **Potential Growth in Rainwater Harvesting**
- **Potential Growth in Urban Sewage**
- **Potential Growth in Watersheds & Micro-irrigation**

Potential Growth in Rainwater Harvesting

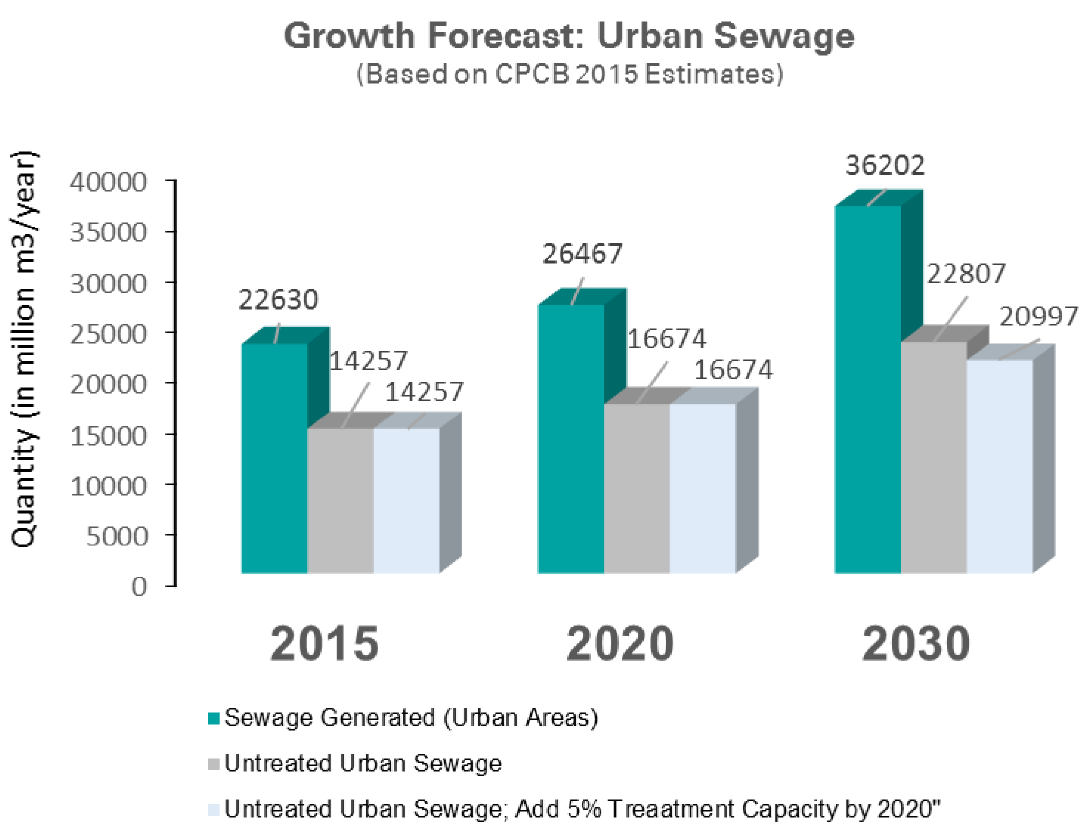
Industrialization and a growing population have given rise to a severe fresh water shortage in many countries. RWH, which involves the collection and storage of rainwater, is an affordable and sustainable solution to this problem. Although RWH has been practiced for several years, it is only in recent years that countries have given it a serious thought with several passing legislations and offering incentives to promote the concept. A significant driver for the RWH market in India has been the state level legislations that have made RWH mandatory for all new buildings in certain states, as per a report on market prospects, the global rainwater harvesting market is expected to grow at a CAGR of 4.8% during the period 2016-2020.

Roof water harvesting was practiced, as a matter of necessity, mostly in the low rainfall areas of the country, having annual rainfall less than 500 mm per year. The rainwater that falls on the surface / rooftop is channelized to bore wells or pits or new / old abandoned well through small diameter pipes to recharge the underground water, which can be harvested to the extent of 55000 liters per 100 m^2 areas per year *(Athavle, 1998*). Figure below gives the estimated increase in building area and the corresponding rainwater harvesting potential.



Potential Growth in Urban Sewage

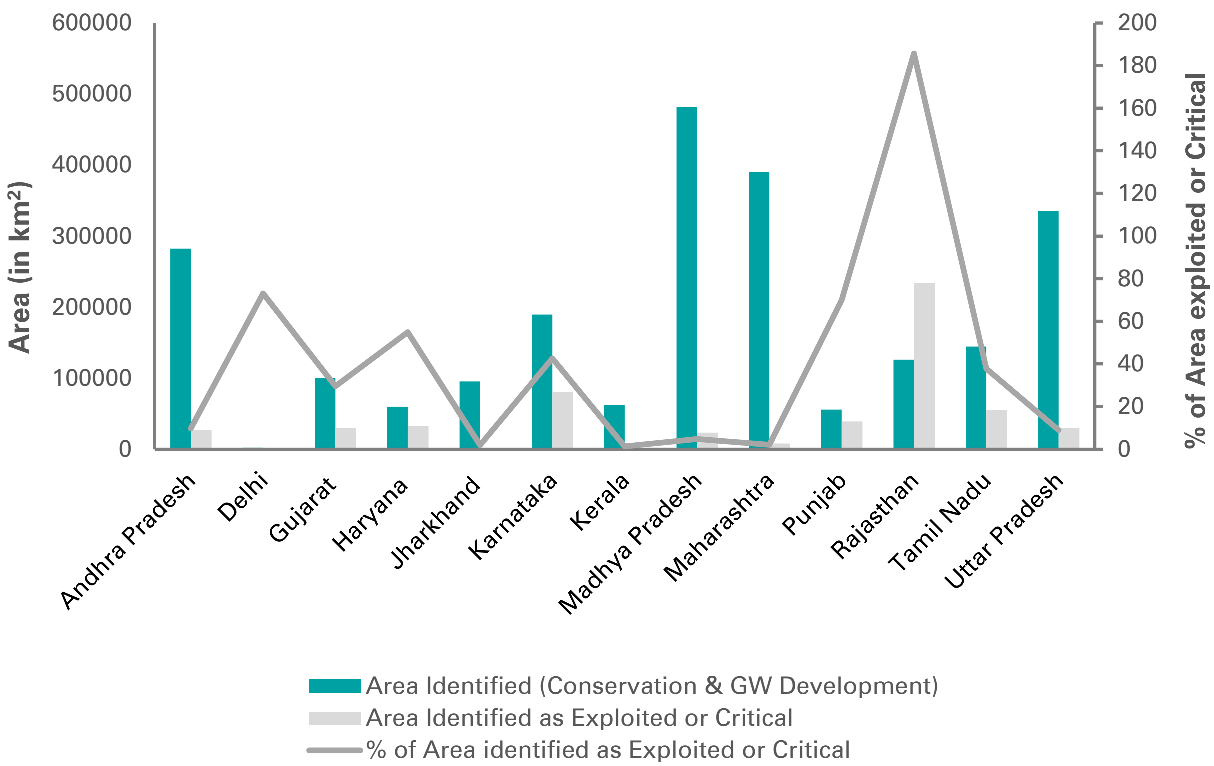
About 62,000 million litres per day (MLD) of sewage is generated from urban areas in India (CPCB, 2015) and with an installed treatment capacity is about 37% of the total sewage generated. As per CPHEEO estimates, 70-80% of water supplied in urban areas become wastewater and only 30% of total sewage generated in urban India is treated. Urban water demand for India in the year 2013 stood at 190.2 billion cubic meter (BCM) which is expected to increase to 440 BCM by 2030 (Encon perspectives, 2016). The expected increase in urban sewage quantity can be based on two different criteria's viz., % increase in urban water demand and % increase in urban population. We based our projections on the criteria of % increase in urban population up to 2020 and thereafter from 2020 to 2030. As per the census 2011 data, the urban population has increased from 286 million in the year 2001 to 377 million in the year 2011 which translates to 31.82% increase in a decade. Considering the same percentage growth up to 2030 for urban sewage, the sewage generated from urban areas is expected to increase from 22630 million m^3/year to 36202 million m^3/year. The treatment capacity is estimated at 37% in 2015, considering the business as usual scenario, the volume of untreated sewage is expected to reach 22807 million m^3/year by 2030. Considering that there might be some increase in installed sewage treatment capacity (assuming an additional 5% installed sewage treatment capacity by 2020), the growth estimates on the volume of untreated sewage are also made for the scenario with an installed treatment capacity of 42%. The volume of untreated sewage is expected to reach 20997 million m^3 / year by 2030 (considering an additional 5% treatment capacity).



Potential Growth in Watersheds & Micro-irrigation

As per CGWB, 2012 Report on the status of Indian aquifers, the total area of the country suitable for groundwater development stands at 1963791 km². The report also highlights that 486573 km² area of the blocks is overexploited and 76201 km² area of the country is critical. Figure below gives the statistics of the country along with the two key states viz., Karnataka and Tamil Nadu which are facing water shortages. The area suitable for water conservation and harvesting i.e., 695457 km² is the area in which micro-irrigation related technologies like sprinklers, MIS etc. needs to be promoted for agriculture and landscaping related water usages.

State	Area Suitable for Groundwater Development (in km²)	Area suitable for water conservation and harvesting (in km²)	Area delineated for artificial recharge (in km²)	Area under over exploited (OE) blocks (in km²)	Area under critical blocks (in km²)
India	1963791	695457	704941	486573	76201



Source: Aquifer Systems of India, CGWB, 2012. **Table** below gives the category of aquifers as defined by CGWB

Stages of ground water development	Category of Aquifer
<=90%	Safe
>90% and<=100%	Critical
>100%	Over-Exploited (OE)

Chapter 3
Technological Options

- **Technological Options: Rainwater Harvesting**
- **Technological Options: Sewage Treatment**
- **Technological Options: Watershed Management**

Technological Options: Rainwater Harvesting

Rainwater harvesting (RWH) is a cost effective simple technique which can be done at very low-technology, and is applicable at small-scale with a minimum of specific expertise or knowledge; or in more sophisticated systems at large-scale (e.g. a whole housing area / gated communities).The most common technique in urban areas (besides storm water management*)* is rooftop rainwater harvesting which is described in the **Table** below:

Technology	Description
Roof-Top Rainwater Harvesting	It is a system of catching rainwater where it falls. In rooftop harvesting, the roof becomes the catchments, and Rainwater can be collected from most forms of roof. Tiled roofs, or roofs sheeted with corrugated mild steel *etc.* are preferable, since they are the easiest to use and give the cleanest water. Thatched or palm leafed surfaces are also feasible, although they are difficult to clean and can often taint the run-off. Asbestos sheeting or lead-painted surfaces should be avoided. The rainwater is collected in guttering placed around the eaves of the building. The rainwater is collected from the roof of the house/building can either be stored in a tank or diverted to artificial recharge system. This method is less expensive and very effective and if implemented properly helps in augmenting the ground water level of the area. The main sub-components of Roof-Top Rainwater Harvesting are: Catchment, Transportation, First flush and Filter which are described below: ▪ Catchment: The surface that receives rainfall directly is the catchment of rainwater harvesting system. It may be terrace, courtyard, or paved or unpaved open ground. The terrace may be flat RCC/stone roof or sloping roof. Therefore the catchment is the area, which actually contributes rainwater to the harvesting system. ▪ Transportation: Rainwater from rooftop should be carried through down take water pipes or drains to storage/harvesting system. Water pipes should be UV resistant (ISI HDPE/PVC pipes) of required capacity. Water from sloping roofs could be caught through gutters and down take pipe. At terraces, mouth of the each drain should have wire mesh to restrict floating material. ▪ First Flush: First flush is a device used to flush off the water received in first shower. The first shower of rains needs to be flushed-off to avoid contaminating storable/rechargeable water by the probable contaminants of the atmosphere and the catchment roof. It will also help in cleaning of silt and other material deposited on roof during dry seasons Provisions of first rain separator should be made at outlet of each drainpipe. ▪ Filter: There is always some skepticism regarding Roof Top Rainwater harvesting since doubts are raised that rainwater may contaminate groundwater. Filters are used for treatment of water to effectively remove turbidity, color and microorganisms. After first flushing of rainfall, water should pass through filters. There are different types of filters in practice, but basic function is to purify water.

Technological Options: Sewage Treatment

Activated sludge treatment process (ASP) is the most common process used for the treatment of wastewater. Apart from ASP, various other technological options can be used for the treatment of domestic wastewater (or sewage) generated from the urban areas. As per a study conducted by CPCB, 2014, the STPs designed on Trickling filter and Sequential Batch Reactor (SBR) technologies are meeting the standards and having more than 90 % efficiency in terms of BOD removal. The various technological options are mentioned in the **Table** below:

Technology	Description
Activated Sludge Process (Conventional/ Extended Aeration)	The essential features of activated sludge process are: an aeration stage, solids- liquid separation following aeration, and a sludge recycle system. Wastewater after primary treatment enters an aeration tank where the organic matter is brought into intimate contact with the sludge from the secondary clarifier. This sludge is heavily laden with micro-organisms which are in an active state of growth. Air is introduced into the tank either in the form of bubbles through diffusers or by surface aerators. The micro-organisms utilize the oxygen in the air and convert the organic matter into stabilized, low-energy compounds such as NO_3, SO_4, and CO_2 and synthesize new bacterial cells. The effluent from the aeration tank containing the flocculent microbial mass, known as sludge, is separated in a settling tank, sometimes called a secondary settler or a clarifier. In the settling tank the separated sludge exits without contact with the organic matter and becomes activated. A portion of the activated sludge is recycled to the aeration tank as a seed; the rest is wasted. If all the activated sludge is recycled, then the bacterial mass would keep increasing to the stage where the system gets clogged with solids
Fluidized Aerobic Bed Treatment	Fluidized bed reactor is widely applied in many industries for various applications recently. It has been found promising to use fluidized bed reactor for water treatment procedures. When the conventional treatment procedures failed to remove recalcitrant compounds in waste water, advanced oxidation processes came as a foremost choice by the researchers. However, AOPs are yet not without limitations. Studies reveal that an effective contacting device system can increase the potential of advanced oxidation systems. Fluidized bed reactors can be considered as an improvement over the traditional water treatment methods associated with Fenton oxidation for pollutant degradation. Operation of FBR has confirmed many advantages that include high degradation efficiency, lesser reaction time and better catalyst re-circulation.
Trickling Filters	A Trickling filter is a fixed bed, biological reactor that operates under (mostly) aerobic conditions. Pre-settled wastewater is continuously “trickled” or sprayed over the filter. As the water migrates through the pores of the filter, organics are aerobically degraded by the biofilm covering the filter material. The advantage of trickling filter is that it is compact (applicable in dense urban population settings) and that they efficiently reduces organic matter. However, they are high tech and generally require skilled staff for construction as well as operation.

Up flow Anaerobic Sludge Blanket Reactors (UASB)	UASB technology include grit chamber as preliminary treatment unit and one-day retention time pond as the terminal polishing unit. Operationally, this treatment scheme is one of the most economical ones, as it merely requires passing the sewage through treatment scheme, with an added advantage of biogas generation. Ideally, this makes UASB technology as the most suited for cities of all sizes. However, all anaerobic treatment processes including UASB technology are very sensitive to environmental changes. Intermittent feeding can greatly affect the performance of a UASB reactor, as the anaerobic bacteria are very sensitive to shock loading.
Aerated Lagoons	An aerated lagoon or aerated basin is a holding and/or treatment pond provided with artificial aeration to promote the biological oxidation of wastewaters. An aerated lagoon is a large, mixed aerobic reactor similar to facultative ponds in waste stabilization pond systems with the difference that natural oxygenation is enhanced. Mechanical aerators provide oxygen and keep the aerobic organisms suspended and mixed with water to achieve a high rate of organic degradation. As natural oxygenation is enhanced, ponds can be deeper (thus smaller in surface) and are suited also for colder climates compared. There are two types of aerated ponds: common aerated lagoons (enhanced facultative ponds) and completely mixed aerated ponds are in essence activated sludge systems without sludge. The effluent of aerated ponds may be reused or used for recharge, but settled sludge requires a further treatment or correct disposal.
Stabilization Ponds	Waste or Wastewater Stabilization Ponds (WSPs) are large, man-made water bodies in which black water, grey water **or** fecal sludge are treated by natural occurring processes and the influence of solar light, wind, microorganisms and algae. The ponds can be used individually, or linked in a series for improved treatment. There are three types of ponds viz., anaerobic, facultative and aerobic (maturation), each with different treatment and design characteristics.

Technological Options: Watershed Management

Satellite based sensing and monitoring is a key technology that is used for management of aquifers and developing the command areas. This is described in the Table below:

Technology	Description
Remote Sensing and Geographical information system (GIS)	Remote sensing in combination with the Global positioning system (GPS) and Geographical Information System (GIS) produces the terrain maps at this location accuracy and containing detailed information of the variables under study. In India, satellite remote sensing technology is being used effectively in the areas of irrigation performance evaluation, snowmelt-runoff forecasts, reservoir sedimentation, watershed treatment, drought monitoring, flood mapping and management. Multi temporal satellite data are used as an aid to capacity survey of many reservoirs in a cost and time effective manner.
Aquifer Storage Transfer and Recovery Technique (ASTR)	The Aquifer Storage Transfer and Recovery (ASTR) technique is a process for converting storm water into water of drinkable quality. The technique involves injecting storm water, which was treated by being passed through a reed bed or wetland, into an aquifer. The water, stored in darkened conditions for a prolonged period, becomes potable by natural processes. Recharge and recovery wells are maintained separately to allow the aquifer ample storage time and travel distance, which in turn act as a natural bio filter. The extra water treatment achieved through this process grants better control of chemical and microbial contaminant attenuation of the stored water within the aquifer. A time gap of approximately 12-15 months is maintained between water injection and recovery.

Chapter 4
Business Opportunities and Estimates

- **Business Opportunities: Rainwater Harvesting**
- **Business Opportunities: Sewage Treatment**
- **Business Model: Watershed Management / Rural Drinking Water**
    - Successful Watershed Programmes: A Snapshot

Business Opportunities: Rainwater Harvesting

Rainwater harvesting as a business, the entrepreneurial perspective will be to understand the market segmentation comprehensively. This will provide an idea companies providing services in the segment and then plan a marketing technique. The person can promote his/her business activities through promoting business online and offline (Registering with local newspapers/magazines) or through attending real estate and construction related market events / fairs, sanitary equipment shops. The person needs to build/develop a business website with detailed information on customized solutions offered and related discounts (Put postings on advantages about rainwater harvesting and cost effectiveness). Initially can offer promotional discounts to customers.

Financial need assessment and technical need assessment needs to be balanced based on the business requirements. Once the capital need assessment for starting a new business have been identified, the potential Revenue streams w.r.t sales. In Technical Assessment, the sourcing / employing of subject matter expertise on planning, design and budgeting needs to be done. Following assessment, equipment procurement and devising can be done as discussed below:

- Equipment Procurement: Rainwater harvesting equipment & accessories sourcing: It doesn't require complex equipment and tools to install a basic cost-effective rainwater harvesting system. Some of the important are storage tank, pipes, water level indicator, first flush diverters, leaf eater, gutter outlets, canal adaptor and filter pits. Find a global company providing tools and accessories for rainwater harvesting system. Verify the price, quality and warranty for their products before making purchases (Figure out the benefits in case of long term purchase agreements).
- Devising: Customized planning (as per client's requirements) Solutions.

Approach: Rainwater Harvesting business can be set-up through either of the following options:-

- Purchasing an existing franchise
- Setting up New Brand

Case Studies: Rainwater Harvesting System

The various case studies based on Rainwater harvesting system is depicted in the Table below:

Case Study / Location	Description

Tihar Jail, Delhi	**Rainwater Available for Harvesting:** It is estimated from the Total area and average annual rainfall in Delhi. o Total area (Ward 1 and Ward 13): 4125 m^2 o Average annual rainfall in Delhi: 611 millimeters (mm). o Total volume of water harvested: 1280 m^3 or 12, 80,000 liters' o This represents 50.78 per cent of total rainwater harvesting potential. **Water Supply Source: Estimating Rooftop rainwater and runoff from unpaved areas** **Ward 1:** In Ward 1, the rooftop rainwater from the barracks and the surface runoff from the unpaved area are collected in a low-lying area between the buildings. This water is collected by a collection chamber measuring 0.5m x 0.5m x 0.5m, which is covered by a perforated RCC slab. The water collected in the chamber is diverted to recharge well measuring 1m x 1m x 2m with a recharge bore of 150mm diameter and 10m deep. The recharge well is filled with layers of pebbles and coarse sand, which act as filtering media to improve the quality of the water harvested. **Ward 13:** The rooftop rainwater from the buildings and the surface runoff from the open areas are collected in a low-lying area located at southwest corner of the ward. This water is collected in a collection chamber measuring 0.5m x 0.5m x 0.5m, which is covered by a perforated RCC slab. The water collected in the chamber is diverted to a recharge well measuring 1m x 1m x 2m in size with a recharge bore of 150mm diameter and 10m deep. The recharge well is filled with layers of pebbles and coarse sand, which act as filtering media to improve the quality of the water harvested. The implementation was completed in November 2002 and the water level on February 2003 was recorded at 9.40m below ground level (bgl). The cost of the entire rainwater harvesting system was INR 0.2 lakh. **Impact**: Monitoring: Water level data: This project demonstrated that rainwater harvesting can help solve the problem of water logging. Tihar Jail's barracks used to remain flooded for hours after every rainfall. The water level in the jail was 14m below ground level (bgl) in April 2003. Concerned with flooding in the barracks and with sharply declining water levels in the area, the Tihar Jail authorities decided adopt rainwater harvesting in Central Jail No. 4.
Mira Model School	**Rainwater Available for Harvesting** o Total rooftop and surface area: 16,200 m^2 o Average annual rainfall in Delhi: 611 mm o Total volume of rainwater harvested: 4,454 cubic meters (m^3), or 4454000 liters. o This is 45 per cent of the total water harvesting potential. **Water Supply Source: Estimating Rooftop rainwater and runoff from unpaved areas:** Rooftop rainwater and surface runoff harvesting **Western Side of the Building:** A part of the rooftop along with the surface runoff from the paved area near the playground is intercepted in a drain that is connected to a de-silting chamber. The silt-free water from the chamber (measuring 300mm x 300mm x 300mm) enters a recharge structure of 1m x 1m x 1m. To facilitate recharge, a 15m deep bore well of 100mm diameter is provided inside the recharge well. A layer of pebbles and sand filled inside the recharge well acts as filtering media,

	ensuring the quality of runoff that is being recharged. **Eastern Side of the Building:** Rooftop rainwater and surface runoff in the eastern side of the building is channelized through a storm water drain to a recharge structure measuring 2m x 2m x 3m. To facilitate recharge, an 8m deep bore well of 100mm diameter is provided inside the recharge well. **The football ground:** Runoff from the playground is captured on the north-western corner of the playground in a recharge well of 1.5m x 1.5m x 1.5m by means of a trench filled with pebbles surrounding the pit. The 14m deep bore well provided inside the recharge well facilitates recharging of the aquifer. Overflow from this structure drains into another recharge well of dimensions 2m x 2m x 2m through a network of pipes linked through chambers. The project was implemented in June 2001. The cost of the entire rainwater harvesting system was INR 1.20 lakhs. **Impact:** Although water levels are very shallow in this area, they are declining rapidly due to the heavy exploitation of ground water.

Business Opportunities: Sewage Treatment

Wastewater Treatment Plant: Design and Construction Projects: Technical Services in Design, Construction and operation of sewage treatment plants. The various opportunities for revenue are discussed in the Table as below:

Business Opportunity Area	Source of Revenue
Design and Construction of sewage treatment plants (STP's)	▪ Consulting Fees for design and construction of STP's.
Operating Sewage Treatment Plants/ Common Effluent Treatment Plants (CETP's)	▪ Charging sub-contractor fees (for operation and annual maintenance)
Build Operate Transfer (BOT) Model	▪ Revenue from sell of treated wastewater to municipalities, Industries or domestic consumers after advanced treatment
Sludge Processing Plant	▪ Power generation from Sludge. Fee for sludge processing, selling power generated and selling of sludge as manure.

Business Case: Power Generation from Sludge Incineration in China:

The drying and incineration joint treatment technology adopting the series of operations of low-temperature drying- high temperature incineration put up in plants. These two systems adopt foreign technology while being locally manufactured. The sludge drying and incineration equipment required a gross investment of CNY80 million and has now been put into operation. The sludge dewatering and drying technology can reduce water content from 70% to 10% (5% at the lowest) by adopting fluidized bed drying technology. Incineration refers to incineration of the dewatered sludge in the circulating fluidized bed incinerator and recycling the heat in the flue gas in the form of transfer oil (or steam), and the reclaimed heat is used for the drying system.

Business Model: Watershed Management/Rural Drinking Water

Rural Drinking Water: Scheme: Installation of Water ATM's in Villages

Water ATMs

Water ATMs are automated water dispensing units, which provide communities with 24/7 safe water access. They can be solar powered and cloud connected, thus enabling remote tracking of the water quality and of each pay per use transaction.

Case Study: Smart India

Smart India Pvt. Ltd has established 6800 community water plants in 11 States & serving 7.2 million people every day with safe water at an affordable user charge from 10 paisa to 30 paisa & has created 11,000 jobs directly/ indirectly in the country.

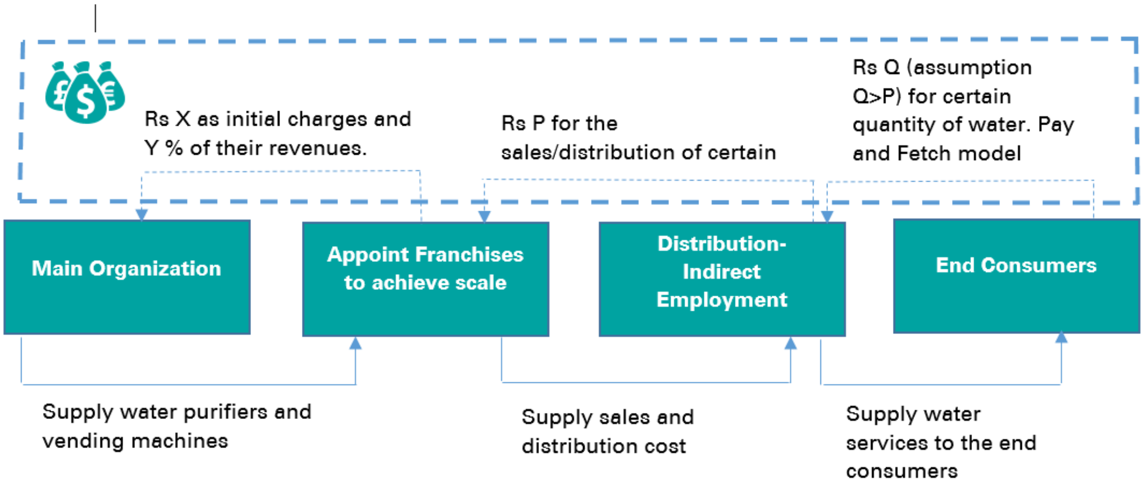
Case Study: Piramal Foundation

Sarvarjal is an initiative by the Piramal Foundation. Sarvarjal, which means "water for all" in Sanskrit was established as a social enterprise in 2008 by the Piramal Foundation to find ways to provide reliable and safe drinking water to poor communities living in remote villages and urban slums. Providing drinking water via a piped grid especially to remote rural locations is costly and often not an option in many developing countries. Sarvarjal, an Indian social enterprise, offers an alternative. Rather than transporting water to communities from external sources, Sarvarjal sells an integrated water purification service that purifies and monitors the quality of local water sources for local consumption, creating local jobs and income in the process.

Developing a workable solution was no easy task. Sarvarjal faced a number of challenges, not least poor roads and intermittent power supplies. Although there were a number of water purification technologies available on the market, the company recognized from the outset the need to develop a financially viable and sustainable business model that could be scaled up.

Water ATM Revenue Concept: Based on Piramal Foundation

Managing the watersheds can increase the water sustainability of the individual villages. The water consumption (in terms of quantity and quality) can be effectively monitored through water ATM. The Concept and business models is discussed as below:



Successful Watershed Management Programs: A Snapshot

NABARD-IGWDP- PUNIYAKUNDI KUSHALGARH (RAJASTHAN)

This project is to promote integrated watershed development through land Water Conservation and Water resource development along with targeting other components viz. livestock development, crop improvement, women and social development, community health and Capacity Building. Almost 597 families have been covered and approximately 320 ha area has been treated.

BILAGADDE WATERSHED: CHIKAMAGALUR; KARNATAKA

The area was affected with problems like depleting groundwater levels, low productivity due to deforestation and faulty agricultural practices. Community participation activities such as bunding, farm ponds, vented check dams, nala revetment were carried out by the villagers which has resulted in increase in groundwater level in various water sources such as open bore wells, increase in cultivable area and crop yield.

RALEGAON SIDDHI: WATERSHED MANAGEMENT (MAHARASHTRA)

Ralegaon siddhi is converted into a model village through people participation and community involvement program. People of Ralegaon siddhi invested thousands of hours in to development activity. Watershed development and utilization of renewable energy have converted the village into a model sustainable village.

WATER SHED PROJECT IN BARWANI & THIKARI BLOCK OF JHABUA

This project is to increase the irrigation potential so as to sustain the livelihood of tribal living in this region. Major achievements under this project are Jalabhishek Jalgrahan Samity in all micro watersheds, Training and capacity building program for GJJS, volunteers and community, treatment of 1950 hectares of land, 229 ha area is treated as SWC Work in 3 villages of the Project area, 84 ha is treated as WRD irrigated area, development of 25.6 ha Pasture land area and Afforestation in 298 hectares. 3600 hectares are treated in this project and 900 farmer households have benefited through the project interventions.

HIWARE BAZAAR-MAHARASHTRA: WATERSHED DEVELOPMENT

The implementation of Employment Guarantee Scheme (EGS) was a turning point for Hiware Bazaar. The village applied for Adarsh Gram Yojana (AGY) of the State Government which is based on five principles a ban on liquor, cutting trees and free grazing, family planning and contributing village labor for development work . This resulted in planting of trees on forestland and a ban on grazing in these areas. The implementation of AGY, EGS and sound water management techniques has transformed Hiware Bazaar into an ideal village with significant increase in irrigation potential and income level for villages.

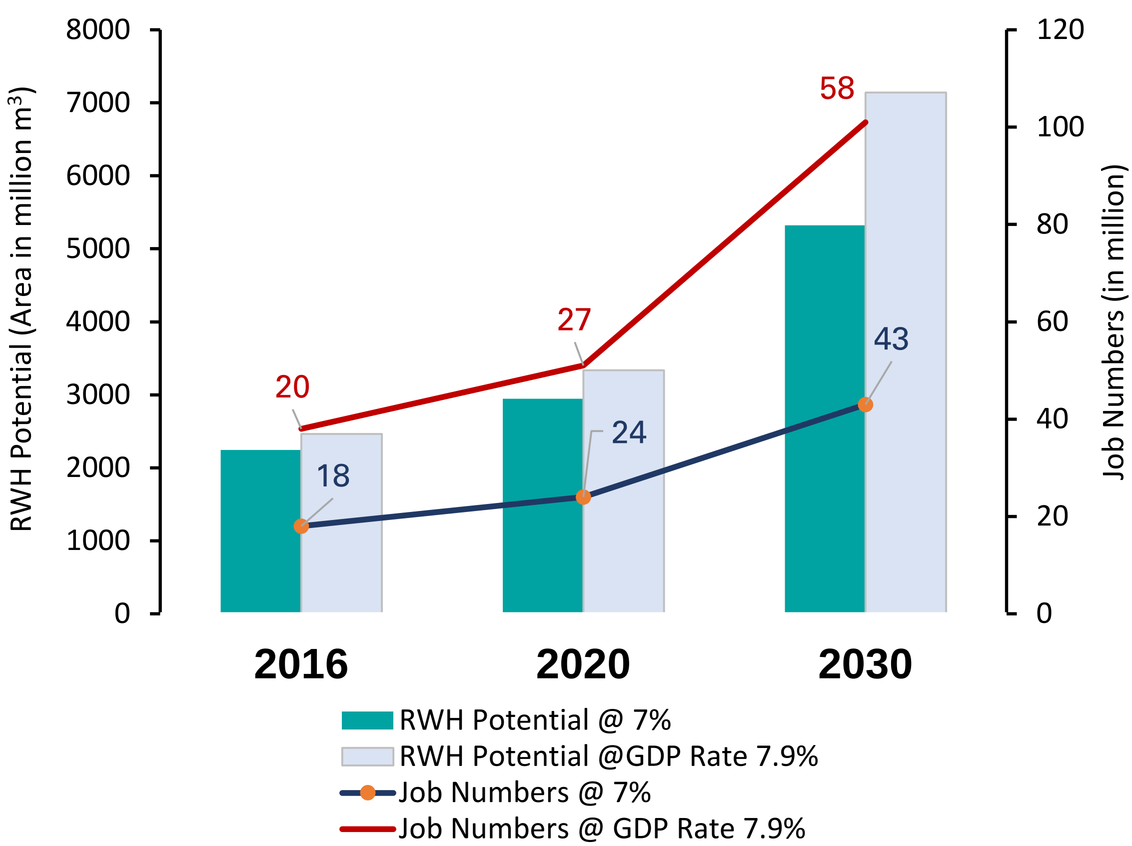
Chapter 5
Job Potential Estimates

- **Job Projections for Rainwater Harvesting**
- **Job Projections for Sewage Treatment**
- **Job Projections for Watershed/Micro-irrigation**

Estimating Job Potential in Water Management Subsector

Job Projections for Rainwater Harvesting

Based on the consultations with stakeholders involved in working on installation and procurement of rainwater harvesting (RWH) systems and experts in Water Management field, an estimated, 6 persons are required i.e., 2 mason and 4 helpers for 120 man-days for constructing RWH system with a collection area of 100 m^2. Estimating 1 person works for 270 man days, the total number of persons that will be required is provided in the figure below:



Job Forecast: Sewage Treatment

Estimating the job requirements based on an assumption that 50 MLD Common Effluent Treatment Plants (CETPs) are installed.

The number of CETPs needed to be installed for achieving 100% sewage treatment capacity will be 914 by the year 2020 and 1250 by the year 2030.

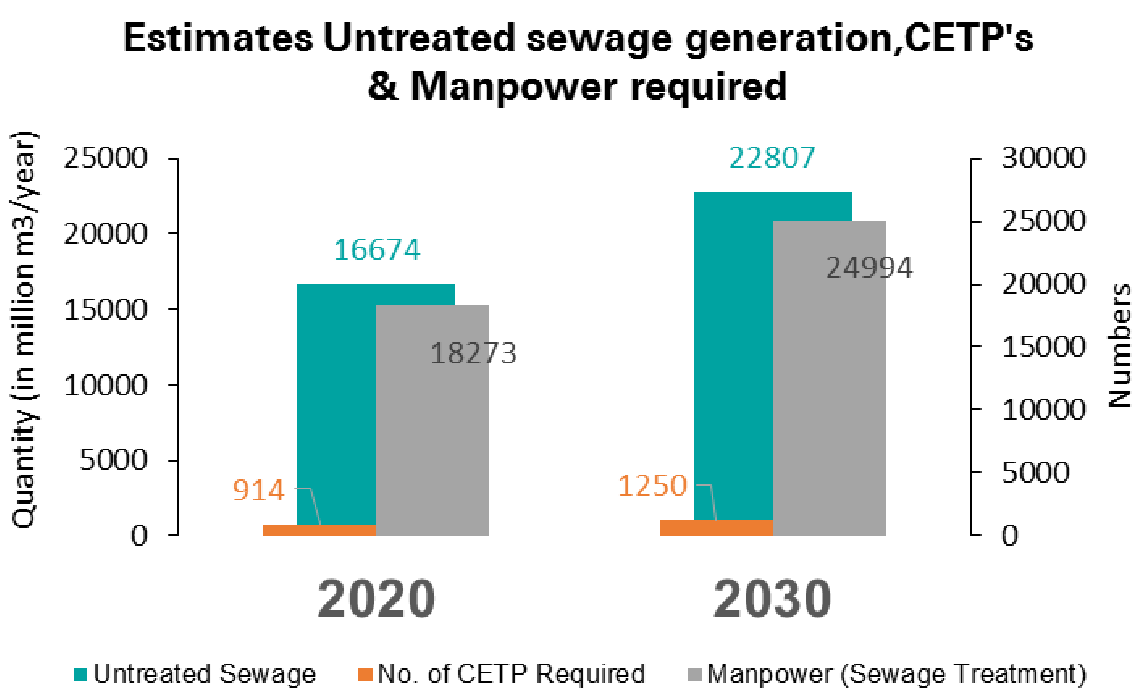
16674/18.25 = 914 (Year 2020)

22807/18.25 = 1250 (Year 2030)

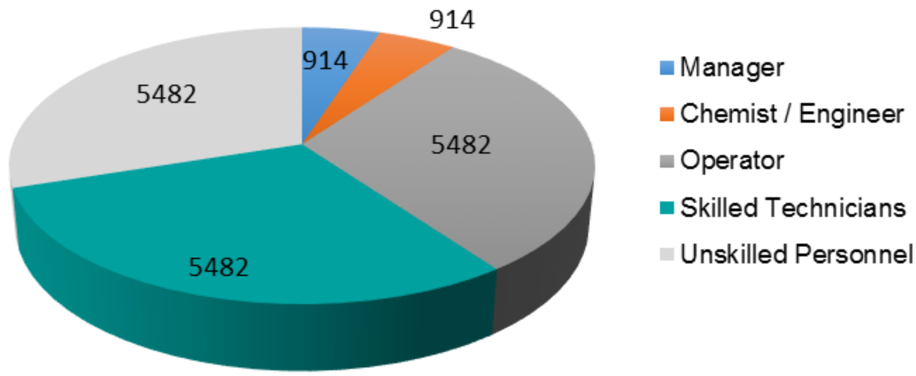
Estimating Manpower requirements: A 50 MLD CETP will require 20 persons for operation in various capacities such as Manager, Chemist/Engineer, Operator, Skilled Technicians and Unskilled Professionals. *(Reference: Sewage Treatment in Class-I Towns, IIT, Kanpur Report, 2010). The division of*

Manpower required for a 50 MLD plant operation is given in the Table below:

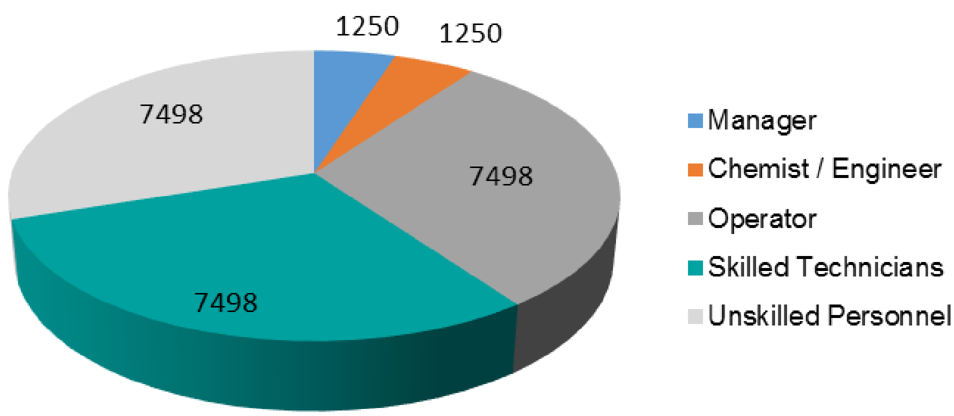
Manager	1
Chemist / Engineer	1
Operator	6
Skilled Technicians	6
Unskilled Personnel	6
Total	**20**



Job Type vs [Numbers]; Year 2020



Job Type vs [Numbers]; Year 2030



Jobs in Watershed Management and Micro-irrigation

The projects in watershed management are participatory projects requiring community participation. The jobs related to this field are those which are specialized such as watershed management expert, watershed contractor etc. which are identified in Occupational Mapping Chapter of this Report.

Chapter 6
Process Mapping

- **Process Map: Rainwater Harvesting**
- **Process Map: Sewage Treatment**
- **Process Map: Watershed Management**

Process Map: Rainwater Harvesting

Pre-Assessment

- Estimating Rainwater Harvesting Potential (RHP)
- Understanding:
  - Any legal requirements (for system sizing etc.)
  - Potential end-use application
  - Economic considerations for the project

Planning and Procurement

- Preliminary assessment viz., roofing material and other surfaces, areas, run-off coefficients etc.
- Design of system components such as:
  - Collection tank, material type, pumping requirements; material and Specifications of conveyances system viz., slope, material type, length.
- Quotations from vendors, contractors and making informed decisions

Installation and Operation

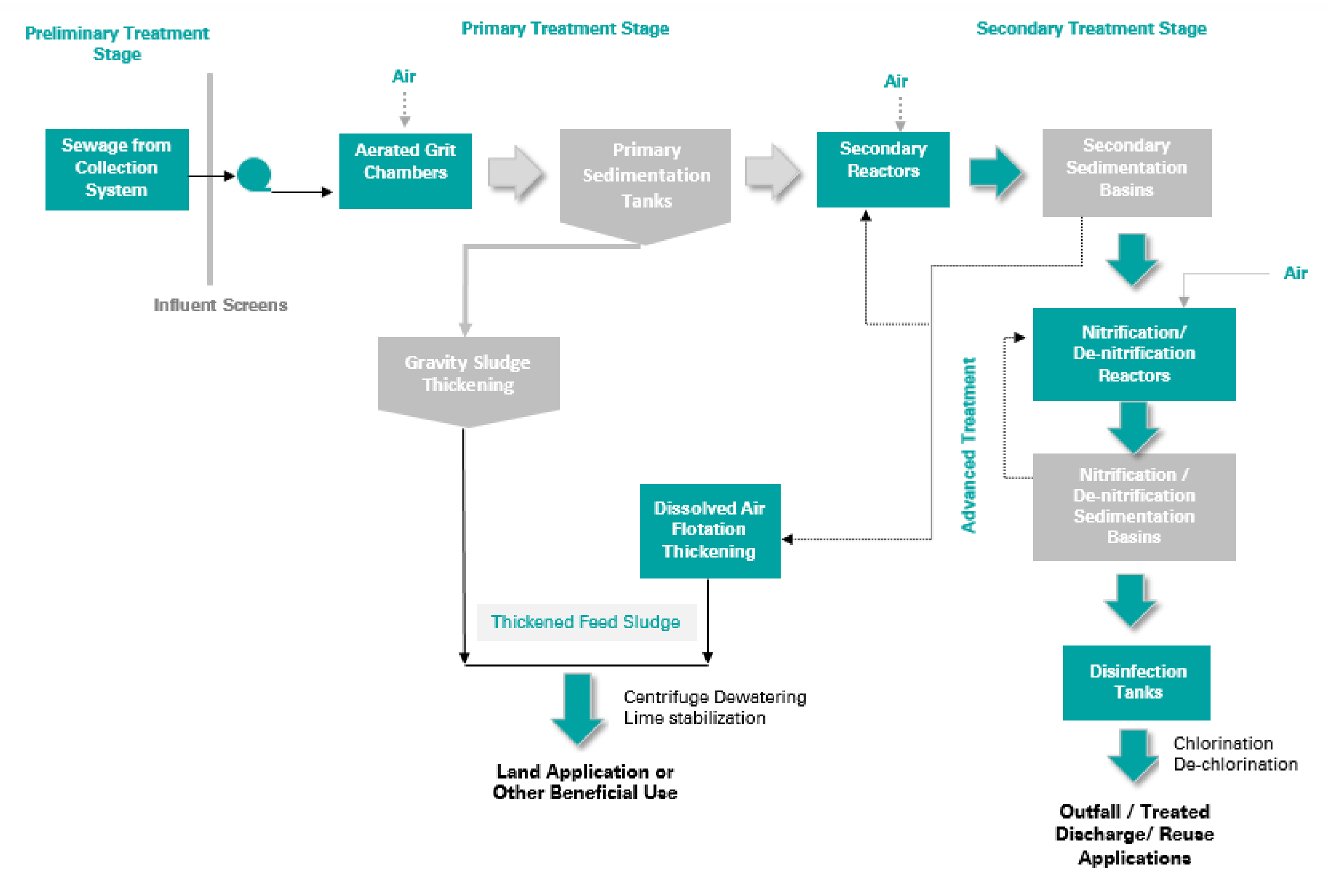
- Setting-up and assembling of system components
- Installation and commissioning
- Assessing of system deficiencies
- Corrections and handover

Monitoring and Maintenance

- Water quality and Filtration system
- Clogging of components
- Installation and commissioning
- Structural damages etc.

Stage	Key Activities
Pre assessment	Review of applicable policies and regulations, incentive programs
	Calculation of Rainwater harvesting Potential - Data on precipitation - Determine collection efficiency based on type of construction material - Identify size of the building type of the building (commercial, institutional, industrial or residential) since the collection efficiency and run off coefficients differ for types of roof and land surfaces, etc.
Site Evaluation	Study of drainage area, placement of collection tank, type, amount and design of conveyance piping,
	Study of type, abundance and distribution of precipitation
	Assess catchment possibilities and determine drainage patterns
	Assess possible placement of system components
	Understanding building use and expected occupancy (Occupancy will not only include building staff but visitors also)
Rainwater Harvesting System Design and Planning	Area contributing for runoff i.e. how much area and land use pattern, whether industrial, residential or green belts and general built up pattern of the area
	Major components of RWH system:- - Catchment Area / Roof: Surface where rain falls. - Gutters & Downspouts: Transport Channels from catchment surface to storage. - Leaf screens and roof washers: System that remove contamination and debris. - Cisterns or storage tanks: Collected rainwater is stored. - Conveying: Delivery system for treated rain water, either by gravity or pump. - Water Treatment: filters and equipment and additives to settle, filter and disinfect.
Installation	Locate system components, ancillary equipment and assemble components according to stage 3
	Development of final documentation on system installation
	Construct a maintainable system and Put inspection plan in place
	Operational startup
Operation, Maintenance & Monitoring	Adjusting operational controls
	Tank maintenance
	Collection system maintenance
	Disinfection system maintenance
	Roof washer or water diverter maintenance
	Test water quality
	Record operational data
	Assess function to identify malfunctioning components and take corrective measures

Process Map: Sewage Treatment

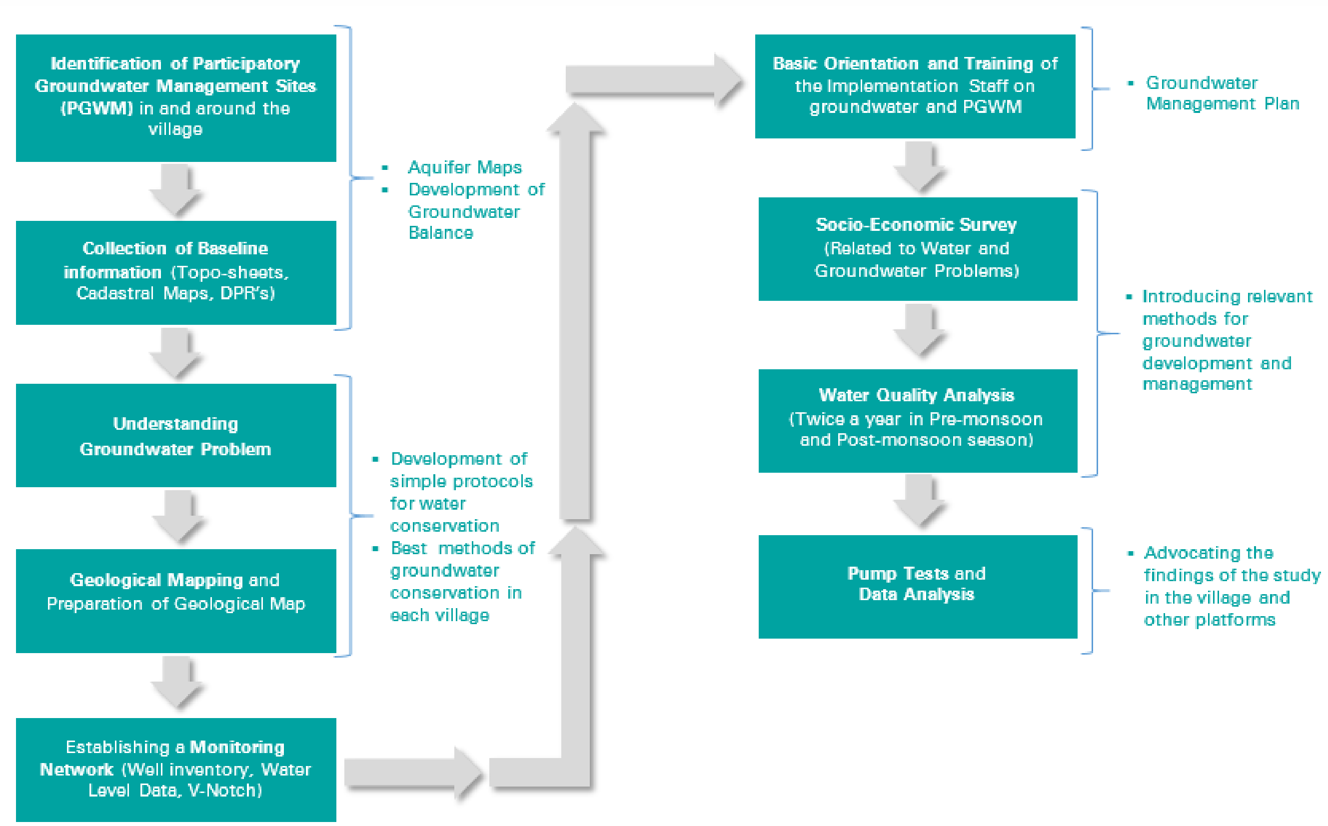


Stage	Key Activities
Planning and Assessment Stage	**Design: Initial Assessment & Evaluation** The objective of the stage is to identify a plan for wastewater (sewage and industrial effluents) management (treatment and infrastructure services within the area). Other objectives of the stage are: o Identification of a plan for future development, expansion or up-gradation of existing wastewater systems for accommodating changing needs. Estimation of the associated costs / financing mechanisms of the existing and planned systems. o Taking informed decisions about land use, infrastructure funding and any necessary permits or licensing requirements. o Assessing project sustainability (primarily financial):Integrating capital plan into the planning process, ensuring adequate budget for new, expanded or improved services, and ensuring proper allocation of fees to users of new infrastructure. Information relating to the planning aspects will include the following: o Inventory of the wastewater management systems in the planning area or region. o Estimating current and future wastewater (Sewage and Industrial Effluent) management needs of the planning area. o Identification of options for addressing the needs and select an appropriate approach. o Outline how the selected approach will be implemented and financed (including phasing and timelines). Factors influencing the wastewater management system:- o Size of the planning area, Land use types, Water Use o Rate of development / population growth, Fiscal capacity o Environmental features and influences o Relationships with neighboring jurisdictions
Preliminary Review	**Design: Preliminary Review** *(This section of the WWMP summarizes how the municipality or planning district currently manages wastewater)* [2A]: Describing the sources of wastewater in the planning area and how much wastewater is being produced annually: o Source Mapping: Locate the settlement areas /residences, commercial, institutional and industrial developments. Special emphasis must be given on those with high wastewater production rates or those requiring special wastewater treatment. o Estimating the future needs and wastewater volumes: Describing the annual wastewater volume produced by the sources listed during source mapping. o Existing wastewater system annual volume data can be used (if available) and the growth rates can be projected to calculate future needs. If existing volume data is not available, annual volume can be estimated with information such as: o Current population and past growth rates. o Number of residential units and average number of people per household. o Estimating average volumes of wastewater produced per person. o Estimating the organic loading. o Estimating the amount of truck hauled wastewater being produced from onsite systems, including septic tanks and holding tanks. o Obtaining details on wastewater management programs currently in place that may reduce the volume produced.

	[2B]: Describe the type(s) of wastewater management systems currently used to manage/treat wastewater in the planning area: o Provide the annual volume treated, treatment type and remaining capacity available for each wastewater management system. o Identify how and where septage from onsite systems is treated and any impact it has on the system that treats it. o Identify areas that have wastewater servicing limitations or problem areas (Nutrient Management Zone 4, high water table, poor soil quality, topographical issues, etc.). o Identify any sources of wastewater from outside the planning area boundary o If any wastewater produced in the planning area is managed at a facility outside the boundary of the planning area, identify the facility and any service arrangements with the operator. o Provide a history of how the current wastewater management system came to be, explaining why the existing systems were adopted.
	[2C] Estimation (How well current system address current needs) Describe the condition of the current system, including any limitations: o Age and condition of existing lagoons and treatment plants (continuous discharge or storage) o Damage or outstanding repairs o Leakage or seepage, extraneous flows into the collection system o Operational issues of concern o Obsolete technology or inadequate chemical facilities o Combined sewer and storm lines o Condition of onsite systems o Estimation of the volumes and nature of the wastewater/effluents:
Projection and Analysis Stage	**Design: Projecting Needs and Considerations:** *In this stage, estimates are provided for wastewater treatment (sewage and industrial) needs (short term and long term). Usually these estimates are provided for a 25 year period).*
	[3A] Describing the anticipated growth rate and land-use pattern in the planning area: o Estimating populations and providing demographic projections for the area over the next 25 years (using background studies on supply and demand, demographic statistics etc.). o Based on these estimates and trends, describing the anticipated rate of development that will take place over the short (next five to 10 years), medium (11 to 20 years) and long (20+ years) terms. o Identification of any anticipated commercial, industrial and institutional developments which are expected to have significant wastewater management needs. o Identifying areas that are currently using onsite treatment services, but expected to connect to a wastewater treatment facility within 25 years. [3B] Anticipating the amount of wastewater to be produced in the area and how will it affect the current system based on the data on current volumes, anticipated growth rates and land-use patterns as described in Stage 3A. o Reviewing the development plan and Estimating the volume of wastewater to be produced by anticipated development over certain period (short and long term). o Estimating future treatment and storage capacity needed to accommodate wastewater produced by all potential development (Identifying the capacity needed to handle wastewater and septage from existing and anticipated development with onsite systems). o Describing the ability of the current system to accommodate new or expanded residential, institutional, commercial, industrial or other developments over the short, medium and long terms. o Identifying the impacts of any anticipated changes in the density of development on the current system.

	Design: Mapping
	[4A] Preparation of wastewater management map: o In this stage, wastewater (including sewage and industrial effluents) management map is prepared which identifies where current wastewater servicing exists and where it is planned. This map is critical for determining where wastewater servicing should be avoided (for topographical, environmental or financial reasons).
Sewage Treatment	**Wastewater management requirements and costs**
	[5A] Evaluation/Exploring of treatment systems o Exploring different types of systems available to manage wastewater [5B] Comparative Analysis o Assessing the feasibility of different options based on the geography, size, rate of growth and development, and financial capacity. o Other considerations to help decide on an approach include: Regional systems, Service sharing and other agreements [5C] Based on the approach selected, describe the improvements necessary and the associated costs: o Repairs to fix leaks and other damage o Upgraded technology or facilities to meet standards for treatment and storage, Operational enhancements, Elimination of combined sewers o Demand management strategies to reduce wastewater production and need for expansion, Decommissioning failing on-site systems and associated remediation
	[6A] Wastewater treatment stages: o Treatment Stage 1: Primary (mechanical) treatment is designed to remove gross, suspended and floating solids from influent. It includes screening to trap solid objects and sedimentation by gravity to remove suspended solids. o Treatment Stage 2: It removes the dissolved organic matter that escapes primary treatment. This is achieved by microbes consuming the organic matter as food, and converting it to carbon dioxide, water, and energy for their own growth and reproduction. o Treatment Stage 3: It is an additional treatment beyond secondary and it removes more than 99 percent of all the impurities from sewage, producing an effluent of almost drinking-water quality. Disinfection: Disinfection can be the final step before discharge of the effluent. However, some environmental authorities are concerned that chlorine residuals in the effluent can be a problem in their own right, and have moved away from this process.

Process Map: Watershed Management



Steps in Value Chain	Activities Involved
Identification of Participatory Groundwater Management Sites and Collection of Baseline information	▪ Background information of the area *viz.*, topography, soil type, climatic pattern, agricultural pattern, drainages, geology, location of existing wells etc. ▪ Identification of potential recharge sites based on the background information.
Understanding Groundwater Problem and Collection of Baseline information	▪ Collecting information on the water withdrawal patterns, nature aquifers, area of the aquifers, specific yields, water level fluctuations. ▪ Ascertaining volume of groundwater recharge and discharge and aquifer discharge rate.
Establishing a Monitoring Network and Basic Training of Implementation Staff	▪ Establishing a water monitoring network *viz.,* Weather station, well inventory, water level data, V-Notch. ▪ Orientation training for implementation staff on groundwater and PGWM.
Socio-Economic Survey	▪ Survey on water and groundwater problems in the area ▪ Introducing methods for groundwater development and management for crop water management and drinking water security.
Water Quality Analysis, Pump Tests and Data Analysis	▪ Analyzing water quality twice a year viz., pre-monsoon and post-monsoon. ▪ Advocating the findings of study in the village and various other platforms.

Chapter 7
Occupational Mapping

- **List of Occupational Job Roles and NSQF Levels**
- **Occupational Map**
  - OM-Rainwater Harvesting
  - OM-Urban Sewage (Design of Sewage Treatment Plant)
  - OM-Urban Sewage (STP Operation and Sewage Treatment)
  - OM-Watershed Management & Micro-irrigation

The job roles related to water management sector were finalized in discussion with the industrial stakeholders and technical experts dealing with or related to water conservation, harvesting, waste water treatment and management. The job roles listed are a result of comprehensive discussions and reflect the type of occupations that will be required in to realize the full potential of water management sector (*i.e.,* Rainwater harvesting, urban sewage treatment, watershed management and micro-irrigation). Reasonable assumptions were wherever required in the absence of authenticated published data to reflect number of jobs that are presented in the earlier chapters. Table below and flowchart thereafter lists key occupational job roles that were identified along with their NSQF levels.

List of Key Occupational Job Roles & NSQF Levels

Job Role Title	NSQF Level
Rainwater Harvesting	
Director (RWH Systems Design & Operations)	7
Technical Expert (Roofing System Design)	7 - 8
Manager (Technical)	6
Manager (Commercial)	6
Executive (IT Online/ Customer Care)	4
Sourcing Executive (Supply Chain & Logistics)	4 - 5
Executive (Sales & Marketing)	4
Rooftop RWH Installer	4 - 5
Supervisor (Plumbing & Assembly)	3
Maintenance Supervisor (RWH Assembly)	3
Mason	1 - 3
Plumber	1 - 3
Assembler	1 - 3
Urban Sewage (STP Design)	
Project Manager	6
Environmental Engineer	5 - 6
Civil Engineer (Design)	5 - 6
Auto CAD Expert (Design & Simulation)	5 - 6
Executive (Proposal and Costing)	4 - 5
Surveyor	4 - 5
Assistant (Material Procurement and Finance)	3 - 4
Construction Supervisor	3 - 4
Mason	1 - 3
Plumber	1 - 3
Loader	1 - 3

Helper (Construction)	1 - 3

Urban Sewage (Treatment)

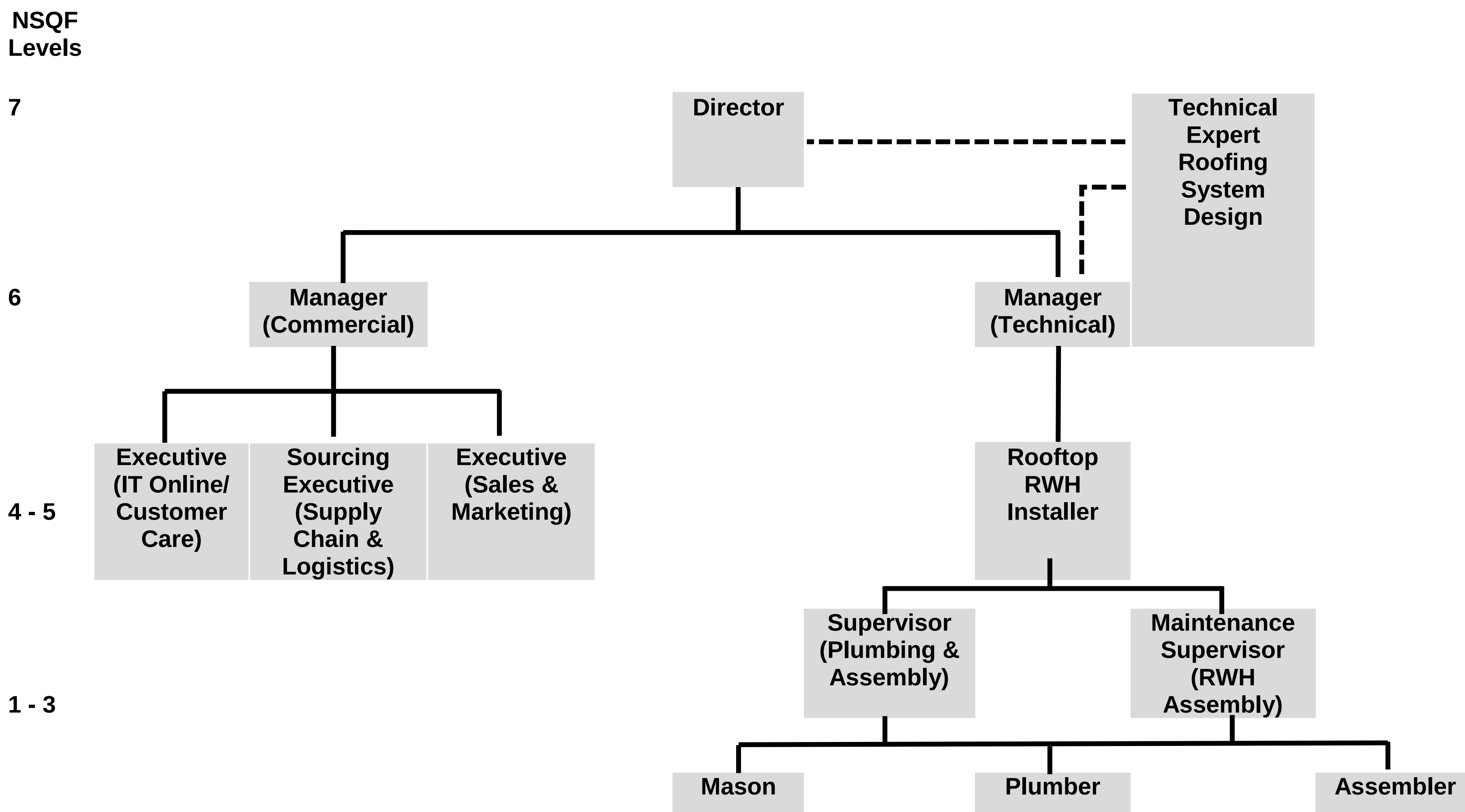
Manager (Environment)	5 - 6
Analyst (QA/QC)	4
STP Operator	3 - 4
Assistant (Equipment Maintenance)	3 - 4
Helper (STP Operation)	1 - 3
Plumber / Fitter	1 - 3

Watershed Management / Micro-irrigation / Drinking Water

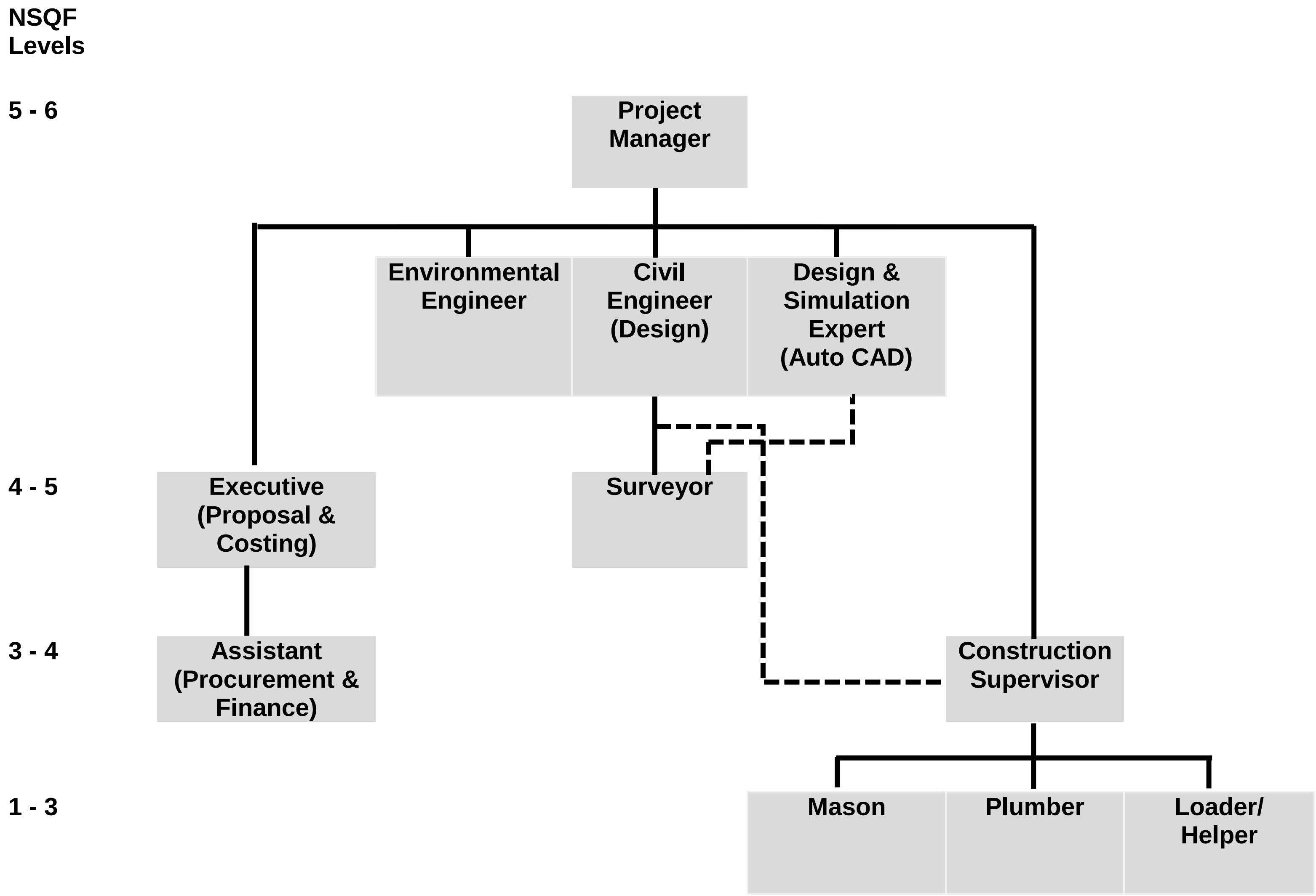
Specialist (Traditional Water Harvesting Technique)	7
Water Resources / Groundwater Expert	7
Integrated Watershed Management Expert	7
Micro-irrigation System Entrepreneur	6
Watershed Development Contractor	5
Drinking Water ATM Installer	4

Occupational Map

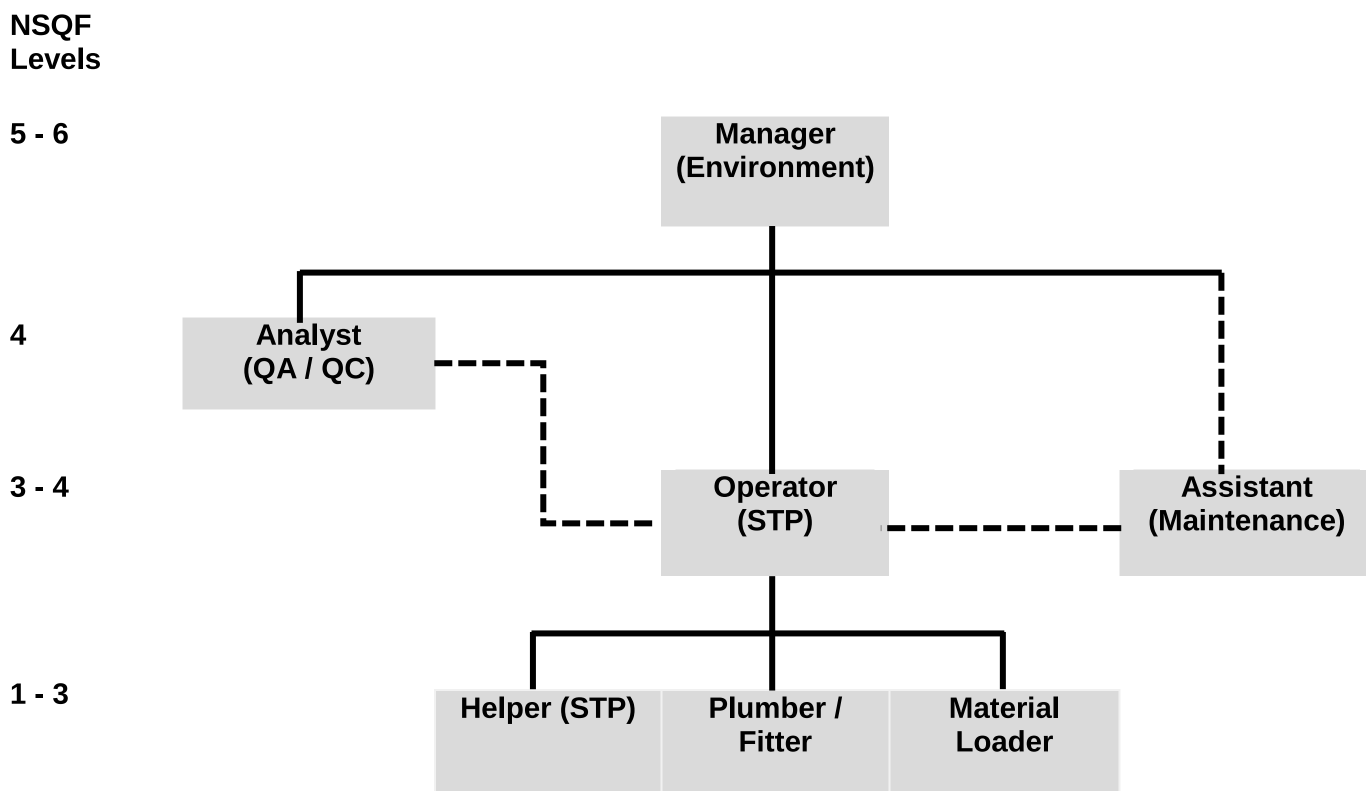
A. Occupational Map: Rainwater Harvesting



B. Occupational Map: Urban Sewage (Design of Sewage Treatment Plant)



C. Occupational Map: Urban Sewage (Operation of Sewage Treatment Plant)



D. Occupational Map: Watershed Management and Micro-irrigation

NSQF Levels			
7	Specialist (Traditional Water Harvesting Techniques)	Water Resources / Groundwater Expert	Integrated Watershed Management Expert
6	Micro-irrigation System Entrepreneur		
5		Watershed Development Contractor	
4		Drinking Water ATM Entrepreneur	

Projects are mainly run under PPP Mode
(Public/ Community Participation)

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