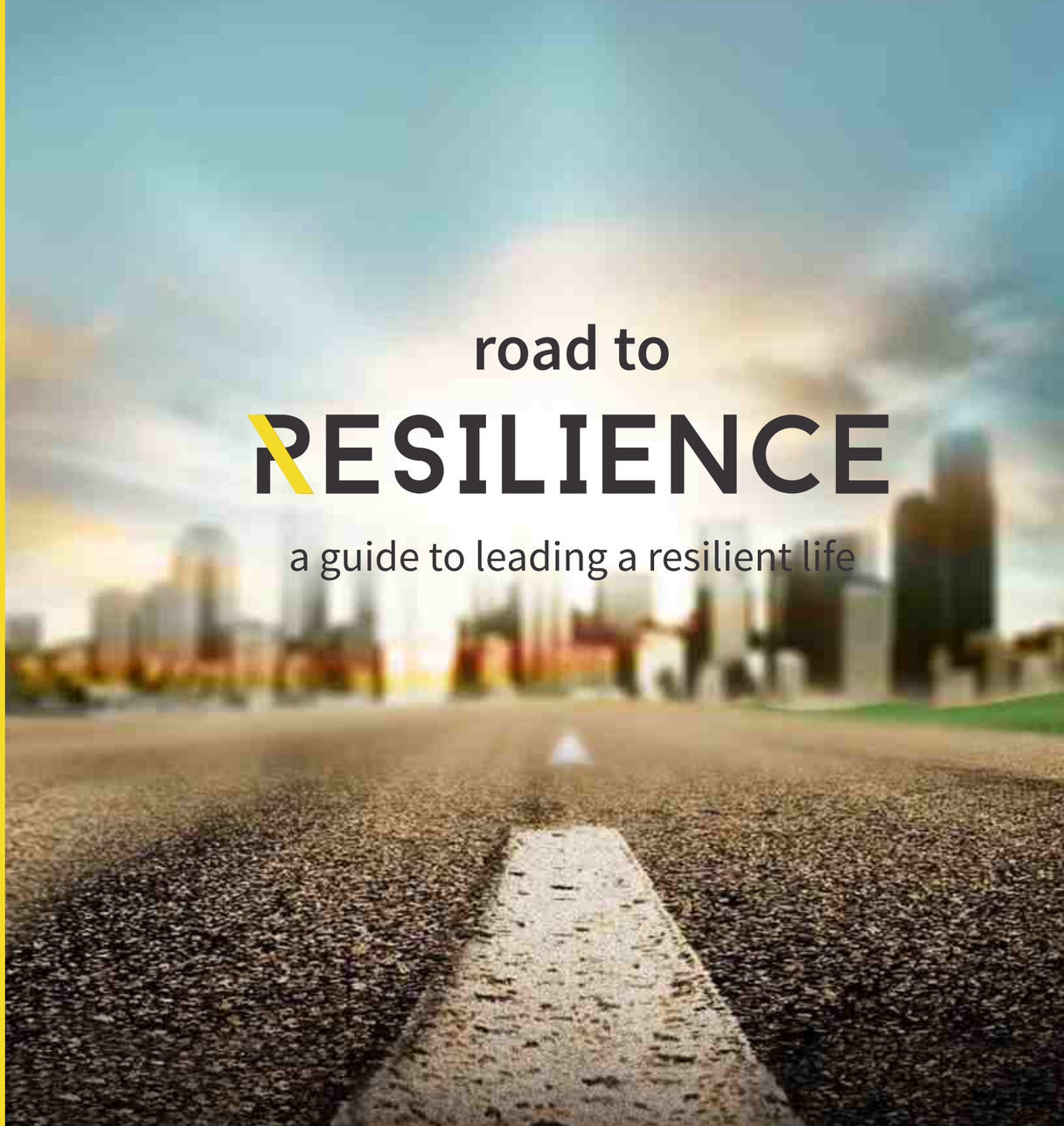
road to RESILIENCE a guide to leading a resilient life



This research is dedicated to all individuals and groups who are striving to build a resilient society.

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road to RESILIENCE

a guide to leading a resilient life

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This book is the outcome of experience we gained by observing how people and institutions build resilience. The inspiration for this came from a village near Ujjain. Every year, the villagers gather on Diwali to mark the water level in a particular well. They compare it with previous years' levels and plan sowing area for Rabi crops. I thank the villagers for inspiring me to think about living within the resource limits. Likewise, we thank several people from cities, especially Indore, Gorakhpur and Surat, who taught us several lessons of coping and resilience. Living under perpetual scarcities, they have done frugal innovations that can be formalized to build resilience bottom upwards.

We particularly thank our city partners: Surat Climate Change Trust, Surat Municipal Corporation, Indore Municipal Corporation and Centre for Environment Protection Research and Development, Indore. Their support over the years has enabled us to draw significant lessons from the ground. I specially thank Mr. Kamlesh Yagnik, Dr. Vikas Desai and Mr. Jatin Shah from Surat and Mr. Hans Kumar Jain from Indore.

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Preface

Half of the world's population today lives in urban areas which account for more than three-fourths of the global economy. City governments are mandated to provide basic services that enable citizens to focus on economic activities. Cities provide opportunities to improve resource efficiency through integration of water, energy, transport and waste management systems. Water and energy are two most essential resources required for the functioning of cities, and any impact on one can snowball into a major crisis affecting the whole city.

Rapid urbanization in developing countries has resulted in widening the gap between the demand for basic services and the capacity of urban systems to supply. Decrepit and inadequate water and energy distribution systems result in high losses depriving basic services to poor. As per Census 2011, more than one-third of the urban households in India had to rely on untreated water sources. Currently, about two-thirds of municipal sewage and effluents from over 900 Indian cities and towns are not treated and directly discharged into rivers. Poor and inadequate sewerage and solid waste management systems are polluting groundwater and waterbodies in cities. While local resources are polluted, city utilities are pumping water from distant sources to meet growing demands. Poor basic services directly impact health and well-being of citizens.

Urbanization has resulted in major changes in the microenvironments of cities. An increase in the proportion of built-up areas has reduced the recharge of groundwater and increased flooding and waterlogging during monsoons. Construction of roads, bridges and embankments have modified the natural drainage system, further amplifying flood frequency and intensity. Increasing built-up areas are intensifying urban heat island effects, raising the energy demands for space cooling. Increasing space cooling energy demands stress the electricity grids and cause repeated power cuts and breakdowns. Late onset of monsoon can increase the electricity demand further and can cause catastrophic failure of the electricity systems as evidenced by the Eastern grid failure affecting nearly 600 million people in the summer of 2012.

Climate change is expected to increase temperature, uncertainties in rainfall and sea level rise. Urbanization can further amplify the climate variability impacts, resulting in additional stresses on already inadequate infrastructure and services. The citizens often do not notice the stresses building upon these basic services, until a major crisis happens.

The urban planning of the 20th century took for granted the availability of unlimited resources and aimed at economies of scale. City administrations and utilities built centralized solutions for water supply, waste management as well as energy supply. The citizens have externalized the responsibility and management of the services to the urban local bodies. Since these lifeline services are highly subsidized, urban local bodies are unable to generate funds for repairing and augmenting infrastructure and services. As the service quality deteriorates,

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users are forced to adopt coping measures such as extracting local sources and competing for limited resources. Upper and middle class households are able to afford these coping measures, whereas the poor face the brunt of scarcities and uncertainties on a daily basis. The total economic and social costs of autonomous coping measures and reduced efficiency are often more than the cost of infrastructure improvement.

Renewable energy and water resources are distributed unevenly across locations and seasons. While some of these resources are amenable to centralized management, other small and distributed resources like rainwater, groundwater, solar energy, recycled waste water can be easily tapped at the local level. More than half of the sewage can be recycled to meet low-end uses like flushing and gardening at points of generation. Miniaturization and automation technologies have enabled development of a variety of affordable household options for managing and improving quality of local resources. Household reverse osmosis water filters and solar photovoltaic systems have revolutionized the management of water and energy at household and cluster levels. Reducing the costs of solar energy, water filtration equipment and sewage treatment technologies have made these options comparable in cost with the city-level grid-based services. Mobile-based apps have made monitoring and remote control of these systems possible.

Cluster level water, energy technologies offer new opportunities to increase autonomy in the management of basic services. Integrating waste water recycling at the cluster level can reduce the overall demand on the lifeline services further. Some of the extractive technologies, such as bore-wells, can lead to overexploitation of local resources and will require careful monitoring and conservation. A paradigm shift is now possible where local- and city-level resource and services management can be integrated to achieve higher efficiency and improve resilience of households.

As the local resources can be prone to overexploitation and misuse, it is necessary to provide monitoring and knowledge support to cluster-level institutions. City managers can develop resource models as envisaged by the city-level groundwater authorities as well as solar city plans to provide knowledge support. With the development of meshed ICT networks, cluster-level management can be synergized with city-level services.

This book presents several grassroots level options for managing lifeline services suitable for urban households, colonies and clusters. These options can improve resilience of the clusters to face growing scarcity and quality degradation challenges. Waste recycling and decentralized solar energy options open up opportunities to reduce reliance on external resources and city grid supplies. Efficient utilization of local water and energy resources, can reduce challenges such as waterlogging, flooding, urban heat islands and power cuts to a great extent. As the clusters conserve and optimally use local resources, they can become fairly autonomous and withstand

Preface

breakdown of city grids during emergencies. The reader can further explore options based on conjunctive management and demand-focussed end use and subsidiarity frameworks.

Conjunctive management relies on the use of multiple sources to meet resource demands. Options such as rainwater harvesting, solar energy and waste recycling are explained. Demand-focussed end use framework explores the quality requirements of different end uses (e.g., water for drinking, flushing, irrigation; energy for lighting, cooking, heating water) and matches the characteristics of resources with the demand. Subsidiarity is an organizing principle that matters, should be devolved to the smallest, lowest or least centralized competent authority.

A significant proportion of colonies and multistoried residential complexes have resident welfare associations, which can be strengthened to manage distribution of water and electricity as well as managing local resources. Devolving responsibilities to cluster-level institutions can reduce the burden of maintaining millions of individual household-level water and electricity connections to a few thousand bulk meters at colony levels. Some states are already devolving electricity distribution within housing colonies to the resident welfare associations. The urban local bodies can then focus on bulk supply, monitoring and regulatory roles.

The technologies and processes discussed in the following sections can be applied in different urban contexts and scales. It is advisable to conduct a context analysis of local resources, social and economic situations, infrastructure and services to select technology options, financing and maintenance mechanisms. Expert advice may be necessary to implement and manage these systems. Annual maintenance by the local enterprises can provide assured livelihoods for the poor. It is hoped that such grassroots processes can improve resilience of communities to stresses and shocks from rapid urbanization and climate change.

This initiative is supported by The Rockefeller Foundation through Asian Cities Climate Change Resilience Network (ACCCRN) programme. Under ACCCRN programme, several decentralized options were demonstrated in Indore and Surat. The demonstration projects included resource and community context analysis to develop options, demonstration of community-managed water and waste water recycling systems, restoration of degraded urban lakes, cool roofs and passive ventilation systems. The ACCCRN programme also provided opportunities to explore ward-level planning options to improve the resilience of communities. We learnt that urban resilience building can be best realised through multiple coordinated interventions to achieve synergy across scales and sectors. We sincerely thank The Rockefeller Foundation for supporting these interventions.

Contents






Foreword

Ashvin Dayal

The challenge of meeting the basic needs of people in rapidly growing cities is beyond historical precedent, placing new social, fiscal and political pressures on urban systems. Indeed, climate change alone has been aptly called the greatest threat multiplier of our age. Yet while the 21st century poses daunting challenges, we also have opportunities to act in ways that might not have been possible even a decade ago. We have new, sophisticated models for better understanding how different conditions will play our in local context, for example in terms of water scarcity, heat stress, or flooding. And we have an unprecedented opportunity to deploy new technologies and data systems that can help aware and active urban residents – the people who will read this book - to collaborate, make choices, and express their voice more effectively to solve pressing problems.

The Rockefeller Foundation defines urban resilience as the capacity of cities to survive, adapt, and thrive in the face of stress and shocks, and even transform when conditions require it. Under the Asian Cities Climate Change Resilience Network (www.acccrn.org), a 9 year effort to build more resilient cities, we have assisted dozens of cities across India and Asia to assess, plan, and act on issues such as inadequate water, poor sanitation, heat waves, changing health patterns, poor drainage, flooding, extreme storms and lack of waste disposal in a holistic and integrated manner. Through this effort we have learnt some important lessons about what is needed to move forward positively. These include:

- **A combination of hard and soft measures:** Greater city resilience depends on physical, policy, social capital, and institutions -- that is on tangibles like infrastructure and housing, as well as intangibles such as knowledge, networks, and behaviours.

- **The centrality of multi-stakeholder processes:** It is by engaging across different sectors (government, business, civil society, and academia) to develop a shared vision and agenda that we have seen the most transformative changes take place.

- **The future is now:** While building resilience requires engagement with uncertain, unpredictable shifts in the future, it is essential to ensure tangible benefits to people today to gain support and engagement.

Foreword

- **The importance of leadership and active residents:** Efforts are most likely to be accelerated and sustained when you have a combination of strong leadership driving commitment from above, and active engagement of informed communities and residents demanding action.

- **A focus on vulnerability and poor people:** While resilience measures are needed at multiple levels, asking the question 'resilience for who?' is important to ensure that poverty and equity concerns are being kept at the heart of the agenda.

Let me congratulate Taru Leading Edge on the production of this beautiful book that addresses a serious matter in an accessible way and engaging manner. Ultimately, if ordinary people do not start thinking about the future they want for their cities, no concrete action will follow. I am sure this book can play a vital role in building awareness and understanding, sparking dialogue and exchange, and promoting practical action by the people who are most affected by the shocks, stresses and uncertainties we face – the residents themselves!

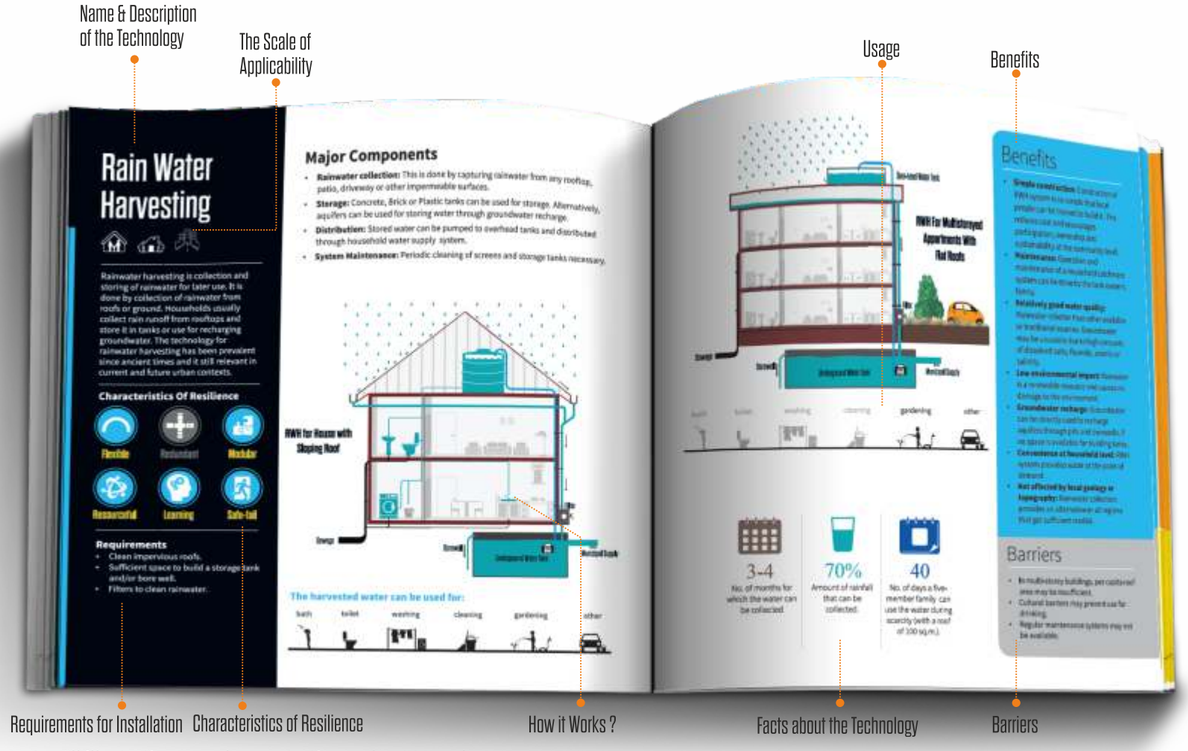
Ashvin Dayal
Associate Vice President and Managing Director
THE ROCKEFELLER FOUNDATION

How To Use The Book

The book primarily discusses the three main sectors: Water, Energy & Sanitation.
Each sector is covered in six parts.

1. Introduction
2. Current situation and future scenario
3. Current issues and future challenges
4. Where we can make the difference
5. Adoptable resilient technologies
6. Household practices for day to day life

Discussion of each technology is presented in the following format:



Note: All illustrations are demonstrative and not to scale

Introduction To Icons

Sectors

Water · Energy · Sanitation · Health

Scales

Household · Colony · City · Singlestorey · Multistorey

Characteristics of Resilience

Flexiblility · Redundancy · Modularity · Resourcefulness · Learning · Safe-fail · Inclusion

Options to build Resilience

Reducing consumption · Developing alternative resources · Recycling · Quality Improvement

Others

Did you know?

Introduction

road to RESILIENCE

Once upon a time, in this lovely house,
Lived a family of six,
Happy and settled,
Everything solved, all issues fixed.

Once upon a time, in this lovely house,
Taps had running water day and night,
Cooling fans and comfortable heat,
Electricity 24/7 without a break!

Once upon a time, in this lovely house,
Everybody was healthy, fit and fine,
Enough to eat and pure air to breathe,
Present pleasant and future bright!

The times they changed,
The earth's resources depleted fast,
New challenges emerged,
The song of abundance a thing of past

Grim still is the time to come,
The water unsafe and never enough,
The overburdened grids poised to fail
Mounds of waste in every lane.

Act now, don't wait for the world to come,
Bring back happiness for the family of six,
Browse these pages, learn what you can fix,
Delay not, time is of essence,
Let's walk together on the **Road to Resilience.**

What Is RESILIENCE ?

The capacity of people, organizations and systems to:

- prepare for, respond to, recover from and thrive in the face of difficulties,
- develop the ability to face continual change and
- transcend towards a sustainable life.

Resilience is about creating an attitude towards life by

- managing shocks (such as floods, heat waves) and chronic stresses (such as electricity and water shortages),
- learning from lessons of the past and
- anticipating and avoiding risks.

It is not simply a case of asking “do we live in hazard zones”, but “how well prepared are we for the potential hazards?”

The skyline of lower Manhattan in darkness after a preventive power outage caused by giant storm Sandy in New York

RESILIENCE ?

Why and How?

What we, the citizens, do today will define our common future

Today, we experience scarcity and uncertainty in our basic lifeline support systems such as water, energy and mobility. Growing mounds of waste pollute our land, water and air.
Ideally, the urban systems should address these issues, but they are saddled with growing demands and hampered by scarce resources.
Yet people expect municipalities to provide efficient services.
In our houses, we build coping mechanisms and hope to solve our problems.
In the long run, problems keep growing.

It is time for us to act. Let us start by learning what can be done and make changes in our homes. Let us involve our neighbours, our friends and our community and address these issues collectively.
Efforts are needed at all scales, each supporting the next.
Let us save where we can develop available resources and recycle the wastes - many such actions can make us strong.

This is how we head towards **a resilient society!**

"Life doesn't get easier or more forgiving, we get stronger and more resilient."

- Steve Maraboli

Characteristics Of Resilient Practices

The actions that we take for building urban climate resilience involve practices and technologies, which largely have the following characteristics:

Flexibility

The ability to change, adapt and evolve in changing conditions.
A system should be able to modify its structure and/or behaviour in response to changing conditions.

Modularity

Systems designed as small and fairly independent units.
Systems should have small multiple units that are independent and capable of functioning, even if one or few such units fail.

Safe-failure

Slow and predictable failure.
Failure, under extreme conditions, is acceptable. Systems should be designed and managed so that they fail slowly and predictably, ensuring that sufficient time is available to take remedial actions.

Inclusion

Benefitting politically, socially and economically marginalized sections of society.
Cities function by the collective efforts of all. Even the poorest of the poor contribute to a city's efficiency, and their welfare and needs have to be integrated.

Learning

Ability to learn from past and develop strategies for the future.
Systems can learn from past experiences, avoid repeating mistakes and exercise caution in making future decisions. Mechanisms to modify standards and processes, based on learnings, are necessary.

Redundancy

Additional capacity to deal with shocks and failures.
Systems should have the capacity to accommodate increasing demands or extreme shocks. If one component of a system fails, other components should be able to take over the functions, preventing collapse or failure.

Resourcefulness

Ability to manage crisis with innovative solutions.
The ability of systems to apply new methods and mobilize various assets and human resources to overcome the challenges.

Options To Build Resilience

There are various methods to build resilience. First steps in this direction are to make minor changes to our lifestyle and adopt simple technologies. We need to understand the building blocks that are essential to reach the goal of resilience.

Reducing consumption

Saving more by consuming less.
Adopt new technologies that provide same facilities using less resources. Consume with care. Cultivate a **"waste not, want not"** attitude.

Developing alternative resources

Augmenting Resources
Unutilized resources such as rainwater and solar energy can be developed to meet part of the demand.

Recycling

Converting wastes into resources.
Systems for converting wastes into new resources should be set in place. Sewage water as well as waste energy can be recycled and used for low-end uses.

Quality Improvement

Achieving better quality products from the existing resources.
Some resources like groundwater may have unacceptable levels of dissolved solids, which make it unsuitable for high-end uses like drinking. Technologies, such as reverse osmosis, can be used to improve the quality of such water.

Key Sectors For Developing Resilience

Water Management

Water is a scarce resource. Better water management is necessary to deal with recurrent scarcities and disasters such as floods and water-logging.
Different uses of water require different qualities of water. For example, lower quality water can be used for cleaning floors or watering gardens.
Water can be managed by better assessment of resources, control of use and improvement of quality. Recycling wastewater can reduce dependence on distant resources.

Off-grid Energy

Natural catastrophes can lead to unpredictable failures in grid power supply. Since both hydropower as well as thermal power stations require huge amounts of water, droughts can reduce the energy generation. Also, heat waves can result in increasing demands for space cooling for which the grid systems may not be designed.
Affordable off-grid back-up solutions (e.g. roof top solar photovoltaic systems) for basic lighting and space cooling can improve the ability of urban households to cope with power cuts and grid failures.

Healthcare

Rising temperatures or waterlogging can increase risk of mosquito and waterborne diseases. Water scarcity and floods can cause waterborne diseases and decline in the sanitary conditions. Poor households living along the streams and waterlogged areas are differentially vulnerable to these diseases. These events can be predicted by early warning systems and preventive actions can be taken. Water recycling can reduce waterlogging and water- and mosquito-borne diseases.

Sanitation

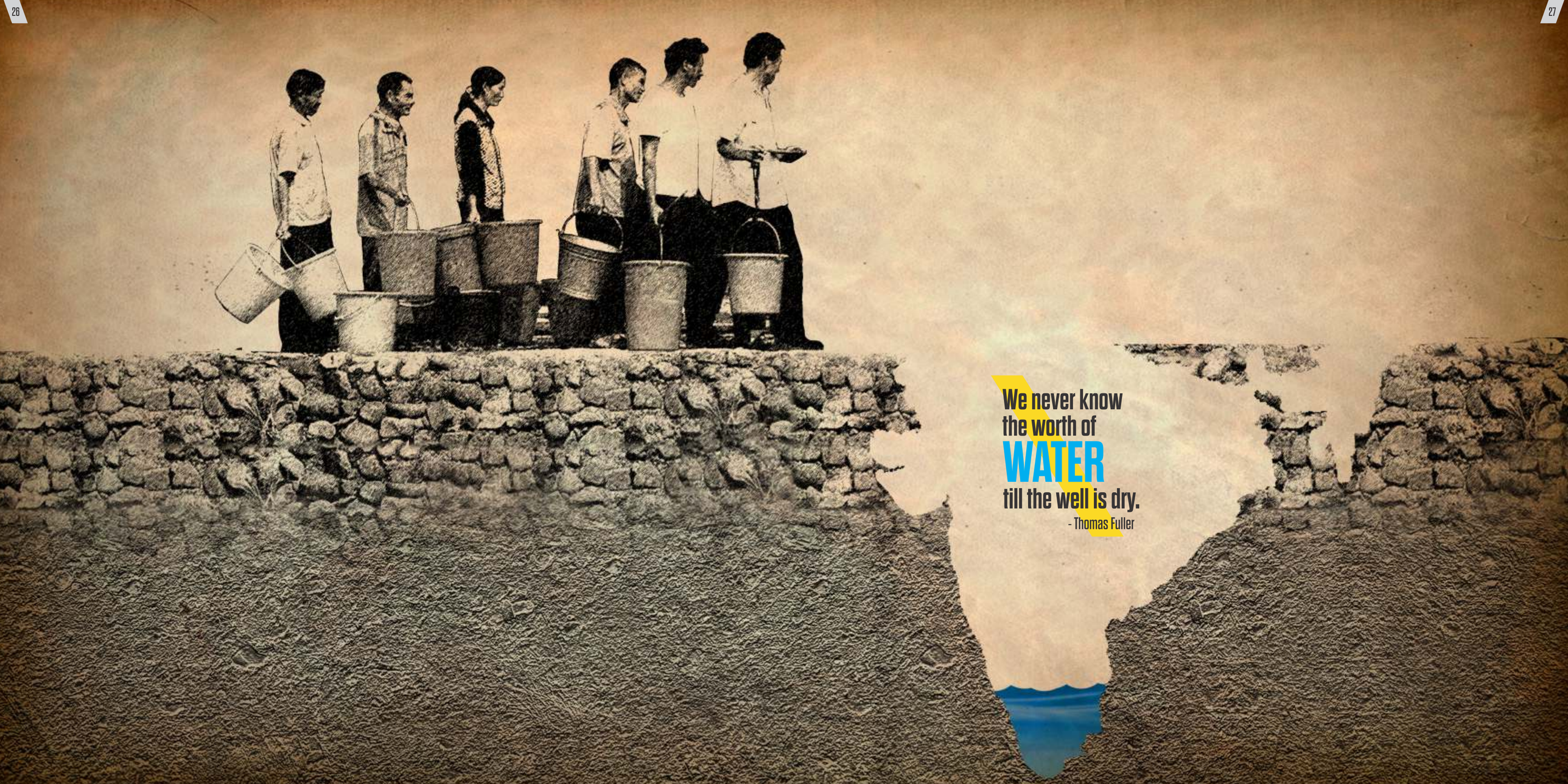
Poor solid waste management can lead to clogging of the urban sewerage and drainage systems, which in turn can lead to frequent floods, water logging and contamination of groundwater. Solid waste dumps become breeding grounds for rats and other disease vectors.
Robust local level waste management systems can enhance the capacity of cities to cope with the changing climate and reduce potential health hazards.

Where Can We Make The Difference?

In our cities, we face daily challenges of low quality lifeline services (e.g. water and electricity) as well as seasonal risks (e.g. floods, heat waves). These affect our quality of life today and our survival in the future. We are forced to adopt various coping mechanisms such as water tanker supplies and electricity inverters. Such temporary solutions alleviate the problems to some extent, but are bound to fail when the challenges intensify.

In this book, we present a set of reliable, easily adoptable and long term solutions to deal with the rising challenges. These can provide us certain degree of autonomy and make us less reliant on centralized services. To start with, we can make a significant difference by taking actions in our homes and communities. The different levels of the society and the issues that can be addressed at each level are presented. Together, we can adopt practices and change our behaviour that can improve our quality of life, efficiency and resilience.

Actions At Different Scales


We never know
the worth of
WATER
till the well is dry.
- Thomas Fuller

Introduction

Human beings require freshwater resources to meet their basic needs, such as drinking and farming. While the resources are limited, increasing population and economic development have led to over-extraction and pollution of the surface and groundwater resources. Increased demand for water has led to the supplies shrinking in various regions of the world. As a consequence, the conflicts between urban and rural areas over the available water resources have aggravated. Lack of appropriate wastewater treatment and overexploitation of limited resources have led to 'water poverty', which is often the cause of disputes between different users. As the precipitation pattern changes, the stress on the available resources is likely to increase.

To overcome these challenges, urban households need to focus on reduced consumption through simple and innovative water management techniques and practices. Such measures will lead to better water conservation and decreased burden on the freshwater reserves.

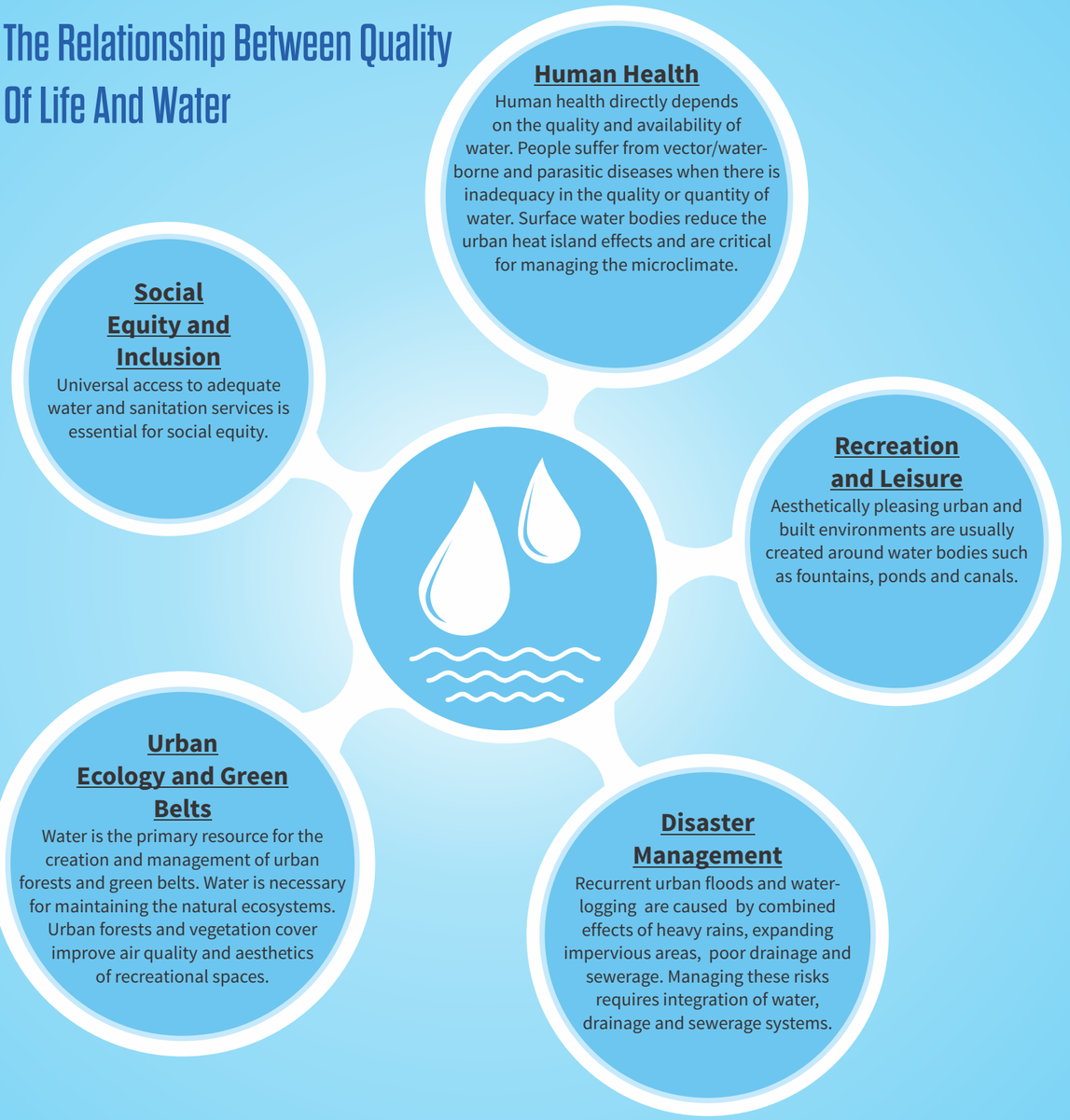
There are several small resources, such as urban water bodies, groundwater and rainwater, which are either not utilized or used informally as backup sources. These can be developed and conserved at household/colony levels. These resources can supplement the city water supplies and also provide back-up options during emergencies.

Quality of Life and Water

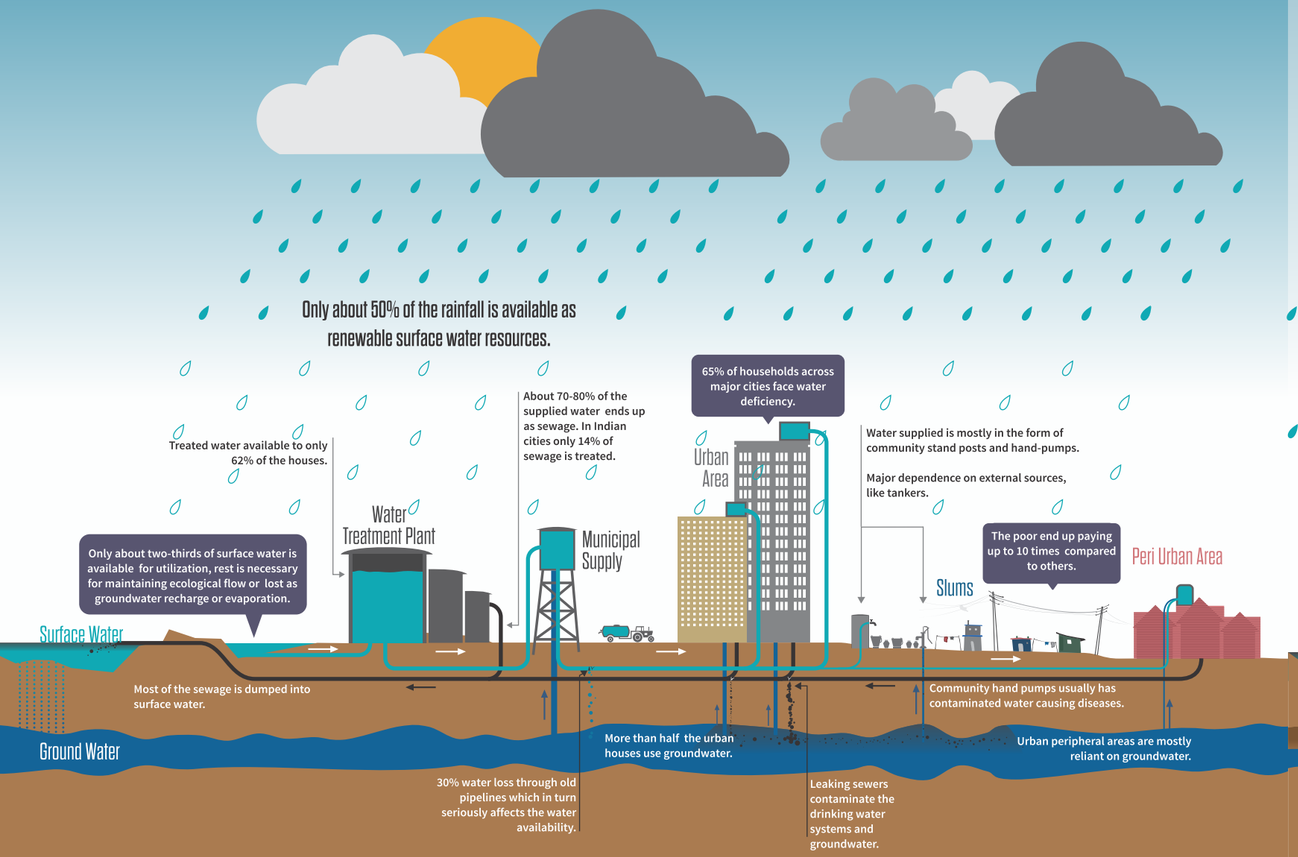
The quality of urban lives, which is measured through yardsticks of social, economic and environmental well-being, is directly related to water. When properly managed, water systems have the potential to improve the living standards of people and economic efficiencies. Adequate water supplies and proper sanitation systems are the basic minimum requirements of urban residents. Cities are points of high water demand as well as generators of large quantity of wastes. Adequate water supply that meets the quality criteria of various end uses is critical in managing the quality of life in urban areas. Quality of life is impacted by various systems such as energy, health and safety. Although water is just one of the systems in this portfolio of needs, it directly and indirectly affects the living standards of people.

Water

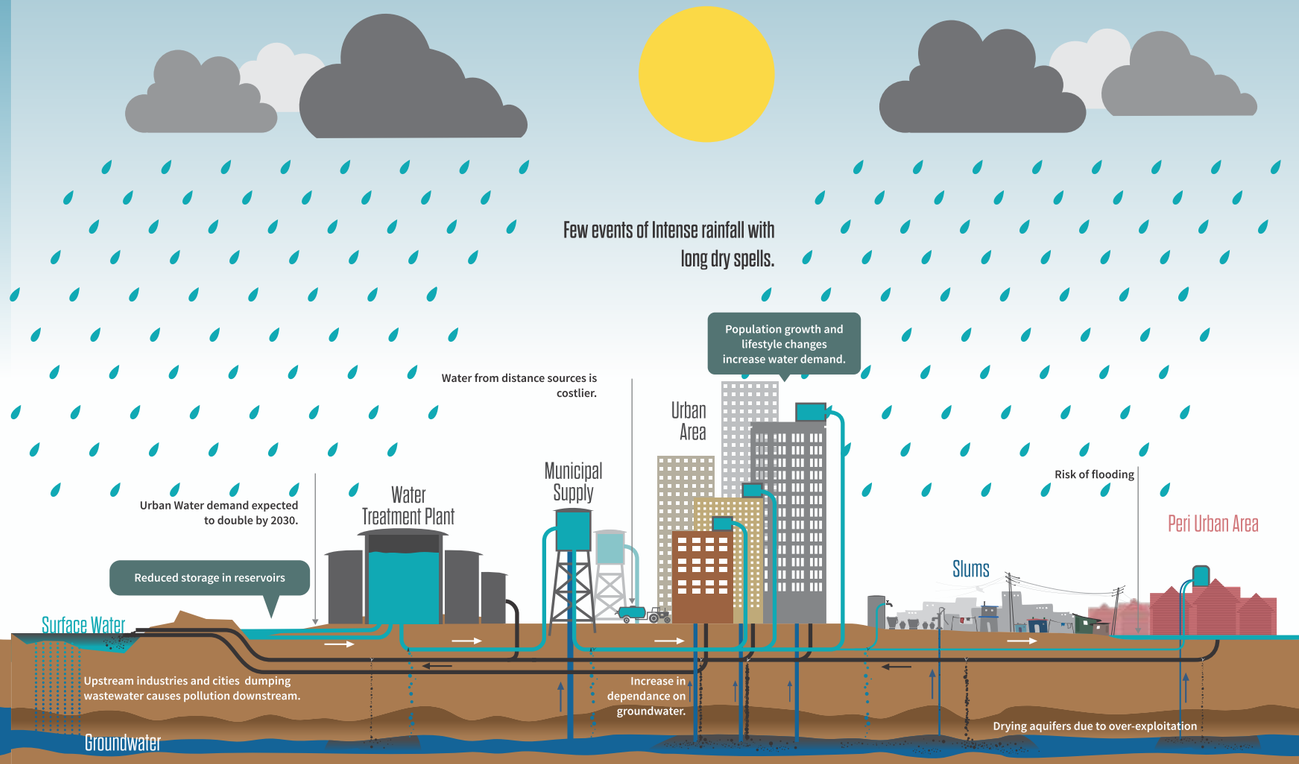
The Relationship Between Quality Of Life And Water



Water Scenario: TODAY

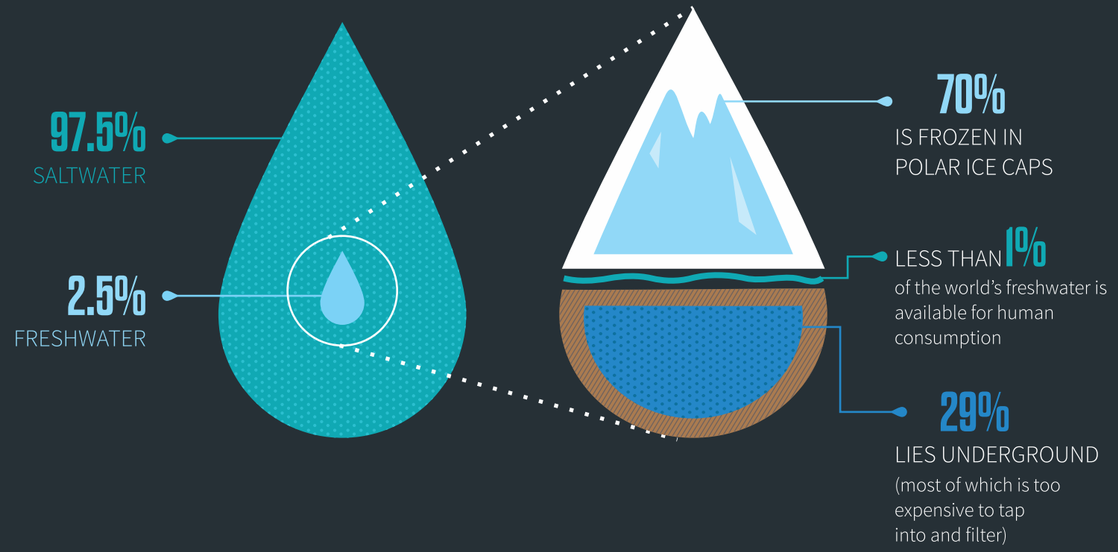


Water Scenario: TOMORROW



Water Scenario: TODAY

Where all the Water is...



Average domestic water needs in urban areas

= 90 liters

- 28% Bathing 25 lt.
- 20% Toilet 18 lt.
- 19% Washing 17 lt.
- 28% House Cleaning 6 lt.
- 4% Drinking 4 lt.
- 3% Cooking 3 lt.
- 16% Washing Utensils 14 lt.
- 2% Miscellaneous 2 lt.

Present household situation

Out of 8, only 6 get Safe, Treated drinking water

Regular water demand

Households are forced to spend on coping mechanisms such as tankers, private wells and filters.

Added costs towards coping mechanism

Water Scenario: TOMORROW

According to the international norms, a country is classified as '***water stressed***' when its annual water availability is less than 1,700 cubic meter/year (cum/yr) and '***water scarce***' when it's less than 1,000 cum/yr. In 2001, per capita renewable water available in India was about 1,545 cum/yr. It has been projected that per capita surface water availability is likely to be reduced to 1,401 cum/yr and 1,191 cum/yr by the years 2025 and 2050, respectively.

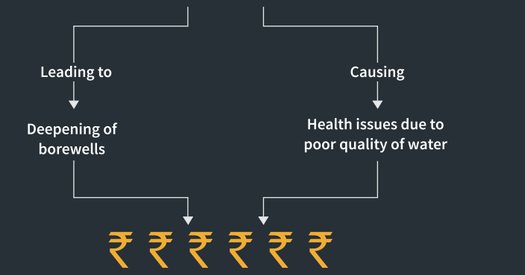
Water is essential to meet direct domestic demands as well as indirect agricultural and industrial demands such as food production, manufacture of metals, paper and energy generation. Water resources in India are unevenly distributed and some regions in eastern and central India have already reached the '***water scarce***' stage.

Large parts of our country are drought prone. Climate change is expected to increase uncertainties in rainfall by prolonged dry periods and occasional heavy rains. Increasing temperatures can concurrently escalate evaporation of water as well as the water demands to manage heat. Coastal aquifers are expected to become more saline from increasing groundwater withdrawal as well as rising sea levels.

Conflicts over water are expected to rise at all levels – neighborhoods could be at war with each other and there could even be interstate conflicts. Human-induced changes in city landscapes – such as increased impervious built-up areas – can increase flood intensities and prolonged waterlogging, especially during heavy rainfall events.

Water demand

Decrease in water level and quality of ground water



CURRENT ISSUES

Some of the key water-related problems currently impacting our cities are as follows:

Water Availability

- Intermittent water supply to part of the population; poor are forced to rely on local resources or informal water markets.
- Water scarcity worsening further during summers.
- High water losses from old decrepit infrastructure and theft .
- Households and colonies are coping through extensive contaminated groundwater use.
- Drying aquifers leading to amplification of scarcity, especially during summers.

Water Cost

- Seasonal scarcities often catalyse formal and informal water markets.
- Informal systems (e.g., tankers) charge high 'scarcity' prices.
- Groundwater users are forced to invest on frequent deepening of wells and high head pumps to deal with declining water levels.
- The poor pay an even higher price for informal water sources and also forced to divert productive time to deal with water scarcity.

Water Quality

- About one-third of Indian urban households use untreated water.
- Leaking sewage lines, laid next to water supply lines, contaminate drinking water.
- Groundwater may have high dissolved solids and may also get contaminated by leaking sewerage system.
- Sewage and solidwaste disposal into surface water pollutes local lakes, springs and rivers.

Investment challenges

- Water is available for free or is highly subsidized.
- Leaking pipes and water theft lead to high unaccounted water losses.
- More than 40% of the urban water supplied in India doesn't generate any revenue.
- Since water is subsidized, there is no incentive for utilities to meter the connections.
- Due to poor revenues, the utilities are unable to invest on leak reduction and capacity augmentation activities.

Future challenges

Population Growth and Urbanization

- Increasing water demand.
- Per capita demand rises due to lifestyle changes.

Energy Use

- More energy is required to convey water from distant sources.
- Energy costs impact the financial viability of the city water supply systems.

Climate Change

- Increasing risks of flooding and waterlogging due to increasing frequency and intensity of heavy rainfall events.
- Increasing rainfall variability amplifying drought and water scarcity risks.

Economic Development

- Growing water scarcity and high coping costs can impact the economy.
- Increasing water scarcity leads to loss of livelihoods and growth opportunities.
- Increasing urban and industrial pollution can impact downstream cities.

Deterioration of Infrastructure

- Leaking pipes.
- Fixing and repairing faulty or old pipelines can increase the cost of maintenance.

Where we can make the difference

Wastewater Management

The volume of wastewater can be reduced by recycling it at the point of demand. Decentralized wastewater recycling systems can reduce the design capacity of gridded sewage systems. To maintain the health of ecosystems, the total waste generated should be less than their carrying capacity.

Freshwater Availability

Since water resources are limited, optimizing water use and conservation of local resources like lakes, rainwater and groundwater are important. Recycling water at colony levels can reduce the net demand from distant sources.

Stormwater Management

Risk of disasters – especially floods caused by changing climate – should be addressed. Rainwater can be used for recharging groundwater to maintain adequate emergency reserves as well as reducing intensity of floods. It is also important to conserve natural water sources by preventing pollution of storm water from sewage and solid wastes.

To make a big difference, we must explore new and integrated practices. Some approaches that can be effective are as follows:

1. Overall Approach: A physical and institutional integration should be planned between systems managing freshwater, stormwater and wastewater. These, in turn, should further be integrated with other urban services through efficiently managed systems.

2. Water Demand: While working out options to reduce demand, harvesting rainwater and recycling wastewater should be given priority over that of augmenting capacity of water supply systems.

3. Stormwater: Stormwater can be used as a resource, by recharging aquifers and water bodies and storing for direct use.

4. Wastewater: Wastewater can be treated and reused at colony/cluster levels for low-end uses like flushing, irrigation and managing water bodies.

5. Technologies: Existing or new technologies can be integrated to enhance water supply, and to manage and reuse water resources.

6. Infrastructure: Ecological treatment systems can be developed and managed, wherever possible.

7. Scales for Action: Water can be managed across household, colony, city levels through harvesting and recycling, wherever feasible.

Rainwater Harvesting

Rainwater harvesting is collection and storing of rainwater for later use. It is done by collection of rainwater from roofs or ground. Households usually collect rain runoff from rooftops and store it in tanks or use for recharging groundwater. The technology for rainwater harvesting has been prevalent since ancient times and is still relevant in current and future urban contexts.

Characteristics Of Resilience

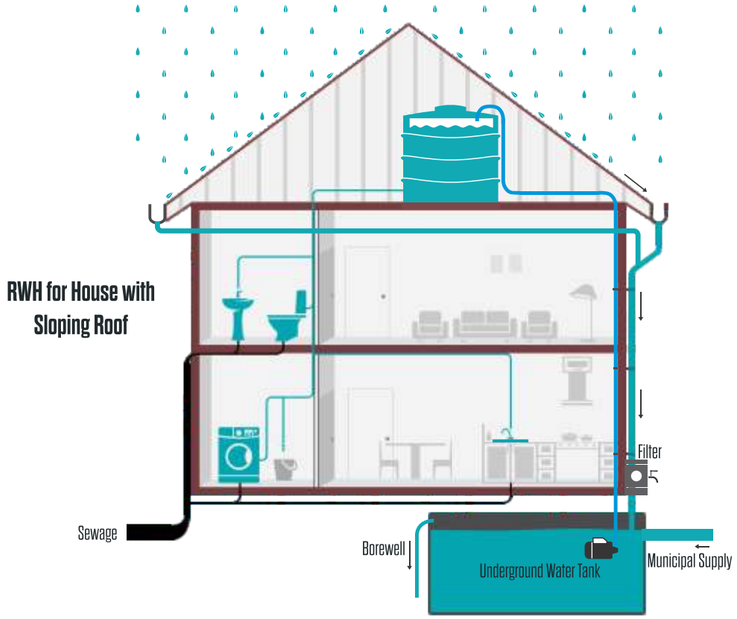
- Flexible
- Redundant
- Modular
- Resourceful
- Learning
- Safe-fail

Requirements

- Clean impervious roofs.
- Sufficient space to build a storage tank and/or bore well.
- Filters to clean rainwater.

Major Components

- **Rainwater collection:** This is done by capturing rainwater from any rooftop, patio, driveway or other impermeable surfaces.
- **Storage:** Concrete, brick or plastic tanks can be used for storage. Alternatively, aquifers can be used for storing water through groundwater recharge.
- **Distribution:** Stored water can be pumped to overhead tanks and distributed through household water supply system.
- **System maintenance:** Periodic cleaning of screens and storage tanks necessary.



The harvested water can be used for:

3-4
No. of months for which the water can be collected.

70%
Amount of rainfall that can be collected.

40
No. of days a five-member family can use the water during scarcity (with a roof of 100 sq.m.).

Benefits

- **Simple construction:** Construction of RWH system is so simple that local people can be trained to build it. This reduces cost and encourages participation, ownership and sustainability at the community level.
- **Maintenance:** Operation and maintenance of a household catchment system can be done by the tank owner's family.
- **Relatively good water quality:** Rainwater is better than other available or traditional sources. Groundwater may be unusable due to high amounts of dissolved salts, fluoride, arsenic or salinity.
- **Low environmental impact:** Rainwater is a renewable resource and causes no damage to the environment.
- **Groundwater recharge:** Groundwater can be directly used to recharge aquifers through pits and borewells, if no space is available for building tanks.
- **Convenience at household level:** RWH system provides water at the point of demand.
- **Not affected by local geology or topography:** Rainwater collection provides an alternative in all regions that get sufficient rainfall.

Barriers

- In multi-storey buildings, per capita roof area may be insufficient.
- Cultural barriers may prevent use for drinking.
- Regular maintenance systems may not be available.

Intelligent Storage Tanks

Storage tanks provide buffer stock in areas with intermittent water supply. Intelligent tanks with electronic sensors can be used to monitor water inflow, storage volume and outflow. Wireless data from these sensors can be read through mobile apps or computers. They can also be linked to electronic valves to reduce consumption, in case of emergencies. They can also be managed at colony levels to create competition for saving water.

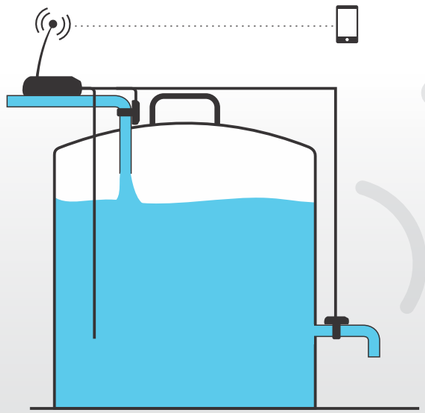
Characteristics Of Resilience

Flexible | Redundant | Modular

Resourceful | Learning | Safe-fail

Requirements

- Tanks must be protected by a cover.
- Tanks must have sensors and electronic control valves.
- The capacity and location of the tanks should be calculated based on frequency & volume of supply, daily water demand as well as hazard risks.



Major Highlights

- **Resilience:** A combination of sump–pump–overhead tanks can be linked with photovoltaic panels to provide resilience against power breakdowns.
- **Learning and responsiveness:** The apps can be used to conserve water and respond to impending scarcities.
- **Costs:** The costs depend on the storage capacity and instrumentation. The returns can be high on a longer run.
- **O&M:** It is important to regularly clean the tanks, inspect power supply, electronic components and monitor water quality.
- **Main strength:** The storage capacity can be tuned to meet the water demand.
- **Integration:** The system can be easily linked to multiple sources like groundwater, rainwater and municipal supplies.

Instrumentation and Mobile app

- Sensors for measuring inflow, storage and outflow.
- Actuators (electronic control valves).
- Digital processing unit and wireless or SIM-based modem.
- Possible information from the system: previous day's collection, previous day's consumption, possible number of days with current consumption.

3

Number of days for which water stored in a 1000 L tank would last for an average household.

12

Square feet area needed to place a 500 Ltr tank.

Benefits

- **Availability:** 24X7 water availability even in intermittent supply situations.
- **Savings:** Time and energy saved can be used for other economic activities.
- **Easy installation:** Easily available in the market and ready-to-use. Water flow and water level sensors are available at fairly cheap prices.
- **System integration:** During monsoon season, rainwater harvesting can be done to ensure that water is available at the doorstep, instead of fetching it from the source.
- **Use in calamities:** Freshwater can be collected before natural calamities such as floods and cyclones. Emergency storage can help in tiding over any breakdown of grid water supplies for a few days.

Barriers

- High initial costs.
- Expertise required for installation.
- Regular maintenance needs.

Q-Drum

Q-Drum is a durable, doughnut-shaped 50 liter plastic container which can be rolled on smooth surfaces. It is suitable for areas without piped water supply.

Greywater Reuse

Greywater is wastewater disposed from kitchen, washing machine and bath. The black water refers to water from the toilets also. This practice is a smart way to recycle greywater use at home. Depending on the type of demand, wastewater can be used directly or after treatment. Treated greywater can be used for flushing toilets, watering plants and cleaning floors.

Characteristics Of Resilience

Flexible · Redundant · Modular · Resourceful · Learning · Safe-fail

Requirements

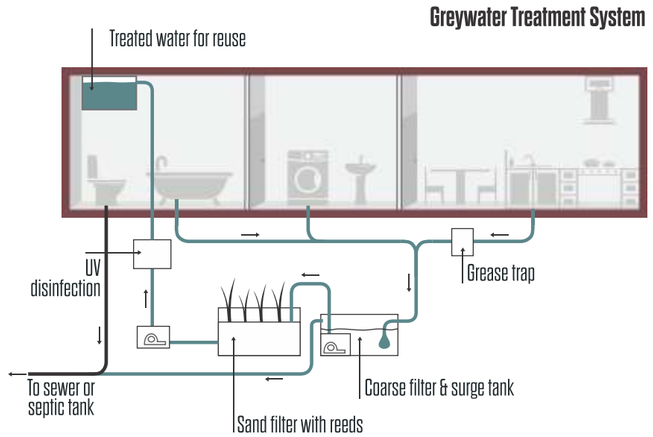
- Quality of water should be adequate enough to meet its low-end use.
- Regular testing of water quality for nutrients and contaminants.
- Further treatment with UV/ozone treatment is necessary, if treated water is to be used for bathing or in kitchen.

How does it work?

The quality of greywater needs to be ascertained and matched with the quality requirements of particular end use. Depending on the quality, greywater can be either used directly for purposes such as irrigating gardens or treated before reuse.

Direct reuse
Water of a relatively high quality with few contaminants can be directly reused. Pipes can be fitted to divert wastewater from appliances like showers and washing machines to irrigate gardens through underground porous pipes.

Treated reuse
If wastewater is not suitable for direct reuse, household/colony level wastewater treatment options may be used to reduce the level of contaminants to a level that is safe for reuse. Once treated sufficiently, wastewater can be used for gardening and flushing purposes. Separate pipelines may have to be installed to isolate treated wastewater from drinking water.

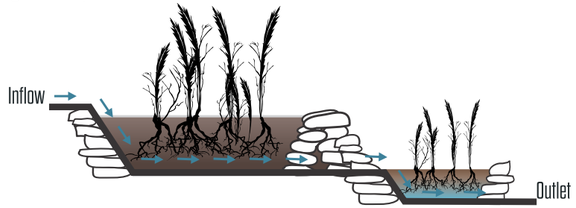


The Greywater reuse can include:

Reed bed filters

A reed bed is essentially a channel lined with an impermeable membrane, filled with gravel and planted with large, water-loving plants such as Canna, Colocasia (Hindi: Arbi), Alocasia (Giant Taro), grasses, reeds and rushes.

Wastewater is passed through the root zone, where the plants absorb nutrients and release enzymes and treat the wastewater. Inlet and outlet pipes are positioned below the gravel surface, so that water always remains below the gravel surface, thus preventing direct human exposure to wastewater, waterlogging, mosquito breeding and unpleasant odours.

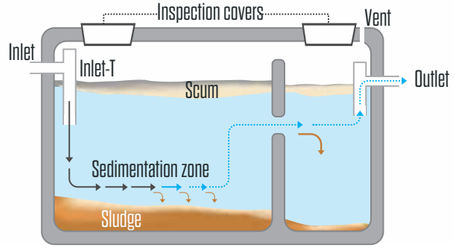


UV Disinfection

Concentrated ultraviolet (UV) light is used to kill pathogenic microorganisms in treated wastewater and make it usable for cooking and washing purposes. UV tube water disinfection devices offer effective, low-cost and simple means for rapid disinfection. These devices can run on grid power supply or solar power. They can be used at households, communities or institutions. However, UV systems cannot treat chemical contamination or reduce dissolved solids in water.

Septic Tank

Septic tank is a watertight brick or concrete chamber to store and treat sewage. For recycling greywater, separate septic tank connected to greywater sources only should be installed. Baffles and aeration can be provided to improve treatment.



Liquid waste gets treated and flows through the tank, solid waste sinks to the bottom and scum (mostly oil and grease) floats on the top. The quality of the treated water output from septic tank can be further improved using a reed bed.

Benefits

- **Reduced water usage:** Grey water reuse reduces household water consumption and increases resilience to water scarcity.
- **Reduced expenses:** The systems applied in greywater reuse lead to lesser water charges, along with reduced energy costs for water supply.
- **Environment friendly:** Outflow to city sewerage systems is reduced and also less contamination risk along the route to city sewage treatment plant.
- **Food security:** Greywater can be used in for growing vegetables in kitchen and rooftop gardens.
- **Reduced pressure on local water resources:** Recycled wastewater can significantly reduce demand for groundwater.

Barriers

- Greywater for high-end uses such as drinking and bathing may not be culturally acceptable.
- Greywater treatment systems may have to be built during the construction phase as separate land is required for the treatment. However, partial underground facilities can also be built to reduce land requirement.
- Retrofitting in gardens and public places maybe possible, but it is difficult in low income and dense settlements.

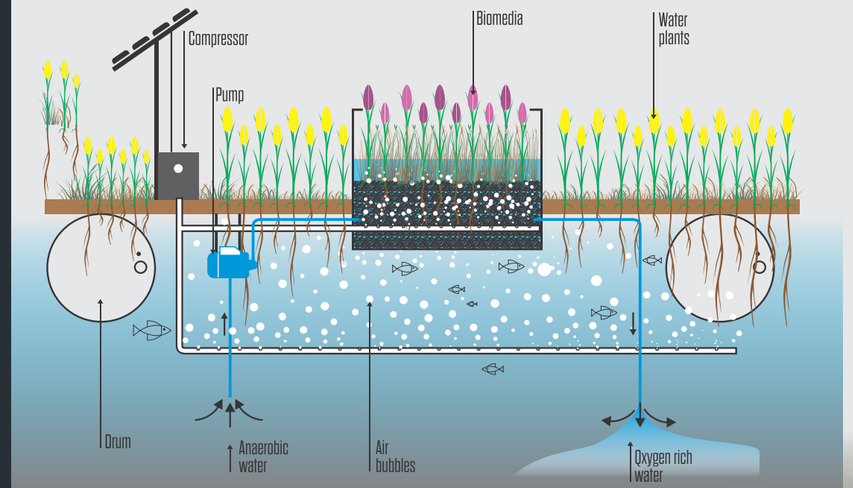
Floating Wetlands

Artificial floating island is a porous floating raft with aquatic plants growing on shallow nutrient poor soil. The plant roots grow in the water. Roots and attached microorganisms extract nutrients and pollutants. Aeration can be provided through small compressors to improve treatment efficiency. Also in extremely polluted lakes, the anoxic water can be pumped and aerated in tanks to remove nutrients. Organisms such as snails and fish can be grown to reduce sludge. These micro-habitats also improve aesthetics of lakes.

Characteristics Of Resilience

Requirements

- A floating raft or frame to support plant growth.
- A minimum depth of 1 m water to avoid large plants rooting to the bottom of the lake.
- Pumps, air compressors, aerators and solar PV systems and storage batteries for advanced systems.



Peri-urban lakes are often polluted with inflow from untreated sewage. Though most of the rural lakes are seasonal, urban lakes get perennial flow of untreated sewage from settlements in the catchment. While it is necessary to maintain water level in the urban lakes for functions like recreation and maintaining microclimate, sewage inflow leads to pollution, proliferation of aquatic weeds and breeding of mosquitoes.

Structure and function

- This system consists of aquatic and land plants growing on a floating raft.
- This is similar to hydroponics system, as the submerged roots take nutrition directly from water.
- The formation of hanging roots and biofilms provide surface area for biochemical processes that consume nutrients and reduce pollution.
- This process allows the growth of non-photosynthetic bacteria on the roots of plants.
- The bacterial community around the roots and the enzymes released by the roots further help in the treatment of water.
- Plants are chosen based on water quality, climate and other support systems like pumping and aeration.

Benefits

- Urban real estate prices are very high and this technology does not require any land.
- The system has a good ability to cope with variable water depths that are typical of stormwater and surface run-off water.
- Since most pollutants are treated, sludge formation is reduced.
- Based on the materials and floats used, the system is easy to assemble.
- When fully developed, the islands enhance the aesthetic value of lakes.
- Fish kills are quite common in urban and peri-urban lakes. Aerated artificial floating islands can provide oxygen-rich micro-habitats that can help fish survive.

Barriers

- Local fishermen may initially oppose floating wetlands, but once they see the improvement of aquatic habitats they may take interest in managing them.
- Community participation may be required to ensure maintenance of floating wetlands.

Porous Paving

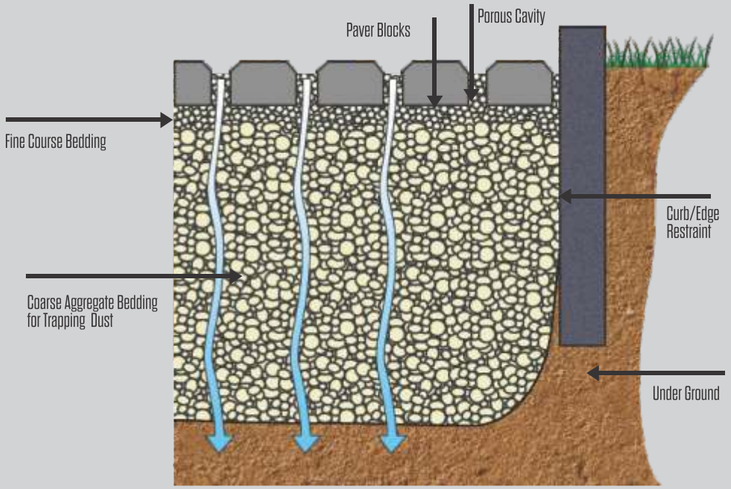
Paver blocks that allow rainwater to seep into the ground are known as porous paving. These blocks are made of concrete or stone, and they are laid with spaces between them filled with sand or grass. These pavers, apart from providing a greener look, trap rainwater and improve groundwater recharge. Porous pavers are effective in reducing surface run-off, risk of floods and water-logging. Also, they reduce glare.

Characteristics Of Resilience

Flexible | Redundant | Modular | Resourceful | Learning | **Safe-fail**

Requirements

- Good workmanship
- Channels to divert excess runoff

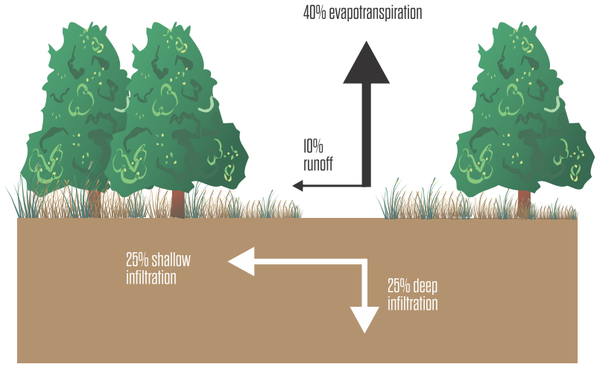


Where to use?

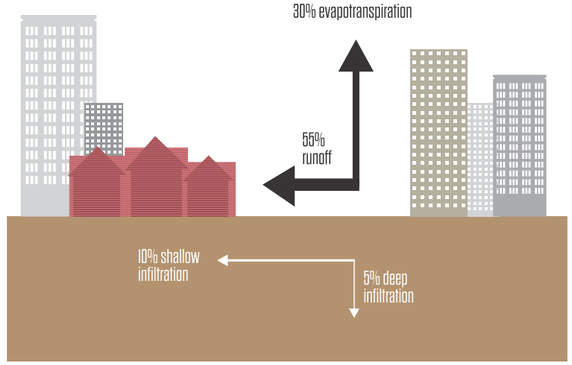
- Highly effective for low traffic areas such as parking lots, colony driveways and household gardens.
- Suitable in sloping areas with risks of soil erosion.
- Areas facing groundwater decline due to over extraction and reduced recharge from concrete surfaces.

Maintenance and cost considerations

- Require occasional replacement of broken blocks.
- Are costly to install, but require less frequent replacements.
- Decrease the overall cost on urban infrastructure such as curbs, gutters and storm sewer due to reduced surface run-off.



Natural Ground Cover



75%-100% Impervious Surface

Benefits

- Allows the ground to absorb surface run-off water, thereby recharging aquifers. Recharged aquifers lead to shallower water tables, thus reducing the cost of digging deeper borewells and reduce energy costs for pumping.
- Easy installation.
- These pervious surfaces reduce heat island effects by evaporation and reflection of thermal radiation from the grass patches. On a large scale, the small green pockets help in cleaning the air.
- Green grasses create interesting patterns and look better than the monotonous concrete surface. They also reduce glare during sunny days.

Barriers

- Higher costs
- Acceptance by the local users

Sand Filters

Sand filters are used for removal of pathogenic bacteria and suspended solids from drinking water. They are cost-effective to build and maintain. They are of two types: bio-sand filters and slow-sand filters. Bio-sand filters are small household units. They are suitable for households and communities without access to treated drinking water sources.

Characteristics Of Resilience

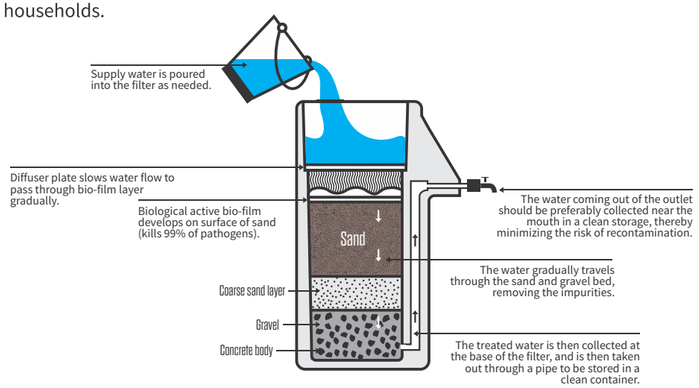
Flexible · Redundant · Modular · Resourceful · Learning · Safe-fail

Requirements

- Impurity level of water should be low initially, otherwise pre-treatment is necessary.
- Moderate climate conditions, as the filter does not work in extremely low temperatures.
- Experienced contractor for construction and trained caretaker for operation and maintenance.

Bio-sand Filter

Bio-sand filters are simple water treatment devices for household use. They consist of a concrete or plastic container, filled with specially graded sand and gravel. When water is poured into the filter, it passes through various layers that remove the impurities present by physical filtering. These systems are highly effective for households.

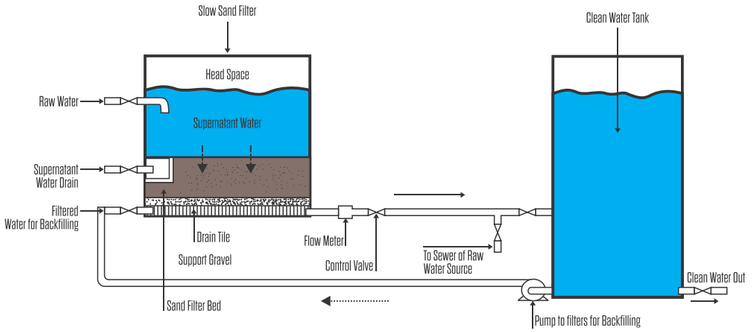


Applicability

- Bio-sand filters are suitable for the treatment of water at the household level.
- They can directly treat surface or groundwater.
- They cannot remove dissolved chemicals or organic pesticides.
- Water can be further chlorinated for the consumption of infants or elders in the household.
- Bio-sand filters should be designed by trained people, as an incorrect set-up can lead to poor filtration.

Slow-sand Filter

This is a medium-scale water purification system that can be used at colony or community levels. Slow-sand filters are similar to bio-sand filters, which are modified to serve the larger needs of the colony. Similar to bio-sand filters, slow-sand filters also effectively remove pathogens and suspended solids. Slow-sand filter is a highly effective tool for water filtration in slums. It works with a fairly acceptable quality of water source and can also be used for recycling wastewater, especially greywater with some modifications.



1 Hour is needed to get 12–18 L of filtered water from household refrigerator sized bio-sand filter.

2 Rupees is the maximum cost of production per litre.

90% Average of impurities that can be removed using this technology.

40% Incidences of diarrhoea can be reduced.

Benefits

- Effective removal of most pathogens and suspended solids.
- Simplicity of design (simple and cheap construction).
- High self-help compatibility (simple operation and maintenance).
- No electricity required.
- Construction with local material and knowledge.
- No chemicals required.
- Long lifespan (>10 years) with periodic back flush to rejuvenate filters.

Barriers

- Capital costs.
- Cultural acceptability compared to boiling or other filtration devices.

SODIS

SOlar water DISinfection or SODIS is a simple and low-cost method that uses solar energy to disinfect and kill the germs in water. It helps in achieving safe drinking water at the household level. World Health Organization recommends this method for water disinfection.

Characteristics Of Resilience

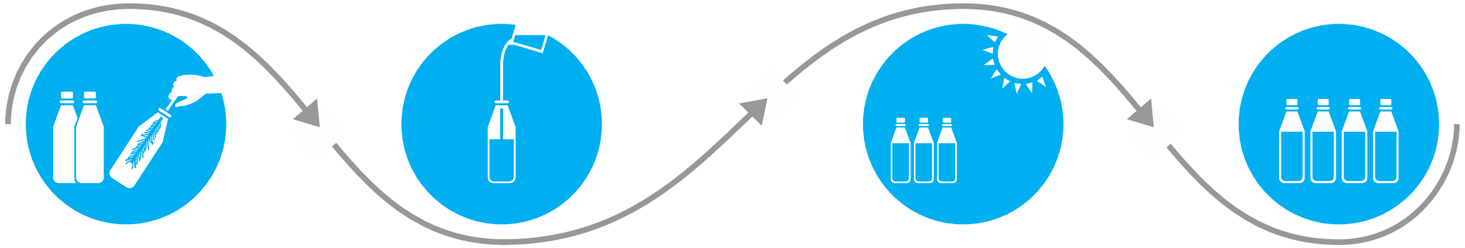
Flexible · Redundant · Modular · Resourceful · Learning · Safe-fail

Requirements

- Clear bottles, preferably made of glass. PET or plastic bottles can also be used in emergencies.
- Adequate sunshine.
- A clean space (generally roof tops) to place the bottles horizontally.

How does it work?

Sunlight contains UV-A radiation, which kills pathogenic germs in water. When microbially polluted water is exposed to solar light in transparent PET bottles, bacteria, virus and some parasites are inactivated by the solar UV-A radiation.



Wash the bottle well, the first time you use it

Bottles

Use only clean glass or food grade PET (Poly Ethylene Terephthalate) bottles. Avoid using plastic bottles, unless there is an emergency, since they can transfer organic chemicals to the water. Sometimes, water treated in plastic bottles may taste unpleasant. The bottles must be transparent without scratches, since scratches reduce transparency of the bottles. The capacity of the bottles should not be more than 3 liters. The bottles must be placed horizontally.

Fill bottles with water, and close the cap

Water

Turbidity (cloudiness/haziness) of water reduces the disinfection process. To check for turbidity:

1. Place the filled bottle on top of a newspaper headline.
2. Look at the bottom of the bottle from the neck at the top, through the water. If the letters of the headline are readable, the water can be used. If not, it must be filtered.

Expose to direct sunlight for at least 6 hours (or for two days under very cloudy conditions)

Weather

Cloudy weather affects the strength of sunlight. If less than half the sky is covered with clouds, then six hours of exposure is required. If more than half the sky is clouded, then the bottle must be placed for two consecutive days. This method does not work during rainy and cloudy days.

The Sun's UV-A radiation combined with the increase in water temperature destroys the pathogens in the water.

Treated Water

Treated water must be kept in the bottle and should be consumed immediately.

Benefits

- SODIS works very well in Indian climate due to abundant sunlight.
- It improves the microbiological quality of drinking water.
- It is very simple, easy to use and works at a low cost.
- It relies on locally available resources and sunlight.
- It is suitable for emergency use, such as post cyclones and floods.
- It is suitable for informal settlements that do not have protected water sources.

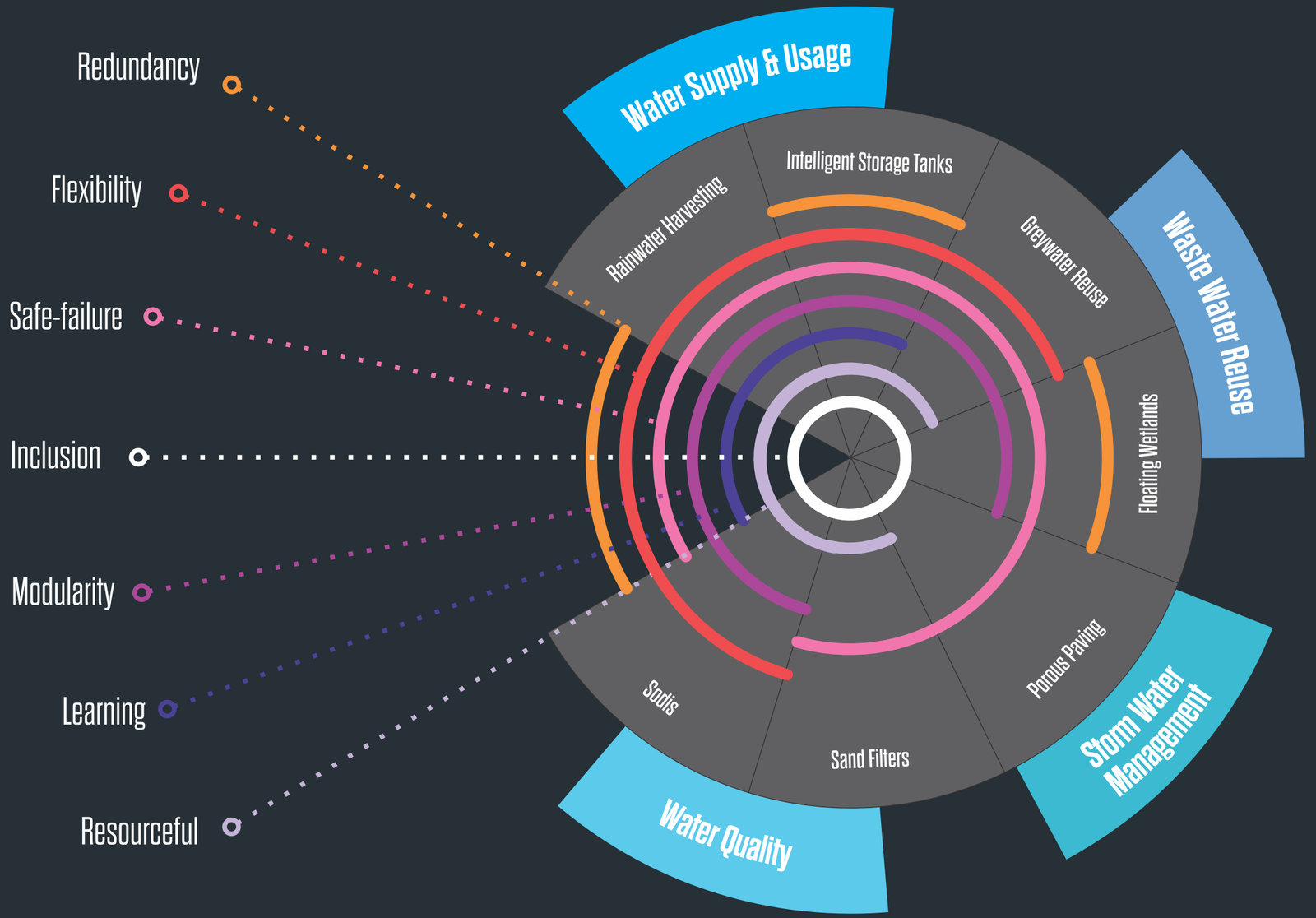
Barriers

- SODIS method does not work if sunlight is inadequate.
- Water is treated only in small quantities at a time.
- It is a time consuming process and needs to be planned for daily use.

Did you know!!!

More than 5 million people around the world clean their drinking water using the SODIS method.

Technologies	Reducing Consumption	Developing Alternate Resources	Recycling	Quality Improvement
Rain Water Harvesting		✓		✓
Intelligent Storage Tanks		✓		
Grey Water Reuse		✓	✓	
Floating Wetlands		✓		✓
Porous Paving		✓		✓
Sand Filters			✓	✓
Sodis				✓



SMALL ACTIONS BIG SAVINGS

Resilience Building through Water Management

Some day-to-day practices are suggested, which would eventually contribute to increased resilience

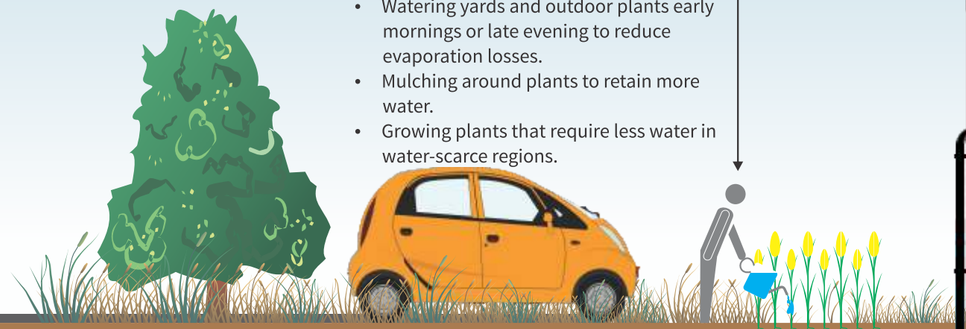
- Use a tumbler for brushing teeth.
- Check for leakages and get them repaired immediately.
- Turn off the running water while brushing teeth, soaping hands, scrubbing dishes and pots.
- Take bucket baths instead of showers.
- Take shorter showers – five minutes or less would be best!!

Use Water efficient technology and upgrade your equipment.

- Install new toilet bowls that use less than 5 liters per flush.
- Use low flow showerheads.
- Install water saving faucet aerators.

Smart Plantations

- Watering yards and outdoor plants early mornings or late evening to reduce evaporation losses.
- Mulching around plants to retain more water.
- Growing plants that require less water in water-scarce regions.



Recycling

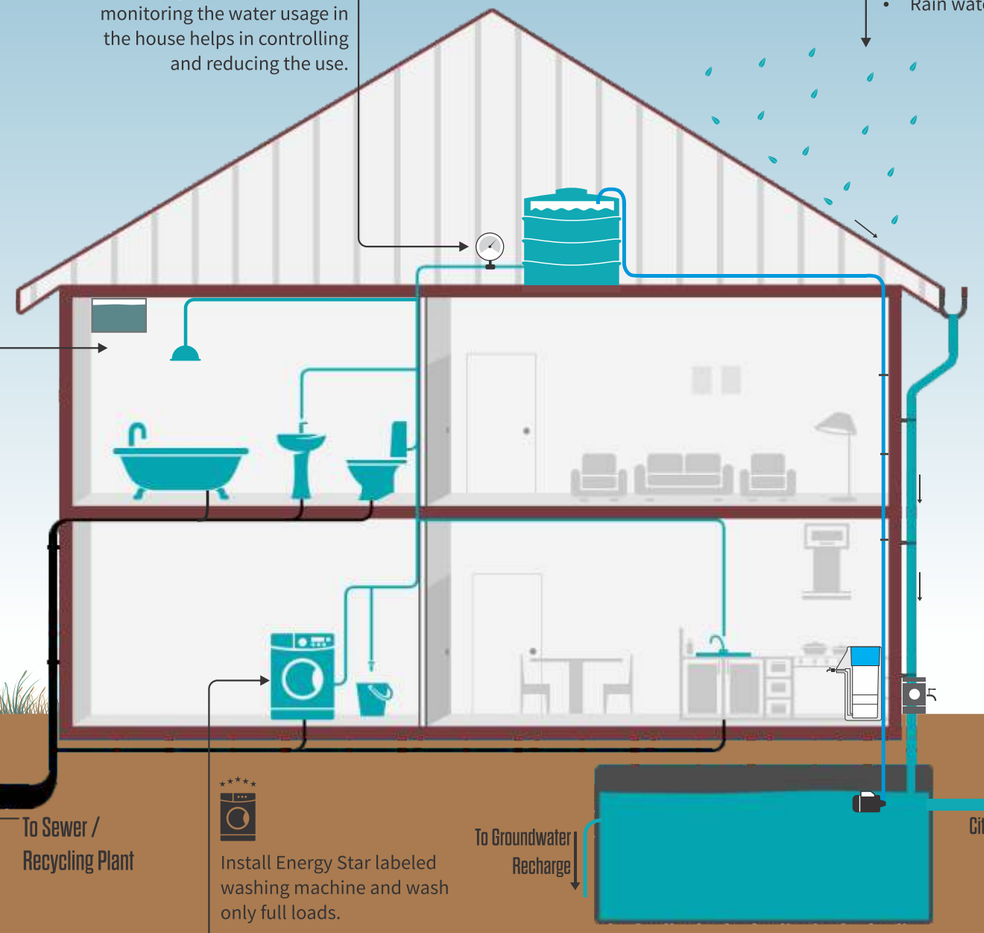
- Using urine from urine separation toilets for gardening.
- Irrigating gardens and other plantations using treated greywater.
- Bio-sand filter for treatment of water on the ground floor.

- Use a bucket for car washing instead of a hose.
- Use a broom instead of hose to clean walkways and driveways.

Installing the water meter for monitoring the water usage in the house helps in controlling and reducing the use.

Water storage

- Install terrace water storage tanks.
- Rain water harvesting.



Conjunctive Water Management (CWM)

An Integrated water management approach by use of multiple resources

City water supply systems work on the assumptions that centralized solutions are economically viable and also easily manageable. This approach leads to the generic solutions such as bulk supply of drinking quality water for all end uses. As the water demands increase and distant sources need to be tapped, the local and decentralized options can provide cheaper solutions, but these require decentralized systems and engagement of local stakeholders. Actually in water scarce urban environments, these sources are informally used, but none take responsibility for conserving these resources.

The city water systems supply drinking quality water for all the purposes, whereas maximum proportion of household uses such as cleaning of floors and flushing toilets can be met by lower quality water. Also, the sewage can be transported to city periphery and treated there, reducing possibility of using treated wastewater for low end uses within the city. Since drainage, sewerage and water supply are managed as separate entities, integrating water, sewage and stormwater is difficult.

With such systems, we miss out on following basic facts:

- Water supply system can be more efficient and resilient by using multiple sources across scales.
- Local sources such as rainwater and groundwater can be used as additional sources to supplement centralized water supply systems; these can increase resilience of the households to scarcities and grid failures.
- Treated wastewater is a resource which is often cheaper and appropriate for end uses such as flushing toilets, cleaning floors and washing cars.

Using multiple sources increase the resource use efficiency as well as resiliency of the systems. Integrated urban water management framework can be used for water management, which aims at conservation of resources across scales through engaging all stakeholders.

Both demand as well as supply side interventions are necessary to sustainably manage water in urban areas. To ensure health and well-being of citizens we need to address water security, efficiency, price and quality under changing demand scenarios as well as water resource uncertainties under changing climate.

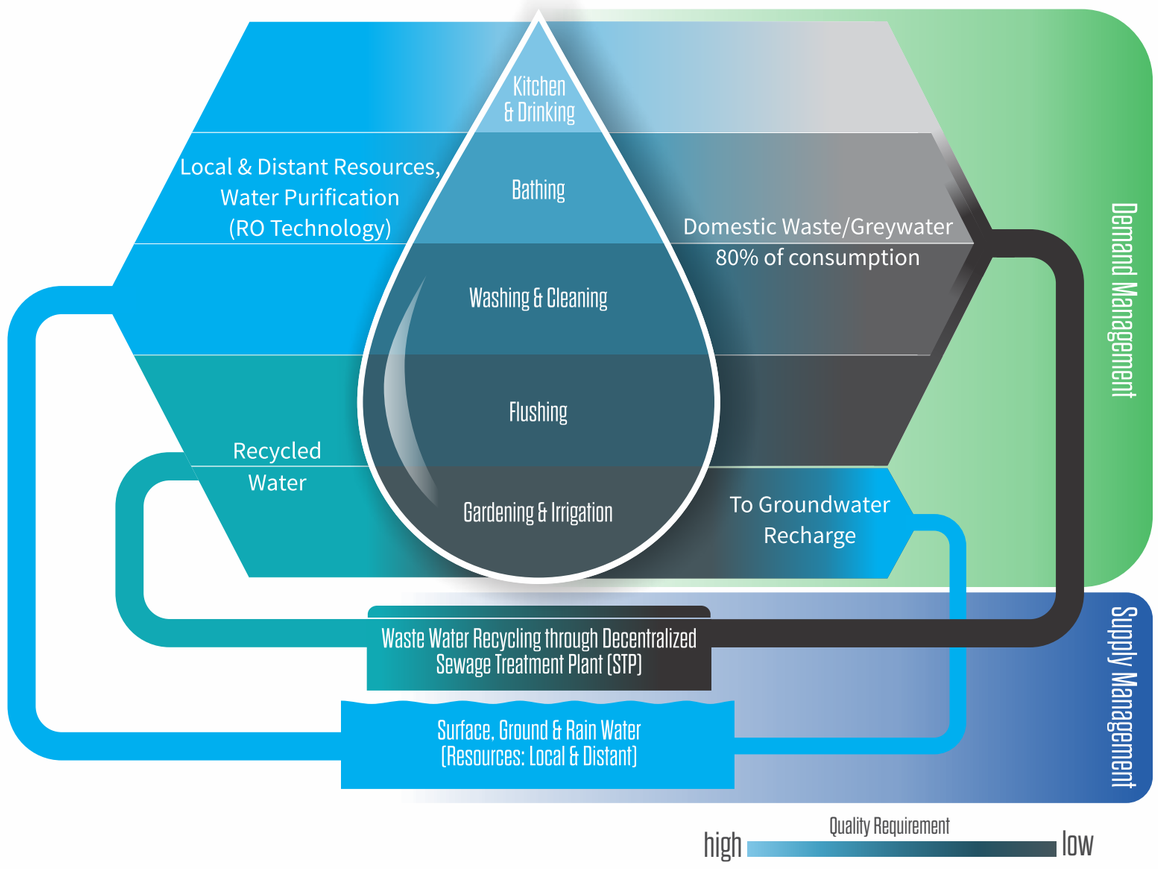
Supply side approach

Conjunctive Water Management (CWM) is defined as optimal use of local resources such as rainwater, surface water, groundwater, treated wastewater and distant resources such as municipal water for meeting various types of water demands.

Demand side approach

Under Demand Focused End Use (DEFENDUS) approach, demands and resources are categorized based on the quality criteria. Allocation of the resources is done by matching the demand quality criteria in the next step. This approach enables use of low quality resources for low end uses and conservation of high quality resources for high end uses.

Decentralized Demand & Supply Management



The CWM and DEFENDUS approaches provide following benefits to users:

- Cost effective local solutions compared to the distant sources.
- Emergency supplies in case of any grid level failure.
- Adequate and appropriate quality water availability to meet diverse types of demands.
- Better control over the local resources and reduced reliance on city water grids.

Seasonality, costs and quality of the resources such as rainwater, groundwater, and treated wastewater needs to be analyzed to implement CWM and DEFENDUS. An efficient system with combination of these approaches can increase the resilience of the users to uncertainties arising from increasing scarcities and extremes of climate.

ENERGY

Because we **don't think** about future generations, they will never **forget us.**

-Henrik Tikkanen

Introduction

Energy is important for economic development and for leading a good quality of life. Availability of cost-effective and sustainable energy sources is the key to economic growth of cities and nations. India depends on import of fossil fuels for meeting nearly 30% of the energy demand, while it has large potential for developing renewable energy systems, especially solar and biomass based energy.

There are huge gaps between energy demand and supply resulting in intermittent and low quality energy supplies. Frequent power cuts and breakdowns impact economic activities as well as the quality of life. There are many options to reduce energy consumption without sacrificing the quality of life or efficiency of economic activities.

Lighting and space cooling are some of the important energy demands of households. Increasing temperatures and urban heat island effects are expected to escalate the energy demand for space cooling. Changing lifestyles have resulted in extensive use of air conditioners in households. Significant savings are possible in both lighting and space cooling in households.

Quality of Life and Energy

The quality of urban lives, including social, economic and environmental well-being, is directly related to energy use. In tropical countries, indoor thermal comfort is critical to overcome heat stress. Energy should be available round-the-clock to ensure thermal comfort, provide lighting and reduce the drudgery of daily chores such as washing, cooking and food processing. Urban water systems depend on distant sources and require energy for pumping and treatment. Water filters in most modern households, which are critical in ensuring good water quality, are dependent on energy. Refrigerators, which run on energy, are crucial for households, hospitals and food processing centres.

Energy

The Relationship Between Quality Of Life And Energy

ENERGY SCENARIO

NONRENEWABLE

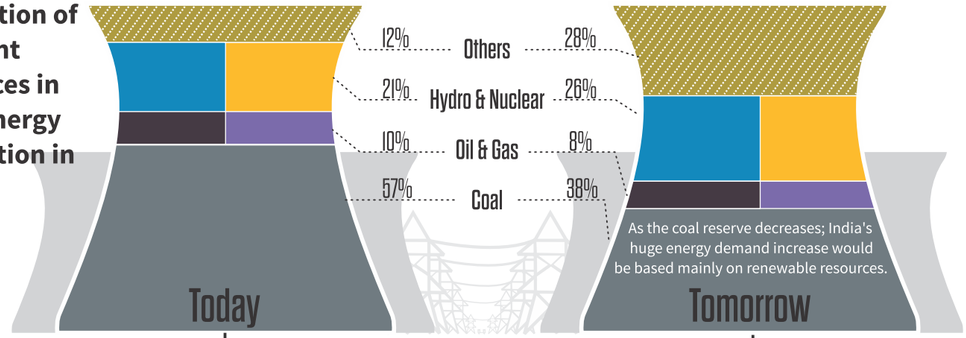
Thermal Power · Nuclear Power · Oil · Natural Gas · Coal · Agricultural & Domestic Waste

RENEWABLE

Solar · Wind · Geothermal · Tidal · Biomass · Fuel Cells · Hydro Power

India is an energy deficient country. More than 400 million people - equivalent to combined population of USA and Germany- do not have access to electricity. Electricity is managed by the states and the distribution is uneven across the country. Most of the rural areas suffer from daily power cuts especially during summers. They are deprived of minimal facilities such as electrical lighting, space cooling and refrigeration.

Proportion of different resources in total energy generation in India



India has the highest distribution losses in the world - nearly 47%, ranking above Myanmar (36 %) and Bangladesh (33 %)

Demand growth for resources

(Mtoe: Million tonnes oil equivalent)

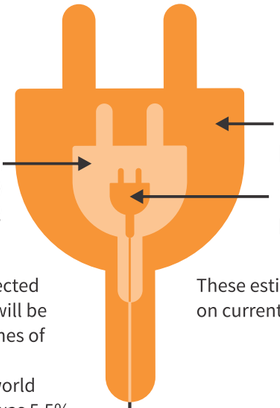
2009		2035
280 Mtoe		618 Mtoe
159 Mtoe		356Mtoe
49 Mtoe		154 Mtoe
5 Mtoe		48 Mtoe
2 Mtoe		36 Mtoe

Did you know!!!

Being located in the tropical region, India receives a fairly high amount of solar radiation; Solar energy will be the greatest source of renewable energy for tomorrow.

The map presents annual average direct normal solar irradiation. (2002-2008)

Estimated future electricity demand in India



2280BkWh (Billion Kilowatt Hours) by 2021-22

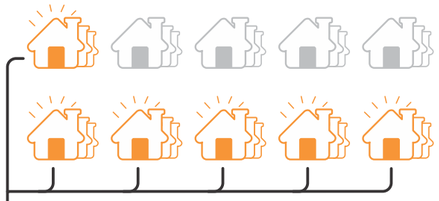
4500 BkWh by 2031-32

778 BkWh Present

By 2031, the expected energy demand will be more than 5.7 times of current demand. India's share in world energy demand was 5.5% in 2009 and expected to reach to 8.6% by 2035.

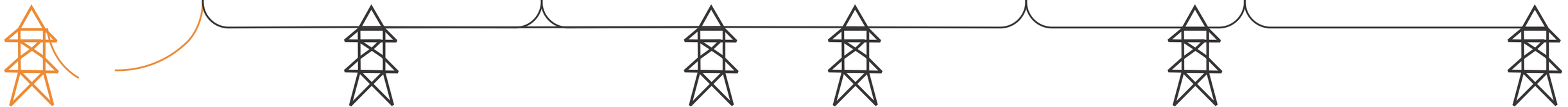
These estimates are based on current GDP growth rate.

Over 40% of the country's population currently does not have access to [grid] electrcity.



Even though, 85% of villages are considered electrified, 57% of the rural households and 12% of urban households, (i.e. 84 million households) in the country, do not have access to electricity.

To reduce the losses and provide access to rural areas, the alternative solution for tomorrow will be decentralized off-grid energy supplies.
For instance, in rural areas, Photovoltaic electricity can replace kerosene for lighting and diesel for pumping. Biogas plant/solar cooking can replace fuelwood.



ISSUES

Insufficient supply

- Fossil fuel shortage and usage of low quality fuel result in lower efficiency and higher costs.
- Fuel shortage results in inadequate energy generation and frequent power cuts.
- The systems are overloaded and face breakdowns due to peak loads.
- Grids can fail catastrophically due to overload or shortage of generation.

Pricing

- Coal imports upset the balance of trade.
- Energy subsidies divert the finances from capacity enhancement to meet growing demands.
- Subsidies lead to wastage of energy as well as overexploitation of groundwater.
- Subsides often do not reach the people who most need them.

Infrastructure

- Over-burdened distribution systems and limited generation capacity result in frequent breakdowns.
- Financial losses result in reduced investments to augment generation capacity.
- Outdated infrastructure causes higher loss in the power supply.

Health & Environment

- Emissions from energy generation lead to deteriorating air quality and smog.
- Global warming and urban heat islands increase thermal discomfort.
- Unreliable power supplies impact other lifeline systems like water supply.

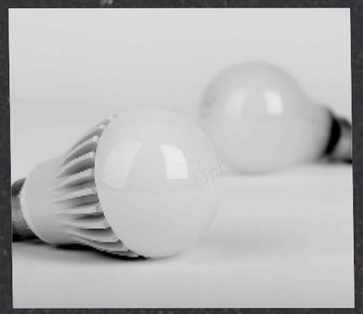
Where we can make the difference

Renewable Energy Supplies

Tropical countries can meet significant proportion of urban energy demand from renewable sources like solar and wind energy. Renewable energy can be generated at household and building levels. Poor households can also meet some of their energy needs from these sources.

Thermal Comfort

Cool roofs and passive ventilation can be integrated with the architectural features, which improve thermal comfort in houses. Reduced heat inflow into buildings can lower energy consumption for space cooling, especially in hot and arid areas. However, if a building is already constructed without these systems, retrofitting of some of these technologies can be done to significantly reduce energy consumption. Some of these technologies can also be used in slums and informal houses.



Energy Conservation

In a normal household, significant proportion of electricity is consumed for lighting. Without compromising on the quality of light, use of efficient lighting, natural lighting etc., can reduce energy consumption. New lighting technologies can reduce energy use by 50 to 75 per cent.

To make a marked difference in building resilience, newer and integrated technologies and practices should be explored. Some approaches are as follows:

1. Overall Approach: Reducing demand, increasing efficiency and generating renewable energy, wherever feasible.

2. Improving Efficiency: Using efficient equipment and devices, monitoring energy use and reducing wastage. Automatic systems can be used to control light and space cooling. Evaporative cooling, natural light and light tunnels can be used during daylight hours. Recycled water can be used for cooling the roofs.

3. Scales: Generating renewable energy at various scales ranging from individual houses to cities. Biogas-generating recycling systems can be used to generate energy from organic wastes and sewage from colony-level upwards. Rooftop solar energy systems can be installed on buildings and can meet daytime energy demands. With storage batteries, emergency supplies for lighting and mobile phone charging can be done.

4. Energy from Domestic Waste: Using solid and liquid waste for generating energy for lighting/cooking purposes at colony level upwards.

5. Technologies: Integrating existing or new technologies to enhance better supply, management and reuse of energy resources.

6. Infrastructure: Moving away from fossil fuel and other non-renewable energy sources and optimally using vegetation and ecological engineering-based systems for space cooling.

7. Integration: There are renewable energy options like solar and biogas energy that can be used at colony levels. These can be used for pumping groundwater. By using solar energy for pumping water, the shocks from prolonged electricity breakdowns can be avoided.

Biogas Use

Biogas plants are renewable energy sources that provide cheap and sustainable energy for lighting, cooking and other needs. Biogas can be produced at colony to city scales and can be used for treating concentrated sewage from the vacuum toilet systems. Methane gas is produced through anaerobic digestion of organic wastes such as human excreta, waste food and vegetables. Biogas plants can be used to treat sludge from sewage treatment plants also. They can be used for generating shaft power through internal combustion engines. They can be designed to treat solid as well as concentrated liquid wastes.

Characteristics Of Resilience

Flexible | Redundant | Modular | Resourceful | Learning | Safe-fail

Requirements

- Open area in close proximity for installing the treatment plant.
- Adequate system of management of sludge generated from the system.
- Special burners/lamps/engines for biogas use.
- Proper safety measures to avoid risk of leakage and explosion.

1 Biogas tanks have brick-constructed or pre-fabricated shells to hold liquids and gases.

2 Depending on the soil condition and waste volume, the tanks may be installed above or below the ground.

3 A biogas tank has a digester, which is a large tank filled with anaerobic bacteria that digest organic wastes and produce biogas.

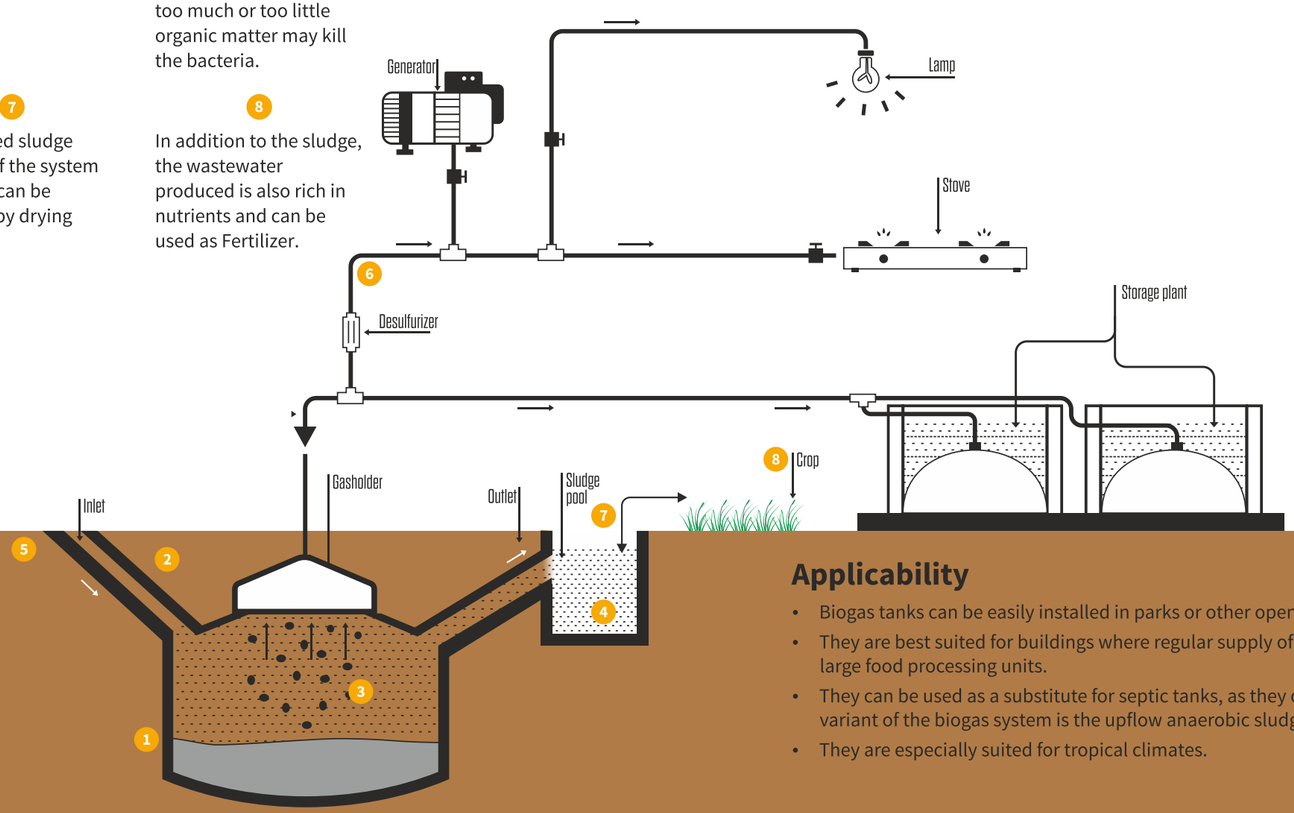
4 As the gas is generated, it exerts pressure and pushes the sludge into an adjoining chamber.

5 The tank may be fed manually or can directly be connected to toilets. However, care should be taken to feed the concentrated waste, as too much or too little organic matter may kill the bacteria.

6 Biogas produced in the system can be used for cooking, lighting and meeting other energy needs.

7 The digested sludge flows out of the system and solids can be separated by drying beds.

8 In addition to the sludge, the wastewater produced is also rich in nutrients and can be used as Fertilizer.



Biogas for Cooking

Biogas appliances are similar to the regular cooking appliances.

This system produces less smoke and less air pollution, and hence is a healthy option. It is much better than using firewood, which pollutes the indoor air.

Biogas for energy

Biogas or dual fuel engines can be used for providing energy to sewage treatment plants or in colonies to pump water. However, in small scale plants it may be better to use the gas for lighting and water heating purposes, which convert gas to heat or light directly.

Applicability

- Biogas tanks can be easily installed in parks or other open areas of colonies in urban environments.
- They are best suited for buildings where regular supply of concentrated sewage from vacuum toilets, urban cattle sheds or solids from large food processing units.
- They can be used as a substitute for septic tanks, as they offer similar level of treatment, along with the added benefit of biogas. A variant of the biogas system is the upflow anaerobic sludge blanket (UASB) system, which is designed to generate biogas.
- They are especially suited for tropical climates.

Benefits

- Cheap and renewable energy source, as it can be produced at the colony levels.
- Reduces dependence on LPG cylinders and other fuels.
- A renewable energy source.
- Low operating cost and easier to handle.
- Long life span.
- Underground construction minimizes land use.

Barriers

- Capital costs.
- Land requirement.
- Concentrated waste is required; so best used with vacuum toilet systems.

Did you know!!!

Installation of an anaerobic digester and utilization of biogas can provide a good return on investment (2–4 years) if the infrastructure for utilizing the biogas already exists.

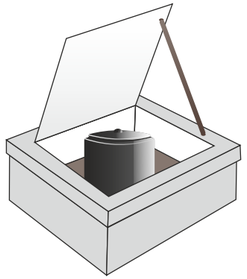
Solar Cooking

Solar cooker is a device that cooks food using the sun's energy as fuel. This cooker can reduce the energy consumption for cooking. While solar cookers are efficient in cooking all kinds of food, they are environment-friendly and save money. Solar water heating systems are already popular in many cities.

Characteristics Of Resilience

Requirements

- An open space with several months of sunny weather.
- An area that gets at least 3–4 hours of sunlight.
- Area protected from strong winds and theft.
- Dark-coloured pots to absorb maximum heat.
- Basic knowledge about cooking and time needed to cook various food products.

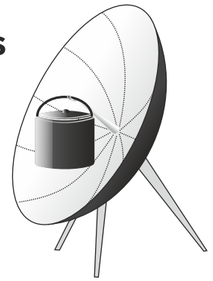


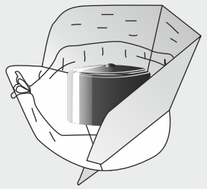
Box Cookers

Box cookers are most widely used in households. There are several lakh (0.1 million) box cookers in India alone.

Curved Concentrator Cookers

Curved concentrators, also known as parabolic cookers are especially suitable for large-scale institutional cooking. They concentrate the solar energy by the parabolic reflectors. While this technique helps in cooking food fast at high temperatures, it needs frequent alignment of the mirror towards sun as well as supervision to ensure safe operation. Modern cookers have automatic control systems that can orient the mirror continuously towards the sun.





Combination Cookers

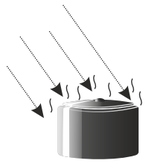
Combination cookers, also known as panel cookers, use some elements of box and curved concentrator cookers. It has some of the benefits of both the types.

Benefits over Curved and Box Cooker

- Unlike a curved concentrated cooker, a combination cooker does not need to be moved to track the sun while cooking.
- The temperature is fairly even over the cooking period.
- It does not produce glare and hence is safer for the eyes.
- It requires no glass insulation unlike the box cookers.
- It is easier to make and cost-effective.
- The system can be folded and stored, consuming less space.
- The materials required for installation are minimum and can be procured from nearby stores.

How does it work?

Solar cookers use sunlight to cook food. These cookers need an open space, preferably terraces, to maximize the sunlight availability. As they require sunlight, they cannot be used during nights or cloudy days.

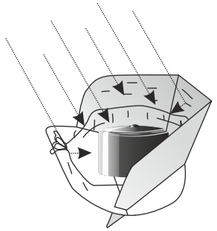


Convert Sunlight to Heat Energy

Dark surfaces are good for capturing the heat through sunlight. Food cooks best in black, shallow and thin metal pots as they help in holding the heat and moisture.

Retain Heat

A transparent heat trap, like a heat resistant plastic bag or glass bowl, helps in trapping the heat around the pot and allows sunlight to pass through.



Capture Extra Sunlight

A shiny surface around the pot helps in reflecting sunlight to the pot, increasing the heating effect.

0

Amount of money spent on energy, fuel or electricity, for cooking meals during the day.

4-6

Number of LPG cylinders saved in a year/household if all cooking is done with solar cookers.

2000

Cost (in Rs.) of a regular box solar cooker.

82-121℃

Temperature at which food cooks in the solar cooker, equivalent to the regular cooking techniques.

Benefits

- This technology helps in solving following issues – shortage of cooking fuel and waterborne diseases. They can be also used for sterilization of water and milk, thus reducing the risk of waterborne diseases.
- Slow cooking enhances the taste of cooked food.
- The fuel for solar cookers, sunlight, is free. It is easy to make solar cookers with a variety of locally available materials.
- This technology eliminates fire hazards and related injuries. It requires the least use of oil, as it enables cooking food with water only.
- Solar cookers can be easily adapted to a variety of eating habits and climatic conditions.
- Use of traditional fuels like firewood and gas pollutes the household air heavily and contributes to global warming. This factor is eliminated, as solar cookers offer a zero-pollution alternative.

Barriers

- Open roof with sufficient direct sunlight is required.
- Cooking takes several hours.
- As they use sunlight, they cannot be used during nights, cloudy or on a rainy days.

Did you know!!!

Solar steam cooking systems can be used to cook for hundreds of people at a time in residential schools, institutions, hotels, hostels, hospitals or industrial canteens. About $ 6,300 (Rs. 400,000) or more can be saved annually on energy spending for cooking 600 meals a day.

Solar Water Heating & Photo-voltaic Systems

Solar Photo-Voltaic (SPV) technology is used to generate electrical energy from the sunlight. The SPV system uses solar panels contain numerous solar cells that generate electricity. It is a standalone system and energy can be directly used for pumping during day time. Part of the energy can be stored with storage batteries for meeting night and emergency demands.

Characteristics Of Resilience

- Flexible
- Redundant
- **Modular**
- **Resourceful**
- Learning
- **Safe-fail**

Requirements

- An open roof/terrace space with clear and unobstructed access to sunlight for most or all of the day, throughout the year.
- A roof or area large enough to accommodate the system.

Solar Water Heater

Usage: You can heat 100 litres of water to 60-80 degree Celsius and store it for 24 hours.

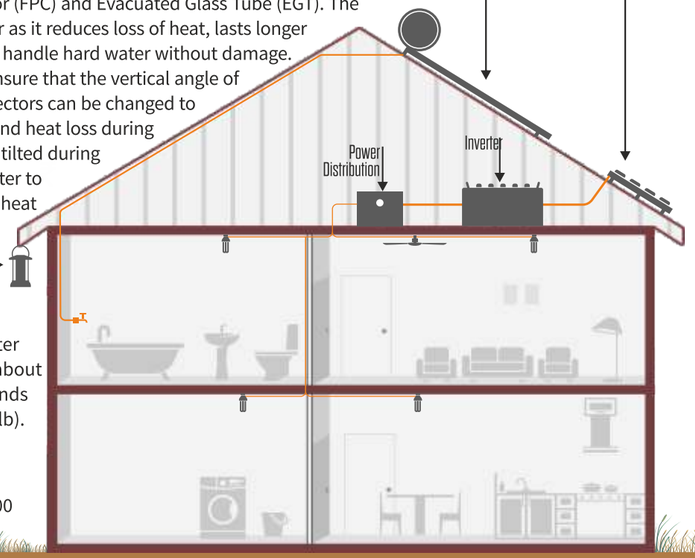
Price: Rs.16,000-22,000 for 100-litres heater. The higher the capacity, the lower the cost.

Life: 25 Years

Cost Recovered: In 6 years

Saving ₹ 1,600 Is the amount you will save during winters (2-hour usage every day for four months) if you use a solar heater rather than an electric geyser.

What to Consider: There are two popular models: Flat Plate Collector (FPC) and Evacuated Glass Tube (EGT). The latter is better as it reduces loss of heat, lasts longer and can even handle hard water without damage. You should ensure that the vertical angle of the solar collectors can be changed to avoid water and heat loss during summer, and tilted during rains and winter to allow greater heat collection.



Solar Lanterns

Usage: 4-10 hours after charging for about 6 hours(depends on type of bulb).

Price: Rs. 1,000-3,500

What to Consider: Solar lanterns can either have CFL bulbs or LED ones. The latter are usually more expensive, but last longer. A warrantee of up to 10 years is available for some LEDs. However, the battery may need to be replaced after 3-5 years.

Saving ₹ 1,440 is the amount you will save annually if you use the solar lantern instead of a regular bulb for 10 hours every day.

Life: 20 Years

Cost Recovered: In 2 years

Photo-Voltaic Panels

Usage: Two CFL bulbs and a fan for 3-4 hours after charging for at least 2 hours.

Price: Rs. 13,500 for a system that has a 35w solar panel, a12v, 40 amp battery, and two 9w CFL bulbs.

Life: 25 Years

Cost Recovered: In 4 years

Saving ₹ 3,500 is the approximate amount you can save every year (If you use two bulbs and a fan for 8 hours every day).

What to Consider: An area directly exposed to sunlight for most of the day is needed. In urban areas, it might not be enough to replace regular power, but it can provide electricity during long power outages. In cloudy regions, storage of energy up to a day is possible for meeting most essential demands.

Solar Street Light

Usage: 10–12 hours after being charged for 8 hours (depends on the type of bulb)
Life: 10 years
Price: 25,000/-
Cost Recovery: 3 years
Savings: Rs. 6,000 can be saved per year on SPVs compared to grid-based systems.

Did you know!!!

Liter of Light is a modified light tunnel using plastic/glass bottles to provide ecologically sustainable and free-of-cost lighting source, especially for underprivileged houses. The system is simple to install. All it needs is a transparent bottle, filled with water and a little bleach to inhibit algal growth. This bottle is then inserted through a specially made hole through the roof, allowing the water inside to transmit sunlight. Such an arrangement can deliver the same amount of light as a 60-watt bulb during day time.

Benefits

- SPV systems can meet part of the daytime energy bills demand and thus help in reducing electricity bill. These systems can be expanded easily to meet increased energy demand by adding more modules to the existing system.
- SPV systems can be combined with other types of electrical generators (e.g., wind, hydro and diesel generators) for charging the storage batteries and providing power on demand.
- This technology provides back-up lighting system at near zero running cost.
- It is easy to install the SPV system.
- Since this is a low voltage (12–24 V) system, there is low or no risk of electrocution.
- As the system is powered by solar energy, the technology is sustainable, energy-efficient and is a clean source. Unlike fossil fuel powered generators, it does not cause air or noise pollution.
- The system has no moving parts, thus eliminating the risk of breakage or loss. Once installed, it requires only regular cleaning of panels.
- These systems are compact and portable, and can be adapted for various locations and applications.
- The cost of solar panels is decreasing while the efficiency of the systems is increasing.

Barriers

- Requires unobstructed south facing or flat roofs in northern hemisphere and vice versa.
- Roof should have sufficient load bearing capacity.
- In cyclone and high wind-prone areas, solar panels may get damaged by flying projectiles.

Sun Shading

Sunshades are generally installed outside the buildings to prevent direct sunlight heating the rooms and walls during summers and allow sunlight to heat during winters. They help in protecting the house from heat in summers, thereby reducing the energy consumed in cooling the house. Sunshades can be natural, like trees, or architectural, like chajjas. They are especially useful in tropical areas.

Characteristics Of Resilience

Flexible | Redundant | Modular | Resourceful | Learning | Safe-fail

Requirements

- An understanding of the sun's path at the location of building in different seasons
- Calculating the sun shading requirement, which will determine the size of the installation

Landscaping:

- Landscaping is an important element used in altering the micro-climate of a place by reducing the air temperature. Proper landscaping reduces direct sunlight from heating up building surfaces. It prevents reflected light from entering a building from the ground or other surfaces.
- Planting deciduous trees, like Mulberry and Champa, on the southern side of a building cuts off direct sunlight during summer. As these trees shed leaves in winter, they allow the sun to heat the building in winter, thus reducing heating costs.
- Natural cooling without air conditioning can be achieved by planting trees to channel south–easterly summer breeze in Indian tropical regions. A study of local wind patterns is necessary to fine-tune the system. Shade can also be created by using a combination of landscaping features, such as shrubs and vines or trellises. Certain climbers are also useful for shading exposed walls from direct sunlight (Green walls).

Building Form:

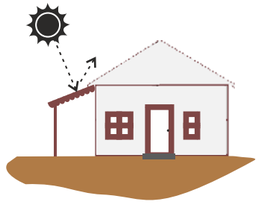
- Building form affects sunlight energy inflow and the rate of heat loss or heat gained through the external envelope. The buildings are designed to cut off a large amount of direct solar radiation absorbed by the walls. Building form also determines the air flow pattern and ventilation. The greater the depth of the room, the higher will be the need for artificial lighting and internal cooling.
- Circular geometry is most energy-efficient building form in composite climate as solar gains from windows as well as building envelope are least in these buildings. Building form should be designed in such a manner that the building is self-shaded and cuts off a large amount of direct solar radiation. Passive ventilation can further reduce the heat inflow.

Orientation:

- Orientation of buildings is a major design consideration with respect to solar radiation, daylight and wind. In tropical climates like India, where east and west directions receive maximum solar radiation during summers, long facades of buildings oriented towards north and south are preferred.
- Good orientation can help reduce the need for cooling, resulting in lower energy bills.

Shading of Walls:

- One of the simplest and most effective ways of reducing the heat load on a building is shading walls from direct sun. Efficient shading can improve internal comfort and reduce the energy costs on air conditioning. As the east and west facades receive maximum solar intensity, especially in summers, shading the west facade gives maximum benefits.
- Shading of walls can be achieved by porches, verandahs, sun roof covers (awnings) and vertical shading (creepers).



Deep porches and verandas:

- These are excellent for reducing solar heat gain in a building because they completely shade the walls. They also cut the solar intensity within the rooms creating cool spaces even without plants or shrubs.

Sun-proof fabric covers:

- These can be attached to the building itself and offer good seasonal solution. They can be made using household fabrics and shade clothes to cut out more than 95 per cent of sunlight. In addition to their function of blocking sunlight, fabric sails can be visually pleasing. They also protect the interiors from dust and rainfall, and can act as a good surface for rainwater harvesting.

Vertical Shading:

- This is the most advisable form of shading to reduce solar heat gain from the walls. It is a vertical sun block placed on the external edge of the wall, covering the complete wall. It could be in the form of movable louvers or creeper plants. Plants also have an additional benefit as they cool the air passing through their leaves. They are also aesthetically pleasing and reduce air pollution. Vertical shades are quite advantageous as they do not occupy much space and are cost-efficient.

Benefits

- They keep direct sunlight from entering the building, thus minimizing the transfer of heat indoors. They offer protection from the ill effects of UV rays, thereby reducing risks of harmful diseases such as skin cancer.
- By reducing load on indoor cooling, the energy requirement is also reduced.
- Effective shading can block up to 90 per cent of the heat generated by direct sunrays.
- It helps reduce summer temperatures, improve comfort and save energy.
- It can decrease the room temperature by 2 °C to 4 °C compared to outside temperature.
- They can be effective even in areas facing frequent power cuts.

Barriers

- Capital costs.
- Maintenance efforts especially for fabric shades and vegetative walls.

Window Shades

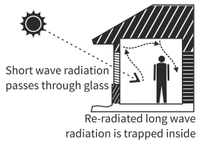
Windows without solar shading cause a lot of heat gain inside a building, along with glare. Installing window shading elements helps in keeping out the solar heat, blocking direct sun and softening harsh daylight and reduced glare. They are also critical for visual and thermal comfort and for minimizing cooling expenses. An effective shading system cuts off direct sunlight during summer and allows winter sunlight to enter into the rooms.

Characteristics Of Resilience

Requirements

- An understanding of the sun's path at the location of the building.
- Identification of windows that need shading.
- Shading devices to be designed according to the orientation of the facade.
- Calculating the sun shading requirement to determine the type of shading device.
- Can be automatically controlled during different times of the day.

Energy Inflow and Impact on Buildings without Shading:



The sun energy gets trapped inside and generates heat.

Cooling devices needed to improve thermal comfort.

Increased electricity consumption

Increased expenditure

A decrease in the indoor temperature by about 2°C to 4°C is noticed with window shading.

Movable Blinds:

- Includes systems like roller blinds and curtains.
- Tends to obstruct view impede the air movement.
- Usually preferred for windows on the east and west facades.
- Doesn't take much space and are cost efficient.

Roller Blind

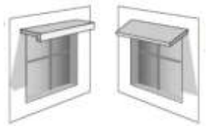
Louvre :

Bahama Shutters

- They are highly cost effective, and can be either fixed or movable.
- These coverings reduce the heat gain to the building and also add aesthetic value to the building.
- Movable louvres can be adjusted according to the solar angles; the fixed one cannot be.

Fixed Overhangs:

- Overhangs, or *Chajjas*, provide efficient sun protection.
- Part of the architectural design, and constructed along with the house.
- Also protect windows from rain.



Criteria of Shading for Various Climatic Zones:

Hot and Dry
Complete year round shading.

Cold and Cloudy
No shading.

Cold and Sunny and Composite
Shading during summer months only.

Warm and Humid
Complete year round shading with proper ventilation.

Temperate
Shading during summer months only.

Design Criteria for Indian conditions:

The design of an external shading device should be based on the orientation of the window and the façade on which the sunrays fall.

Minimum or no shading is required on north-oriented windows.

East and west facades can have movable sunshades, which can be removed when the sun moves to another direction.

East and west facades receive solar heat during the mornings and evenings, and are not as harsh as the noon sun.

In tropical regions, shading devices on south orientation can be permanent, as south receives maximum solar heat due to the sun's orientation.

Benefits

- Direct sunrays increase heat inflow to the building and make the indoor temperatures unbearable, especially in summers. Window shades prevent the entry of sunrays into the house, making it easier to control room temperatures. Window shades decrease the indoor temperature by 2 °C to 4 °C.
- Solar shades block harmful ultraviolet rays from entering into the house, thereby reducing risks of skin cancer.
- Reduced solar penetration into the house makes it easy and comfortable to stay in the house, especially for people with migraine headache. It reduces the glare from sunrays, thus protecting the eyes from strain.
- With reduced need for energy demand for space cooling, such as air conditioning. These systems reduce energy bills.

Did you know!!!

Jalis (pierced screens) were used extensively in historic Indian architecture as windows. Installed in outer walls, were usually made of stone and had holes made in geometric forms. They were ideal for cutting down glare while permitting air circulation. During the day, their shadows make visually pleasing patterns inside the buildings.

Cool Roofs

Cool roofs have reflective surfaces that reduce heat transfer through the roof into the building. These roofs have the potential to reduce energy demands for air conditioning by enhancing the thermal performance of the roof by reflection and insulation. The term cool roof encompasses an extensive array of roof types, colours, textures, paints, coats and slope applications.

Characteristics Of Resilience

Flexible | Redundant | Modular

Resourceful | Learning | Safe-fail

Requirements

- Thorough check of the condition of the existing roof including cracks, tears, blisters, exposed foam and open seams.
- Proper cleaning of the surface with water.
- Trained personnel to lay the cool roof.

Broken China Mosaic

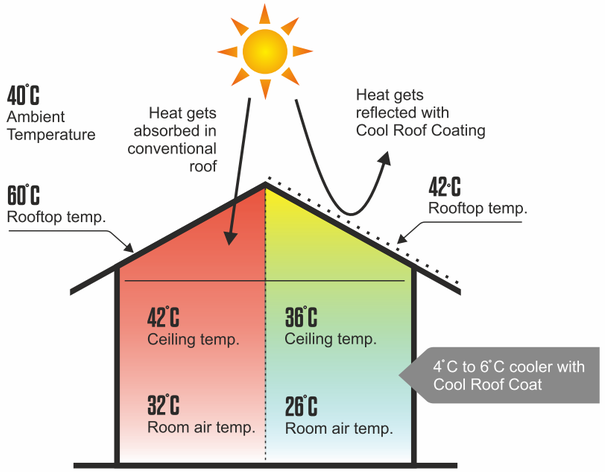
This is the most commonly used technique in India that uses well-graded broken pieces of glossy glazed tiles. These tiles, preferably white, are embedded in wet mortar to provide a smooth surface. This mosaic provides an inexpensive cool roofing option, with the roof reflecting up to 80 per cent of the incident solar energy as compared to 20–40 per cent by a conventional roof. It is cost-effective as waste glazed tiles are cheap.

Inverted Earthen Pot

Covering flat roofs with inverted earthen pots is an easy and cost-effective method to reduce solar gain. In this method, the roof is covered by inverted earthen pots, placed in continuous rows and the space between the pots is filled with cement or lime mortar. The air gaps created by the inverted pots create insulation, thereby reducing heat transfer. It is a traditionally used low cost method of increasing the roof insulation.

Slate or Tile

These roofing products are commonly used in buildings with sloping roofs. Slates and tile products are available with sun-reflective surfaces in a wide range of colours. Additionally, the dense earthen composition of slate and tile products provides increased thermal mass, yielding additional energy savings. White coloured tiles have a high solar reflectance of about 70 per cent, which is almost double the reflectance level of regular red tiles.



Benefits

- Increased indoor comfort, especially during hot summer months.
- Reduced energy demand for space cooling, resulting in **energy savings, typically from 10 to 30 percent.**
- Decreased roof maintenance costs due to **longer roof life.**
- Lower air temperatures resulting in better thermal comfort to the occupants.
- Lower **carbon dioxide emissions** from electricity generating power plants.
- **Decrease of 5 °C to 10 °C** in room temperature.
- Regular cool roof methods like china mosaic, need least maintenance and **pay back the cost within a year** through energy saving.
- Some of the cool roof paints can also be **applied on the walls** to reduce the heat gain from walls.

Barriers

- High capital costs.
- Only useful for the top floors of the building. Some of the cool roof paints can be used to reduce heat gain from walls also.

Earth Air Tunnels

It is a system for cooling the air by passing it through a system of underground tunnels or tubes. The system has been in use for thousands of years and the best examples can be seen in Islamic and Persian architecture. As the temperature at a depth of a few metres under the ground, remains lower and constant round the year, the air passing through the tunnel gets cooled. In India, it is commonly known as earth tunnels.

Characteristics Of Resilience

Flexible · Redundant · Modular

Resourceful · Learning · Safe-fail

Requirements

- A network of pipes made of concrete, PVC, steel, rigid or semi-rigid plastic.
- Proper length and depth of the tunnel below the ground.
- Proper space around the house to lay the system with minimal turns and bends to allow minimal friction losses.
- Controllable fans to help the system function at optimum levels.

What it is all about...

The temperature of the earth below 3-4 m depth remains constant throughout the year. The air that stays in the underground tunnels gets cooled over time. This system has an underground tunnel network and mechanism to continuously transfer the cool air into the building. The length of the tunnel network is carefully designed to cool specific volume of indoor space. The air inside the tunnel stays for a certain length of time beneath the ground and gets sufficiently cooled before it is drawn in to the building.

Design Guidelines

- The depth should be at least 4 m below the ground for constant ground temperature.
- The length of the tunnel should be limited to 60–70 m for optimum results.
- It can be constructed using any type of pipe, concrete or masonry.
- The diameter of the pipe should preferably be at least 0.15 m.
- The ground above the pipes should be loose or covered with lawn.
- Avoid 90° turns for smoother air flow.

Earth tunnels are aided by...

Wind Tower: It uses a tower or a stack where hot air rises up and moves out. The tower is like a chimney that projects out of the roof. It can also double up as a wind catcher. It helps in sucking in cool air and letting it flow down into the living areas and removes hot air from the leeward side of the wind.

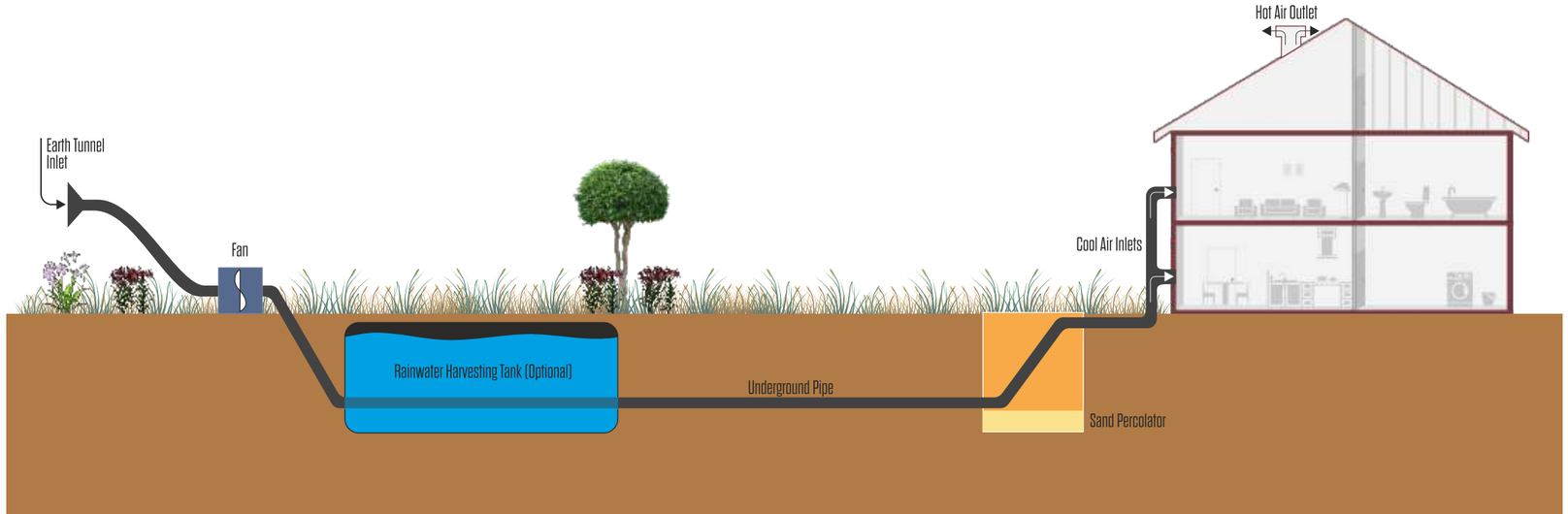
Landscaping: The presence of vegetation helps in reducing the underground temperature considerably. The earth gets shade and is wetted by sprinkling water. This water seeps through and dampens the tunnel walls, thus cooling the passing air. Also, the presence of water helps in cooling the air through evaporation.

10°
Reduction in internal temperature, in comparison to the external temperature during peak hot seasons.

2/3
The average reduction in electricity when compared to using conventional air conditioners.

100%
Availability of fresh air and reduction in the bacterial levels.

70%
Cost saving with respect to conventional air conditioning system.



Benefits

- Earth air tunnels are effective alternatives to mechanical air conditioners, with negligible energy costs. They also help in enhancing the indoor air quality by circulating air.
- By reducing the energy consumed for air conditioning, they indirectly help in reducing greenhouse gases emissions from thermal power plants.
- This system allows circulation of fresh air that is not possible in conventional air conditioning. This system facilitates better indoor air quality and is especially beneficial for public buildings.
- As the use of mechanized air conditioning is reduced or eliminated, the bacterial and fungal load in the air is reduced. This helps eliminate various health issues that are caused by fungus and bacteria.

Barriers

- Land area around the building is required.
- High capital costs.

Did you know!!!

The earth air tunnel system installed at New Kar Bhavan at Jaipur is used to provide comfort for an area of 2,200 sq. ft. at a comfortable indoor temperature of 28 °C, even when the temperature outside is above 40 °C.

Passive Lighting

Passive solar lighting is the system of collecting sunlight and reflecting it to living and working spaces. These systems supplement electric lighting with natural sunlight. They work by reflection and diffusion of light. They use static and non-moving elements like windows, sliding glass doors, skylights and tubes.

Characteristics Of Resilience

Flexible | Redundant | Modular

Resourceful | Learning | Safe-fail

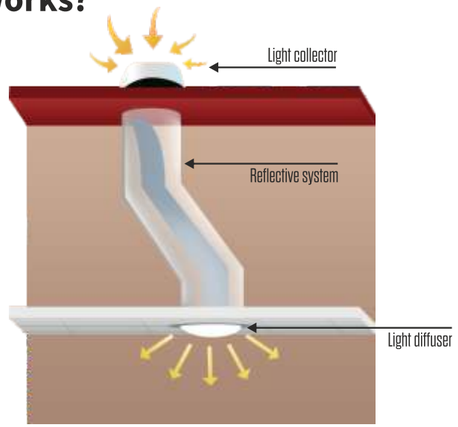
Requirements

- An understanding of orientation, space organization and geometry of the space to be lit.
- For passive daylight integration, the desirable internal and external finish of the building should be light in colour, since light surfaces reflect more daylight than dark surfaces.

Light Tubes

Light tubes, also known as light pipes, are installed in buildings for conveying and distributing natural light. Light tubes make it possible for daylight to be transmitted through thick roofs and lighten up dark interior spaces in the building. This system works on the simple mechanism of light reflection. It is easy to install in a new building or to retrofit in an existing roof. As one light tube can light up a limited area, it is practically limited to smaller rooms. In a building, the presence of attic or false ceiling helps in the installation of light tubes as the tubes get concealed inside the space. Generally, a light tube may refer to a tube or pipe for transporting light to another location, minimizing the loss of light. Bundles of optical fibres can also be used as light tubes.

How it works?



Light Collector

High impact strength, UV stable, light collector collects sunlight from all directions and delivers light effectively through out the day even at low sun angles.

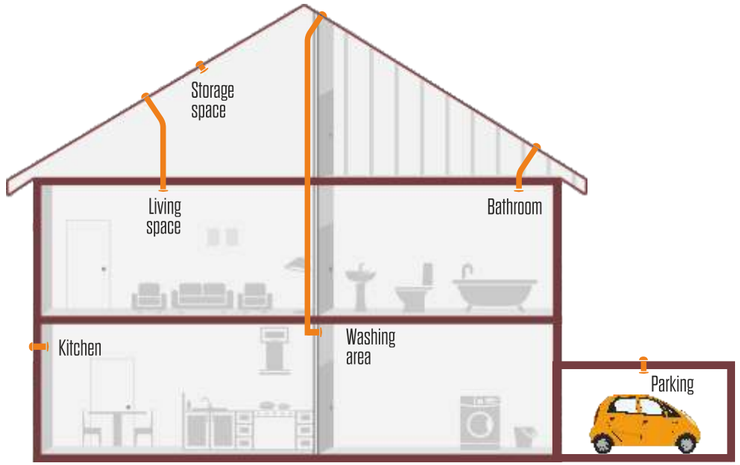
Reflective System

The special reflective tube transfers the light with minimal loss.

Light Diffuser

The intensified sunlight in Light tube is controlled and distributed into indoor space by light diffuser.

Where the light tubes can be used



Benefits

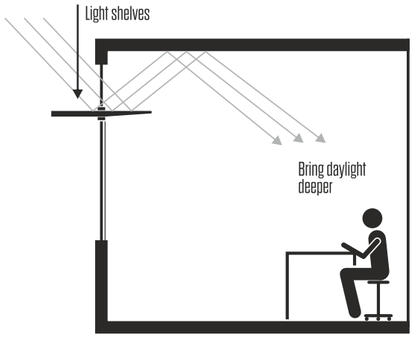
- Light tubes use no electricity or other forms of energy. Therefore, reduction in the use of artificial lights is an obvious advantage.
- As light tubes eliminate the use of all kinds of electric supply, they are most suitable for use in wet areas like bathrooms and pools, where electrical fittings could become potential hazards.
- The tubes increase daily skin exposure to natural sunlight that can be of great use to people suffering from disorders such as vitamin D deficiency caused by lack of exposure to natural daylight.
- As the tubes substitute for the light coming through windows, they allow shading of windows, thereby reducing the heat gain inside.
- Light tubes are flexible and can be used in inner rooms, which have no exterior walls or windows.

Barriers

- In multi-storeyed buildings external fittings may be required.
- High capital costs.

Light Shelves

- Light shelves are horizontal reflectors used to convey daylight deep inside the rooms. These shelves are mounted on windows above the eye-level. They have reflecting surfaces oriented to transfer day light into the building. They can also shade the windows to reduce glare or create a sun patch. They are especially suitable for north or south facing rooms.
- By varying the height, angle and internal or external projection, intensity and depth of light penetration can be controlled. Light shelves should be light in colour and require frequent cleaning. They reduce the need for artificial lighting in buildings. They are generally preferred in mild climates and not in tropical or desert climates due to the intense solar heat gain.



External shading device reduced glares

Green Roofs

Green roofs are ecologically engineered vegetative cover over the normal roof. They reduce heat gain from roofs by partial reflection of sunlight, shading, insulation and evaporative cooling. They reduce air conditioning energy demands of building's top floor. Green roofs, if adopted at city scales, can reduce urban heat island effects. They may have irrigated or hydroponic gardens and can be used for growing vegetables and flowers.

Characteristics Of Resilience

Flexible | Redundant | **Modular**

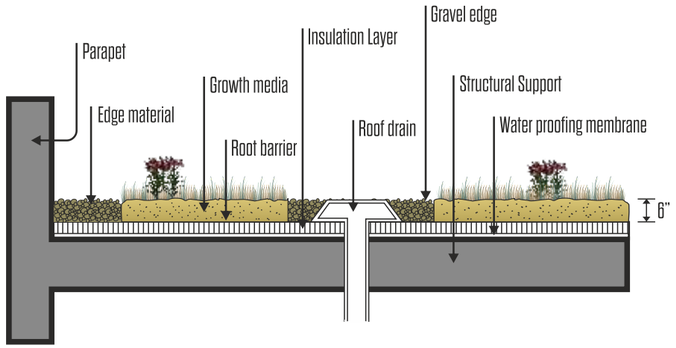
Resourceful | **Learning** | **Safe-fail**

Requirements

- The weight of the proposed green roof should be checked and the roof should be certified for sufficient load-bearing capacity.
- Green roofs have to be adequately waterproofed to ensure that water does not seep in to the building.
- Outlets and downpipes should be easily accessible to enable maintenance and inspection.

The Components of Green Roof

A green roof is an ecologically engineered system with different species of plants. The system includes layers that protect buildings from leaks, allow excess water drain, retain sufficient water to support vegetation and prevent plant roots from penetrating the roof membrane. Green roofs typically comprise certain basic components that are shown in the figure below.



Vegetation: The vegetation grown on green roofs should be light in weight as far as possible. It can include plants that grow with least maintenance and little soil depth.

Growing medium: Growing medium is usually light in weight and contains a mixture of light soil, coco-peat and vermiculite.

Drainage layer: This layer is laid beneath the growing medium and is used to allow excess water to flow into the roof drainage system. It is usually made of polythene or plastic aggregates, glass wool or sand.

Insulation layer: This layer is made of coverings that protect the roof structure from leaks and water seepage.

Waterproofing membrane: This membrane is laid beneath the insulation layer and acts as a second layer of protection from water seepage. The membrane is either made of monolithic waterproof substances or interconnected sheets.

Structural support: This is the layer that supports all the above layers and forms the base of the green roof.

Types of Green Roofs

Depending on the cultivated depth, type and density of vegetative cover, green roofs are divided into three main categories as follows:

1.Intensive systems: Intensive vegetative roof systems feel and function like gardens and may be accessible as parks or as a building amenity. Such systems add considerable load to the structure of the roof requiring a minimum soil depth of 300 mm. Small trees, shrubs and other landscape features may add up to an additional roof load of 400 to 750 kg/sq. m. Such systems are known for their environmental benefits as well as aesthetic appeal.

2.Extensive systems: Extensive roof systems are primarily built for environmental benefits. They require a soil depth of 25 to 125 mm and may contain a modest green cover comprising succulents, thick grasses and hardy plants that are drought-resistant. Additional load to the building is between 75 and 250 kg/sq. m for the extensive system.

3.Modular block systems: Modular block system is made up of portable units, which are arranged on a rooftop. The blocks are self-contained and are typically made of a heavy gauge metal or some plastic trays. They have 100 mm deep soil that can support low-growing plant species. A sheet or pad fastened to the underside of the container regulates the flow of water from the unit. Such systems weigh 60 to 90kg/sq. m. Hydroponics can also be done in such pots with shallow circulating water, controlled aeration and nutrient addition.

75% Reduction in energy consumption (air conditioning) due to green roofs.

15℃ Reduction in the internal room temperature during summers.

80% Average water retention falling on the terrace in case of moderate rains.

Benefits

- The green roof system is beneficial in improving the indoor thermal comfort during the summer season. These systems are especially suitable in tropical regions by reducing the roof temperature considerably.
- Green roofs, over a large areas, allow air cooling, which in turn reduces the urban heat island effect.
- Green roofs are also good for sound absorption.
- Green roofs help purify the air by reducing the pollutants. They also produce oxygen and cool the air through evapotranspiration by plants.
- The roofs can also be used as integrated horticulture- fish culture systems (Aquaponics) or as simple vegetable / flower gardens.
- Water for irrigation can be sourced from recycled wastewater, thereby achieving synergy between water, energy and food cycles in urban environments.

Barriers

- Can be used only on the top floor of the building. Green walls are modifications of this technology that can be used for reducing heat inflow through walls.
- Roofs should have sufficient load bearing capacity.
- Regular maintenance is necessary to manage the vegetation.

LED Lights

LED, which stands for Light Emitting Diode, is a semiconductor that emits light when electricity is passed through the device. LEDs consume only about 15% of energy compared to incandescent light bulb. An LED is more efficient in producing light than incandescent light bulbs or CFL lights.

Characteristics Of Resilience

- Flexible
- Redundant
- Modular
- Resourceful
- Learning
- Safe-fail

How to Choose an LED?

- Choose a bulb depending on the desired light and estimated wattage. The output of a 3 W LED is equivalent to a 45 W incandescent bulb.
- Understand the use of the light. LEDs are available in cool light (ideal for activities like reading) and warm light (commonly used for general lighting).
- Find out the socket type. LEDs are available for numerous types of sockets, including regular household sockets.

How LED Bulbs Works?

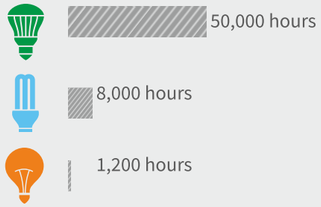
In most homes today, standard incandescent light bulbs have been replaced with Compact Fluorescent Lamps. But there's a more efficient (and greener) way of lighting up your home, and that's by using **LED light bulbs!**

Here's how they work:

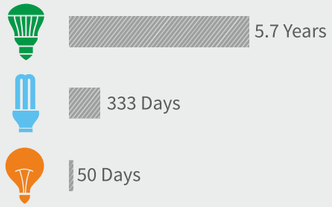
- Light is generated from a semiconductor rather than from a heated metal filament or florescent gas.
- LED lamps produce light when electrons move across semiconductor junctions.

LED CFL Incandescent

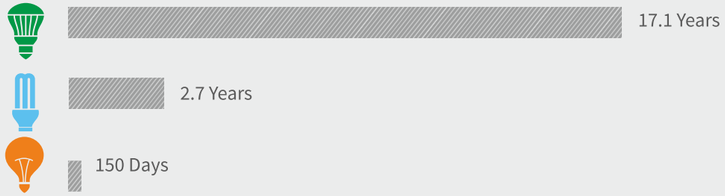
Life Span (Average)



How long bulb will last if run 24/7 (estimated)



How long bulb will last if run 8 hours per day



LEDs Vs CFLs

	LED	CFL	Advantages
Mercury	Does not contain mercury and is environment-friendly.	Contains mercury to function and produce light.	LED eliminates health and environmental hazards, as inhaling mercury vapours is harmful.
Colour	Can be bought in various colours depending upon the space and usage.	Is available in limited range of colours, normally blue/white, or tinged with yellow, and can appear too artificial.	LEDs eliminate the need for lampshades to diffuse light and have a larger applicability.
Mains	Does not need the mains supply and can be powered even with a watch battery.	Needs to be connected to the mains supply to work.	LEDs are perfect for decorative or temporary use, and can even be used when there is no grid power supply.
Longevity	Can work for as long as 60,000 hours, dwarfing the CFL.	Can last for up to 10,000 hours of operation.	LEDs save energy, time and money since they need not be replaced frequently.
Safety	They often contain little or no glass.	A major part of the bulb is made of glass.	Breakage and injuries are minimized.

Benefits

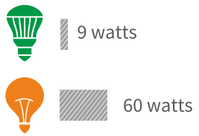
- LED bulbs last up to 10 times longer than the CFLs and incandescent bulbs.
- Unlike regular bulbs, LEDs do not have filaments that can get damaged easily. LEDs withstand simple bumps and jerks.
- As there is no mercury used in the manufacturing of LEDs, they are safer.
- LED bulbs use only one-third to one-thirtieth of energy that incandescent or CFL bulbs use respectively, thus saving electricity.
- Although LEDs are initially expensive, the cost is recovered over time as they last 10 to 15 times longer than incandescent bulbs. Currently, many brands of LEDs are available and the cost is coming down.
- LEDs produce considerably lesser heat when compared to incandescent bulbs, thereby reducing the room heat influx and subsequent air conditioning costs.

Barriers

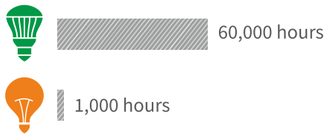
- High capital costs.

LEDs Vs Incandescent Bulb

Energy Usage



Life

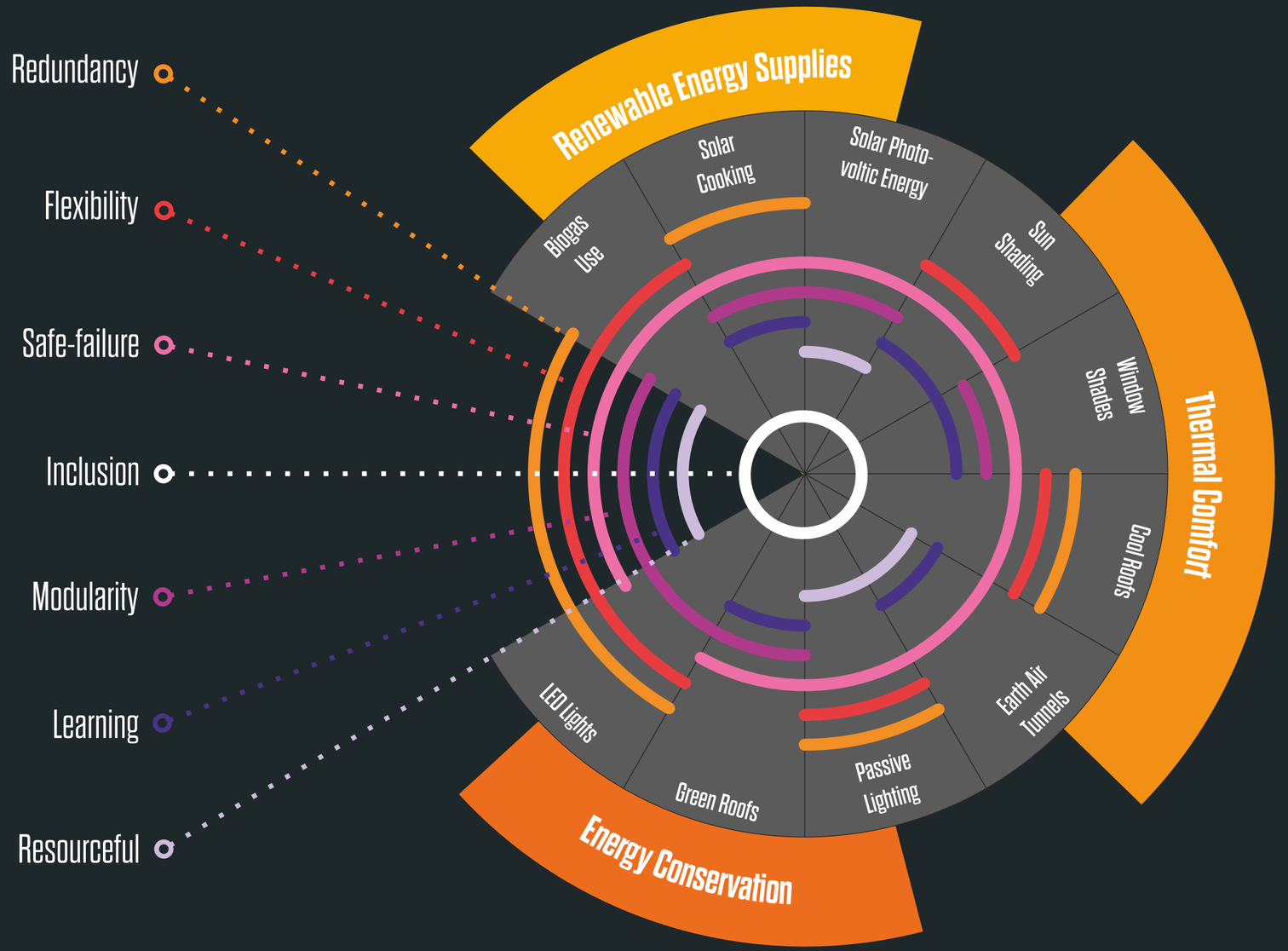


Efficiency

An LED light bulb is 89% more efficient than an incandescent light bulb

Temperature

Technologies	Reducing Consumption	Developing Alternate Resource	Recycling	Quality improvement
Biogas Use		✓	✓	✓
Solar Cooking	✓	✓		✓
Solar Photo-voltic Energy	✓	✓		
Sun Shading	✓			
Window Shades	✓			✓
Cool Roofs				✓
Earth Air Tunnels				✓
Passive Lighting		✓		
Green Roofs	✓		✓	✓
LED Lights	✓			✓



SMALL ACTIONS BIG SAVINGS

Practices for building energy resilience

Some simple day-to-day life practices are suggested, which can eventually contribute to energy saving and resilience!

Computers

Turn off your home and office computers and other energy consuming equipment when not in use.

Shut down the computers!

Replace CRT monitors with LCD or LED monitors to reduce energy consumption.

Screen savers save computer screens, not energy.

A computer that runs 24 hours a day uses more power than an energy-efficient refrigerator.

If your computer must be left on, turn off the monitor since the monitor alone uses more than half the system's energy.

Setting computers, monitors and copiers to sleep mode when not in use, reduces energy costs by approximately 40 per cent.

Battery chargers draw power whenever they are plugged in and are inefficient. Disconnect the battery chargers when not needed to save energy.

Kitchen Appliances

Avoid dry grinding in your food processors (mixers and grinders) as it takes a more energy than grinding liquids. Soak grains for few hours before grinding, if possible.

Microwave ovens consume 50 percent less energy than conventional electric gas stoves.

Do not open the hot oven door too often to check the food condition as each time it is opened it leads to a temperature drop of 25 °C or more.

Use flat-bottomed pans on stoves since they make full contact with the cooking coil or flame.

Air Conditioners

Install air conditioners that automatically turn off when the required room temperature is achieved. Use variable drive air conditioners (Inverter AC) to cut down the power consumption further.

Keep thermostats/remote controllers at 'low cool' position.

Do not set the thermostat at a colder setting than normal when you turn on your air-conditioner. It does not cool any faster and can result in excessive cooling.

Set the thermostat as high as comfortably possible in the summer. The lesser the difference between the indoor and outdoor temperatures, the lower would be the energy consumption.

Lower difference between the indoor and outdoor temperatures reduce thermal shocks, especially for young and old people and also reduce incidence of asthmatic and allergic attacks.

Operate ceiling fans in conjunction with window air conditioners since they can offer an effective distribution of cool air throughout the room.

Seal the doors and windows properly.

Use windows with sun films/curtains.

A roof garden or cool roof reduces the load on the air conditioner.

Planting trees or shrubs to shade air conditioning units helps in reducing as much as 10 percent of electricity use than carrying out the same operation in the sun.

Refrigerator

Leave enough space between the refrigerator and the wall so that air can easily circulate around the refrigerator.

Seal the refrigerator doors airtight.

Do not open the door of refrigerators frequently.

Do not leave the refrigerator door open for longer than necessary, as cold air will escape.

Cover liquids and wrap food and vegetables in the refrigerator. Uncovered foods release moisture making the compressor work harder and food/vegetable dries up.

Avoid keeping hot or warm food straight in the fridge.

Fan

Replace conventional regulators with electronic regulators of ceiling fans.

Washing machines

Always wash with full loads with optimal amount of detergent.

Use hot water only for cleaning very dirty clothes. Always use cold water in the rinse cycle.

Prefer natural drying over electric dryers, especially in tropical regions.

Cooking

When cooking on a gas burner, use moderate flame settings to conserve LPG.

Remember, a blue flame means the gas stove is operating efficiently. Yellowish flame means the burner needs cleaning.

Use lids to cover pans while cooking.

Items taken out of refrigerators (like vegetables, milk etc.) should be brought to room temperature before cooking/heating them.

Pressure cookers save energy.

Lighting

Turn off the lights when not in use.

Take advantage of daylight by using light-coloured, loose-weave curtains on windows that allow natural light to penetrate into the room.

Light-coloured walls reflect more light and increase the brightness of the space.

Keep lighting fixtures dust-free to maintain good illumination.

Use table lamps instead of brightly lighting up entire room. Focus the light where you need it.

Use electronic chokes in place of conventional copper chokes.

Other appliances

Use solar water heater, which is a good replacement for electric water heater.

Do keep appliances in sleep mode on when not in use. Idle operation leads to an energy loss of 10 W per device.


Far more people in
INDIA
have access to a
cell phone than to a
toilet and improved
SANITATION
- United Nations

Water safety is being compromised by open defecation as faeces in the open contaminate drinking water in family and community wells.

In India, more than 1000 children under 5 years of age die each day only due to diarrhea caused by lack of sanitation.
-Squatting Rights

A bleak scenario

India has the highest number of people without access to toilets.

With almost half of the mothers disposing their children's faeces in the open, there is a very high risk of water contamination that causes diarrhea in children, which leads to malnutrition and infections such as pneumonia.

Almost 70 percent of households across rural India do not have access to toilets.

A majority of school children across India do not have access to school toilet facilities, causing health hazards.

Inadequate water supply and sanitation in schools are health hazards and affect school attendance, retention and educational performance.

About one million cases of malaria are reported in India every year, it alone accounts for one third of disease related mortality in India.

About 18 percent of the urban residents (mostly poor) have no access to safe water and sanitation, increasing their risk to water-borne diseases, diarrhea and dysentery.

SANITATION ISSUES

Low Infrastructure Coverage

India has one of the highest population without safe sanitation in the world. While infrastructure coverage is gradually improving, it has so far failed to keep pace with the urban growth. In India it is estimated that nearly one fifth of the urban population currently has limited/no access to any sanitation facilities, while 50–80 percent of wastewater is disposed off without any treatment.

Limited Access to Services

Urban households are primarily concerned about the cleanliness of their immediate surroundings and much less worried about the wider impacts on their neighborhood and environment.

There is a complete lack of facilities, with many settlements having no toilets at all. Sanitation facilities may be available but are inconvenient, unpleasant or unhygienic. Poor maintenance and management are often the major challenges with community toilet blocks. Due to poor maintenance, their useful life is reduced and could, at worst, result in total failure.

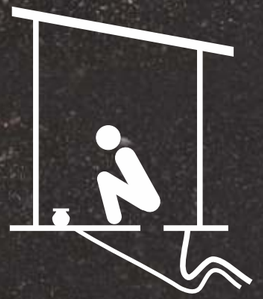
Low Service Usage

Even where toilets are available, some are unused or are underused, with poor households resorting to defecate in open. This might be because there is limited space in their houses or the facilities are unacceptable in some way (for example, people may not be willing to share toilets). Alternatively, people may underuse their public toilets because of poor quality of maintenance.

Weak Institutional Arrangements

State agencies and municipalities often make large investments in sanitation infrastructure, but do not focus on their maintenance. Within the state government and municipalities, sanitation has no 'institutional home', meaning that no single department or agency is accountable for it. Responsibilities for different aspects of sanitation are often assigned to a number of agencies, and coordination between them is not always satisfactory. Lack of ownership by user community and the governments is a major unresolved challenge.

Where we can make the difference

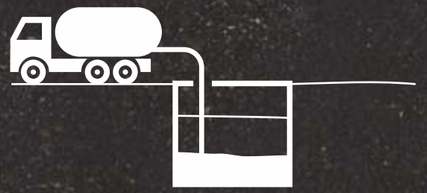


User Interface

This describes the type of toilet, pedestal, pan, or urinal with which the user comes in contact; it is the way by which the user accesses the sanitation system. In many cases, the choice of User Interface will depend on the availability of water. Note that sewage may be treated and recycled on site at the colony levels and can provide additional water for flushing and other low end uses.

Collection and Storage

This describes the ways of collecting, storing and sometimes on-site treatment of the wastes generated. The treatment provided by these technologies is often a function of storage and is usually passive (e.g., requiring no energy input). Many households without access to sewerage (especially in peri-urban areas) use on-site septic tanks to store and partially treat the sewage.



Conveyance and Treatment

It describes the transport of waste and off-site treatment systems that are generally installed and appropriately managed at city level. Although the waste is mostly transported by sewerage systems (liquid waste) and trucks (solid waste), it is the longest, and most important gap in urban waste management systems.

Decentralized wastewater treatment systems can reduce the amount of sewage to be transported and also reduce water demand by recycling. Their capital costs as well and land requirements deter communities from installing them. However, these systems can significantly reduce water demand as well as the design capacity of city level sewerage grids.

Use and/or Disposal

This usually refers to the methods by which products are ultimately returned to the environment, either as useful resources or less hazardous materials. Furthermore, products can also be recycled back into a system (e.g., sludge from sewage treatment plants can be used as manure).

Solid Free Sewers

They are a network of sewers built from small diameter pipes. A grit chamber/screen is provided to collect large solids. They are designed to receive household wastewater, which is devoid of any solids such as grit or grease. The system allows the wastewater to flow into the interceptor tanks, which pre-treats the sewage and settles the solids. The wastewater is transported further to a treatment facility for safe disposal. The network can be laid at shallow depths, with less slopes to function.

Characteristics Of Resilience

Flexible | Redundant | Modular

Resourceful | Learning | Safe-fail

Requirements

- An efficient pre-treatment at the household level.
- The downstream end of the sewer is lower than the upstream end.
- A straight alignment between inspection points.
- Flushing points at all major intersections.

Components of Solid Free Sewer

1

House Connection:

This is the connection at the inlet of the interceptor tank, that allows the wastewater from the household to flow into the tank. The inlet from the house is bigger in diameter as it can also carry some solid matter. Care must be taken to avoid dumping of fabrics, garbage and trash into toilets, as it effects the functioning of the system.

2

Interceptor Tank:

This is a buried water tight tank with an inlet and outlet. This tank is designed to hold water for about 24 hours for allowing solids to settle down. Solid free sewage flows out through a smaller diameter sewer. The settled solids should be periodically removed from the tank through the access points. Sludge pumps can be used to avoid human contact.

3

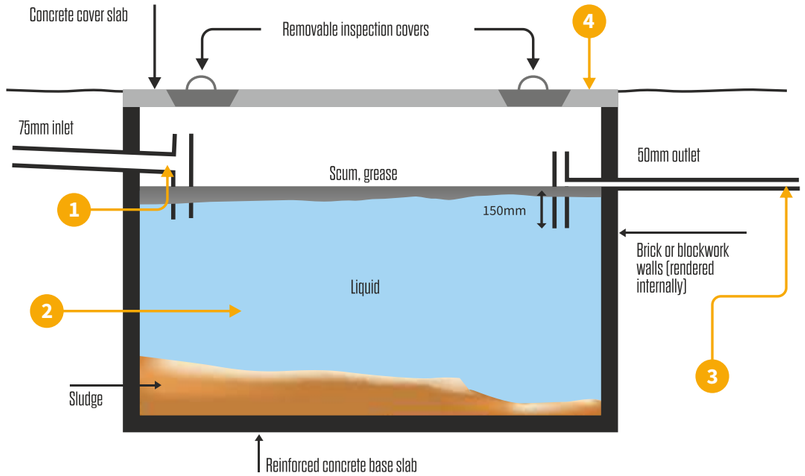
Sewers:

The sewers in this system are not the conventional types, and are smaller in diameter. These pipes are usually 60 – 100mm in diameter, which are installed at a depth of at least 30 cm. As the sewers only transport wastewater, they are not necessarily laid on a uniform and straight alignment.

4

Inspection Covers:

These covers are made at the top of the interceptor tanks, and inspection chambers. These covers are cheaper than regular manholes, and are airtight to avoid the infiltration of dirt and garbage. These covers also act as the access points for the flushing of the sludge that has formed at the bottom of the tank or a pipe section.



Applicability and Suitability

- This sewerage system is best applicable for medium density peri-urban areas as well as high density slums.
- It is most appropriate where there is no space for a soak pit, or where the effluents cannot be disposed on-site.
- These systems are very useful in areas with high groundwater level, as this system doesn't affect the groundwater quality.
- It is extremely suitable for undulating terrain or areas with rocky soil, as the pipes don't have to be laid in a straight line.
- In applicable / suitable areas with growing population, as this system is easily scalable.
- As the technology uses fewer materials, it is suitable for medium and low income group areas.

Benefits

- As the water required for transport of solid free sewage is lower, they are suitable for water scarce areas.
- As the sewerage is laid at shallow depths, excavation cost is lower.
- Since inspection chambers are provided at bends, the alignment can avoid rocks and other obstructions.
- The low construction cost and space requirement makes it possible to be laid in slums and dense settlements that do not have conventional sewer systems.
- Reduced risk of groundwater pollution as the sewers are laid at shallow depths.
- Mostly these systems are built with HDPE (High Density Poly Ethylene) pipes, which are cheaper and have long life.

Barriers

- Require regular maintenance of interceptor tanks and occasional flushing.
- Portable vacuum cleaning equipment that can be transported through narrow lanes may be necessary in slum areas.
- Since they are laid at shallow depths, they cannot be laid under roads with heavy traffic. Culverts may be required at road crossings.

Vacuum Toilets

Toilets that use air suction to flush human wastes are known as vacuum toilets. While these toilets provide the same level of comfort as traditional flush toilets, they minimize water use. Vacuum toilets are specifically adapted for use in combination with sewage treatment. These toilets offer effective sewerage solutions for large buildings and colonies. Sewerage pipe of vacuum toilets need not follow slopes, since they use air suction to convey human wastes.

Characteristics Of Resilience

Flexible | Redundant | **Modular**

Resourceful | **Learning** | Safe-fail

Requirements

- Stable electric supply to run air suction compressors.
- Need of a vacuum station and space for connection.
- Expert professional advice for customized installation.
- Collection tank, depending on the size of the system.

How does it work?

Although there may be slight variations depending on the manufacturer, normally a vacuum system functions as follows:

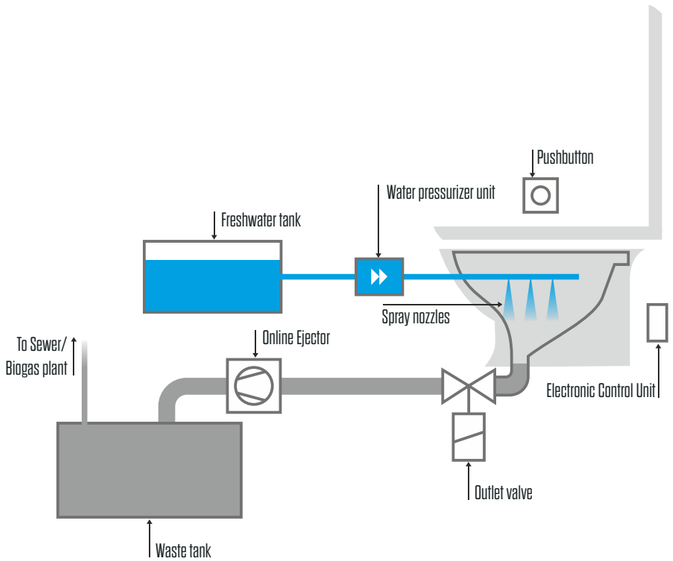
Step 1: The interface valve is opened at the push of a button, waste from toilet bowl is transferred to the collector tank by suction. Subsequently, the water valve is opened to spray water into the bowl for rinsing.

Step 2: As the vacuum valve is shut, the water valve remains open, leaving a small amount of freshwater in the bowl.

Step 3: Clean water that flows in the bowl from Step 2 is retained and the toilet is again ready for use.

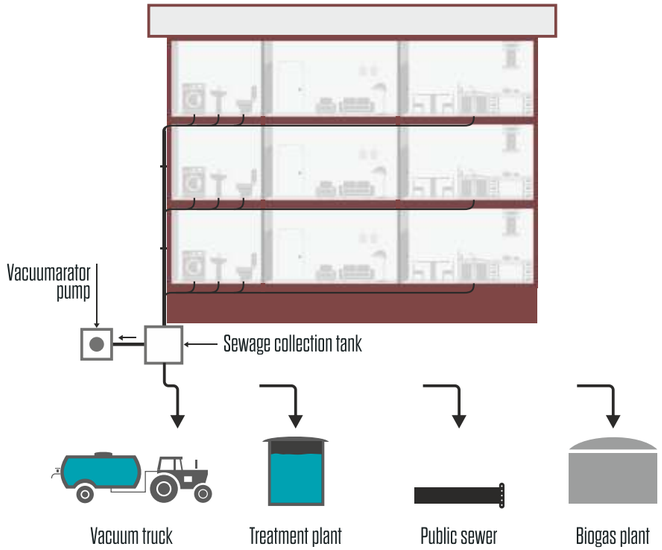
Step 4: When the collection tank is full, sewage can be emptied into a secondary tank for further treatment. Solid waste can be sent to a sewage treatment plant or biogas plant.

A constant vacuum system is usually preferred for multi- storeyed buildings. As it maintains vacuum continuously, it is possible to add more toilets. This system can be expanded at any time and the risk of leakage is low. It also provides alternative solutions for sewage disposal in the form of sewage treatment plant, biogas plant or the conventional sewer system.



Constant Vacuum System

The vacuum pump maintains the continuous vacuum throughout the system and the valve at the toilet end opens to flush the system and convey the sewage.



15
The number of times the vacuum toilet can be used in an hour.

90%
Reduction in fresh water use and sewage generation.

220
Days in which a single person can use the saved fresh water.

Benefits

- **Water saving:** Since air suction is used for conveying waste, water requirement is minimal (0.5–1.5 L per use).
- **Adequacy:** This system can be designed and installed in individual houses, large buildings and even colonies.
- **Performance:** Very reliable system if designed and constructed correctly, based on the needs and surroundings.
- **Facilitates reuse:** These toilets enable greywater and black water separation. Concentrated sewage, which is a valuable resource, can be reused for producing biogas and fertilizer. This is difficult in water flush systems, since the sewage is too diluted.
- **Health:** A vacuum toilet draws air and pathogens into the system with every flush. Practically, no aerosols are released in the process.
- **All terrain:** Vacuum sewers can be laid in shallow trenches in flat, rocky, sandy or swampy terrain, reducing installation and maintenance costs. Also, while common water-based sewage systems require pipelines with proper slope, the vacuum system can work on minor upward slope.

Barriers

- High capital costs.
- Requires expert technical support.

Urine Diversion Flush Toilets

Mixing of urine with faeces leads to faster decomposition and bad odour. Urine is rich in nitrogen and phosphorous and can be used as a fertilizer in gardens.

Characteristics Of Resilience

Flexible | Redundant | **Modular**

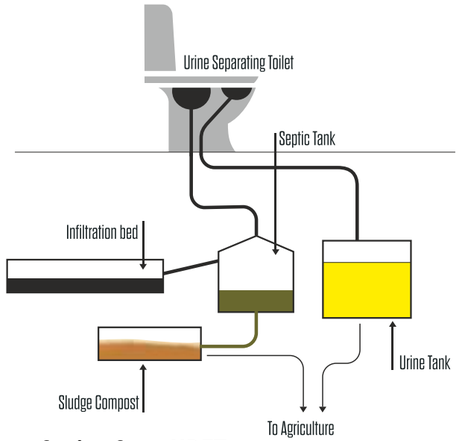
Resourceful | Learning | **Safe-fail**

Requirements

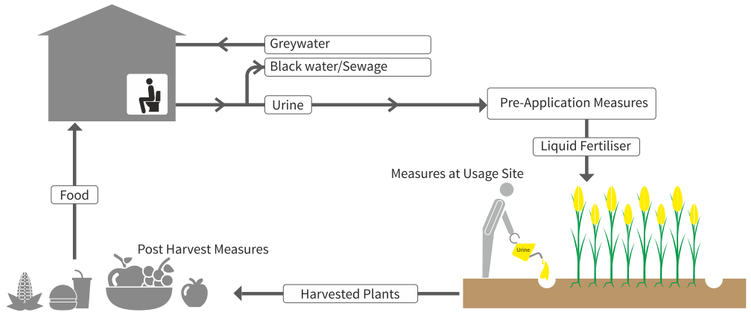
- A collection and storage system for urine.
- An external kitchen or terrace garden.
- Knowledge about the system to prevent clogs.
- Collection tank depending on the size of the household/colony.
- Struvite reactor (optional).

The Concept Cycle

Urine Diversion Flush Toilet (UDFT) allows the separation of urine from faecal matter, which is collected separately for use. The system is applicable in both dry and flush toilets and needs separate piping at the front of the toilet bowl. Urine is collected in a tank attached to the front of the toilet, or is conveyed to a central collection tank. A rinsing spray cleans the urine collection bowl. The collected urine can be processed to precipitate Struvite, which is then used directly or concentrated in solar stills.



Possible uses of urine from UDFT



Why Use Urine to Farm?

- Urine is a liquid product of the human body that is secreted by the kidneys.
- Urine consists of essential plant nutrients like Nitrogen, Phosphorus and Potassium.
- Urine has 95% water, 2% urea, 0.12% phosphorus and 0.15% potassium (by weight).
- Urine is a well balanced nitrogen and phosphorous rich fertilizer.

1
The number of months for which the urine needs to be stored at a household level.

400
The area in sq.mt. which can be fertilized per year by collecting urine from one person.

90%
Reduction in water usage, thus saving on expensive fresh water spending.

Benefits

- **Reduced water usage:** Such toilets can help reduce water consumption as urine flush consumes little water. Since urination is a more frequent activity for which toilets are used, a considerable amount of water is saved.
- **Environmental aspects:** Such toilets help in avoiding direct discharge of urine into the environment, thus preventing eutrophication of water sources, health hazards etc.
- **Food security:** Vegetables and fruits can be grown in kitchen gardens using urine on the roof tops. The productive use of the nutrient and fertilizer value in human urine for growing vegetables at household/colony levels and increasing food security. Treated urine can be applied on small kitchen gardens, container gardens, school gardens, plant pots on terraces, rooftops etc.
- **Urban green belts:** Excess urine can be used as fertilizer in urban green belts and forest patches. Since it offers scope for cheap and effective source of fertilizer with minimum use of water, this system can be used in urban agriculture.

Barriers

- This system requires detailed design and mechanism for collecting and processing or sale of urine.
- The cost of installing separate plumbing and storage tanks as well as disposal/ application units is additional.
- There may not be a ready market for treated urine/Struvite.
- This system may not be culturally acceptable.

Anaerobic Baffled Reactor

An Anaerobic Baffled Reactor (ABR) is an improved septic tank. It has a series of compartments through which sewage or industrial wastewater is treated. Increased contact time with active biomass (sludge) results in improved treatment of wastewater.

Characteristics Of Resilience

Flexible | Redundant | **Modular**

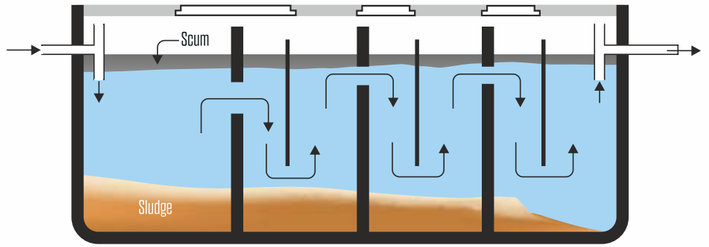
Resourceful | Learning | **Safe-fail**

Steps of Installation

- Design of the system is based on flow rates and quality of wastewater.
- The reactor is a buried tank with compartments and inspection covers.
- The tank is constructed and tested for leaks and pores.
- Leaks are fixed by suitable treatment before use.

The Concept of ABR

- Physical and biological (anaerobic) treatment of wastewater.
- Integrated sedimentation chamber for pre-treatment of wastewater.
- Alternating walls (baffles) and openings to increase travel distance.
- Solids get deposited as a biologically active sludge, while the water moves out of the system after treatment. Solid Retention Time (SRT) separated from Hydraulic Retention Time (HRT).
- High treatment rates due to enhanced contact of incoming wastewater with residual sludge and high solid retention.
- Low sludge production.



How does ABR work?

Stage 1: Wastewater collection
Toilet and kitchen sink are areas that generate highest amount of wastewater. Toilets and flushing systems may require redesign or diversion since the amount of water used for flushing will affect the capacity of the ABR. Medium flush volumes produce concentrated wastewater, which can improve the treatment. So, households that generate large amounts of wastewater can install pour-flush/low flush toilet to control the inflow into ABR.

Stage 2: Shallow sewer
This is small sewer line that connects the household with the ABR system. It is called shallow, because it is not laid deep in the ground, as in the case of municipal sewer lines. Shallow sewers are cheaper to build since they use lower diameter pipes and are placed in shallower depths.

Stage 3: Pre-treatment screening
The screening unit is usually required as a pre-treatment to limit the amount of non-inert material entering the ABR. This helps in reducing the maintenance cost of the ABR and improving the efficiency of the system. In instances where the owners can maintain the system frequently, the screening unit before the ABR may not be necessary. A grit chamber and a screen chamber can be installed to capture non-degradable solids and grit.

Stage 4: Polishing system
After ABR treatment, it may be necessary to remove pathogens from the treated water to make it safe for reuse. Both membrane filtration and constructed wetland would effectively remove pathogens from effluents. UV/ozone treatment can be done at the end, if the recycled water will be exposed to full body contact.

Stage 5: Effluent reuse
The outflow from the polishing system can be safely used for irrigation. However, effluents must be released into a large area to prevent water logging. Contamination of the groundwater or nearby water courses should be avoided.

Stage 6: Monitoring and maintenance
To keep ABR working efficiently, regular monitoring or maintenance of the system is necessary. This helps in preventing mechanical failure, such as blockages, leaks, damage to sewerage and reactor, or any wilful damage. Individual homeowners are responsible for maintaining their own connection and piping on their property, with weekly/monthly maintenance of the shallow sewer and screening units.

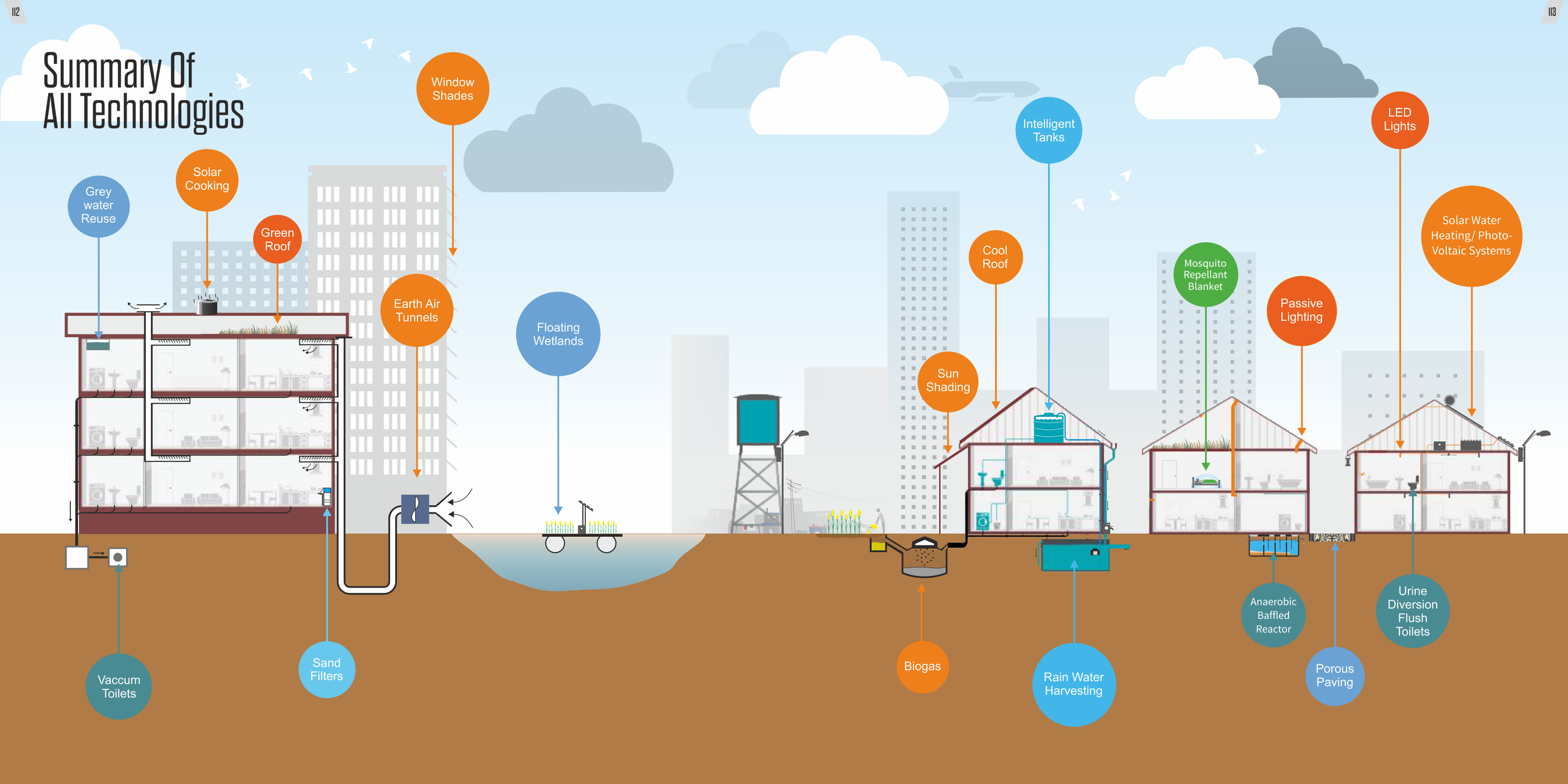
Benefits

- **High performance:** Wastewater treatment in ABRs is better than the others because of its increased contact time with the active biomass bacteria in sludge.
- **Energy efficient:** This system does not require any electrical supply and hence is energy efficient.
- **User-friendly:** This system is simple to construct and install, and is also extremely easy to operate and maintain.
- **Extremely stable:** This system is stable to momentary increase in flow rates and so a sudden surge in the inflow would not affect it. It can be designed to manage daily inflows in the range of a few thousand litres per day up to a half a million litres per day (waste disposed by a few persons to a few thousand persons).
- **Increased applicability:** It can be installed in every type of climate, and is suited for both household level and small neighbourhood.
- **Added benefits:** The system also can be modified to generate biogas that can be used within the house for lighting purposes.

Barriers

- ABR requires space. The total volume of the tanks is about five to six times the daily inflow volume.
- Tertiary treatment by reed beds may be required to remove odours, colour and turbidity.
- It may not be culturally acceptable for higher quality demanding end uses like bathing.

Summary Of All Technologies



Sharing The Roles For Building The Resilience

Rapid urbanization is causing growing demand for resources, urban infrastructure and services and the lag in investments and wastage is leading to growing scarcity. Resilience building under such scenario will require synergistic actions across multiple scales and sectors. Combined efforts of individuals, communities, government and private sector are necessary to build resilience in our urban systems.

As cities grow, urban local bodies need to change their roles from providing services to facilitation & regulation. They also need to formalize coping systems as well as monitor and effectively regulate the resources and services.

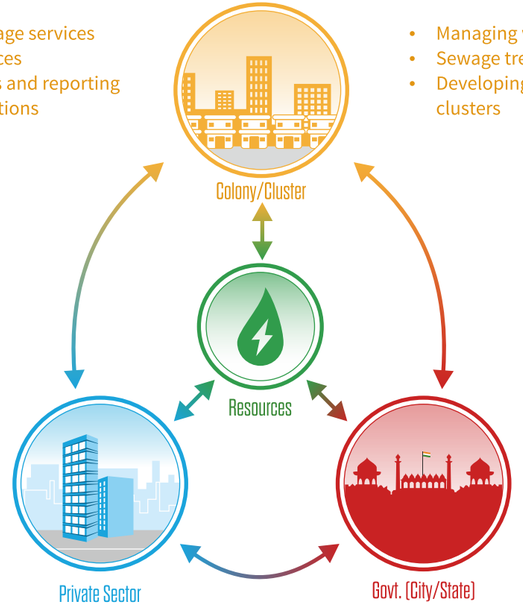
The private sector is already active in infrastructure and services sectors. Micro-water and solar energy grids, can be improved and managed by micro-enterprises. They also can market innovative devices and systems.

Households and Resident Welfare Associations (RWA) can take active role in managing local resources and recycle wastes. They also should inculcate resource use efficiency culture in the society. They can manage multiple services in their clusters including bulk purchase and distribution of water and electricity.

The ultimate purpose of smart cities is to ensure reliable and efficient services to the citizens. Devolving some of the resource conservation functions as per subsidiarity principle can provide some autonomy to the clusters in efficiently managing the resources and risks. Such bottom up approach can improve the availability of services and resilience of the urban systems.

- Strengthening RWAs to manage services
- Conservation of local resources
- Monitoring of local resources and reporting
- Demand focused end use options

- Managing water supply and energy
- Sewage treatment and recycling
- Developing interfaces with neighbouring clusters



- Micro enterprises for AMC of decentralized systems
- Promoting new cluster/HH scale technologies
- Developing private, public, community partnerships

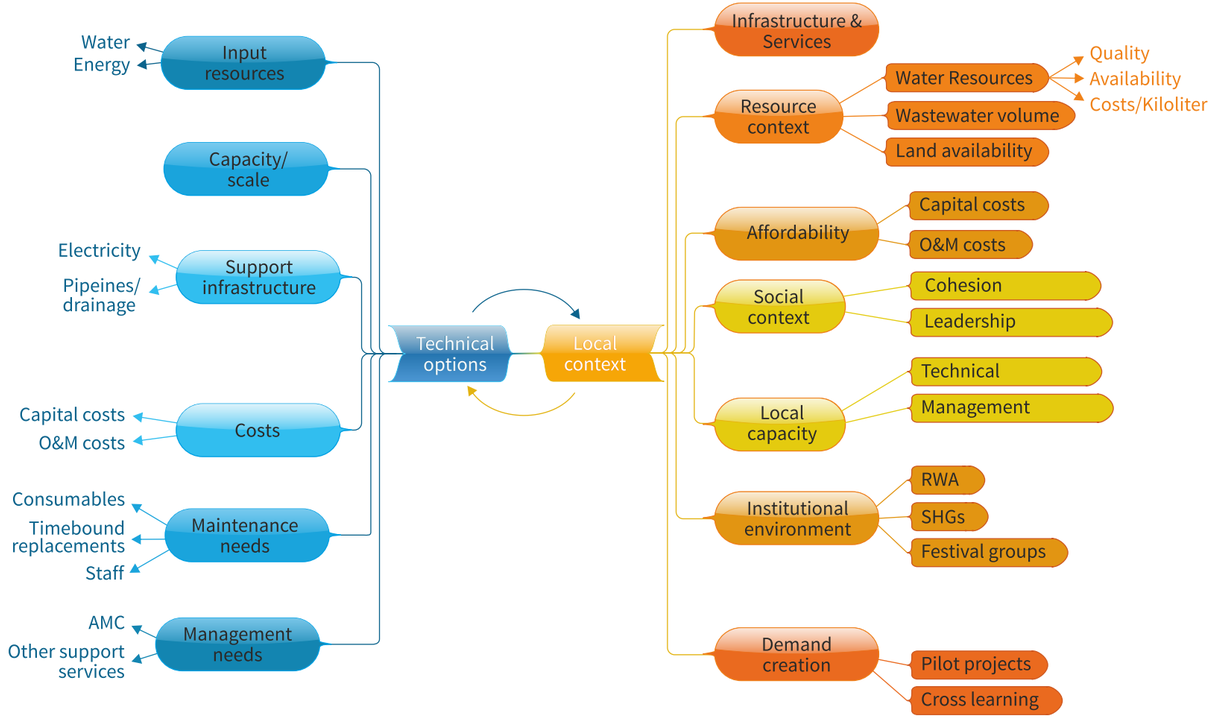
- Water & energy budgets/resource models
- Monitoring all resources and services
- Regulatory bodies to manage resources
- Bulk water supply to clusters
- Technical support cells to clusters
- Training & certification of micro-enterprises
- Incentive structure to recycle/prevent pollution

How To Implement Resilience Building Activities

The following steps are suggested to design resilience building projects:

- Identify the planning boundary (Colony, Cluster, Ward).
- Assess the resource base: Used, unused & external.
- Assess demand: Resource requirements now and for future expansion.
- Assess existing infrastructure: Existing infrastructure, its status and augmentation/upgradation requirements.
- Identify Technologies Options: Weigh your options which technology addresses your needs best.
- Social cohesion/constraints – Cohesion, Willingness to engage and pay.
- Identify Technologies Options and shortlist technologies.
- Detailed project report : Technology, capital and O&M costs, land requirements.
- Develop consensus among user groups.
- Operation and Maintenance mechanisms.

An example of water resilience planning is presented:



Glossary

Academia
The academic world.

Aeration
The act of charging a liquid with air or oxygen for the purpose of purification.

Aerosols
A dispenser that forces a liquid out as a fine spray when a button is pressed.

Aesthetics
The theory or philosophy of taste; the science of the beautiful in nature and art; esp. that which treats of the expression and embodiment of beauty by art.

Ambient
Encompassing on all sides; circumfused; investing.

Anaerobic
Living, active, occurring, or existing in the absence of free oxygen.

Anoxic
Greatly deficient in, or totally lacking, oxygen.

Aquifers
Underground bed or layer yielding ground water for wells and springs etc.

Bio-film
A thin usually resistant layer of microorganisms (as bacteria) that form on and coat various surfaces.

Blackwater
Non-industrial wastewater containing significant food residues, high concentrations of toxic chemicals from household cleaners, and/or toilet flush water.

Catastrophes
An event producing a subversion of the order or system of things; a final event, usually of a calamitous or disastrous nature.

Catchment
A surface of ground on which water may be caught and collected into a reservoir.

Conjunctive
Serving to unite; connecting together.

Coping
The process of managing stressful circumstances.

Defecation
The elimination of fecal waste through the anus.

Ecosystems
A system formed by the interaction of a community of organisms with their physical environment.

Enzymes
Any of several complex proteins that are produced by cells and act as catalysts in specific biochemical reactions.

Epidemiological
The study of how disease spreads and can be controlled.

Eutrophication
The process by which a body of water becomes enriched in dissolved nutrients (as phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen.

Façade
The front of a building.

Faeces
Solid excretory product evacuated from the bowels.

Faucet
A regulator for controlling the flow of a liquid from a reservoir.

Freshwater
Relating to or living in or consisting of water that is not salty.

Green Belts
An area of parkways or parks around an urban area that is protected from large-scale housing.

Greywater
Household wastewater (as from a sink or bath) that does not contain serious contaminants (as from toilets or diapers).

Glossary

Groundwater
Underground water that is held in the soil and in pervious rocks.

Household
Those who dwell under the same roof and compose a family.

Hydroponics
A technique of growing plants (without soil) in water containing dissolved nutrients.

Inert
Moving or acting very slowly.

Irradiation
The condition of being exposed to radiation.

Leeward
Pertaining to, or in the direction of, the part or side toward which the wind blows.

Louvers
One of a set of parallel slats in a door or window to admit air and reject rain.

Microclimate
The climate of a very small or restricted area, especially when this differs from the climate of the surrounding area.

Pathogens
Any microorganism which causes disease.

Per capita
Per unit of population.

Peri urban
Area immediately adjoining an urban area.

Photovoltaic
The generation of voltage by a material that is exposed to light in the visible and invisible ranges.

Precipitation
The quantity of water falling to earth at a specific place within a specified period of time.

Reed
A tall, thin grass that grows in wet areas.

Resilience
The power or ability to recover quickly from a setback, depression, illness, overwork or other adversity; buoyancy; elasticity; - of people.

Sanitary
Of or pertaining to health; designed to secure or preserve health; relating to the preservation or restoration of health; hygienic.

Sewage
The contents of a sewer or drain; refuse liquids or matter carried off by sewers.

Sludge
The precipitate produced by sewage treatment.

Soak pit
A pit filled with rubble, etc, into which rain or waste water drains.

Stakeholder
One who is involved in or affected by a course of action.

Struvite
A crystalline mineral found in guano. It is a hydrous phosphate of magnesia and ammonia.

Succulents
Plants which have soft and juicy leaves or stems.

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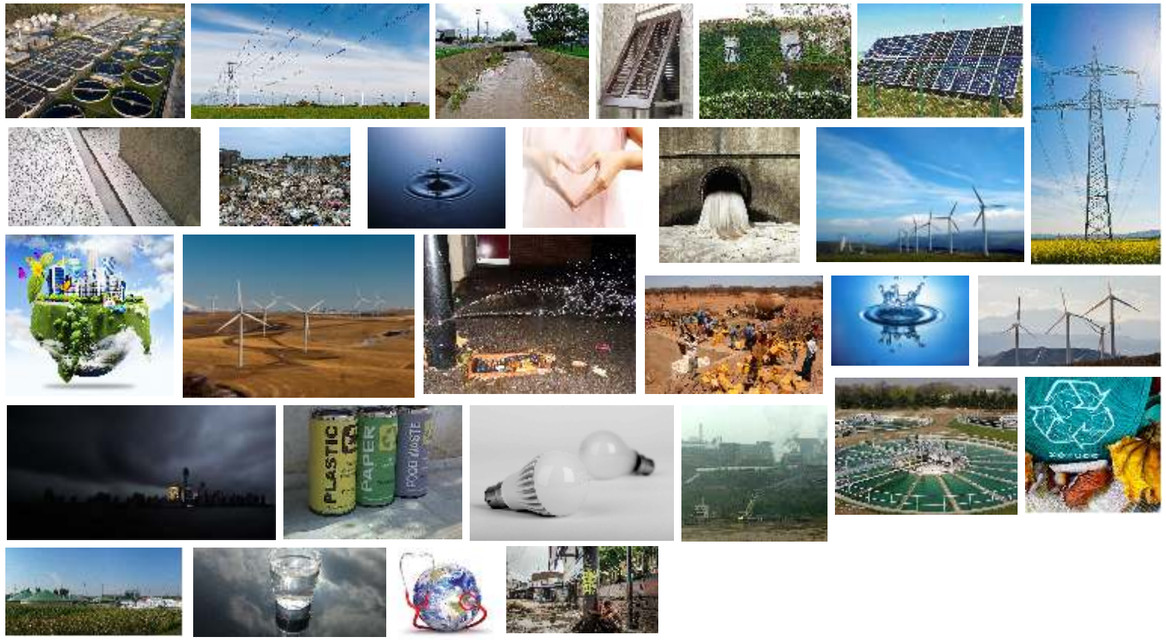
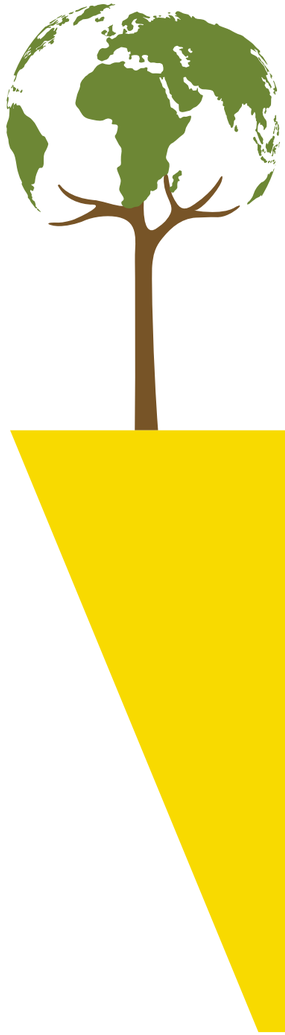


About TARU



TARU was established in 1990 as an institution with trans-disciplinary expertise to engage with India's development challenges. In 1996, it was registered as TARU Leading Edge Private Limited under the Companies Act, offering a commitment of cutting edge research and contextualized consulting services to its clients.

The last two decades have seen us working on a range of institutional, financial, economic, social and technical issues across diverse public systems, cultures and corporate formations, in more than a third of rural and urban domains of India. This includes 28 States and Union Territories, 30 major urban centers across 18 states including 15 million-plus cities. TARU also works in South Asian countries like Nepal, Bangladesh and Myanmar.

TARU's expertise is primarily in six core sectors: Disaster Risk Management & Climate Change, Governance & Institutions, Natural Resource Management, Social Development, Urban Development, and Water, Sanitation and Hygiene. Within these sectors we undertake policy analysis, strategy development, action research, programme design, project management support, assessments and evaluations. Our clients include grassroots institutions, INGOs, bilateral and multilateral organisations, as well as States and Central Government.

We are committed to quality, accuracy and succinctness in our consulting services. The TARU team of professionals has extensive national and international experience, a strong network of advisors, consultants, partner institutions, associations from different parts of the world.

Vision

Improving the quality of life of people.

Mission

To provide contextualized solutions to current and emerging challenges.

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The challenges keep growing

road to RESILIENCE

We will go on exploring solutions

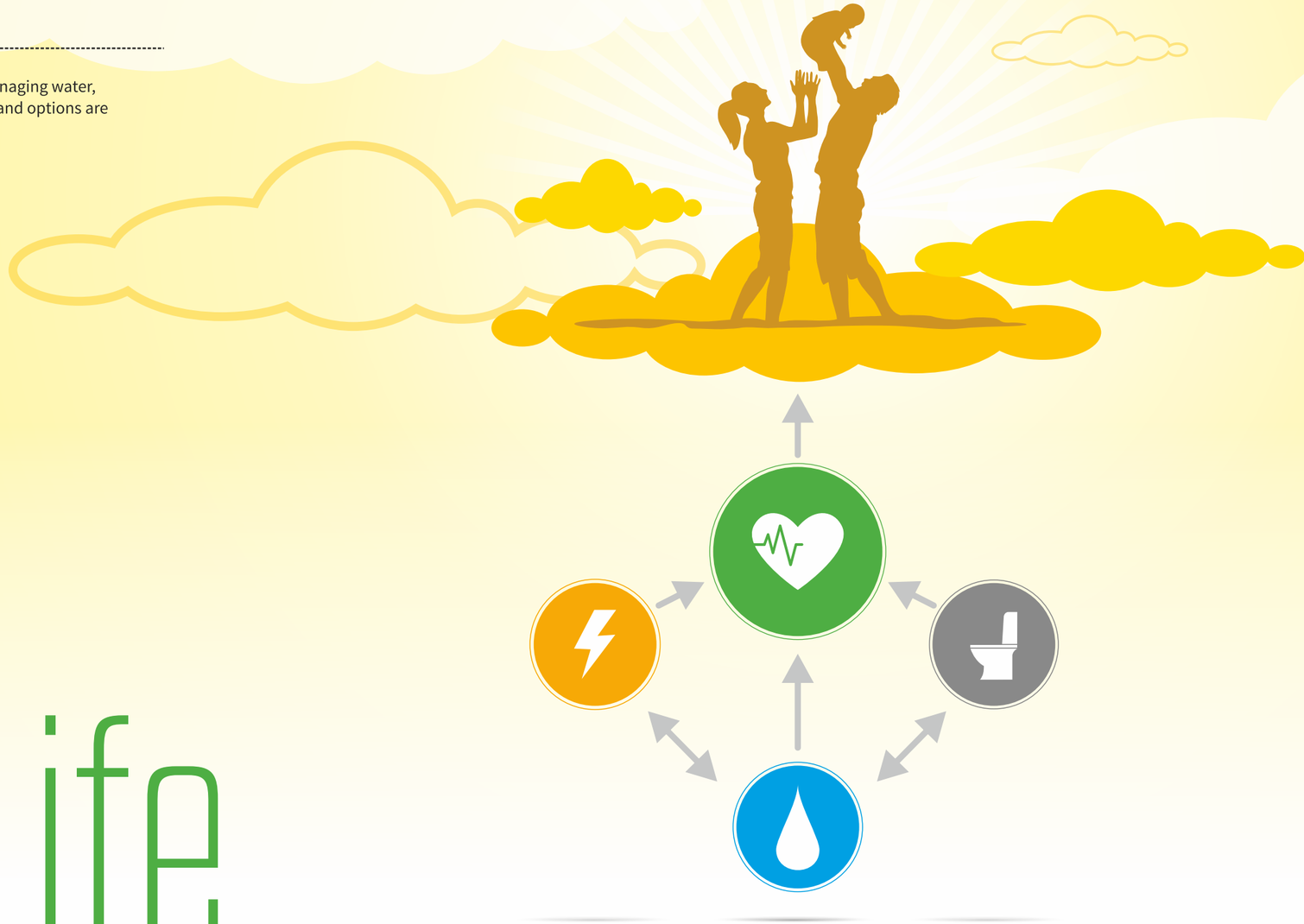
Every human being is the author of his own HEALTH and disease

- Gautam Buddha

Introduction

The term "Quality of life" describes extent of satisfaction of human needs, health and well being. The basic human needs include water, energy, health and sanitation, especially in urban areas. These needs are mostly met by urban services.
With rapid urbanization and climate change, the resources and infrastructure supporting these services are likely to be adversely impacted. These services are interrelated and impact on anyone can impact all other services. The scarcity of water and energy can have adverse impacts on sanitation and health of citizens.

After discussing about local options for managing water, energy and sanitation, a few health issues and options are covered briefly in this section.



Quality Of Life

HEALTH ISSUES

Solid Waste Management and Water Pollution

The solid waste management in Indian cities is very poor, including collection, transportation and disposal of refuse. Solid waste is dumped in open areas and open drains/nallahs. Urban local bodies collect solid waste and crudely dispose them at unprotected land-filling sites. Municipal solid waste is often dumped into the water bodies leading to pollution, growth of weeds like water hyacinth, extinction of fish and proliferation of mosquitoes leading to unhealthy habitat.

Water Logging

One of the basic reasons for waterlogging is lack of drainage and sewerage. Water logging and associated health risks are of great concern. The prolonged water logging causes mosquito-borne outbreaks such as Dengue and Malaria. The dumping of solid waste in open drains also chokes them and worsens waterlogging. These waterlogged areas, become a breeding ground for many waterborne pathogens as well as affecting the water quality, amplifying health risks.

Slum Conditions

The water supply and drainage system as well as access to health services are grossly inadequate in most of the Indian slums. Most of the slums are located in disputed or marginal lands such as river banks and railway lines and are vulnerable to waterlogging as well as flooding and vector-borne diseases.

Poor quality roofs, lack of ventilation and overcrowding results in stuffy and hot indoor environments. The slum dwellers cannot afford space cooling devices beyond fans nor can afford to pay increasing costs of electricity and therefore likely to be differentially impacted by vector-borne diseases and heat waves.

Sanitation

In 2011, about 18.6 percent of urban population did not have access to toilets. Only part of the Indian cities have sewerage and disposal system, that too often inadequate and decrepit. Only a small proportion of sewage collected is treated. The sewage is often directly disposed in the streams.

Disease Surveillance System

The disease surveillance system in our cities are inefficient and are unable to provide advisory or early warning about the disease outbreak risks. Also the urban health services are poor and inadequate. The urban authorities are often forced to take knee jerk actions after the epidemics, resulting in citywide panic. It is often too late to take preventive action, except to provide medical aid.

Where we can make the difference

EFFECTIVE SOLID WASTE MANAGEMENT AND DISPOSAL

Public awareness on segregation of solid waste at household level is critical. House to house garbage collection system can be strengthened and enforced. Most of the solid waste can be managed at colony levels. Biodegradable materials can be converted to biogas or manure by composting and using them in local gardens.

EFFICIENT SEWERAGE NETWORK AND TREATMENT

Most of the sewage can be recycled at colony/household levels and reused for low-end uses such as gardening. At colony level, dual piping system may be installed so that treated water can be used for flushing or for cooling thin sloping roofs and irrigating roof top gardens. Surplus water can be used for maintaining urban forests, parks and lakes.

DISEASE MONITORING SYSTEMS

Disease monitoring system and GIS based DSS (Disease Surveillance System) and UrSMS (Urban Service Monitoring System) - with the epidemiological research support, disease monitoring system and health GIS can be implemented in the city. SMS based health monitoring system can crowd data as well as from urban health clinics, pathological laboratories and hospitals. Prevention of water logging alone can decrease the disease burden significantly. Heat action plans during summers can reduce morbidity from heat waves.

To address urban quality of life challenges we need to integrate multiple urban services. Some of the approaches and options are presented below:

1. It is necessary to provide adequate functional space for urban health in urban planning and management. Building climate change resilience needs to be integrated in urban health policy and practice.

2. A coordinated mechanism within local governments (Departments planning Solid Waste Management, Health, and Water Supply etc.) and engagement with community members, academicians, local experts and industrialists is essential to address the urban health challenges.

3. Evidence based research and real time data collection can reduce disease outbreaks and the data can also be used for effective planning and policy recommendation for urban health in India.

4. A dedicated national level urban health system with sufficient infrastructure and human resources is essential for improving urban health indicators.

5. Urban planning and management should be informed by urban health data to improve quality of life in the cities.

6. Monitoring & evaluation of health interventions by both community leaders as well as service providers is essential to ensure the health services and successful program implementation.

Mosquito Repellant Blanket

A mosquito repellant blanket/net is designed to ensure mosquito-free sleep and reduce the risk of mosquito-borne diseases. They are made of cotton or mixed fabric and impregnated with repellant (pyrethroids) that repel the mosquitoes. This repellant, apart from being odourless, is better than the conventional mosquito repellant coils, which emit more harmful chemicals or cream based repellent that is directly absorbed by skin.

Characteristics Of Resilience

Flexible · Redundant · Modular · Resourceful · Learning · Safe-fail

Features

- Approved by WHO.
- Can be made with cotton or mixed fabric.
- Are environment friendly and long lasting.

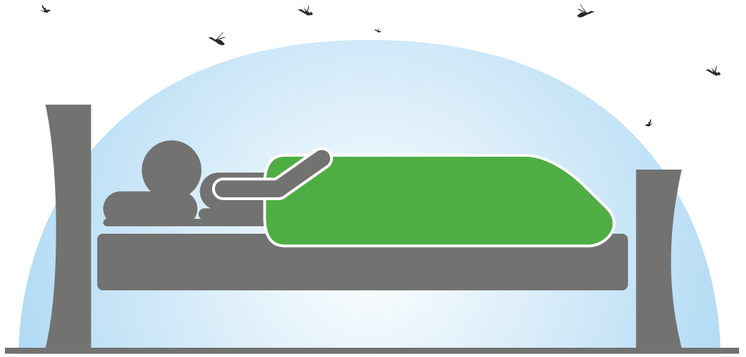
Introduction

Since many of us live in areas where mosquitoes and other insects could be a nuisance and a health threat, the mosquito repellant blankets/nets can reduce these risks. Pyrethrin impregnated nets and blankets are one of the most effective, safe and economical options.

These blankets and nets are quite useful in slum areas, where water logging is common and risk of mosquito-borne diseases is higher.

How does it work?

The pyrethroid repellent on the nets/blankets have molecules that block insects' humidity sensors that prevent insect bites. Inhibition of the sensorial functions, which insects usually use as a guide to locate the warm and humid air rising from the human body, reduces their targeting capacity.



Comparative analysis of Mosquito Repellant Blankets v/s related market products

	Mosquito Mat	Mosquito Coil	Mosquito Cream	Mosquito Spray	**Mosquito Repellant Blankets/Nets**
Harmful Smoke	✗	✓	✗	✗	✗
Electricity Usage	✓	✗	✗	✗	✗
Washable	✗	✗	✗	✗	✓
Re – Usable	✗	✗	✗	✗	✓
Effectiveness/ Durability	8 hours approx	8 hours approx	5-6 hours or until absorbed in skin	Not more than 5 to 6 hours	**More than three & half year (If washed once in a month)**
Health Hazard	Hazardous	Hazardous	Hazardous	Hazardous	**Least hazardous**
Cost per annum	Very high and recurring	Very high and recurring	Very high and recurring	Very high and recurring	**One time high cost , but low annualised cost.**

3
The duration in years for which the blanket/net could be used

50
Number of washes till the blanket/net is effective.

1.5
The per day effective cost (Rupees) of these nets/blankets.

Benefits

- The blanket has a dual purpose; it acts as a regular blanket and a mosquito repellant.
- The blankets/nets are compact and easily portable; thus making them useful for outdoor travels.
- They allow the user to keep their windows open and get sufficient air circulation especially during hot nights without air conditioning facility.
- The blankets/nets emit very low amount of repellant, unlike sprays that tend to get overused and causes harm.
- Minimal health concerns as the repellant is not directly used on the skin.
- Other safety benefits since it doesn't emit any smoke or odour.

Barriers

- The pyrethroid repellents may be allergic to some people. It is advisable to use it for few days and observe any adverse reactions like rashes, swelling etc.
- Avoid using these treated fabrics, if any adverse reactions are experienced.
- These repellents are toxic to cats. Avoid using these blankets/nets, if domestic cats are kept in the house.

Did you know!!!

One can avoid being bitten by making sure of not attracting mosquitoes by avoiding dark clothes and cosmetics. Mosquitos are usually attracted by dark clothing, carbon dioxide, high skin temperature, floral or fruity fragrances and moisture.

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