



Module 3

Natural resources

By

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Learning outcomes

- ↳ Renewable and non-renewable resources
- ↳ Individual's role in conservation of natural resources
- ↳ Equitable use of resources for sustainable lifestyles

Background

Natural resources?

“Natural resources are natural assets (raw materials) occurring in nature that can be used for economic production or consumption.” www.stats.oecd.org

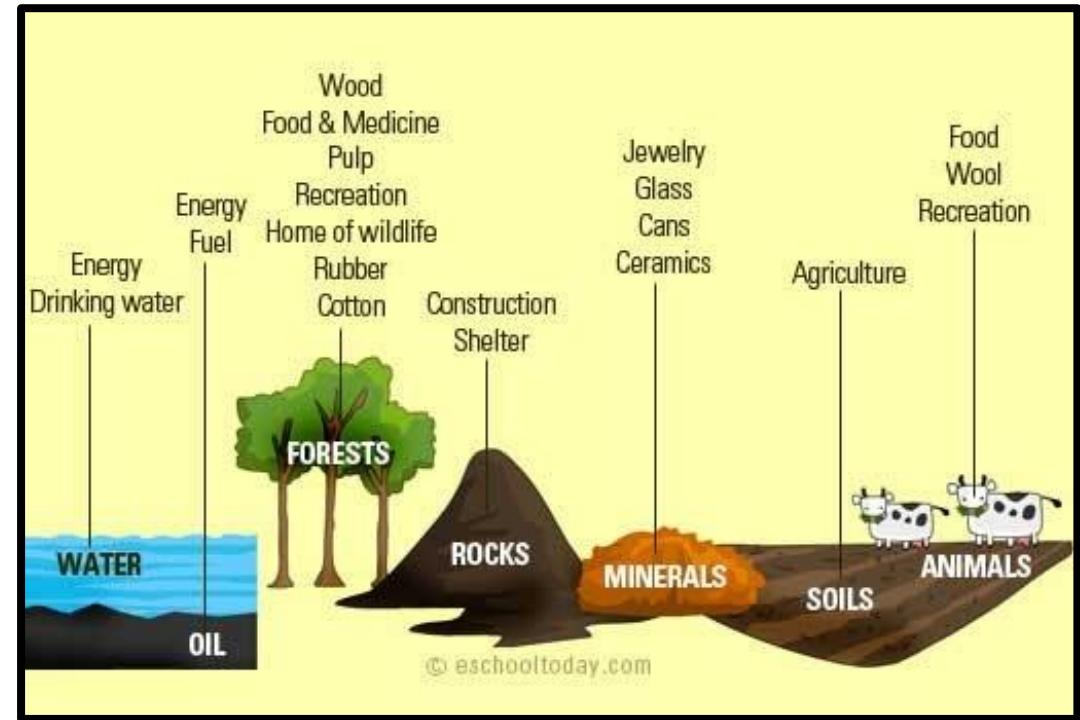
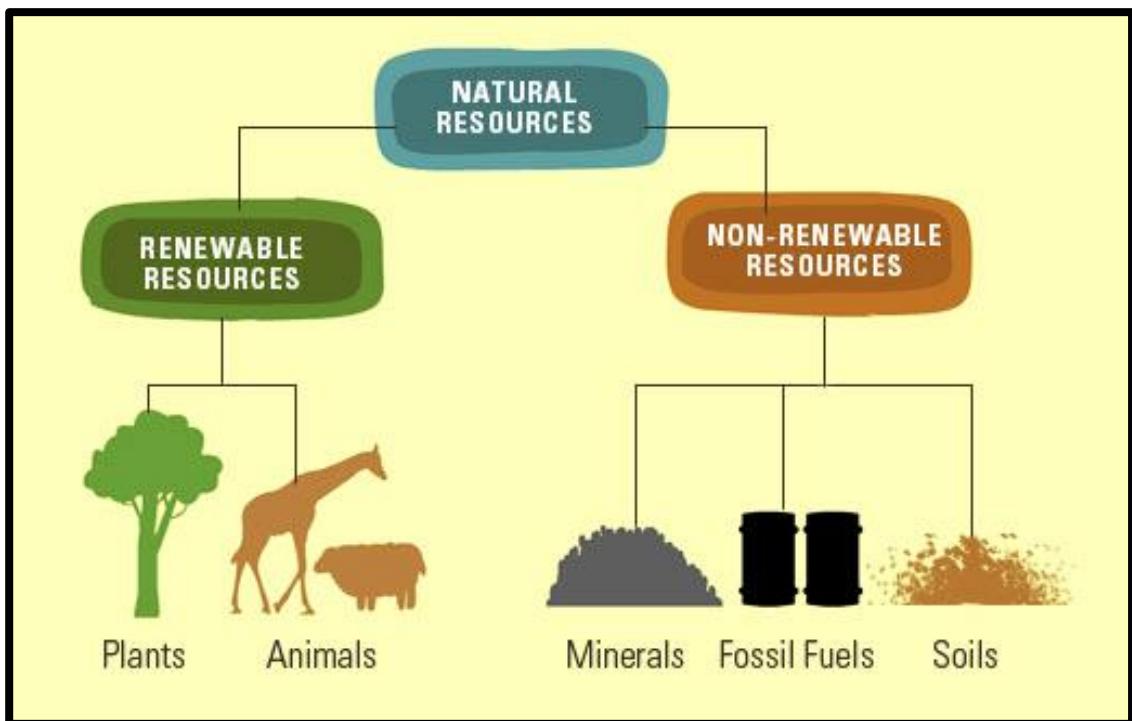
Classification of natural resources

1. On the basis of Origin – Biotic or Abiotic
2. On the basis of the Stage of Development of Natural Resources
3. On the basis of Recovery Rate – Consumption vs. Rate of recovery or replenishment

Water, air, soil, sunlight, and minerals

Actual resources
Reserve resources
Stock resources
Potential resource

Examples of natural resources



Source: <https://eschooldtoday.com/natural-resources/what-is-a-natural-resource.html>



Resource use over time



Historical changes in land and resource use

- ↳ Better health care and improved nutrition system
- ↳ Phenomenal rise – demand - on natural resources
- ↳ Land use pattern and disappearance of valuable resources
- ↳ Greater population?
- ↳ Consumerist society
- ↳ Industrial development – growing demands of consumer items

GLOBAL RESOURCES OUTLOOK 2019

pdf

Source: <https://www.resourcepanel.org/REPORTS/GLOBAL-RESOURCES-OUTLOOK>

01. The use of natural resources has more than tripled from 1970 and continues to grow.



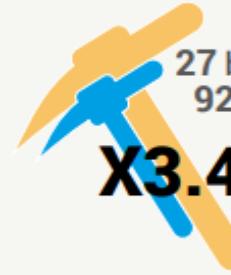
Global population



Global gross
domestic product



Global per capita
GDP



Annual
27 billion tonnes to
92 billion tonnes
X3.4



Annual
7.4 tonnes to
12.2 tonnes
X1.7



Biomass



Metals



Non-metallic minerals



Fossil fuels



Remaining economy

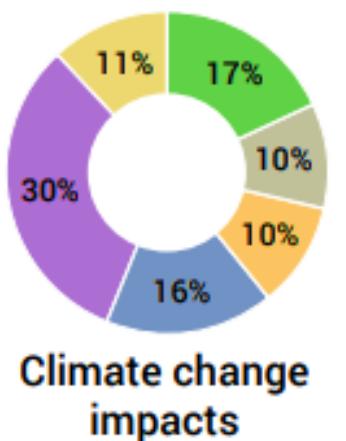


Households

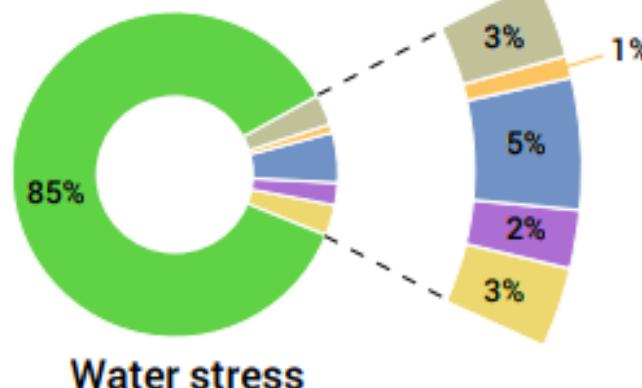
90 % - biodiversity loss
and water stress

11% of global species were lost by 2010 because of land use patterns

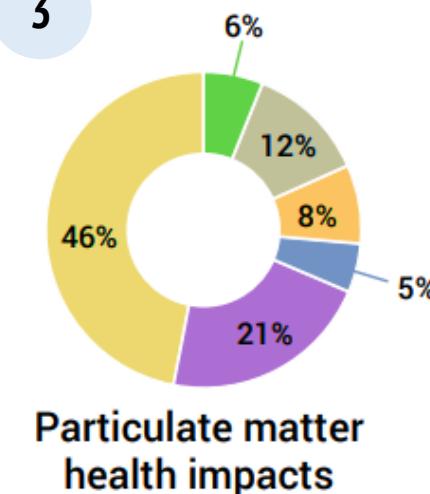
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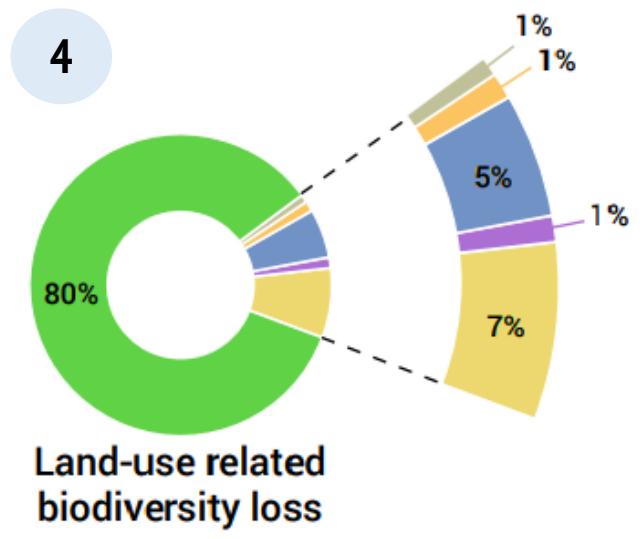
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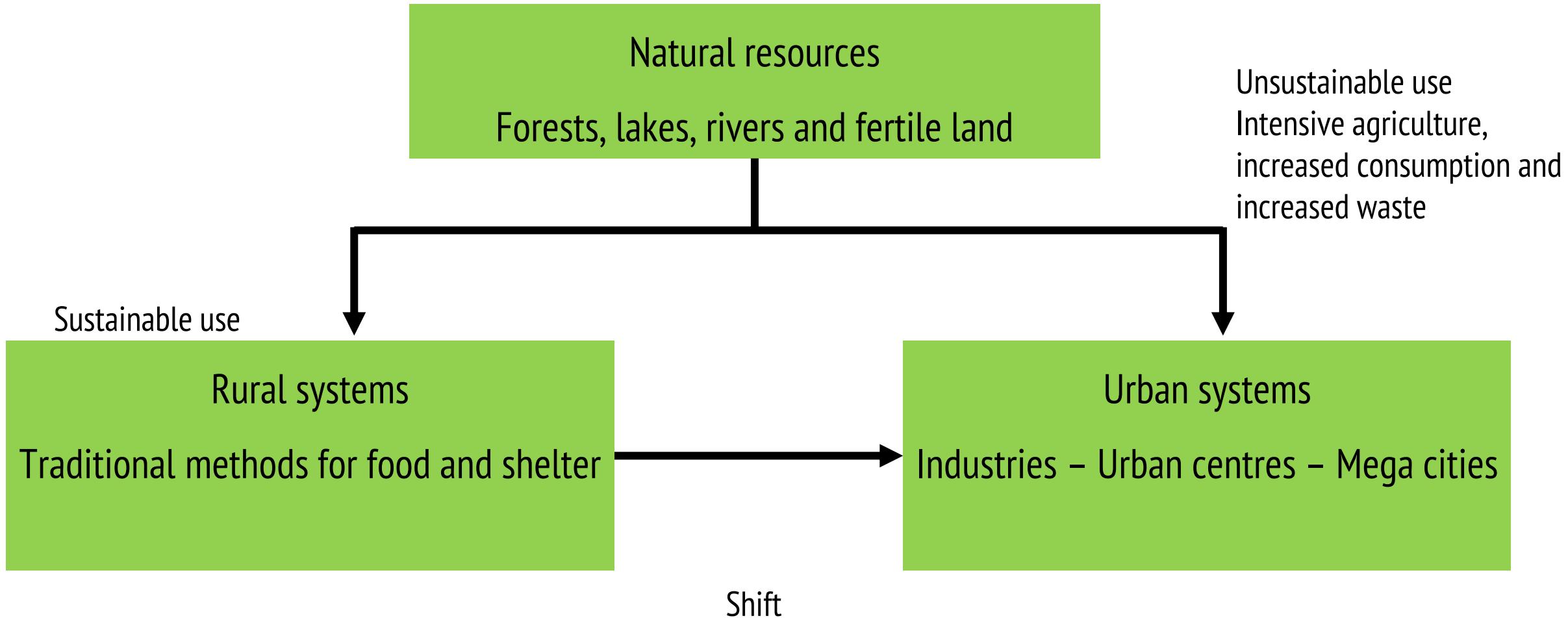


3



4





Shift in pressure of natural resources from urban to rural systems

Components of Earth





Components of Earth

Atmosphere

Oxygen for respiration

Oxygen is used by flora and fauna – we use it as food



Carbon Dioxide
and
Oxygen Cycle

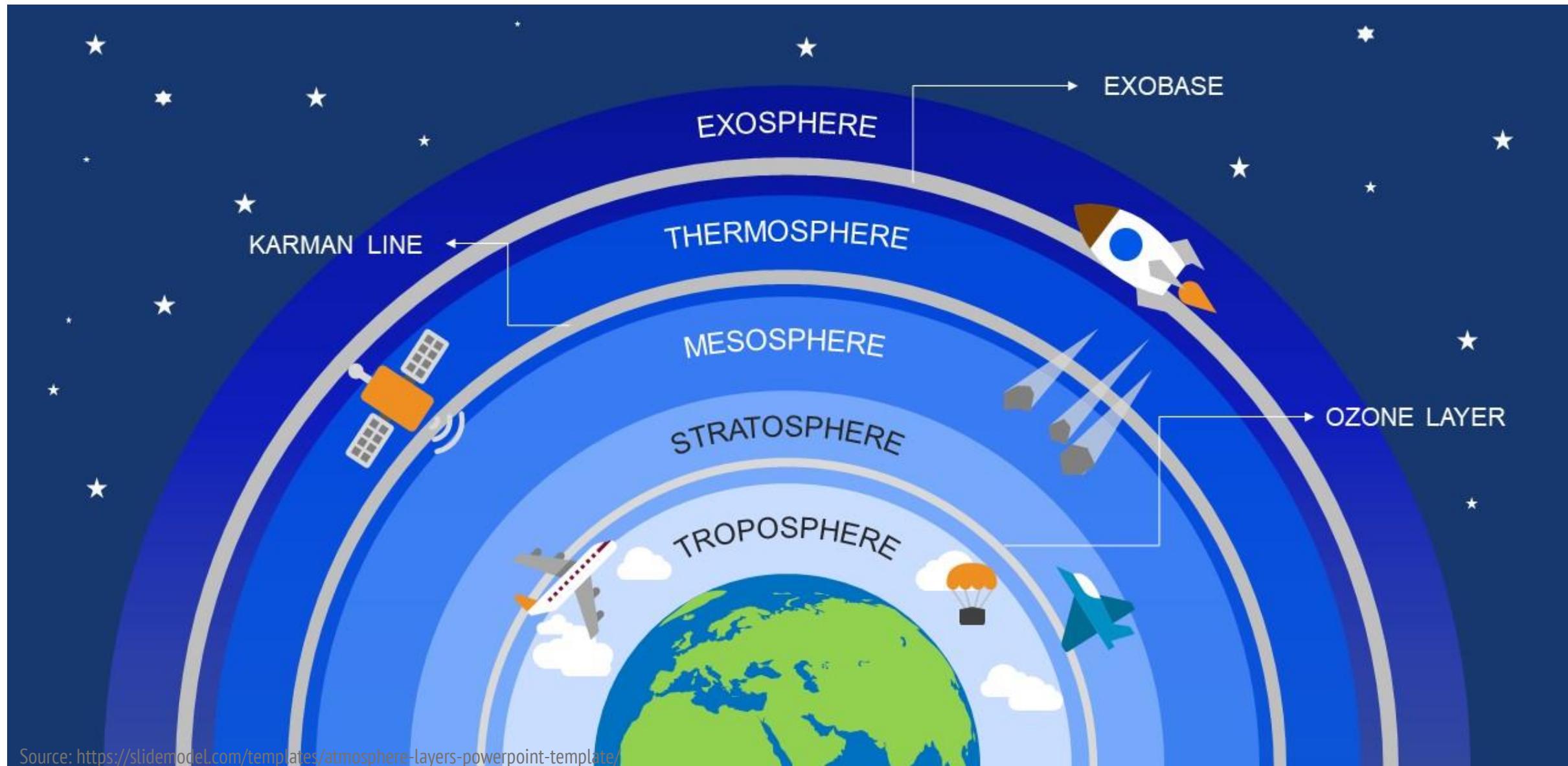
Composition of gases in Earth's atmosphere

Nitrogen 78%

Oxygen 21%

Rest other gases

Atmosphere



Source: <https://slidemodel.com/templates/atmosphere-layers-powerpoint-template/>



Hydrosphere

Water – Drinking, cooking and cleaning

Food sources from sea and freshwater

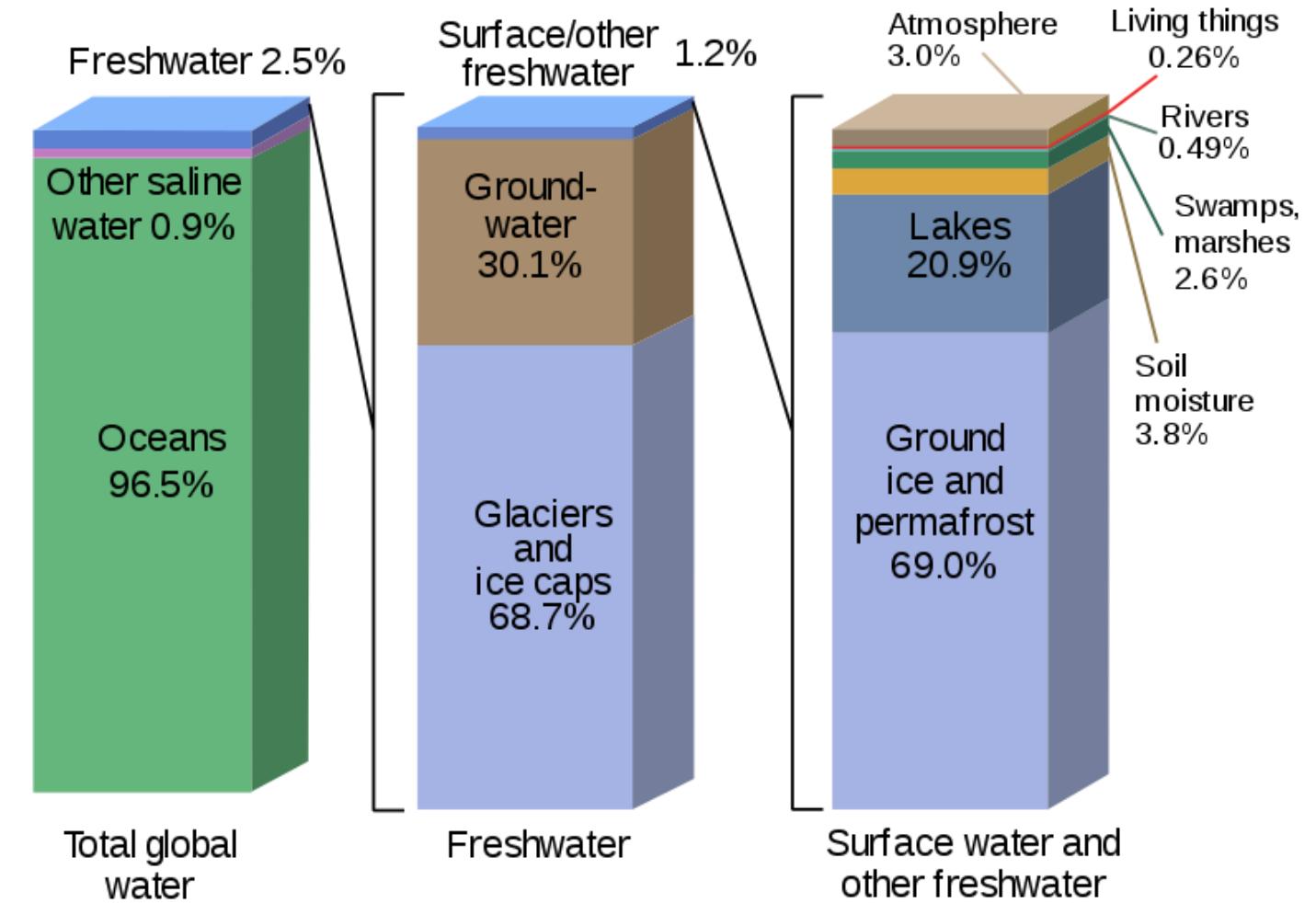
Water – electricity



Where is Earth's Water?



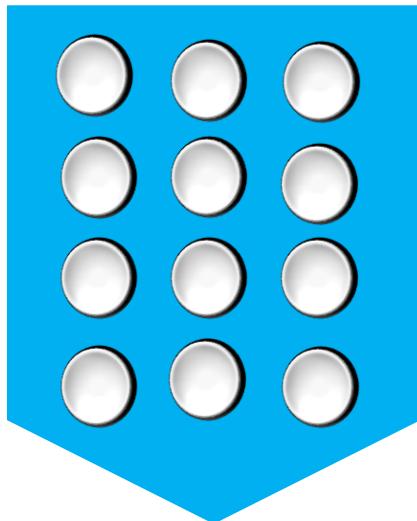
Water 70% Land 30%



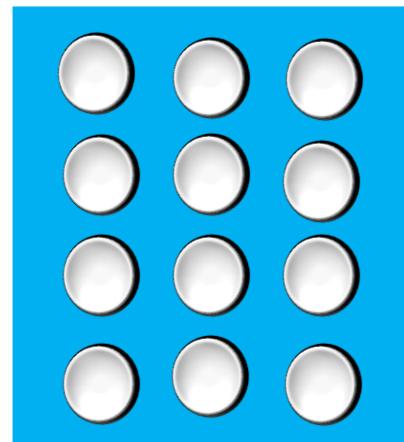
Source: https://www.usgs.gov/special-topic/water-science-school/science/where-earths-water?qt-science_center_objects=0#qt-science_center_objects

Hydrosphere

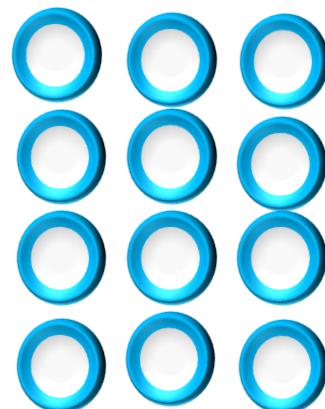
Hydrosphere comprises all water resources such as ocean, seas, lakes, rivers, reservoirs, icecaps, glaciers, and ground water.



Gravitational water



Capillary water



Hygroscopic water

Lithosphere

Soil – agriculture

Micronutrients – essential for plant growth

Microorganisms reside in soil – decomposition

Construction – sand stone and gravel

Minerals – industries

Extraction of fossil fuels ex: Coal, gas and oil

Source: https://www.pioneer.com/us/agronomy/micronutrients_crop_production.html

Element	Function in plant
B	Important in sugar transport, cell division, and amino acid production
Cl	Used in turgor regulation, resisting diseases and photosynthesis reactions
Cu	Component of enzymes, involved with photosynthesis
Fe	Component of enzymes, essential for chlorophyll synthesis, photosynthesis
Mo	Involved in nitrogen metabolism, essential in nitrogen fixation by legumes
Mn	Chloroplast production, cofactor in many plant reactions, activates enzymes
Zn	Component of many enzymes, essential for plant hormone balance and auxin activity

Biosphere

Food from crops and domestic animals – human metabolism

Food chains

Energy – Biomass – Organic matter

Infrastructure

Renewable and non renewable sources

Natural resources and associated problems

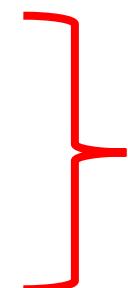
► The unequal consumption of natural resources

- North
- South
- Ecological foot print

► Planning land use

► The need for sustainable lifestyles

- Increased longevity
- An increase in knowledge
- An enhancement in income



The Brandt Line

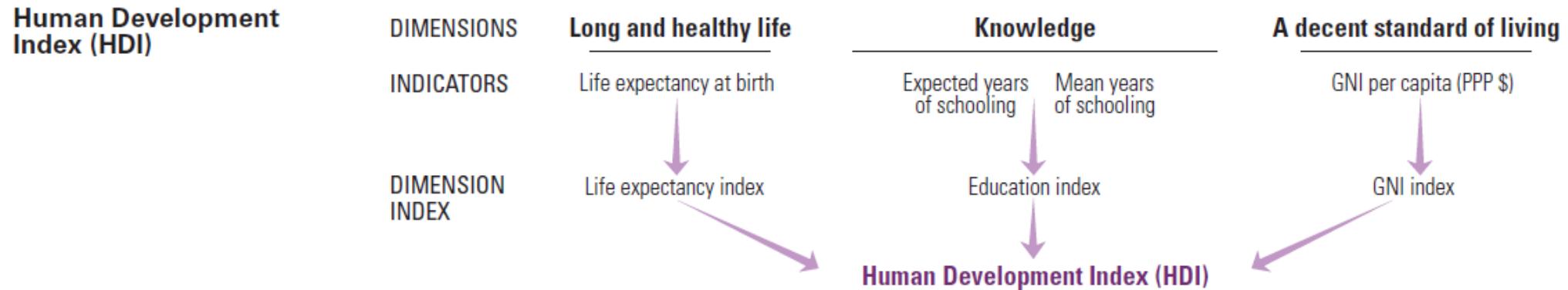


The Brandt Line (Royal Geographical Society, www.rgs.org)

Human development index (HDI)

Human development index

India's place in HDI?



Indicators for the quality of the ecosystems

1. A stabilised population or the percentage of species loss
2. Species diversity in ecosystems, and
3. The state of 'naturalness' of ecosystems

<http://hdr.undp.org/en/composite/HDI>

Renewable resources

Renewable energy, often referred to as clean energy, comes from natural sources or processes that are constantly replenished.

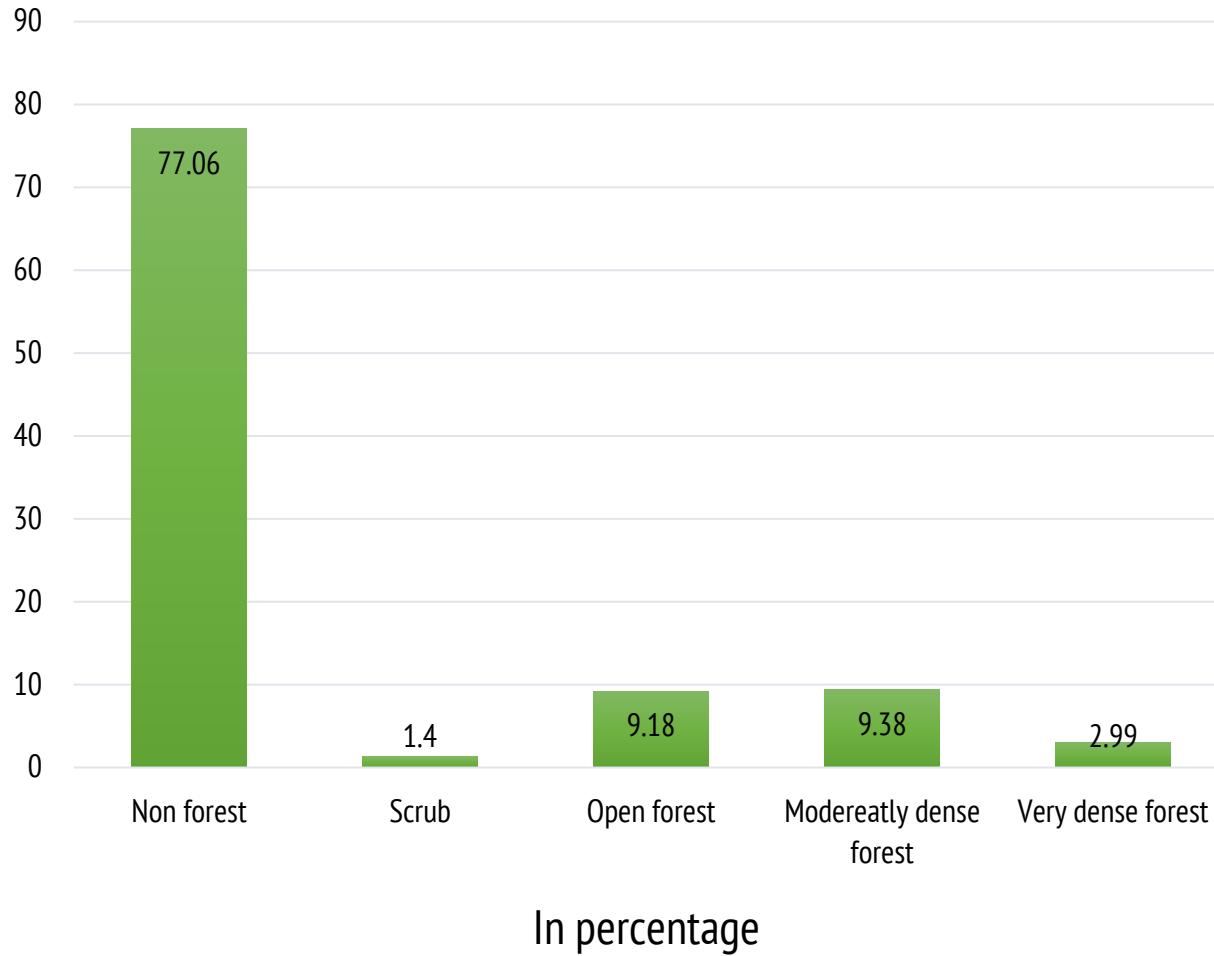
1. Forest resources, <http://fsi.nic.in/>

2. Water resources

3. Mineral resources

4. Food resources

5. Energy resources



Source: <http://fsi.nic.in/isfr2017/isfr-forest-cover-2017.pdf>

Satellite used for the assessment

LISS III

Resourcesat - 2

IRS P6



Table 2.3 Forest cover of India

Class	Area (sq km)	Percent of Geographic Area
Very Dense Forest	98,158	2.99
Moderately Dense Forest	3,08,318	9.38
Open Forest	3,01,797	9.18
Total Forest Cover *	7,08,273	21.54
Scrub	45,979	1.40
Non-Forest	25,33,217	77.06
Total Geographic Area	32,87,469	100.00

*Includes 4,921 sq km under Mangrove Cover
Percentage rounded off

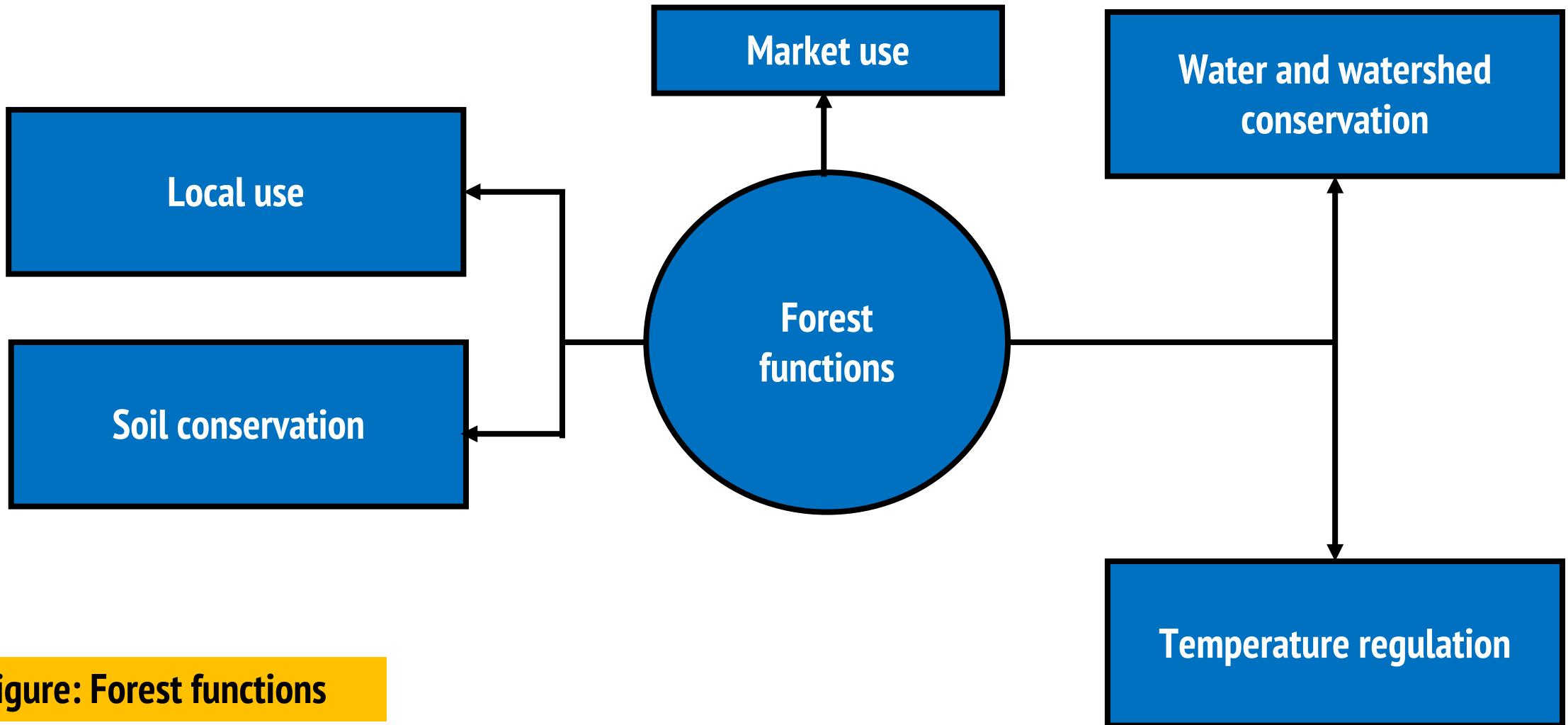
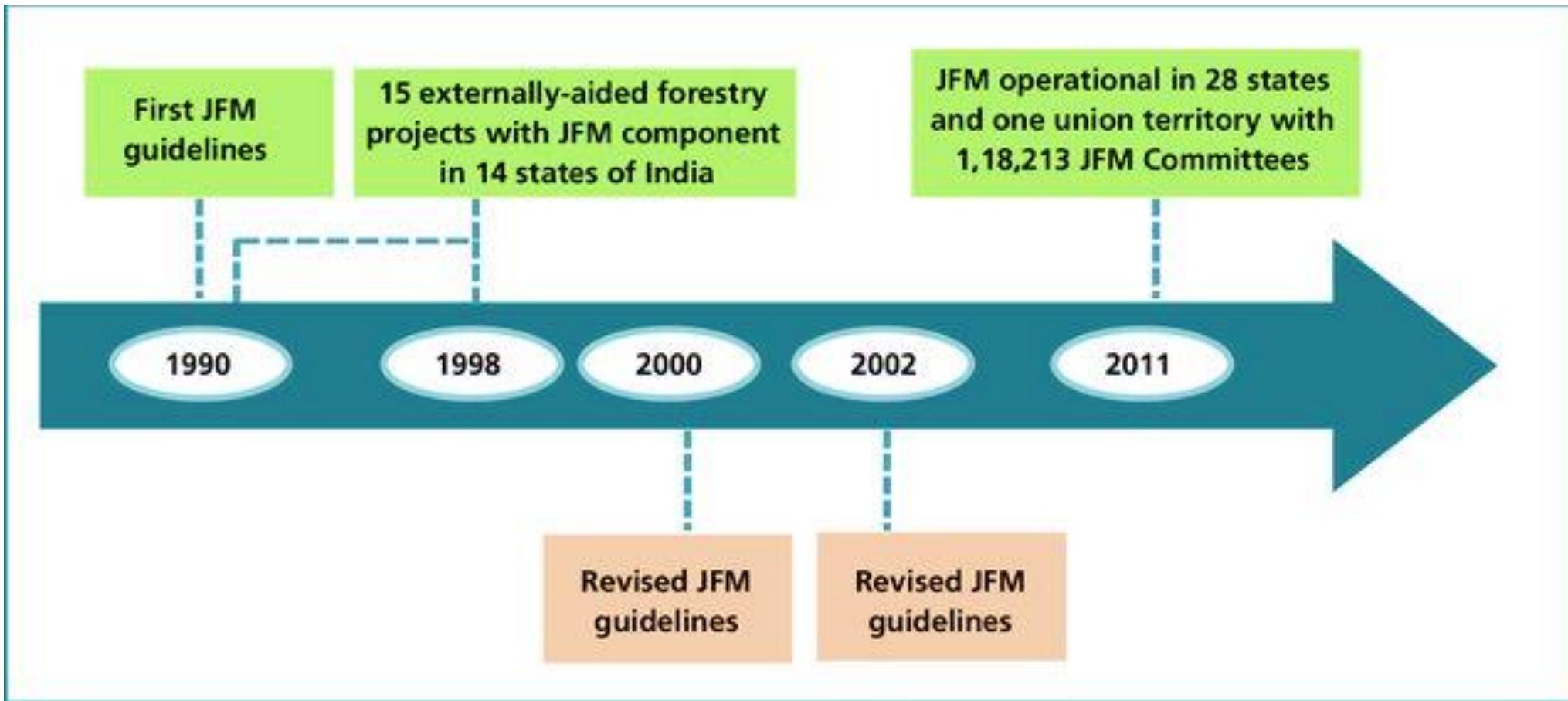
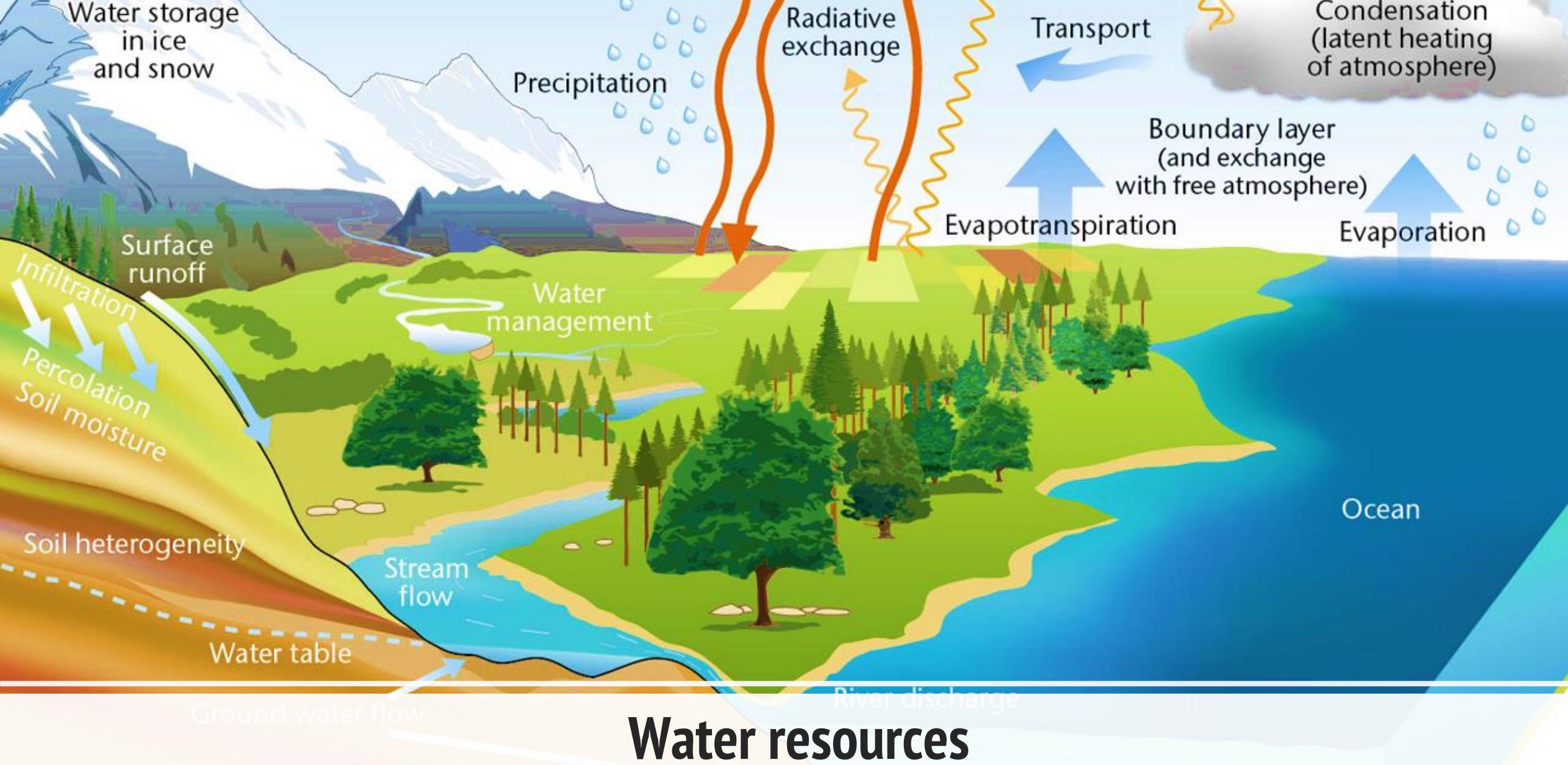


Figure: Forest functions

Case study: Joint forest management



Source: Conservation Across Landscapes: India's Approaches to Biodiversity Governance, UNDP India



Water resources

Water sources

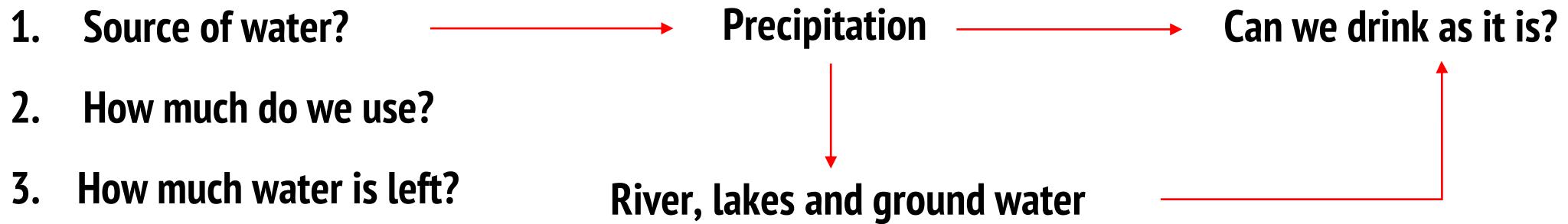
- 1. Mismanagement and pollution of water resources**
- 2. Global climate change**
- 3. Water for agriculture and power generation**
- 4. Problem caused by dams**



Mismanagement and pollution of water resources

Mismanagement | 18% of world's population and 4% of fresh water resources

Source – Spent = Left



Causes of excessive water usage?

1. Unsustainable consumption
2. Industrial development
3. Agriculture

54%
of India
Faces
**High to
Extremely
High**
Water Stress

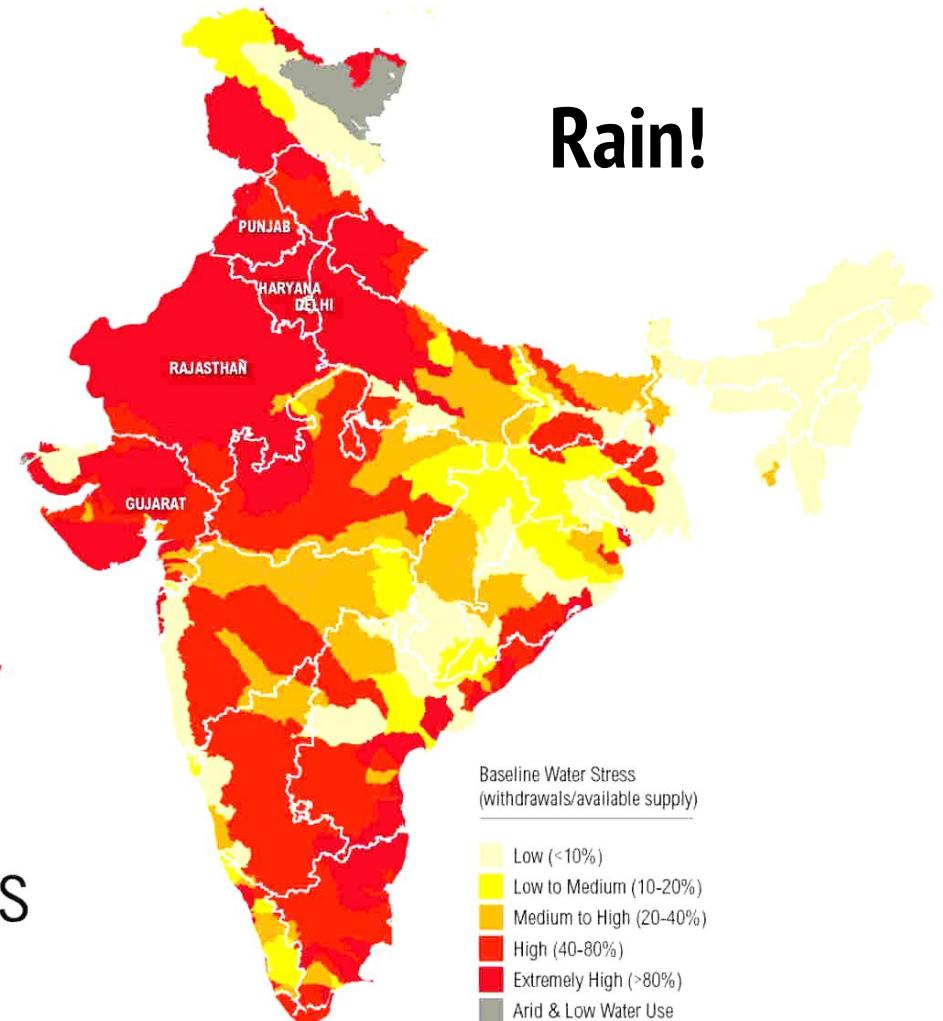
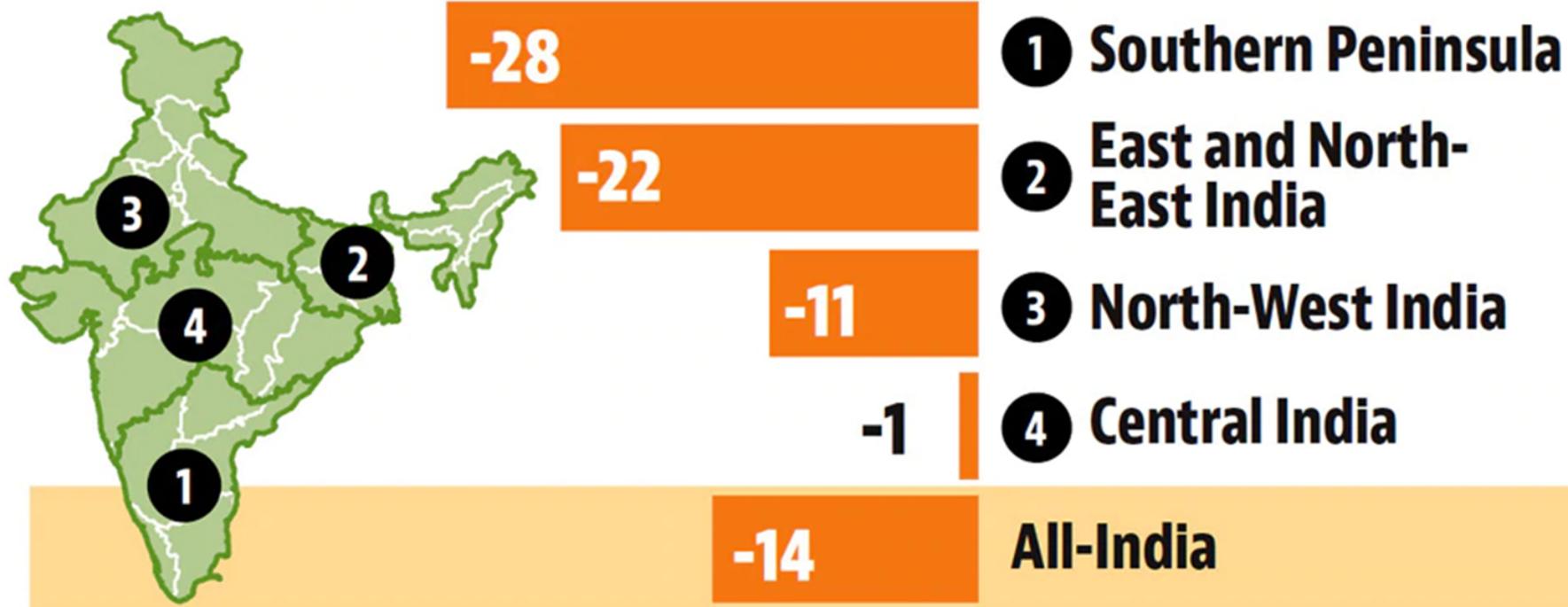


CHART 1

Rainfall shortage most severe in the southern peninsula

■ Departure in Southwest Monsoon rainfall from long-period average (%) *

As on July 10



* Long-period average is calculated for rainfall from June-September in the years 1951-2000

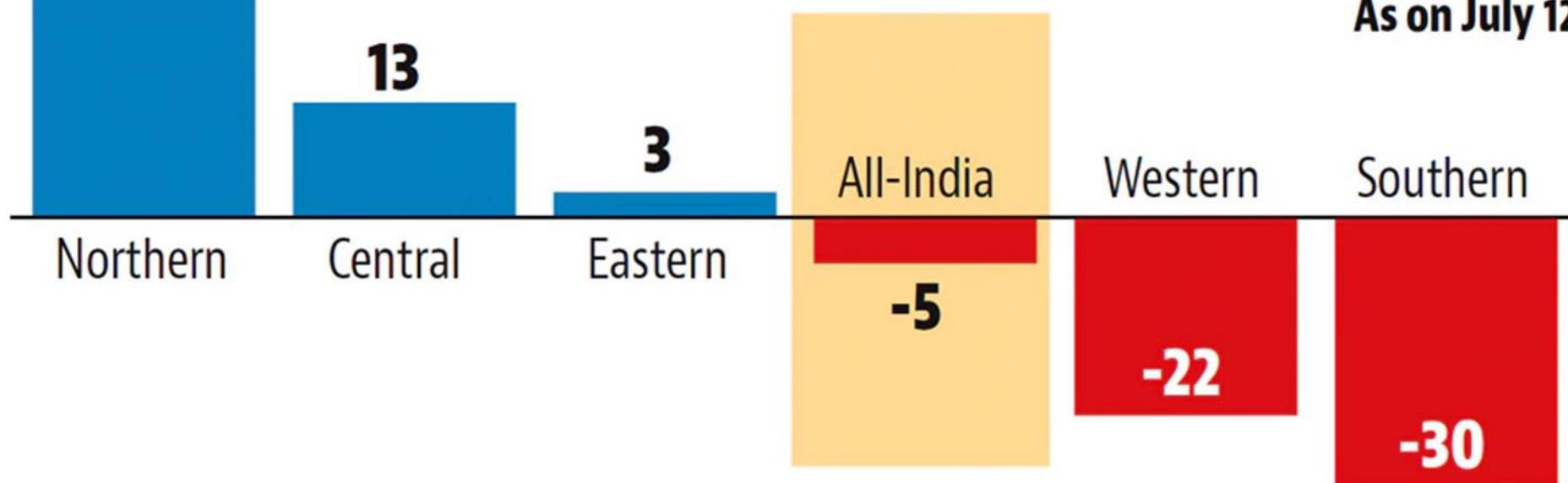
Source: Indian Meteorological Department

CHART 2

Southern reservoirs show the greatest shortfall in water levels

% departure of water level in reservoirs from avg of last 10 years

As on July 12



Source: Central Water Commission

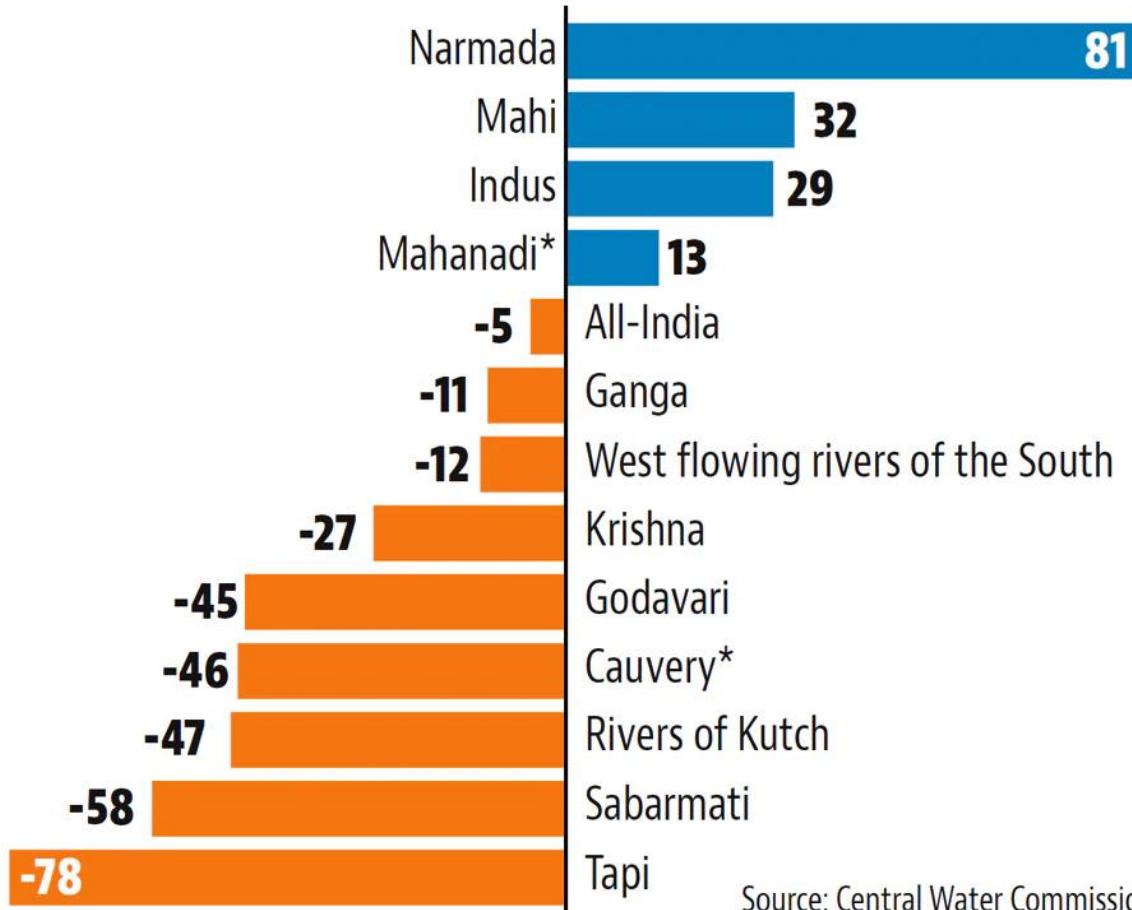
Source: <https://www.hindustantimes.com/india-news/poor-monsoon-fans-concerns-of-2016-like-water-crisis-in-south/story-9915wrtIP0OFbKz3FLRlkl.html>

CHART 3 Southern peninsula river basins show a shortage of water

% departure of water level in reservoirs from avg of last 10 years

* Includes neighbouring East flowing rivers

As on July 12



Source: Central Water Commission

Source: <https://www.hindustantimes.com/india-news/poor-monsoon-fans-concerns-of-2016-like-water-crisis-in-south/story-9915wrtIP00FbKz3FLRIkl.html>

Agriculture: 80% of the water

Climate Change

Water mafia!

India's water crisis is already here. Climate change will compound it.

Droughts and floods have pushed the nation's leaky, polluted, and half-done water systems to the brink.

Source: <https://www.technologyreview.com/s/613344/indias-water-crisis-is-already-here-climate-change-will-compound-it/>

Government's role?

Clean water supply by 2024

Can Ministry of Jal Shakti save Indian rivers?

The new ministry has its work cut out as old ministries' track record in cleaning and saving river basins hasn't been great



[NEXT BLOG >](#)

By Sushmita Sengupta, Rashmi Verma

Last Updated: Friday 21 June 2019



Mismanagement and pollution of water resources

Water Woes

Niti Aayog eyes ways to make sea water usable

India's massive coastline of 7,800 km offers huge opportunity

Large number of desalination plants may come up on sea or on the coast

Ocean energy or solar energy will be used to run these plants

WHY IS IT NEEDED?

By 2020, as many as 21 major Indian cities will run out of water

India ranks second from bottom in global water quality index

600 m people face high to extreme water stress

84% rural homes do not have access to piped water

The effect is skipped because of lockdown in 2020

NITI: National Institution for Transforming India

Helping India manage its complex water resources

Managing Floods and Droughts

Providing Drinking Water to Rural Areas

Improving access to water on dry rainfed lands

Groundwater – 25% water extracted around the world

Cleaning the Ganga – 1/3rd of sewage – National Ganga River Basin Project

Enhancing Dam Safety in India - 5,000+ large dams - 605 dams - 50 years old - 3,000 + are over 25 years.



Source: <https://www.worldbank.org/en/news/feature/2019/03/22/helping-india-manage-its-complex-water-resources>

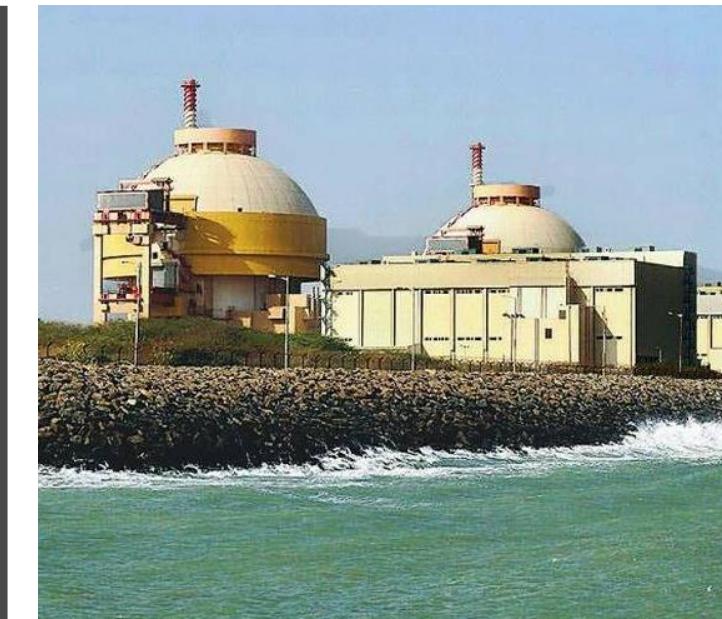


Global climate change

India's water future threatened by the combined effect of climate change and rising demand

- └ Floods and Storms – Warm temperature – Storms
- └ Sea level rise and salt water intrusion
- └ Changing rainfall patterns – Geographical variability and temporal volatility





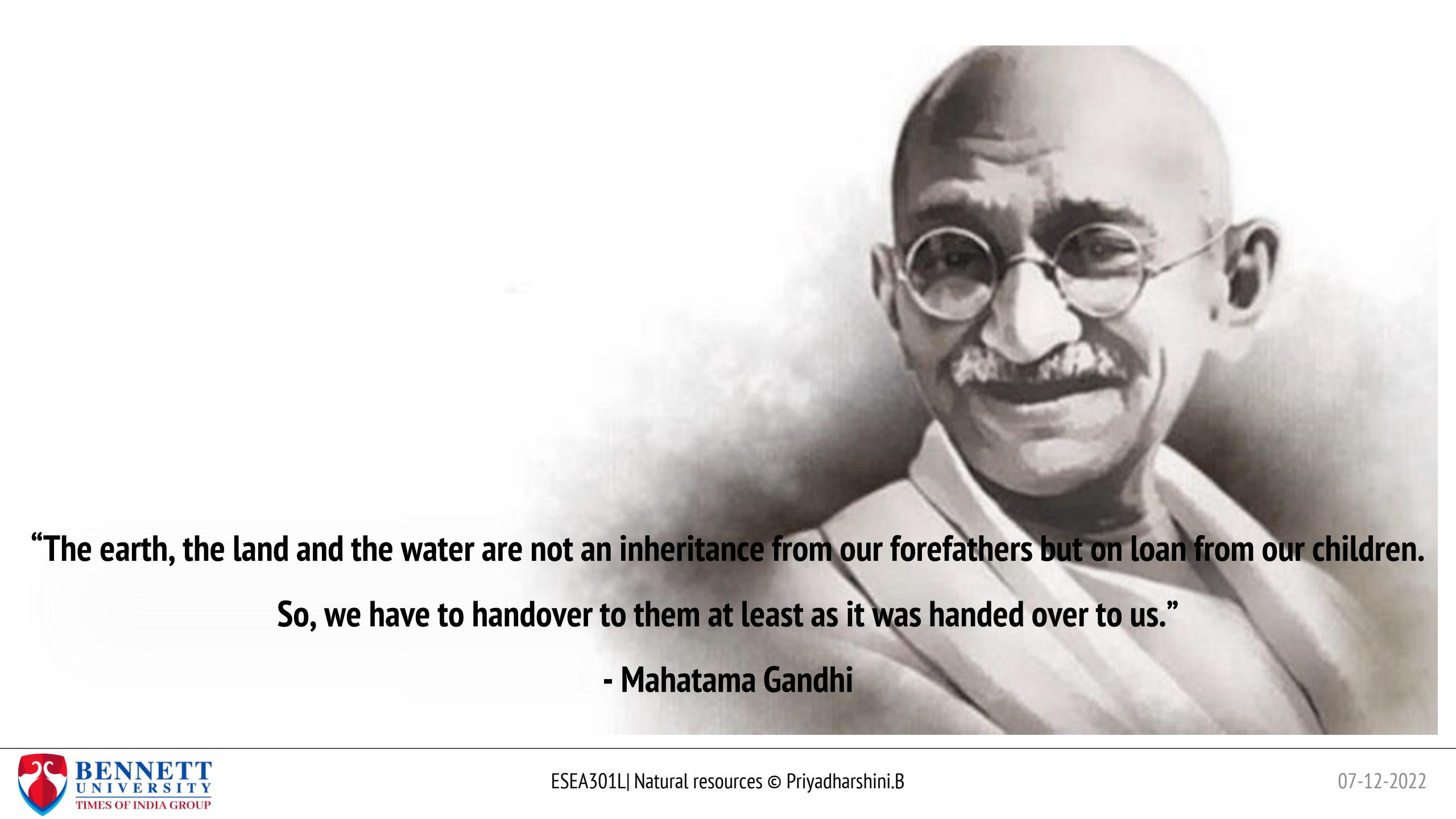
Water for agriculture and power generation

Water for agriculture

- Water is a critical **input** into agriculture
- How much water is required by Agriculture?

80% agriculture – How much of water source India has? - **4% world's water resources**

↓
Threat

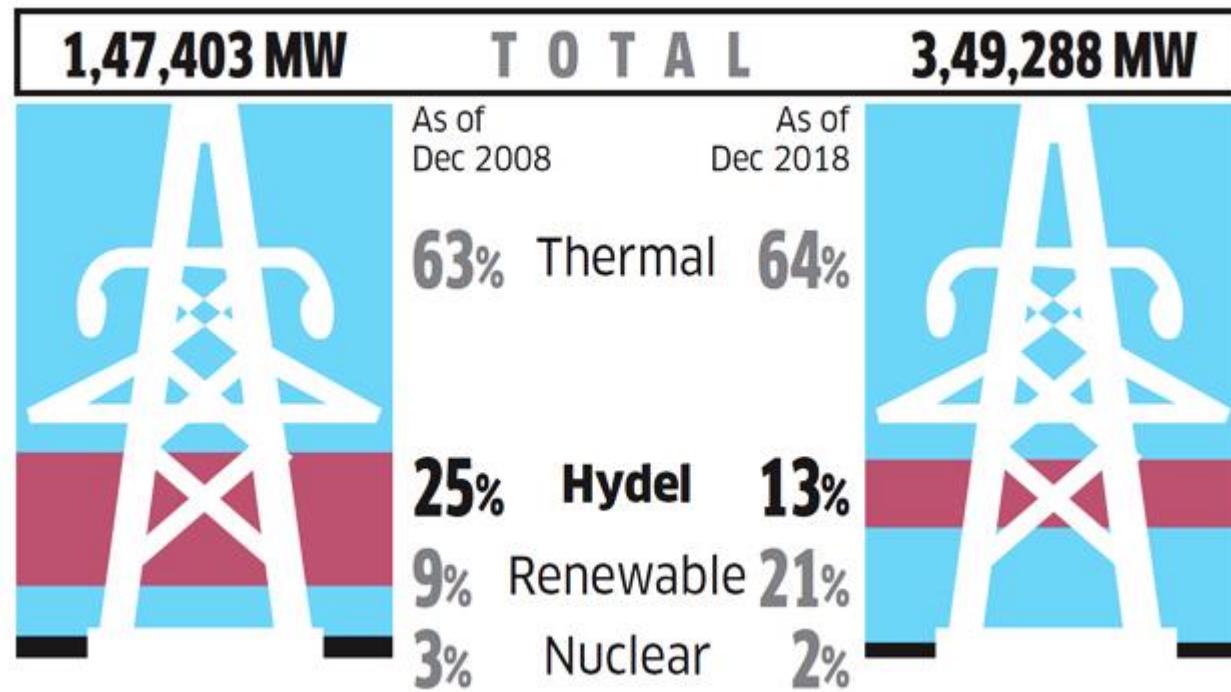


“The earth, the land and the water are not an inheritance from our forefathers but on loan from our children.

So, we have to handover to them at least as it was handed over to us.”

- Mahatama Gandhi

Water and power generation



Power generation stresses an already water-starved India

International Renewable Energy Agency (IRENA) - 85% fresh water sources

Indian power plants - 4-meter cube/hour/MWh

13 coal power plants - Shut down

Problems caused by dams



Problems caused by dams

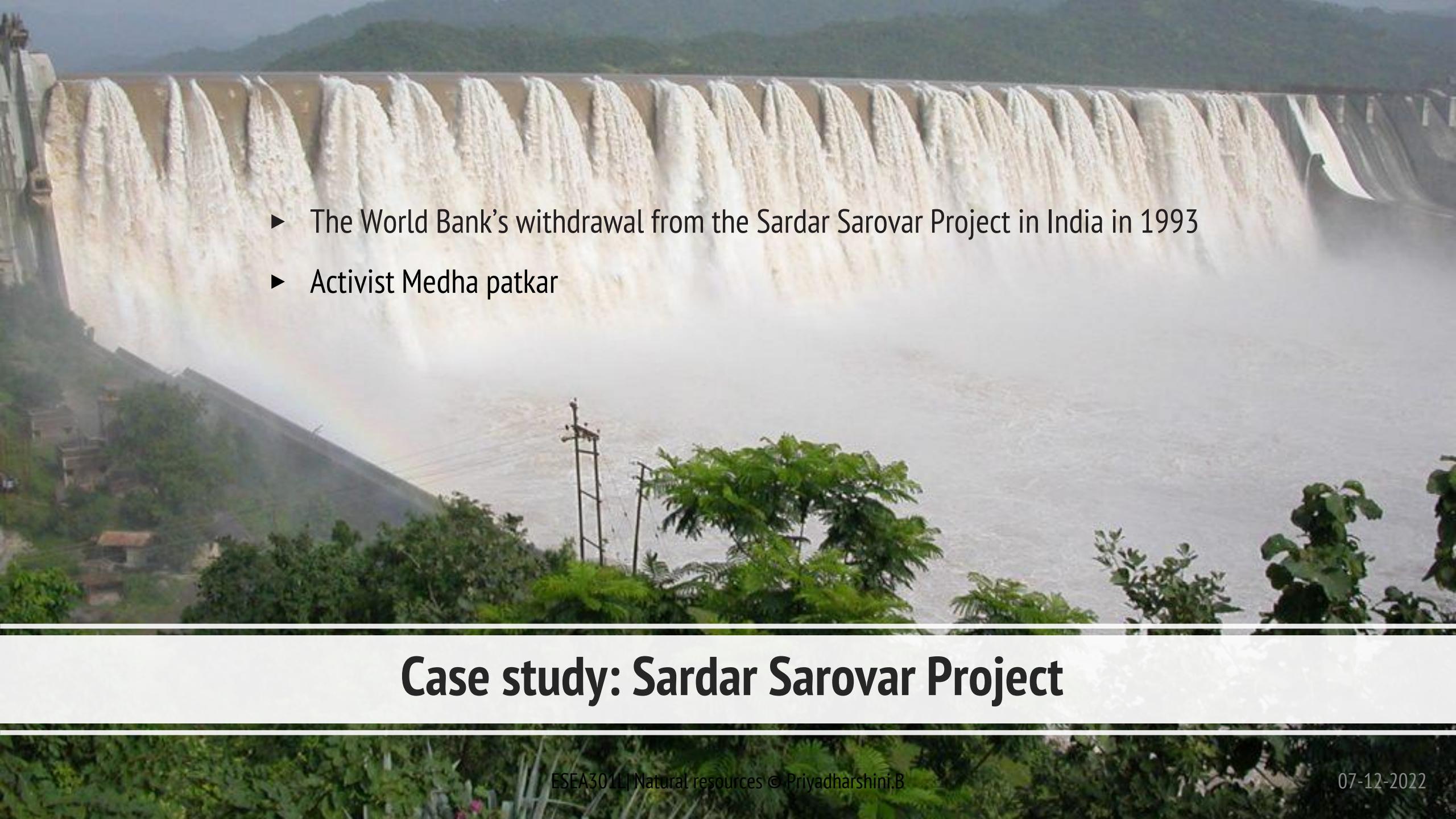
Age of dam (in years)

1. Social impacts – Displacement of people
2. Dislodging animal population, damaging their habitat and cutting off their migratory routes
3. The fragmentation and physical transformation of rivers
4. Serious impact on riverine ecosystems
5. Disruption of fishing and waterway traffic
6. Water - logging and salinization
7. Emission of greenhouse gases – rotting vegetation – carbon inflows from catchment

Area

Path

Issue

- 
- ▶ The World Bank's withdrawal from the Sardar Sarovar Project in India in 1993
 - ▶ Activist Medha patkar

Case study: Sardar Sarovar Project

Dam Safety Bill 2019

Ministry of Jal Sakti

National Committee on Dam Safety (NCDS) – For what?

Chairperson, Central Water Commission

- purpose of maintaining standards of dam safety and prevention of dam failure related disasters.
- evolve dam safety policies and recommend necessary regulations.

Regulatory body, National Dam Safety Authority (NDSA) – Role

- to implement the NCDS's policies and guidelines
- resolve issues between State Dam Safety Organisations (SDSOs)

Task!

Estimate your water consumption

Drinking

Bathing

Flushing of toilets

Washing



Mineral resources



Mines are of two types: surface (open cut or strip mines) or deep or shaft mines



Mineral sources

Prospecting – searching for minerals

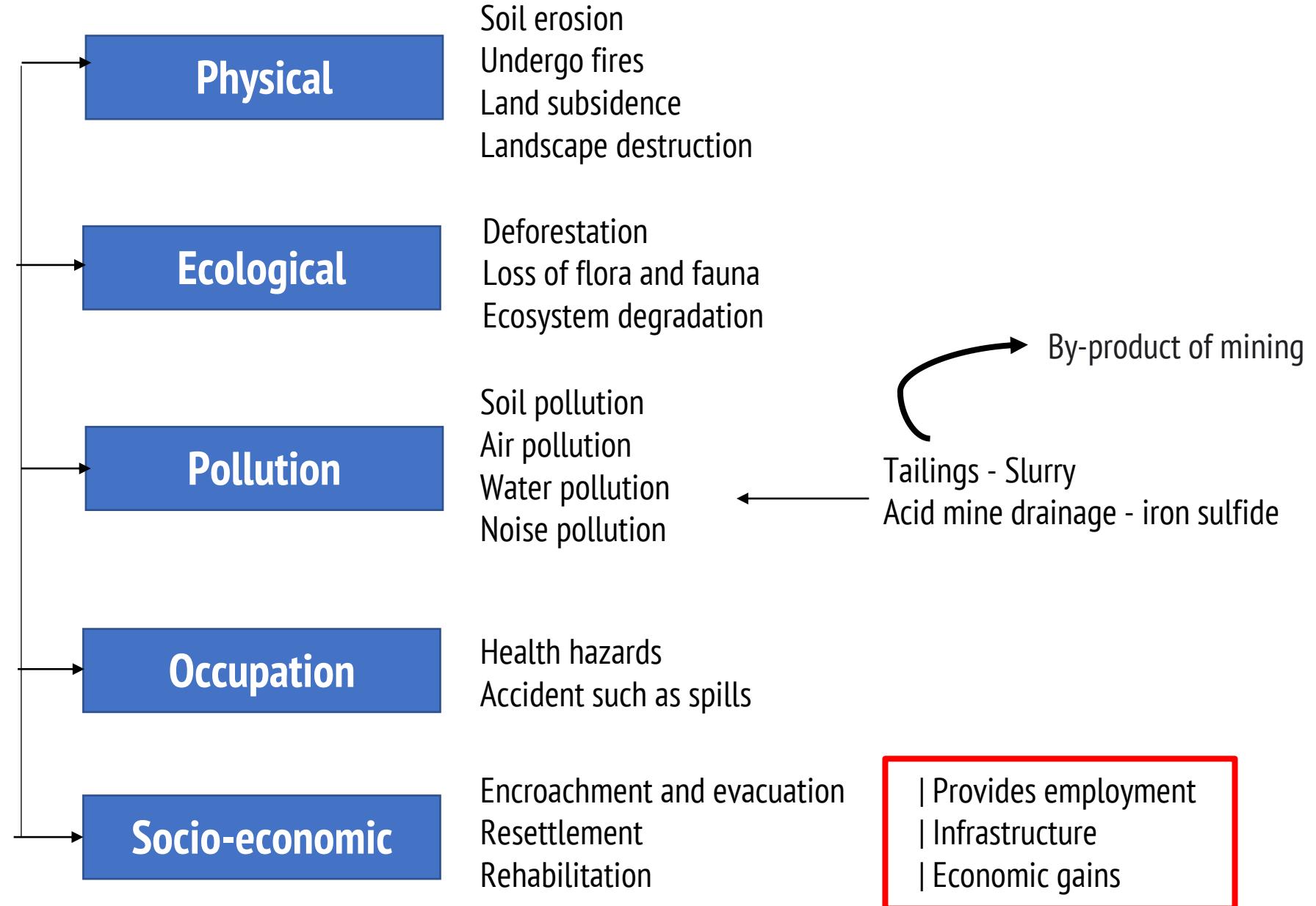
Exploration – assessing the size, shape, location and economic value of deposit

Development – The work of preparing access to the deposit

Exploitation – Extracting the minerals from the mines

Consequences of mining activities

1. Positive
2. Negative



| Provides employment
| Infrastructure
| Economic gains

Health hazard

- Coal workers' pneumoconiosis (CWP), also known as **black lung** disease or **black lung**, is caused by long-term exposure to coal dust. It is common in coal miners and others who work with coal.



Sariska Tiger Reserve, Rajasthan

- The Forest Department has leased land for mining by denotifying forest areas.
- The local people have fought against the mining lobby, and have filed a Public Interest Litigation in the Supreme Court in 1991



CASE STUDY



Food resources



Sustainable agriculture

FAO – Food and agricultural organization – Sustainable agriculture as that which conserves land, water and plant and animal genetic resources, does not degrade the environment and is economically viable and socially acceptable.

Integrated crop management

Integrated crop management (ICM) is a holistic approach to sustainable agriculture.

It considers the situation across the whole farm, including socio-economic and environmental factors to deliver the most suitable and safe approach for long-term benefit.

What is IPM?

Integrated Pest Management is a science-based approach that combines a variety of techniques. By studying their life cycles and how pests interact with the environment, IPM professionals can manage pests with the most current methods to improve management, lower costs, and reduce risks to people and the environment.

IPM tools include:

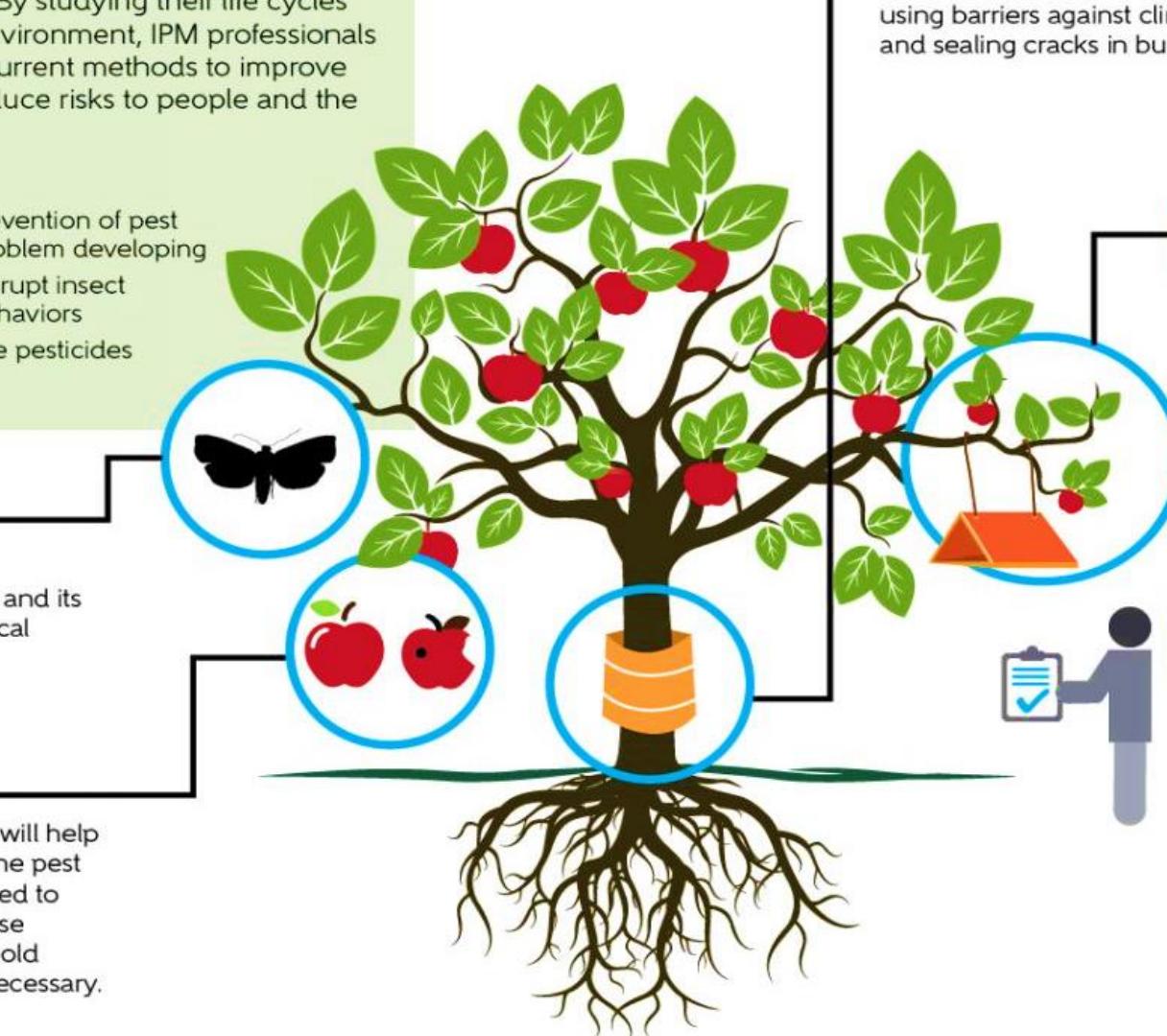
- Alter surroundings
- Add beneficial insects/organisms
- Grow plants that resist pests
- Disrupt development of pest
- Prevention of pest problem developing
- Disrupt insect behaviors
- Use pesticides

1 IDENTIFY/MONITOR

Determine the causal agent and its abundance (contact your local extension agent for help).

2 EVALUATE

The results from monitoring will help to answer the questions: Is the pest causing damage? Do we need to act? As pest numbers increase toward the economic threshold further treatments may be necessary.



3 PREVENT

Some pest problems can be prevented by using resistant plants, planting early, rotating crops, using barriers against climbing pests, sanitation, and sealing cracks in buildings.

4 ACTION

IPM uses multiple tools to reduce pests below an economically damaging level. A careful selection of preventive and curative treatments will reduce reliance on any one tactic and increase likelihood of success.

5 MONITOR

Continue to monitor the pest population. If it remains low or decreases, further treatments may not be necessary, but if it increases and exceeds the action threshold, another IPM tool should be used.

Food resources

1. World food problems
2. Food security
3. Fisheries
4. Loss of genetic diversity
5. Alternate food sources



WORLD FOOD PROBLEMS

Demand

Malnutrition

Less cultivable areas

Loss of nutrients

Overuse of chemicals

Water scarcity



Global hunger index

FOOD SECURITY

Fisheries

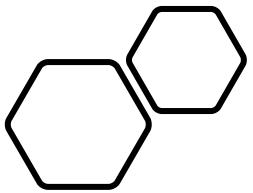
6.3% of global fish production

12.60 million metric tonnes in 2017-2018.

Source: <http://nfdb.gov.in/about-indian-fisheries.htm>



LOSS OF GENETIC DIVERSITY



Seed Bank

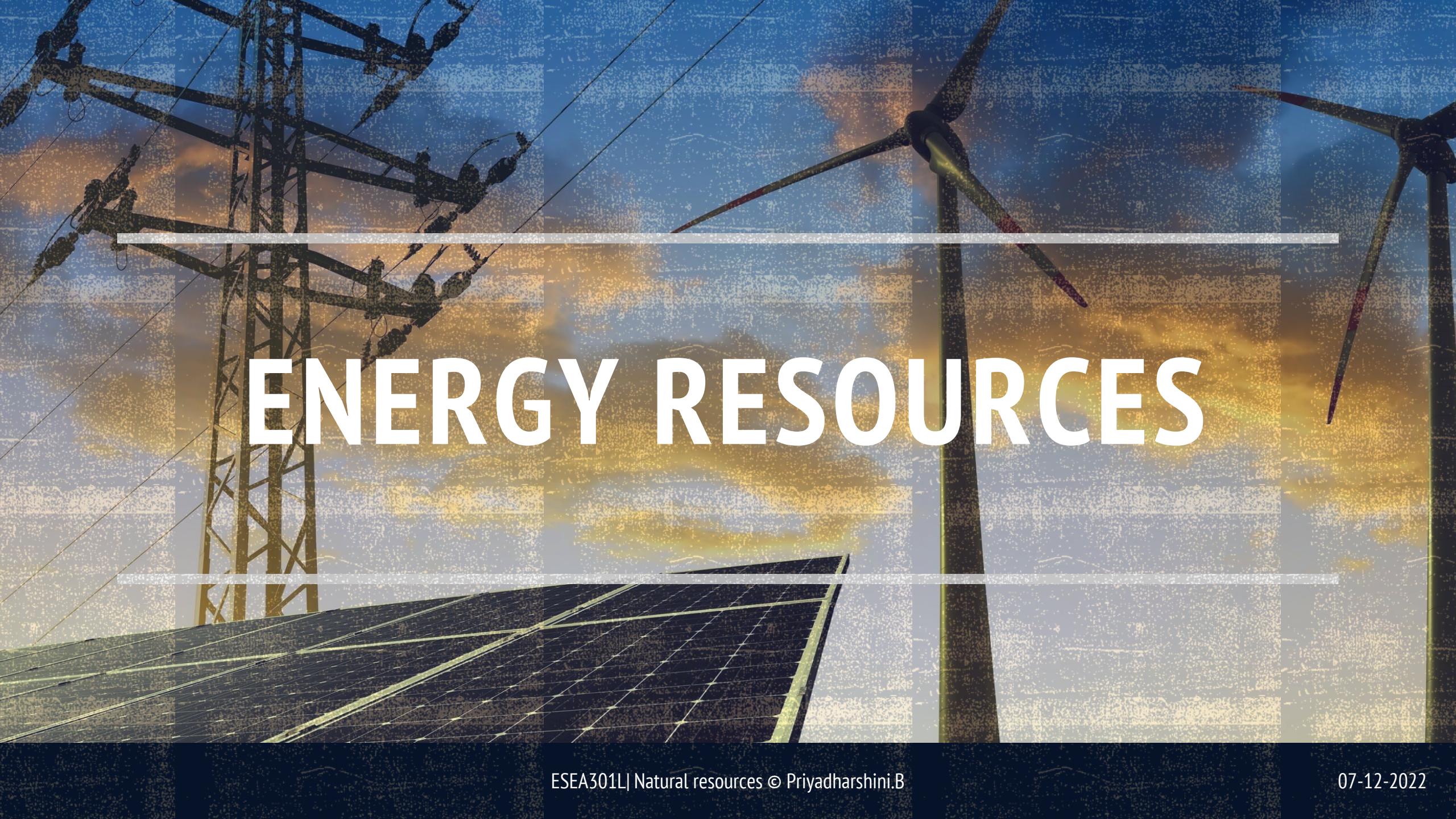
Did you know?

India has a seed bank in
Chang La in the Himalayas



Alternate food sources





ENERGY RESOURCES

Energy, in physics, the capacity for doing work

Energy

The sun is the primary energy source

Uses of energy

1. Agriculture → chemical fertilizers
 2. Household purposes
 3. Production of industrial → Energy-demanding roads and railway lines (transportation)
-

Is energy related technology completely risk free? **No!**

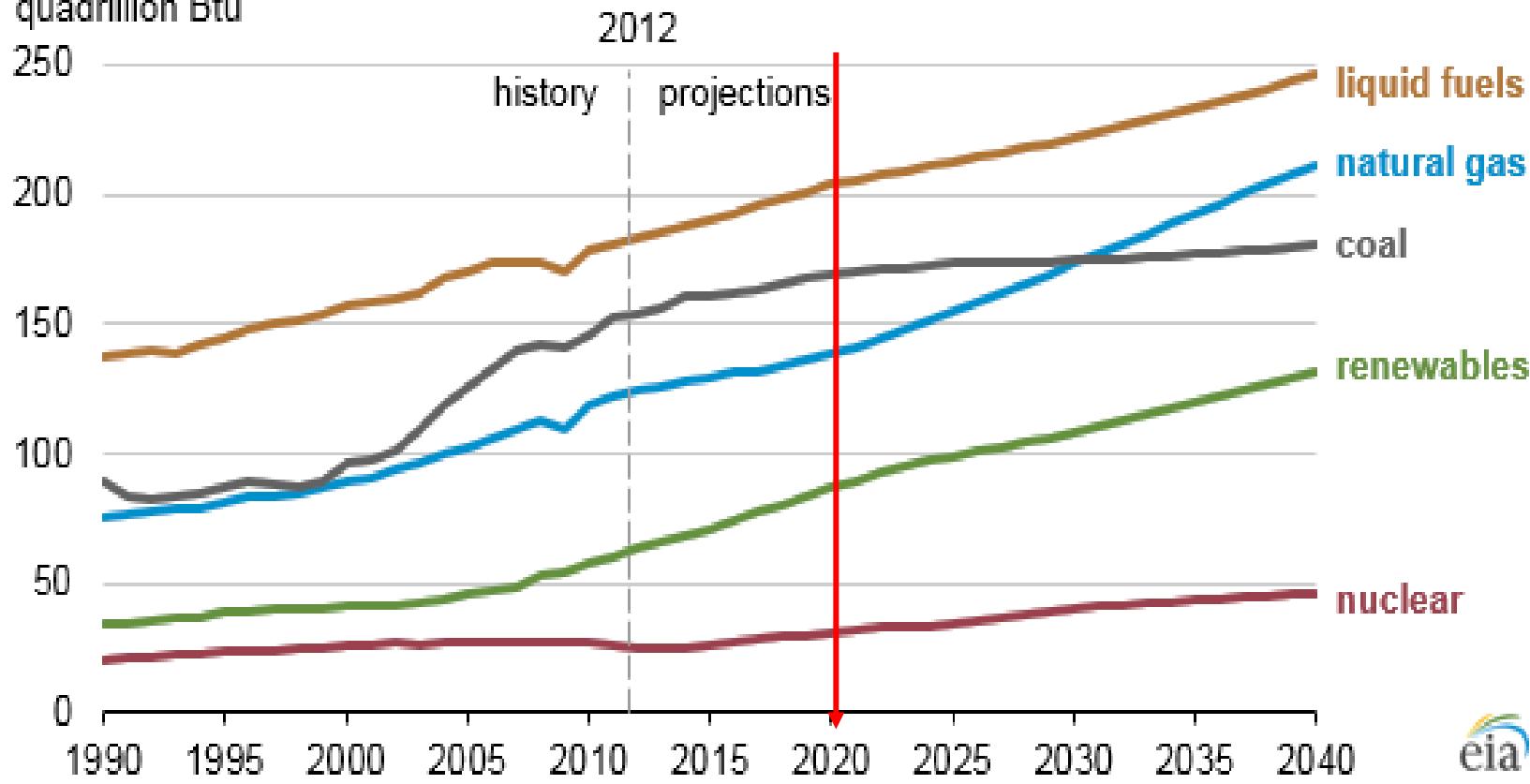
GROWING ENERGY NEEDS



Energy resources

World energy consumption by source, 1990-2040

quadrillion Btu



British thermal unit (Btu or BTU)



India's energy demand outpaces global growth: IEA

Country's primary demand rose **4%** in 2018 Vs **2.3%** growth seen worldwide

The growth in India was led by coal for power generation and oil for transport.

Due to higher energy consumption, the global energy-related CO₂ emissions increased to 33.1 giga tonnes (Gt).

Coal-fired power generation - CO₂ emissions ← Global warming

Source: <https://www.thehindubusinessline.com/economy/india-outpace-global-energy-demand-growth-in-2018-iea/article26643852.ece>

Types of energy

1. Renewable



1. Wind energy
2. Solar energy
3. Biomass energy
4. Hydropower
5. Geothermal energy

2. Non-renewable



1. Oil
2. Coal
3. Natural gas
4. Nuclear energy

Non-renewable energy

These consist of mineral based hydrocarbon based fuels – Coal, oil and natural gas

Collectively called as **Fossil fuels** – Fossilised plants

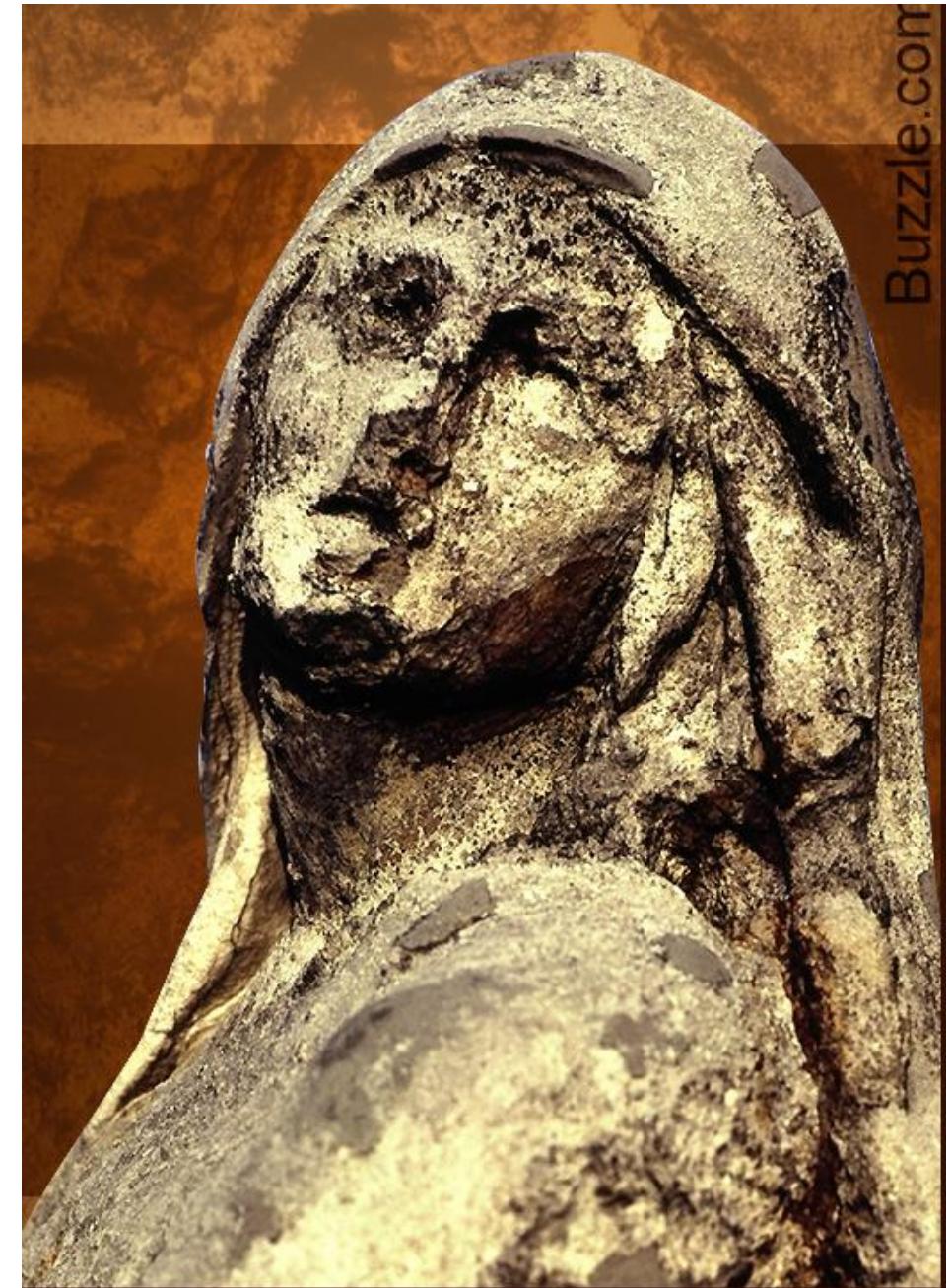
Oil and gas resources are likely to be extinct in another 50 years

When this fuel is burnt they produce waste products such as carbon di oxide, oxides of sulphur, nitrogen and carbon monoxide.

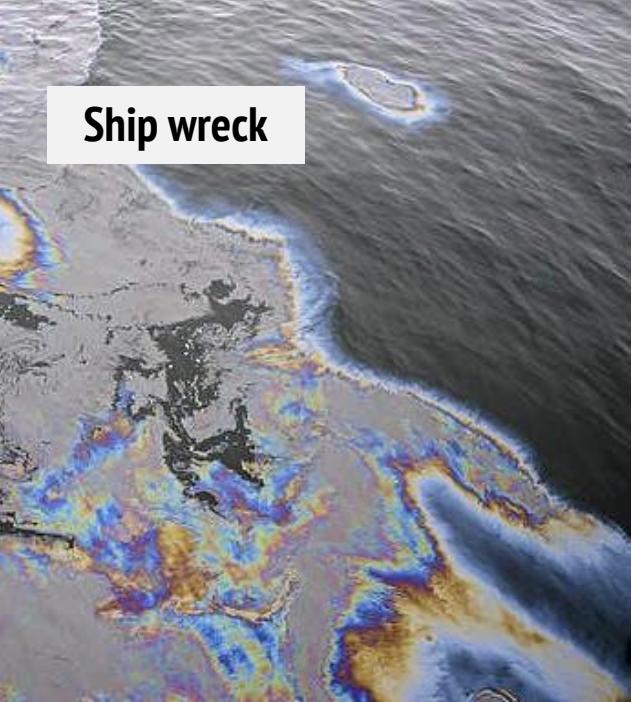
Green house gas effect

Climate change – A substantial part is due to anthropogenic effects

Effects of acid rain



Ship wreck



Oil spills



Air pollution



12/7/2022

Oil and its impact on the environment

- ▶ Brahmaputra valley of north-east India - oldest
- ▶ Gujarat coast in western India
- ▶ Cauvery on-shore basin

65% oil reserves are present in Middle east



Case Study

“Deep water horizon oil spill”

Gulf of Mexico oil spill or BP oil spill

Largest oil spill in the history

Coal and its impact on the environment

- └ Release of SO_x and NO_x – acid rains
- └ Largest contributor of green house gases
- └ Important cause of global warming
- └ Air pollution control devices are not present
- └ Destroys vegetation, damages architectural heritage sites, pollutes water and affects human health.

Hydroelectric power



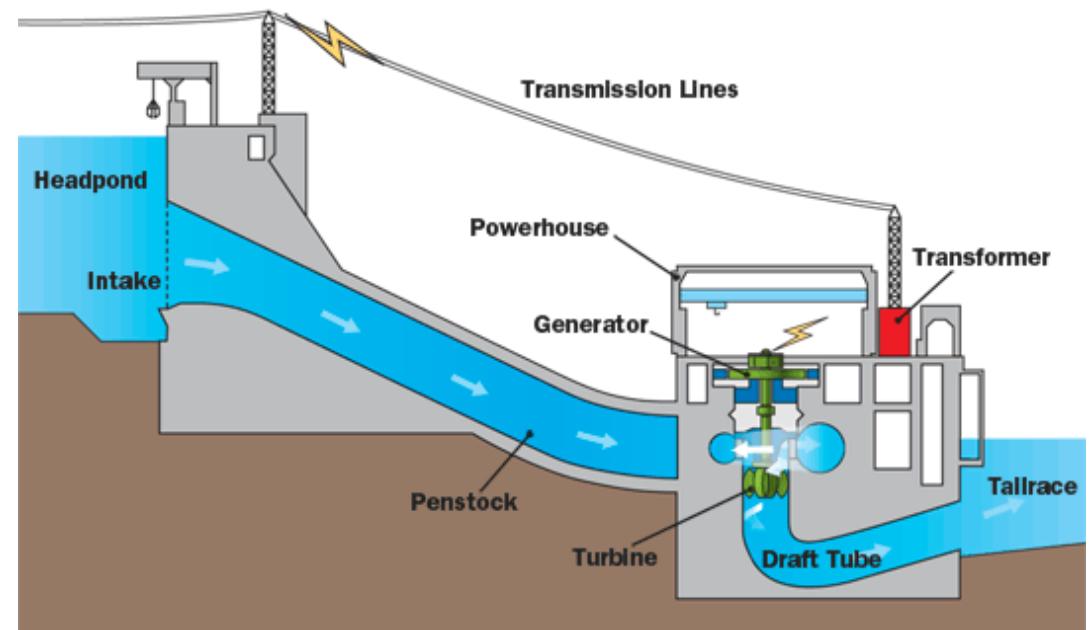
Hydroelectric power

This uses the flowing water down the natural gradient to turn the turbines to generate electricity known as '[hydroelectric power](#)'

Drawbacks!

- Ecological problems - livelihood of the people
- Silting of reservoirs
- Conflicts of water
- Rehabilitation of people
- Induce seismic activity

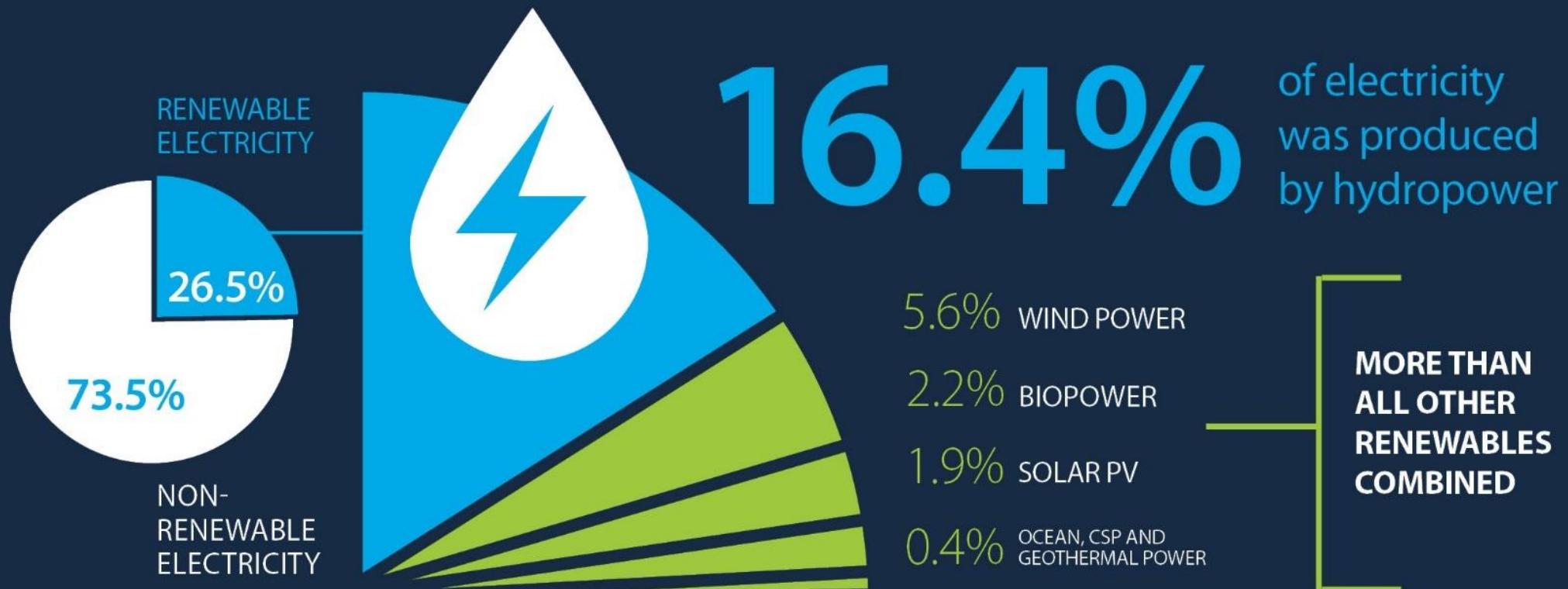
Reservoir-induced seismicity



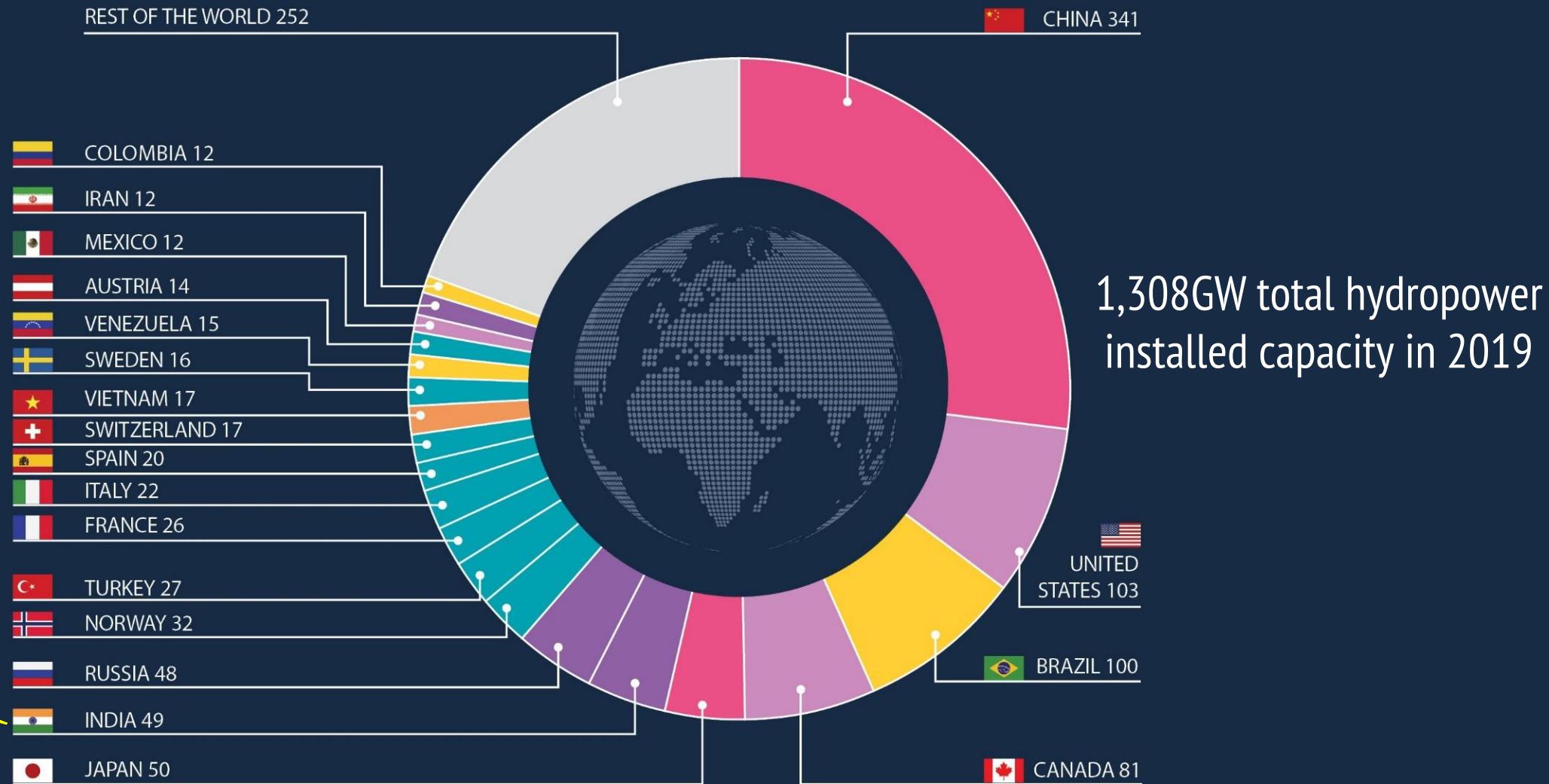
SHARE OF GLOBAL ELECTRICITY GENERATION

Source: REN21 2018

Hydropower is the world's largest source of renewable electricity generation

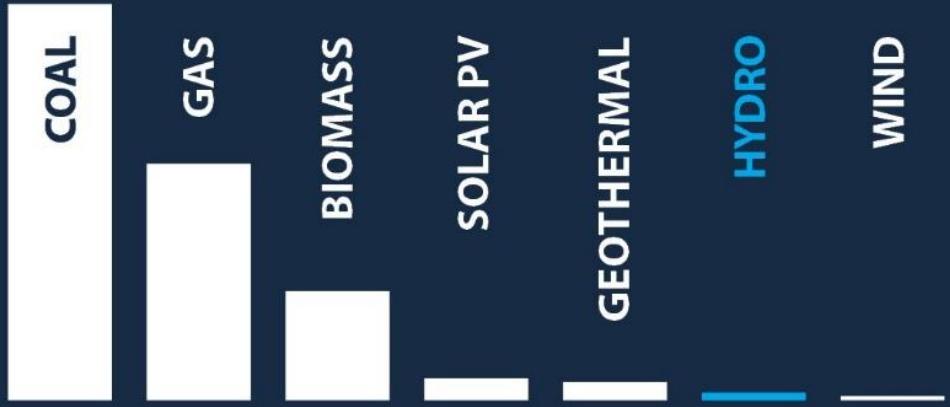


WORLDWIDE HYDROPOWER INSTALLED CAPACITY



Hydropower installed capacity (GW) of top 20 countries including pumped storage in 2017. Source: IHA 2018

Source: https://www.hydروpower.org/sites/default/files/publications-docs/2020_hydropower_status_report.pdf



Hydropower has one of the lowest lifecycle CO₂ emissions per kilowatt hour among all electricity sources

If hydropower was replaced with burning coal, approximately



4 BILLION TONNES

of additional greenhouse gases would have been emitted in 2017

10% HIGHER

and global emissions from fossil fuels and industry would have been at least

Using hydropower instead of coal each year avoids:

148 million tonnes of particulates

62 million tonnes of sulfur dioxide

8 million tonnes of nitrogen oxide



Clean, affordable and reliable energy



Responsibly managed freshwater



Boost to economic growth and jobs



Improved infrastructure and waterways



Community investments in rural areas



Avoiding pollutants and emissions



Enabling solar, wind and other renewables



Protecting from floods and drought



Enhancing cooperation between countries



Recreational activities and tourism





Hydel power in western Ghats

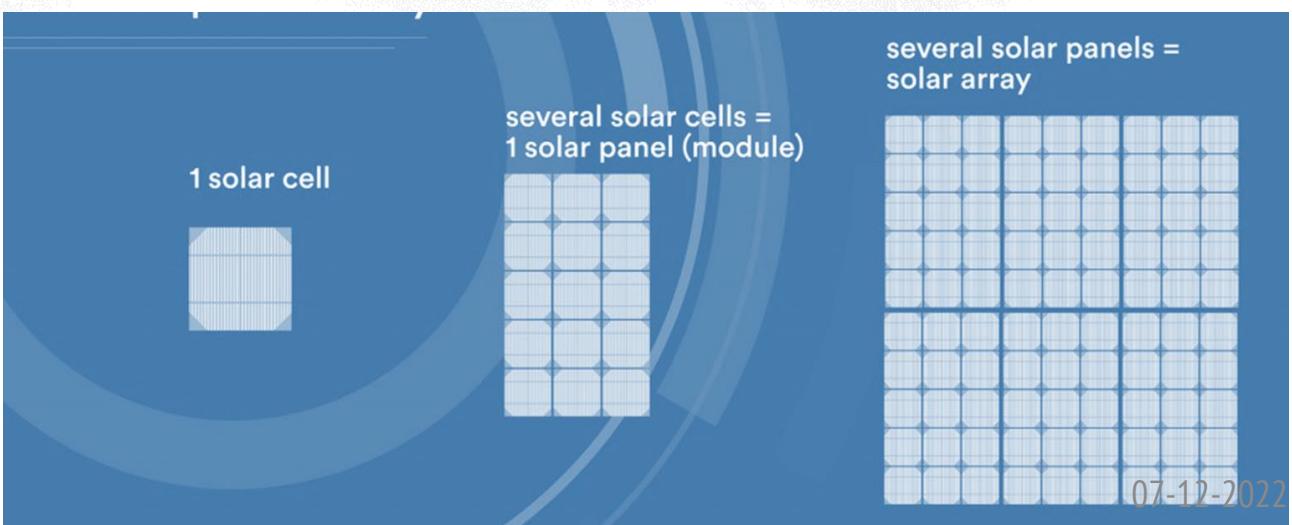
Solar energy

Solar power is energy from the sun that is converted into thermal or electrical energy.

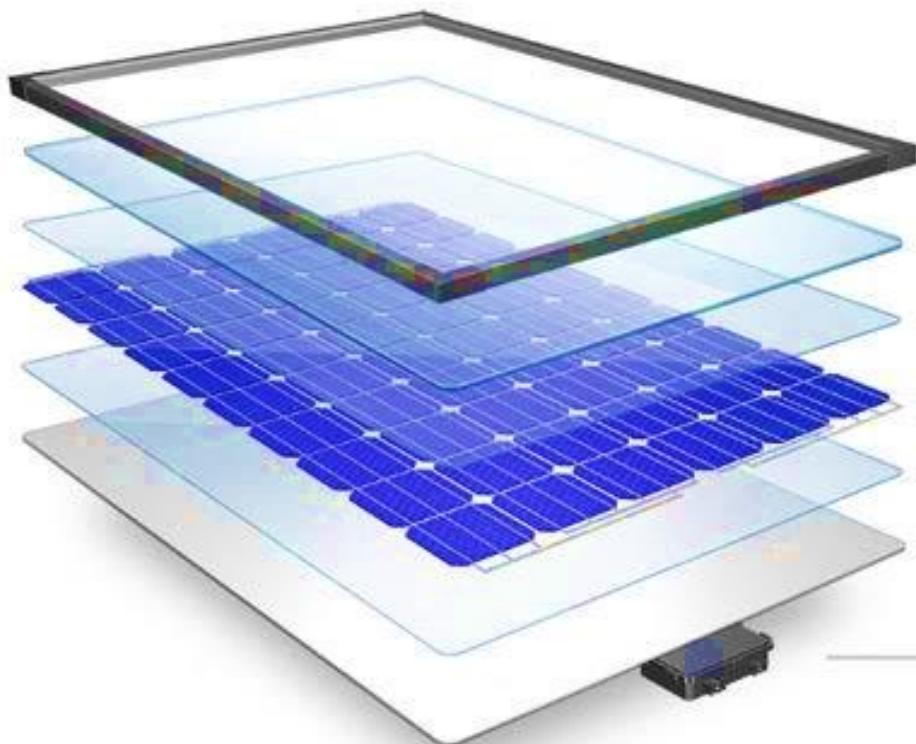




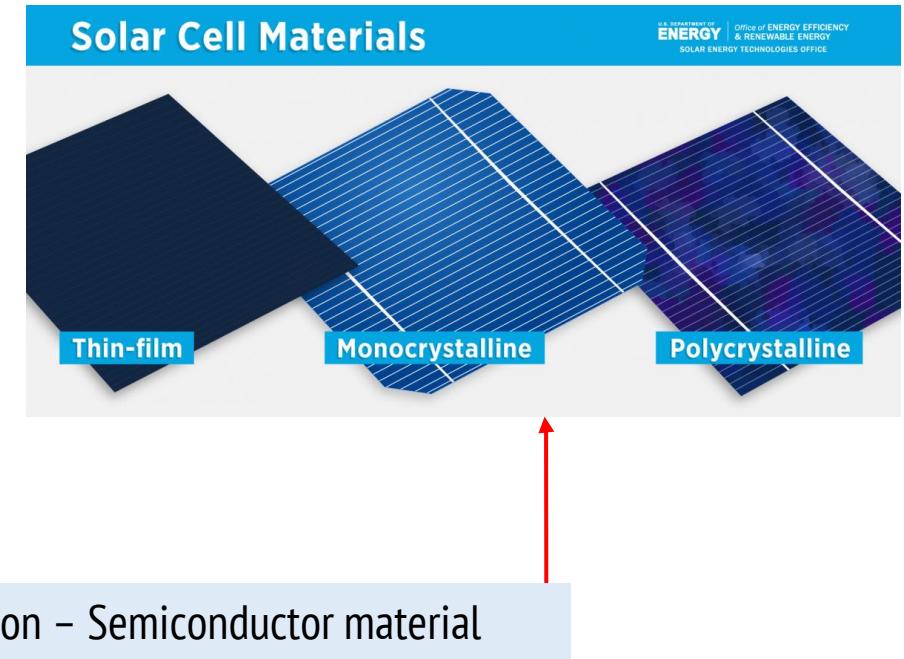
- ▶ **Cell**
- ▶ **Module**
- ▶ **Array**



Components of a solar panel



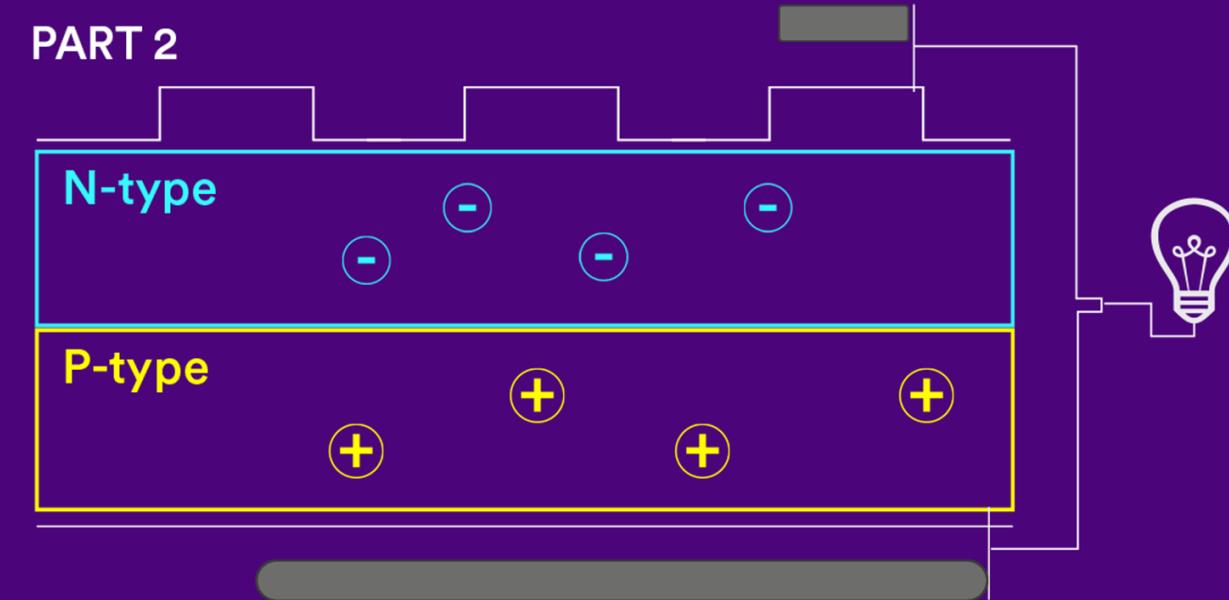
- Frame
- Glass
- Encapsulant
- Solar Cells — Silicon – Semiconductor material
- Encapsulant
- Backsheet
- Junction Box



Favours the flow of electrons

How does a solar cell work?

PART 2

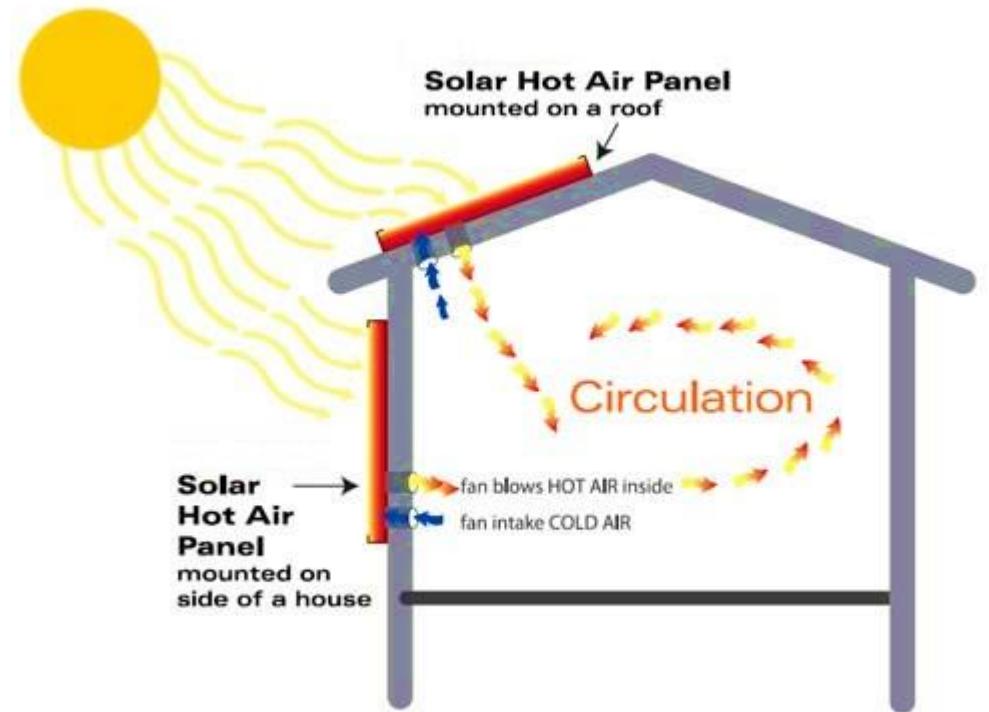


Favours the collection of positive charge

Source: <https://www.tonikenergy.com/blog/how-solar-cells-work/>

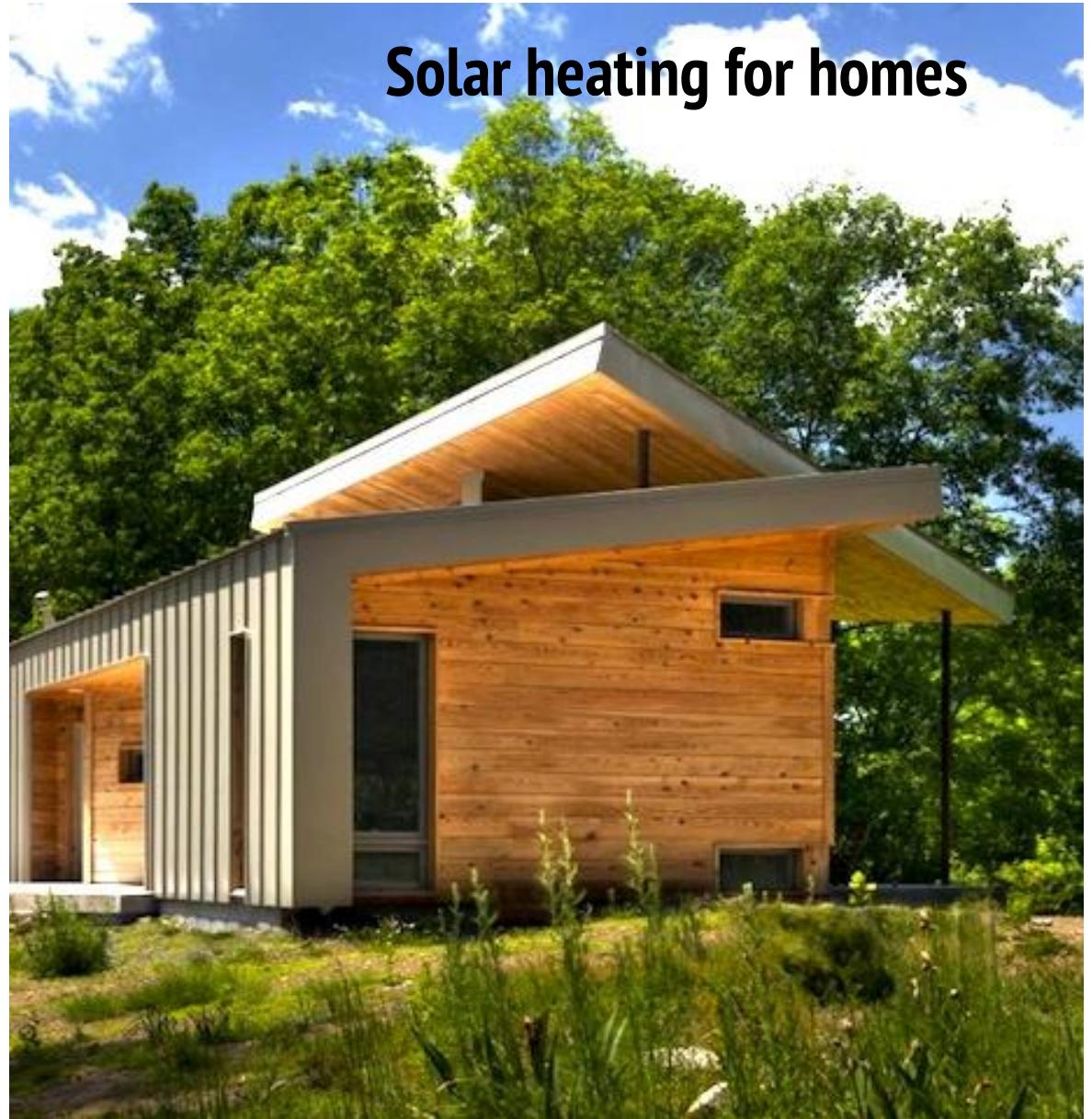
Different uses of solar energy

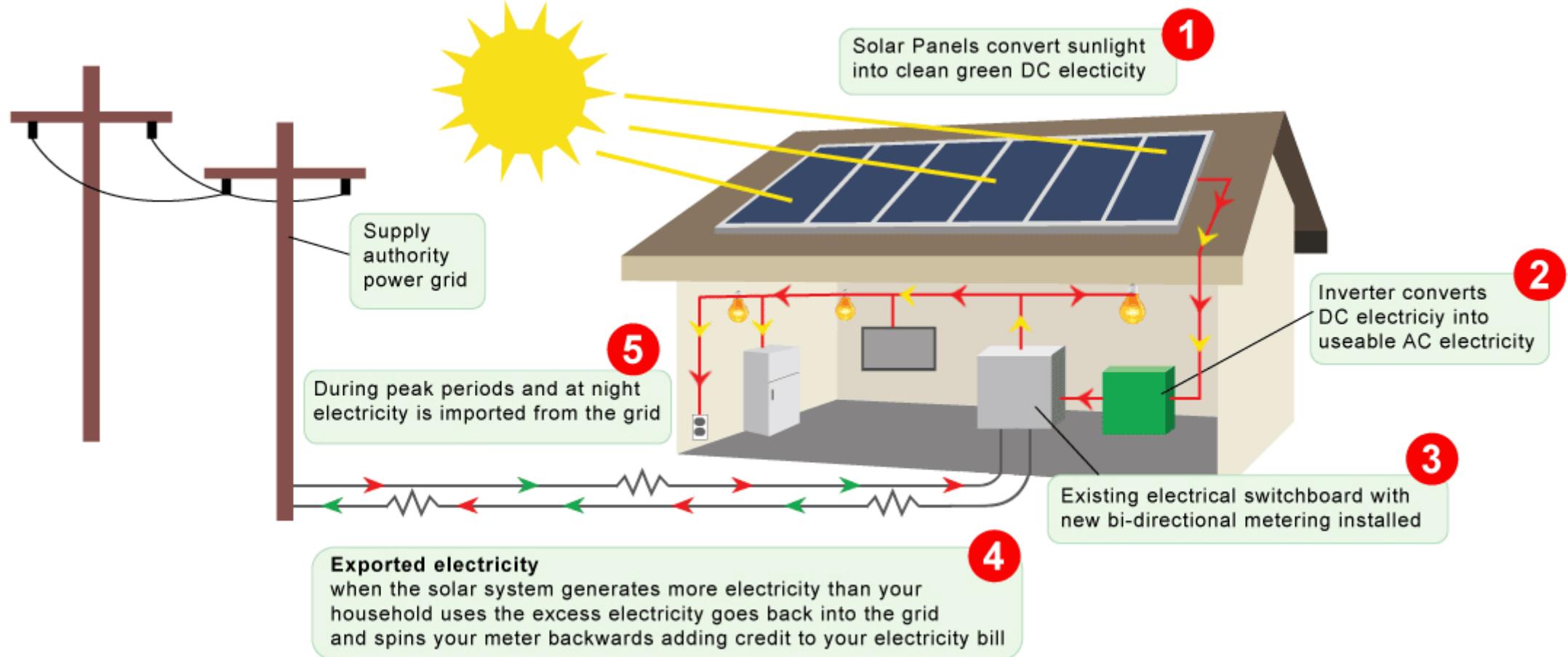
- ▶ Solar heating for homes
- ▶ Solar water heating
- ▶ Solar cookers
- ▶ Other solar powered devices





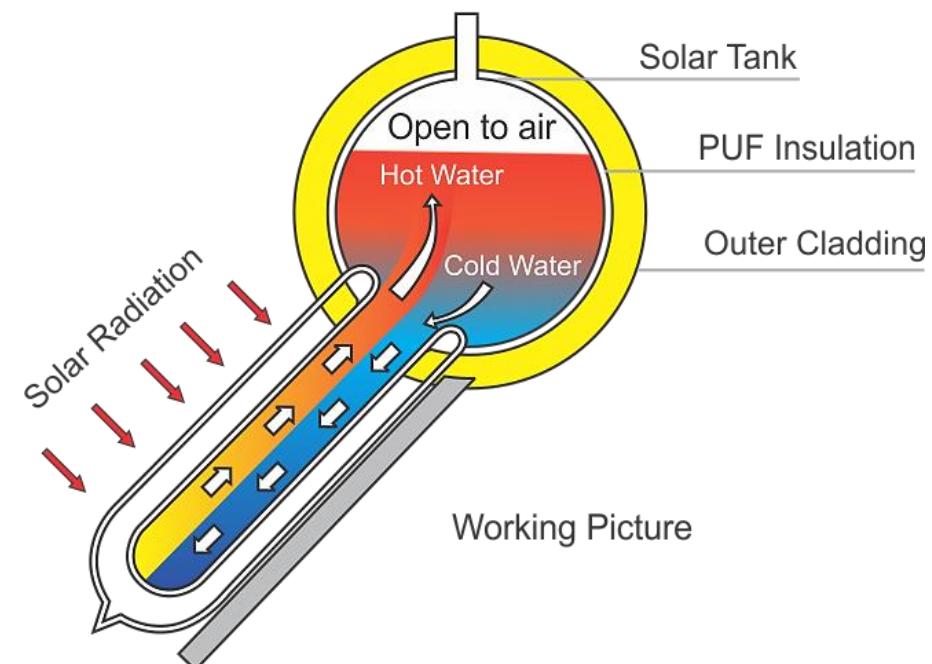
Solar heating for homes





Solar water heating

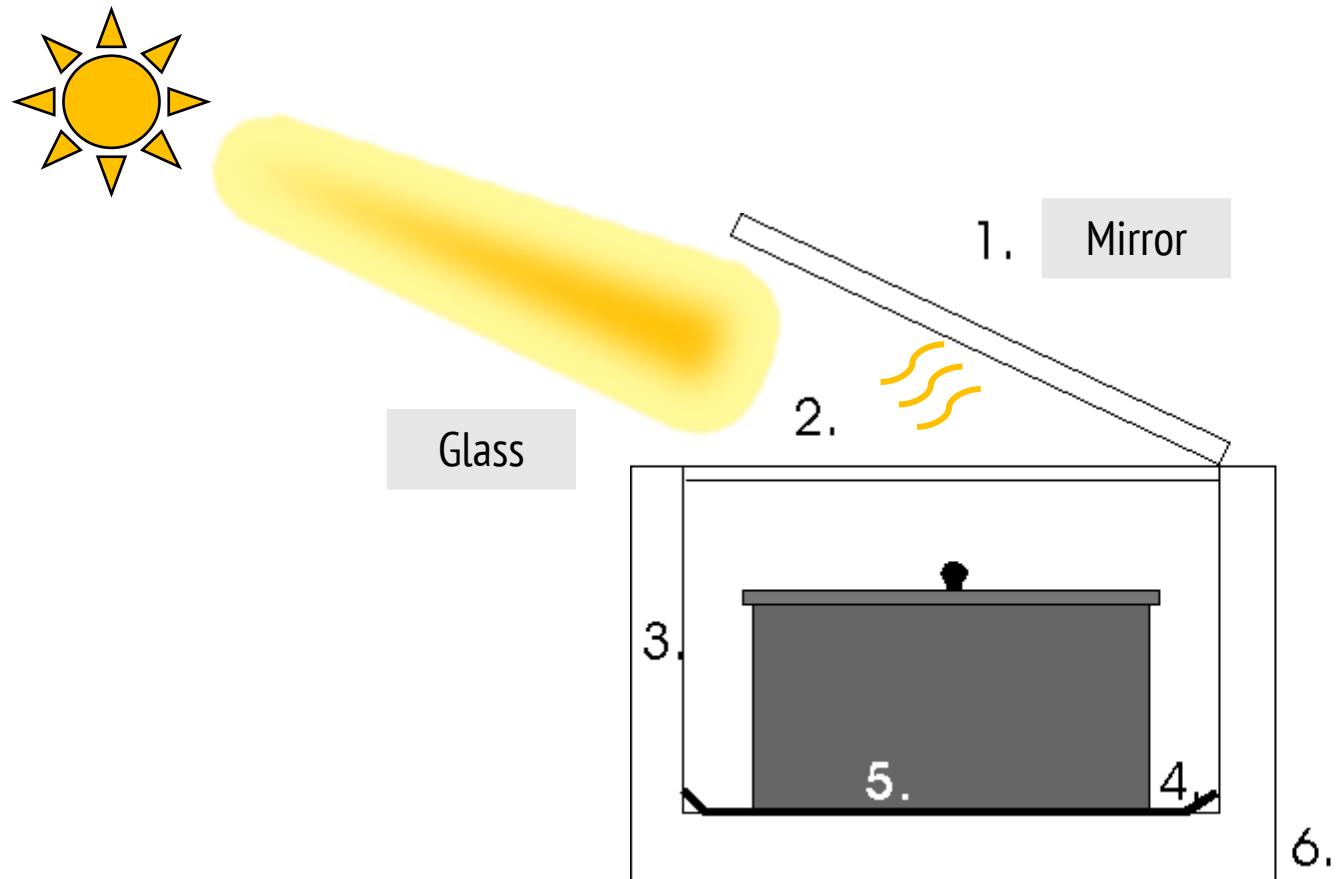
Works on the principle of thermosiphon effect



Source: <http://www.greenlifesolution.in/product/solar-water-heater/>

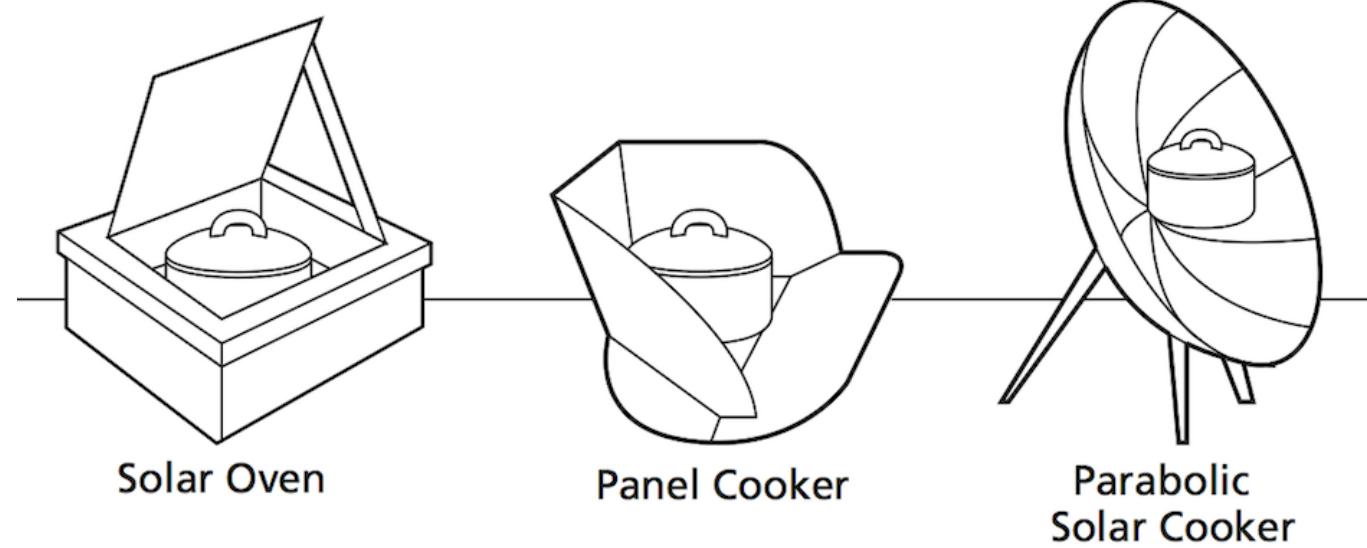
Solar cooker

Is a device that is used to cook food by utilizing the energy radiated by sun



1. Reflective lid
2. Transparent top cover
3. Insulation
4. Absorber plate
5. Cooking vessel
6. Body structure

Solar cookers



Tirupati



Other solar powered devices

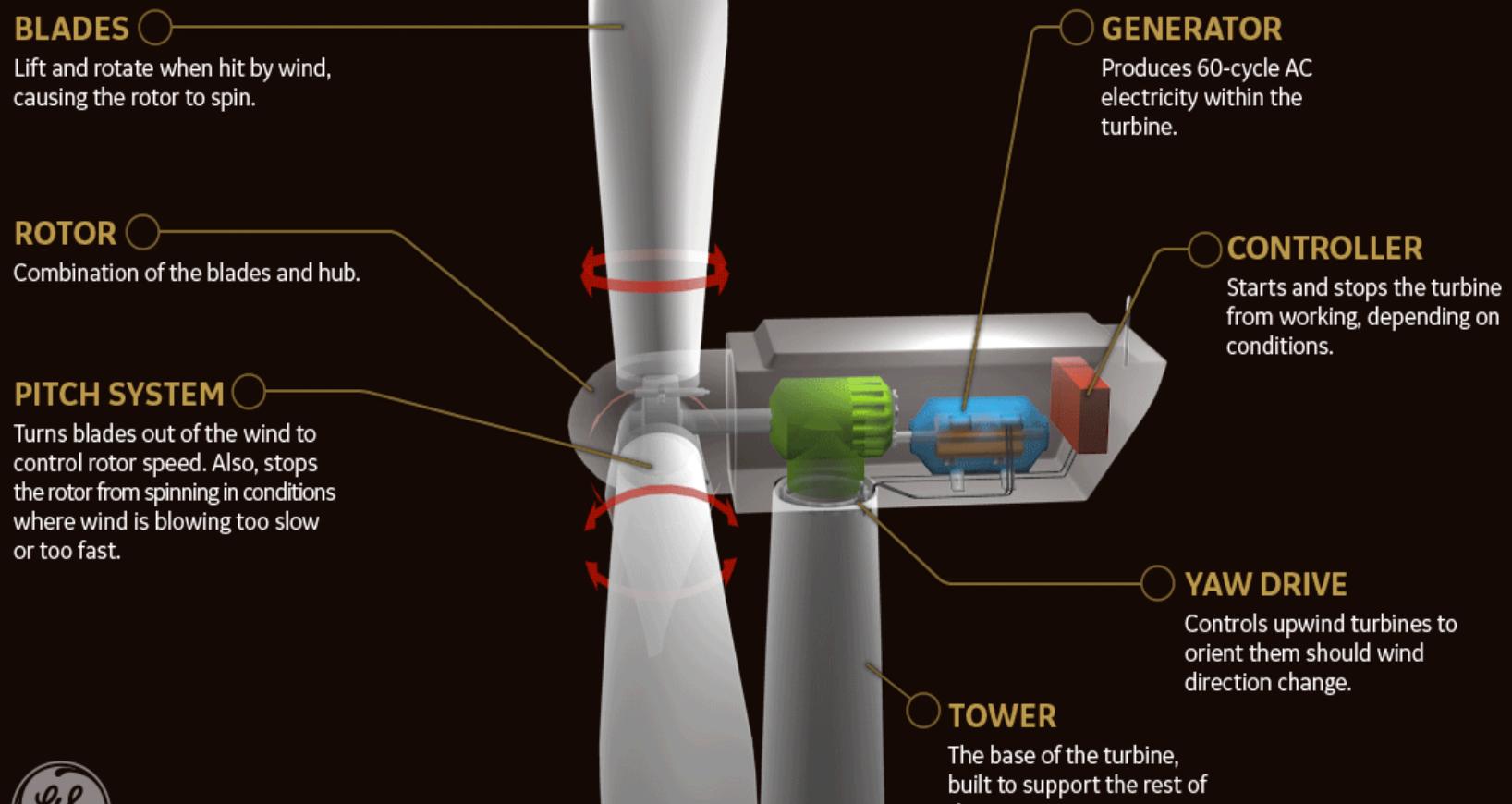


Wind energy

Wind is used to produce electricity using the kinetic energy created by air in motion - IRENA



GE WIND TURBINE



Types of energy involved

- ▶ Kinetic energy
- ▶ Mechanical energy
- ▶ Electrical energy

Source:

<http://www.mechanicaleducation.com/2019/03/wind-turbine-windmills-types.html>



Off-shore

On-shore



Top five countries with the highest wind energy capacity

China - 288.32 GW

United states - 122.32 GW

Germany - 62.85 GW

India - 38.63 GW

Global Wind Report 2021

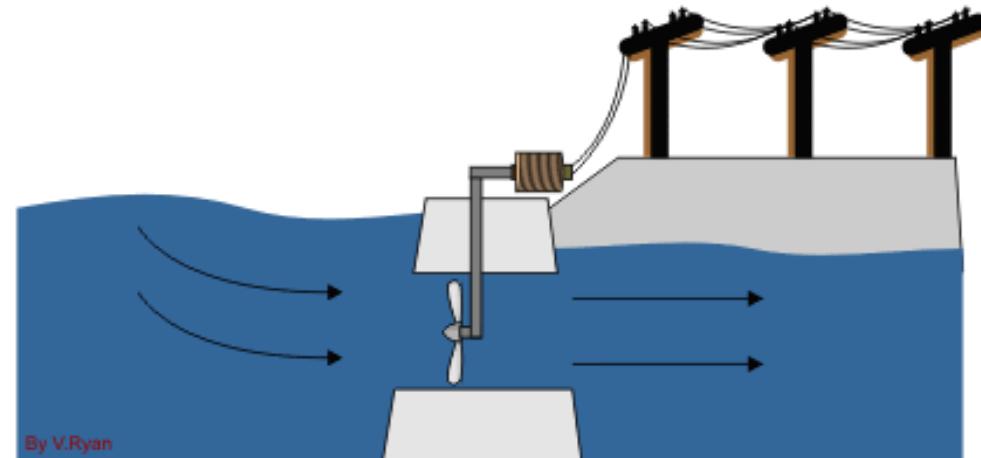
STATE	DEMONSTRATION PROJECTS (in MW)
ANDHRA PRADESH	5.4
GUJARAT	17.3
KARNATAKA	7.1
KERALA	2
MADHYA PRADESH	0.6
MAHARASHTRA	8.4
RAJASTHAN	6.4
TAMIL NADU	19.4
WEST BENGAL	1.1
OTHERS	3.3
TOTAL	71

STATE-WISE DEMONSTRATION WIND POWER PROJECTS

Source: <https://mnre.gov.in/wind>

Tidal power, also called tidal energy, is a form of hydropower that converts the energy of tides into electricity or other useful forms of power.

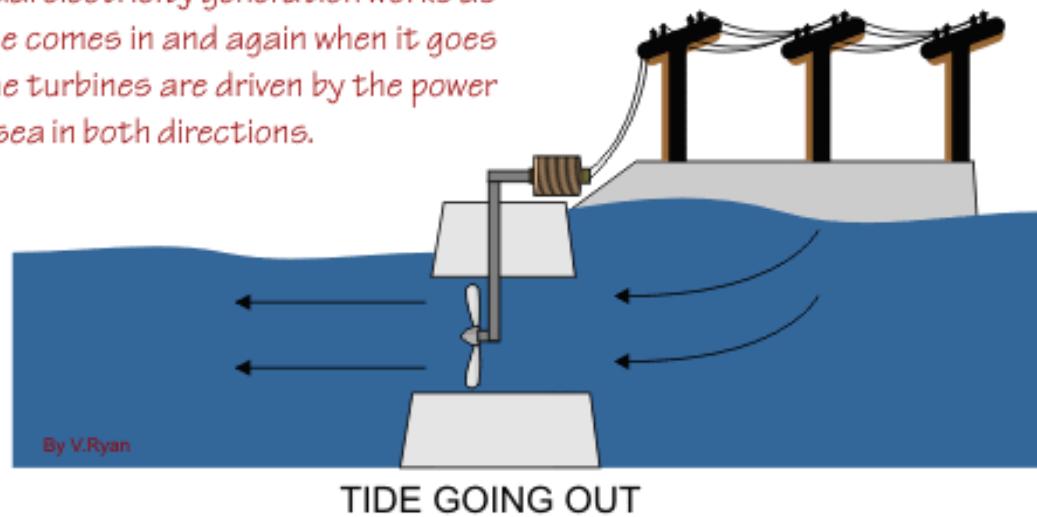
Tidal and wave power



By V.Ryan

TIDE COMING IN

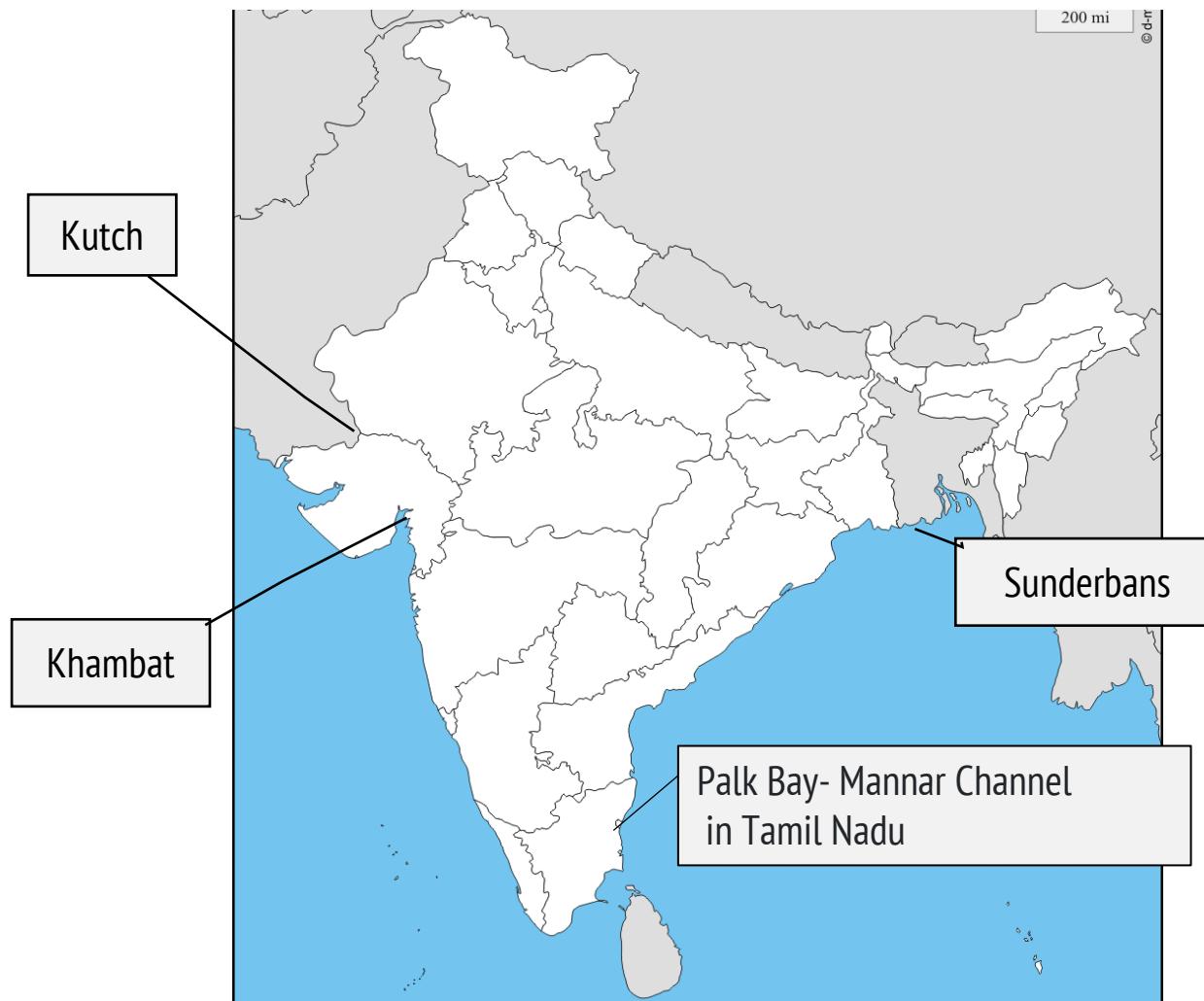
This tidal electricity generation works as the tide comes in and again when it goes out. The turbines are driven by the power of the sea in both directions.



By V.Ryan

TIDE GOING OUT

Tidal energy



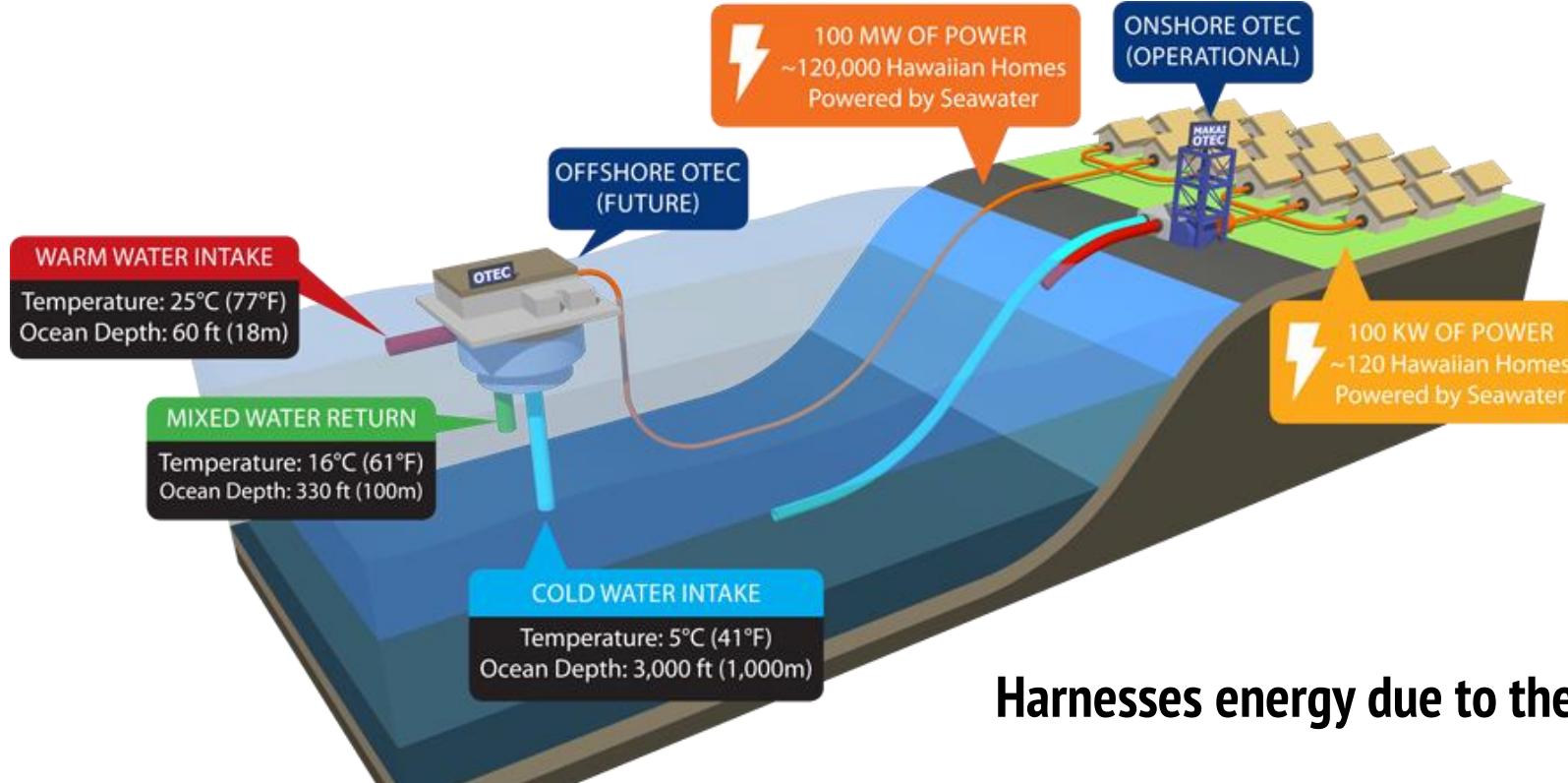
The tidal power potential is estimated at around 12,455 MW - December 2014

- ▶ Gulf of Khambat
- ▶ Gulf of Kutch & southern regions in Gujarat
- ▶ Palk Bay - Mannar Channel in Tamil Nadu and
- ▶ Hoogly river, South Haldia & Sunderbans in West Bengal.

High capital cost - Rs. 30 crore to Rs. 60 crore per MW

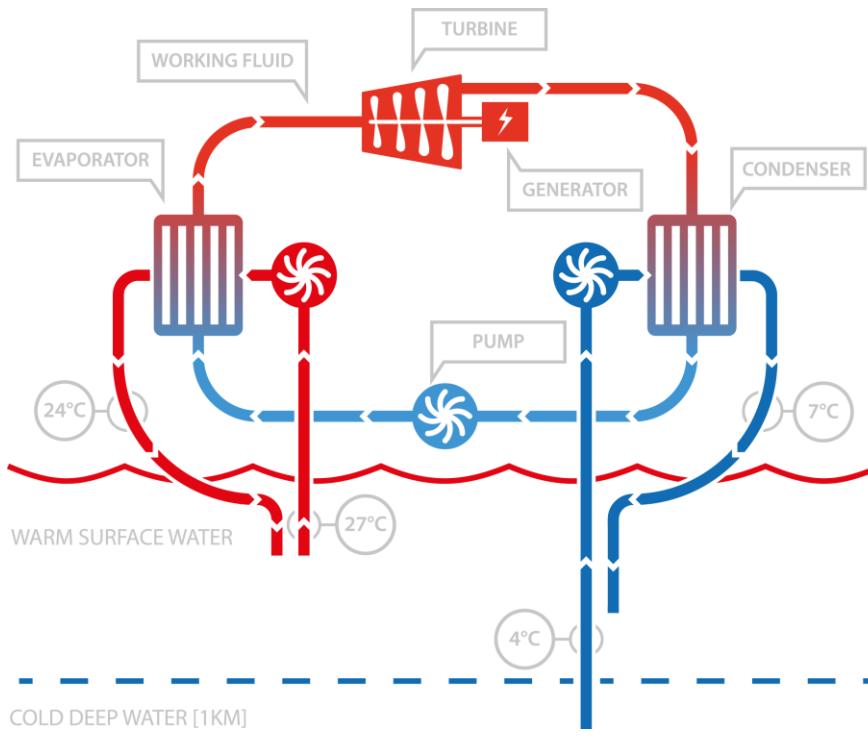
Source:: <https://mnre.gov.in/new-technologies/overview>

Ocean Thermal Energy Conversion (OTEC)



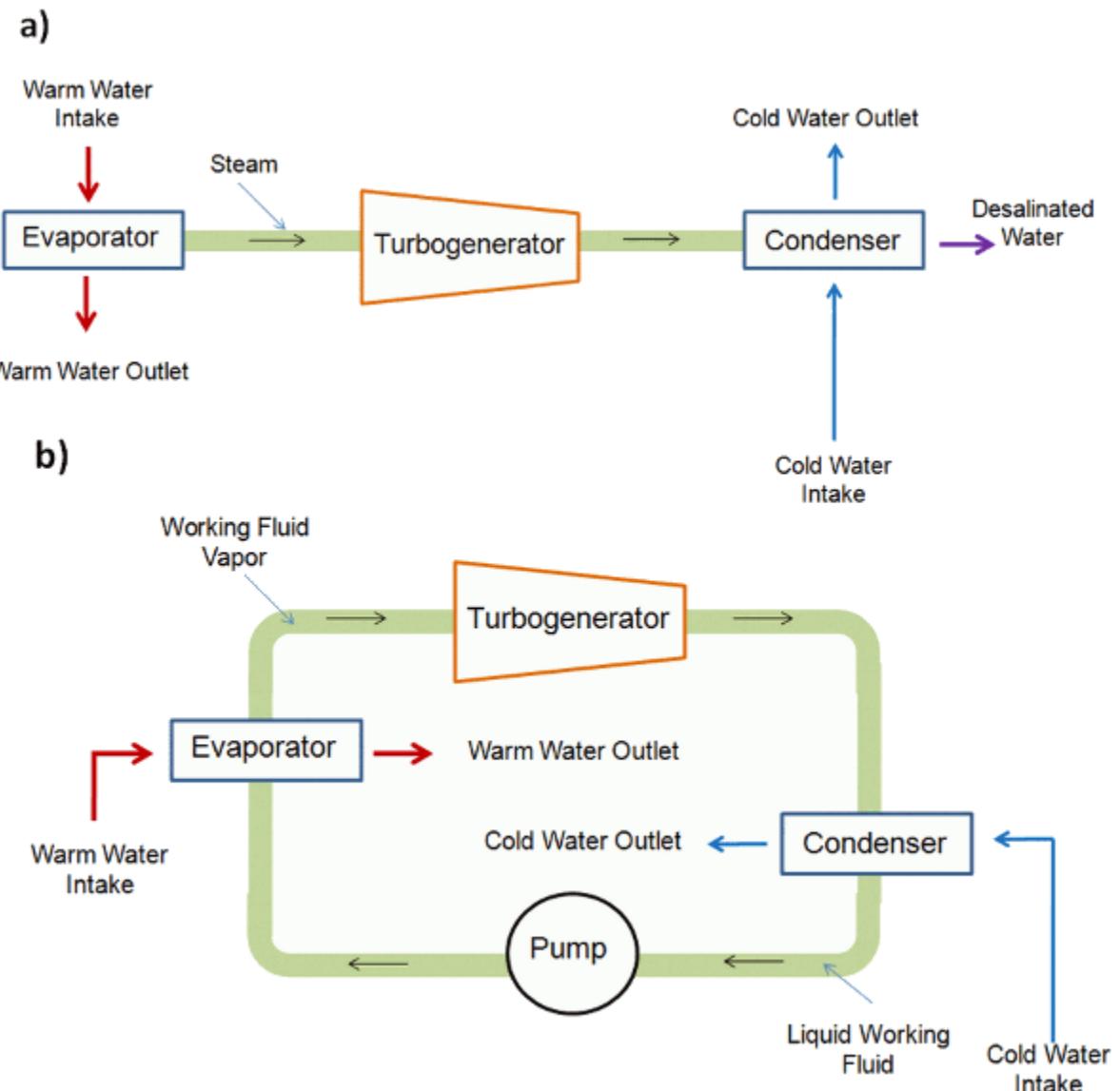
Harnesses energy due to the difference in the temperature

Department of Ocean Development - Tiruchendur



Working principle of OTEC

Sources: <http://large.stanford.edu/courses/2010/ph240/harrison2/>
<https://www.tudelft.nl/en/ocean-energy/research/thermal-gradient-otec/>

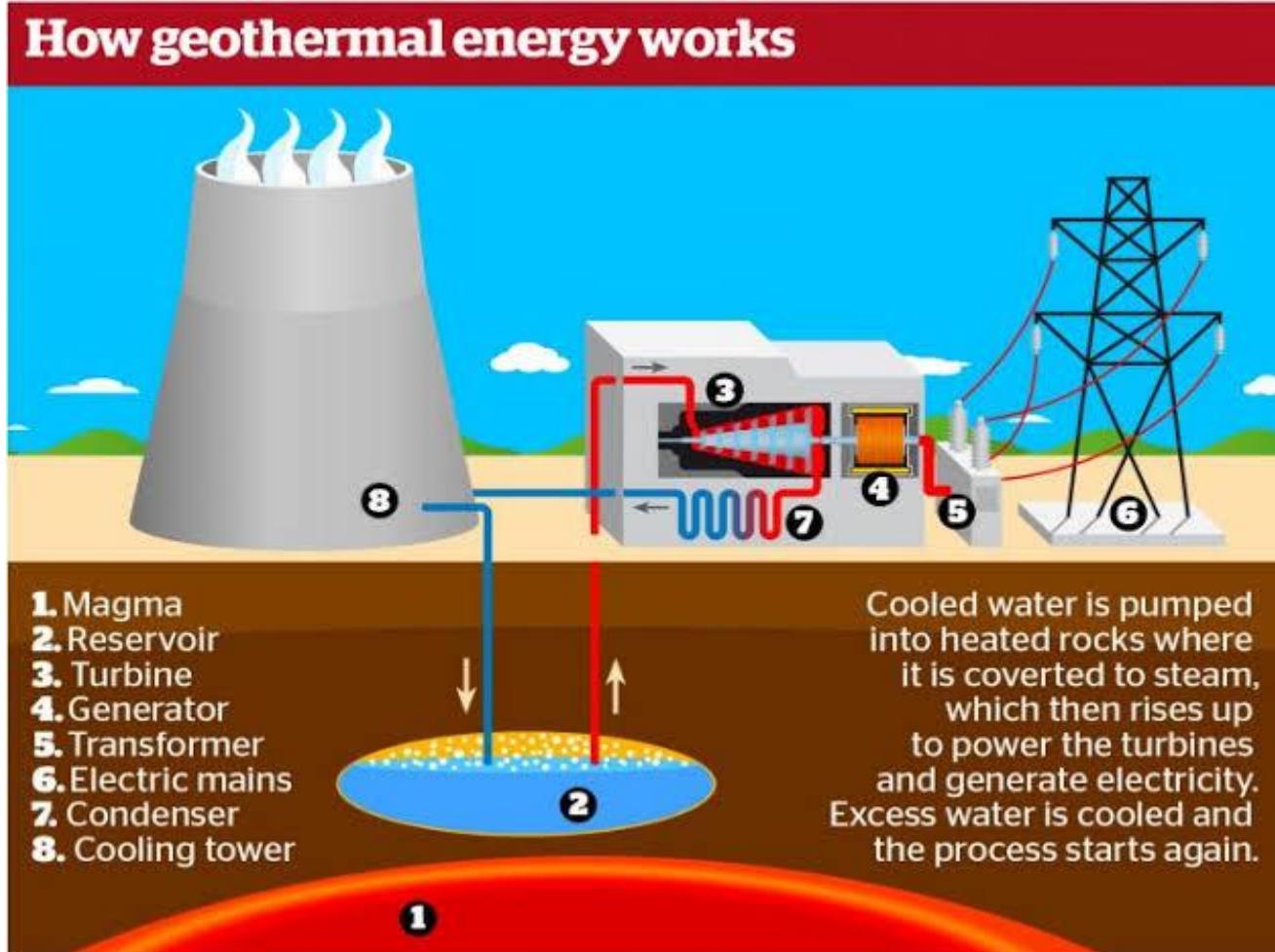


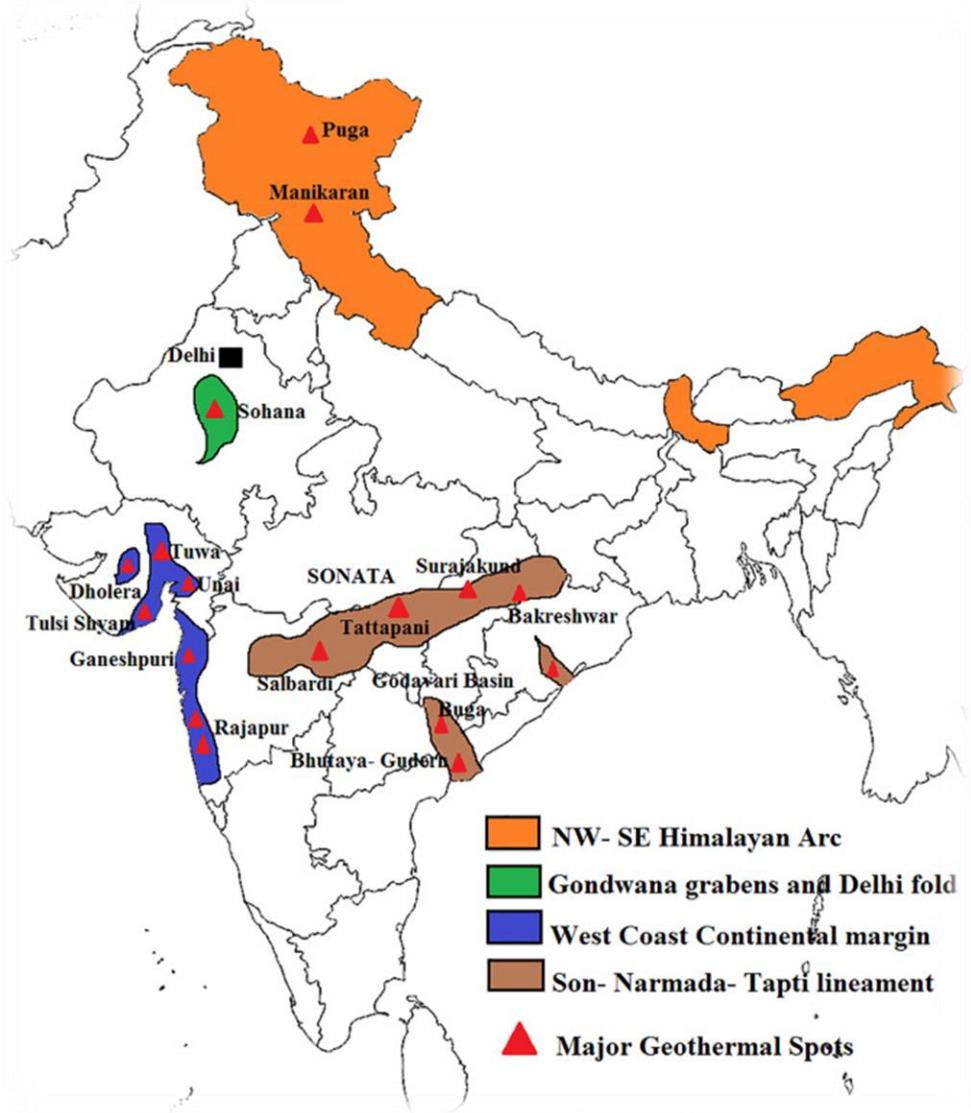
Schematics of (a) open cycle and (b) closed cycle OTEC systems.

Geothermal energy

Geothermal energy is heat derived within the subsurface of the earth.

Geothermal reservoirs





Source: Yadav et al., 2020

In India, by the time, geothermal energy installed capacity is experimental; however, the potential capacity is more than 10,000 MW



Biomass

Biomass energy

Biomass energy as called as 'Bioenergy' – Energy produced from organic matter –Feedstock.

Different feed stock different chemical composition – varying amounts of carbon, H₂O and organic volatiles.

Biomass conversion processes

Combustion – Feed stock burnt in presence of oxygen

Gasification – Syngas (instead of natural gas) – CO and H₂

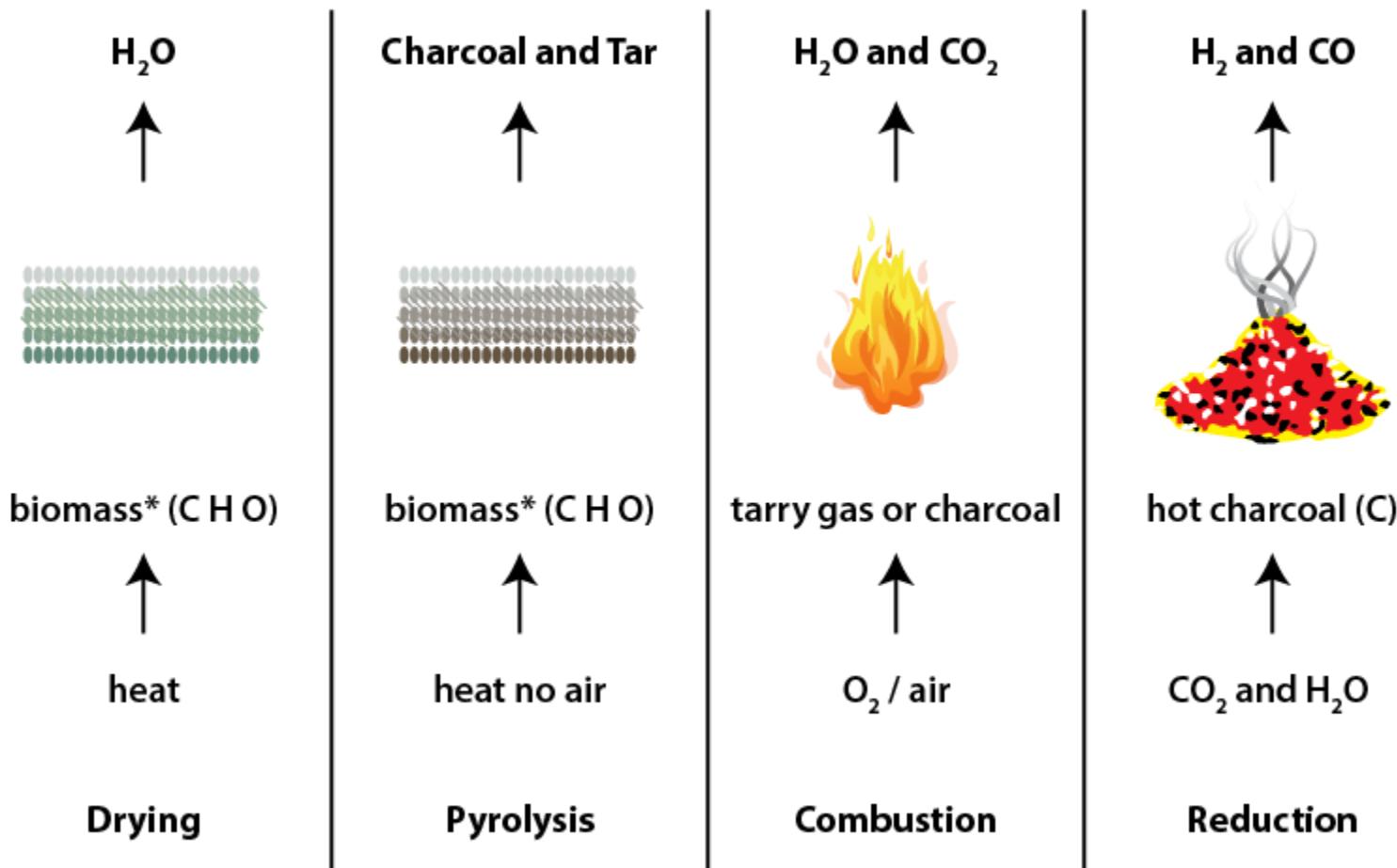
Pyrolysis – heating feedstock at high temperature in the absence of oxygen – Syngas, Bio-char and Bio-oil

Anaerobic digester – bacteria degrades the organic material – residue called as digestate

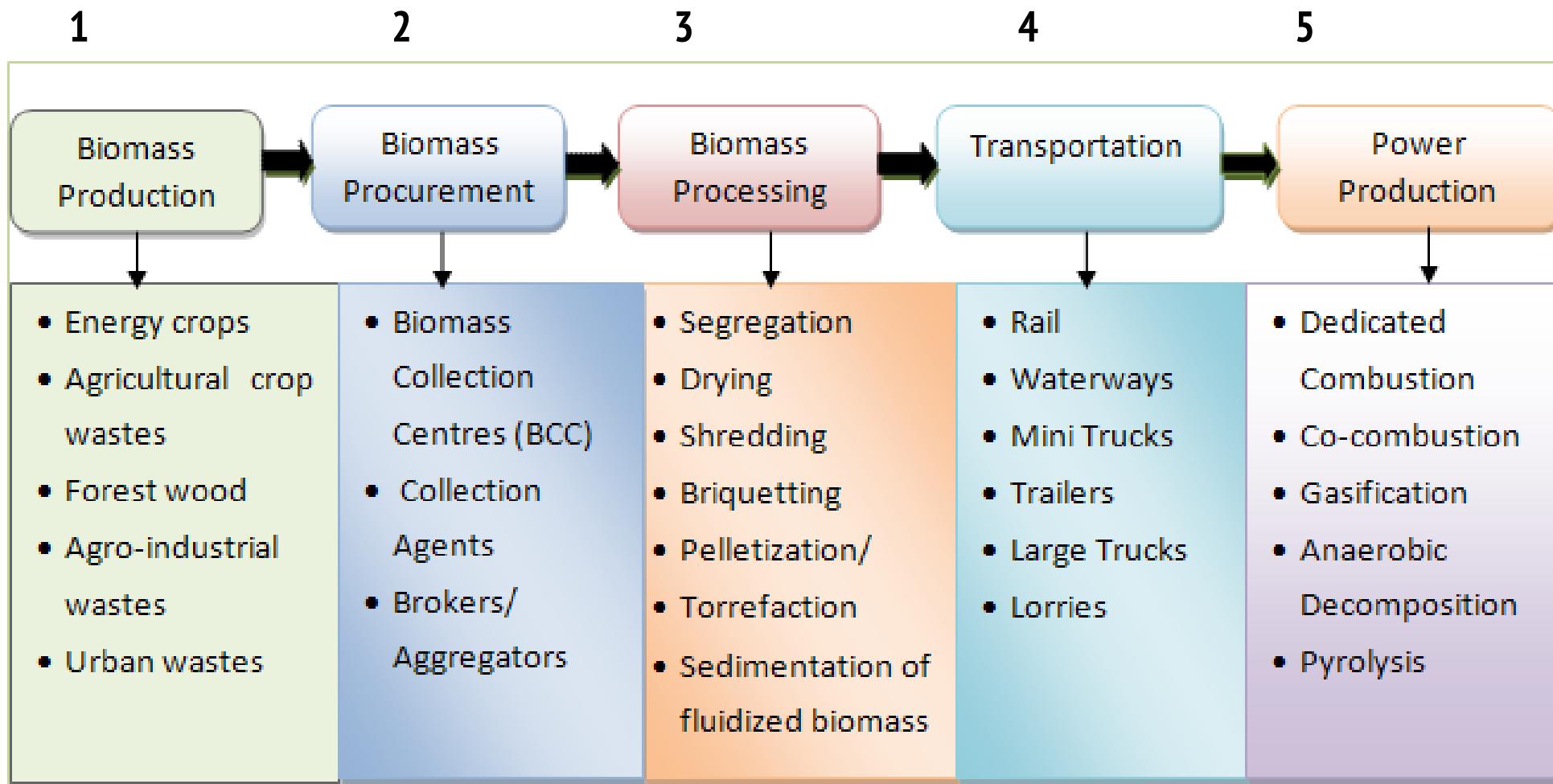
Fermentation – Glucose is converted to ethanol using Yeast.

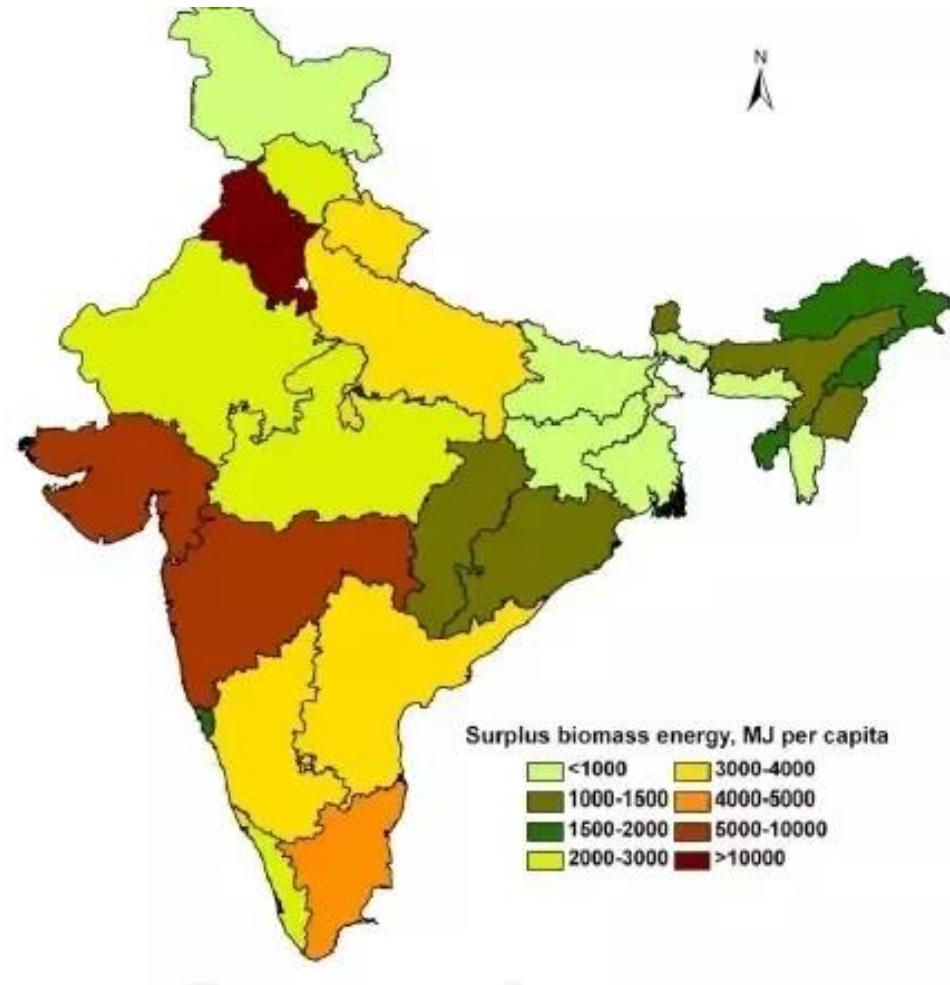
4 Processes in Gasification

not necessarily in order



* Biomass is a combination of C, H, and O (C H_{1.4} O_{0.6})





Biomass energy in India

Sugarcane



Pellets



Bagasse



Pros and Cons of renewable energy ?

ADVANTAGES

Renewable energy won't run out

Renewable energy has lower maintenance requirements

Renewables save money

Renewable energy has numerous environmental benefits

Renewables lower reliance on foreign energy sources

Renewable energy leads to cleaner water and air

Renewable energy creates jobs

Renewable energy can cut down on waste

DISADVANTAGES

Renewable energy has high upfront costs

Renewable energy is intermittent

Renewables have limited storage capabilities

Renewable energy sources have geographic limitations

Renewables aren't always 100% carbon-free

Role of an individual in the conservation of natural resources?

Reference

The images adopted in this lecture are from various sources of Google images.