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PREVENTION OF DROUGHT AND A STRATEGY FOR MITIGATING IT

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ABSTRACT:

When a region observes a deficit in its water supply, whether it is surface water or underground water, it is said to be experiencing a drought. Drought has destructive effects that extend well beyond the planet's arid regions. All continents are experiencing more frequent and severe droughts, which is a sign that freshwater and productive land will become increasingly scarce in the future. Extreme droughts can result in starvation, forced migration, and even armed conflict. The health of the current generation and future generations is a responsibility that every one of us must fulfil immediately and fully.Increased focus on drought mitigation techniques can lessen the frequency and severity of droughts , maintain crop production, and conserve resources that might otherwise be used for relief efforts.Scientific developments in climate forecasting, information and communications technology, and The spread of participatory democracy offer enormous opportunities to develop an effective system for monitoring and managing drought. These include developing drought forecasting systems, Outlininglocation specific crop contingency plans, putting timely relief programmes into place, and concentrating on Longterm drought proofing programmes like watershed development, water harvesting, etc.

Keywords: Drought, Rainfall, Drought Indicator, impact of drought, drought mitigation.

1. INTRODUCTION:

In India, there are often periods of minimal precipitation or monsoon failure. Due to this, famine and drought have occurred. The term "drought" typically refers to a region's lack of water. Aridity is a permanent feature of the climate and the result of several long-term processes, even though droughts and aridity are both caused by a lack of water.
Drought is caused by land degradation and the climate catastrophe; it is not merely the absence of rain. A drought may be declared after only 15 days or it may linger for months or even years. Typically, this happens when a region consistently experiences precipitation levels below average.
According to Ramdas (1960) drought is a situation when the actual seasonal rainfall is deficient by more than twice the mean deviation.
American meteorological society defined drought as a period of abnormally dry weather sufficiently prolonged for lack of water to cause a severe hydrological imbalance in the area affected.

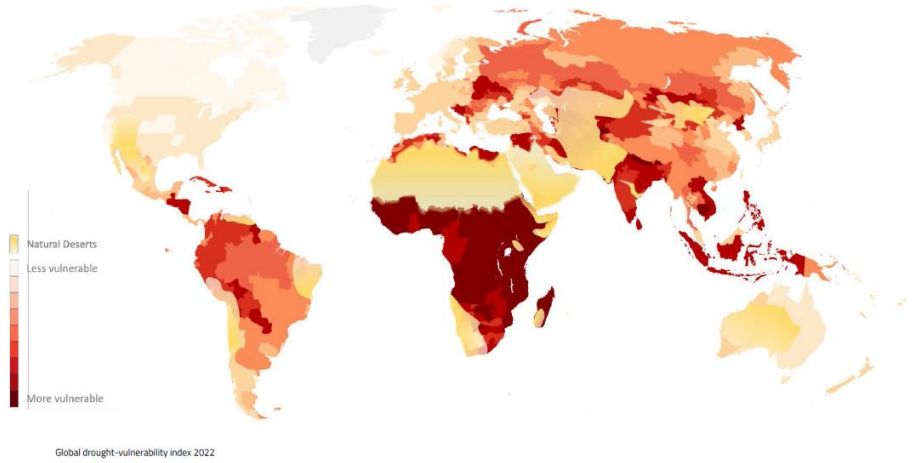
2. LITERATURE REVIEWS:

2.1. DROUGHT AROUND THE WORLD (1900-2022)

• Major drought occurrences caused more than 10 million deaths and hundreds of billions of dollars in economic losses during the course of the last century (Guha-Sapir, D. et al., 2021).
• With almost 300 incidents reported in the last 100 years, Africa has experienced severe drought more frequently than any other continent, making up 44 percent of the global total. The devastating effects of climatic disasters becoming more regular and intense have most recently been felt in sub-Saharan Africa (Taylor et al., 2017; Guha-Sapir, D. et al., 2021).
•In the past century, 45 major drought events occurred in Europe, affecting millions of people and resulting in more than USD 27.8 billion in economic losses. Today, an annual average of 15 percent of

the land area and 17 percent of the population within the European Union is affected by drought (Guha-Sapir, D. et al., 2021; European Environment Agency, 2017)
•In the U.S., crop failures and other economic losses due to drought have totalled several hundred billion USD over the last century – USD 249 billion alone since 1980 (NOAA-NCEI, 2021)
• Over the past century, the highest total number of humans affected by drought were in Asia (Guha-Sapir, D. et al., 2021)

Fig No.1 Global Drought Vulnerability Index 2022.



Source: United Nation Convention to Combat Desertification Drought report

Table no 1: Drought Factors& Duration.

	Particulars	Aridity	Drought
1	Duration	Permanent Feature	Situation Of Short-Term Shortage With Variable Length
2	Factors	Conclusion Of Numerous Lengthy Processes That Take Into Account All Climatic Features	Resulting From Inadequate Rainfall
3	Aspect Described	Description Of Climate	The Availability Of Water Is Described

Source: drought manual

2.2. INDIA DROUGHT CONDITION:

Nearly two-thirds of the country experienced drought from 2020 to 2022, affecting 57% of the country after 1997 drought areas.
Uttar Pradesh received 44 percent less rain than normal as of August 16.
Bihar Jharkhand west Bengal=30%less rainfall than usual
Main cause of drought =precipitation deficiency
Over the last decade, one-third of India's districts have experienced more than four droughts, and drought affects 50 million people each year.

Table 2: Drought Years in the Past Centuries.

Drought years in the past centuries.

Period	Drought years	Number of years
1801 - 1850	1801, 04, 06, 12, 19, 25, 32, 33, 37	9
1851 - 1900	1853, 60, 62, 66, 68, 73, 77**, 91, 99**	9
1901 - 1950	1901*, 04, 05*, 07, 11, 13, 15, 18**, 20, 25, 39, 41*	12
1951 - 2003	1951, 65*, 66, 68, 72**, 74, 79*, 82, 85, 87**, 2002*	11

*Indicates severe drought (>39.5% area affected), ** Phenomenal drought year (> 47.7% area).

Source: India drought manual

Table 3: Probability of Occurrence of Drought in Different Meteorological Sub Divisions

Probability of occurrence of drought in different meteorological sub division.

Meteorological sub division	Frequency of deficient rainfall (75% of normal or less)
Assam	Very rare, once in 15 years
West Bengal, Madhya Pradesh, Konkan, Bihar and Orissa	Once in 5 years
South Interior Karnataka, Eastern Uttar Pradesh and Vidarbha	Once in 4 years
East Rajasthan, Gujarat and Western Uttar Pradesh	Once in 3 years
West Rajasthan, Tamil Nadu, Jammu & Kashmir and Telangana	Once in 2.5 years

Source: India drought manual

2.2.1. **INFERENCE:**

Among the many drought events since Independence, the one in 1987 was one of the worst, with an overall rainfall deficiency of 19% which affected 59–60% of the normal cropped area and a population of 285 million.

This was repeated in 2002 when the overall rainfall deficiency for the country as a whole was 19%. Over 300 million people spread over 18 States were affected by drought along with around 150 million cattle.

In 2009, the overall rainfall deficiency for the country as a whole was 22%, which resulted in decrease of food grain production by 16 million tonnes. Source: Samra, 2004; NRAA, 2012, DAC&FW data

Table 4: Seasonal Distribution of Rainfall in India

Season	Period	Percentage of Distribution
Pre-monsoon	March-May	10.4
South-west monsoon	June-September	73.4
Post-monsoon (Northeast Monsoon)	October-December	13.3
Winter rains	January-February	2.9

Source: India Meteorological Department, Government of India.

Source: India meteorological department, government of India.

Month-wise All India Rainfall Distribution (Percentage departure for the country as a whole in recent major drought years.

Table: 5 month-wise all India rainfall distribution major drought year.

Year	June	July	August	September	June-Sept
1972	-27	-31	-14	-24	-24
1979	-15	-16	-19	-28	-19
1987	-22	-29	-4	-25	-19
2002	+4	-51	-4	-10	-19
2009	-47	-4	-27	-20	-22
2014	-42	-10	-10	+8	-12
2015	+16	-16	-22	-24	-14

Source: India Meteorological Department

By limiting opportunities for the recharge of surface and ground water resources, replenishment of soil moisture, and recovery of agriculturists' financial capacity to make investments in agricultural operations, poor rainfall in succeeding years tends to exacerbate the negative effects of drought.

2.3. TYPES OF DROUGHT:

According to its length, the type of user & the time it occurs drought can be classed.

2.3.1. BASED ON DURATION:

A. **PERMANENT DROUGHT**: This is characteristic of the desert climate where sparse vegetation growing is adapted to drought and agriculture is possible only by irrigation during entire crop season.

B. **TEMPORARY DROUGHT:** this is found in climates with well-defined rainy & dry season.

2.3.2. BASED ON RELEVANCE TO THE USERS

Meteorological	Hydrological	Agricultural
1) A Meteorological Drought Is When There Has Been A Sustained Decrease In Precipitation Compared To The Norm. The Other Kind Of Drought Frequently Follows A Drought Caused By The Weather 2whether The Amount Is Inadequate In A Specific Year Or That Condition Is Related To The Amount Of Rainfall Received. 3) In India Long Average Annual Rainfall =1194mm (1jan-31 Dec). 4) Most Of The Rainfall In Our Country (India) June To Sept =880 Mm (73-75).	1) A Hydrological Drought Occurs When Water Reserves In Resources Like Aquifers, Lakes, And Rivers Are Lower Than The Statistical Norm. Hydrological Droughts Typically Develop More Gradually Because They Require The Use Of Water That Has Been Stored Previously But Has Not Been Restored. 2) Due To The Usage Of Stored Water That Is Not Replaced, Hydrological Droughts Typically Manifest More Gradually.	1)Soil Moisture +Rainfall=Agriculture Drought 2) This Condition Varies From Crop Varies For Example Rice = 600mm Water And This Quantity Is Sufficient For Maize, Pearl Millet, Sorghum, ▪ Depends Upon Of Nature Of Crop. ▪ Soil Characteristic. ▪ The Frequency Of Dry Period (Arid Or Semi-Arid Region) ▪ Erratic Behaviour Of Monsoon(Early Withdraw , Late) ▪ Insufficient Rainfall 3) Those droughts that affect crop production or range ecology are categorised as "agricultural" droughts. Regardless of any change in precipitation level, this state can also arise when soil conditions and erosion caused by improperly planned agricultural endeavours result in a lack of water available to the crop. Even yet, a drought usually develops after a protracted period of below average precipitation.

Table 6: Drought Declaration Condition.

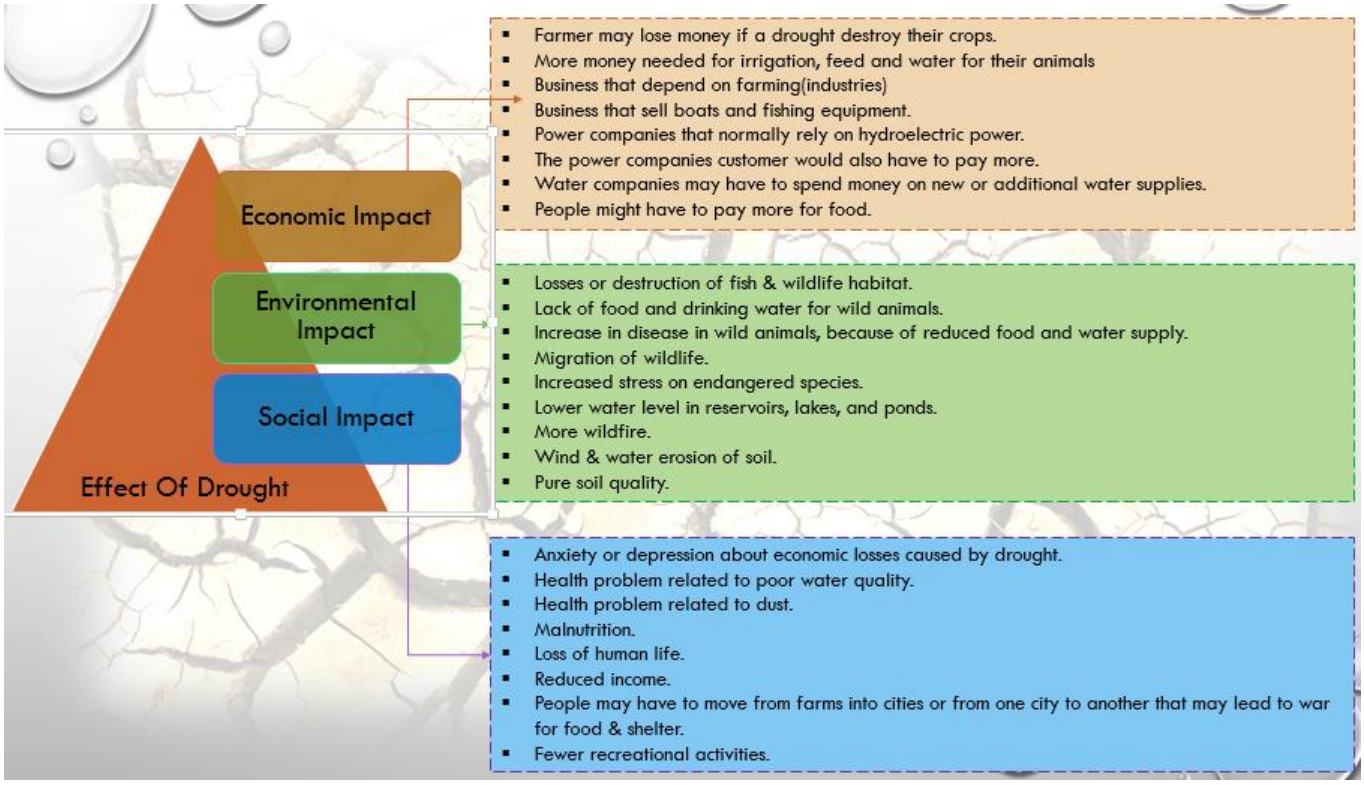
S. .No	Deficient of 880mm (vary area to area)	Drought
1	Less than 25%	No drought
2	26-50%	Moderate drought
3	More than 50 %	Severe drought

Source: India Drought Manual

2.3.3. BASED ON TIME OF OCCURRENCE:

EARLY SEASON DROUGHT	MID SEASON DROUGHT	LATE SEASON DROUGHT
It occurs due to delay in onset of monsoon or due to long dry spells after early sowing.	Occurs due to long gap between two successive rains and stored moisture becoming insufficient during the long dry spell.	Occurs due to early cessation of rainfall and crop water stress at maturity stage.

2.4 . EFFECT OF DROUGHT:



2.5. KEY DROUGHT INDICATORS:

2.5.1 RAINFALL:

- The IMD (India Meteorological Department) and State Governments collect data on rainfall every day during the rainy season.
- **The actual rainfall is compared with the Long-Term Average (LTA), which has been standardized on a daily, weekly, and monthly basis.**
- **Such a comparison provides information on the deficit or excess of rainfall in a particular sub-division for a certain period.**

2.5.2. Storage Water Levels in Reservoirs:

- State Governments collect data on the levels of stored water in important reservoirs through their Irrigation Departments.
- Reservoir storage level is a useful indicator of water shortages.
- The **Central Water Commission** maintains data on water levels in **81 important reservoirs** of the country, where the water storage is compared with the Full Reservoir Level (FRL).

2.5.3. Surface Water and Groundwater Level

- Groundwater levels are also affected due to poor recharge, either due to lack of adequate rainfall or poor water conservation practices.
- Declining groundwater levels are important indicators of drought conditions, though these are often attributed to over-extraction of water. An annual decline in the water table of up to 2 meters is considered normal
- A decline of up to 4 meters is a cause for concern and above 4 meters is a stressful situation.
- The Central Ground Water Board (CGWB), with over 15,000 hydrograph stations across the country, is responsible for monitoring India's groundwater. Monitoring, usually done four times a year, is essentially a recording of the response of the groundwater system to natural and artificial conditions or recharge and discharge

2.5.4. Sowing and Crop Conditions:

- An important indicator of drought is the total area sown.
- The State Government agriculture department provides information on sowing on a weekly basis. A delayed sowing shows rainfall deficiency and indicates the onset of drought.

2.6. DROUGHT TRIGGERS:

According to Steinemann and Cavalcanti (2006), triggers are particular values of indicators that govern the time and scope of activities taken in response to drought circumstances. Based on a single drought indicator or a combination of drought indicators, droughts are often classified as "mild, moderate, severe, or extreme drought" or "level 1, level 2, or level 3 drought." The Famine Early Warning Systems Network (FEWS-NET), which concentrates on the effects of prolonged dry spells, has a more complex strategy (Figure). Each type of drought incidence and impact will have a different set of response triggers.

Figure 2: The Famine Early Warning Systems Network uses the area-based Integrated Phase Classification Version 2.0 to categorise famine.

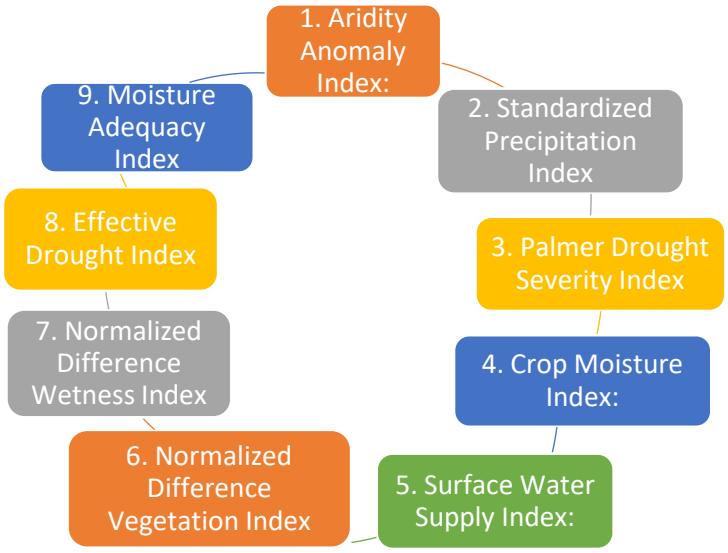
	Phase 1 Minimal	Phase 2 Stressed	Phase 3 Crisis	Phase 4 Emergency	Phase 5 Famine
Phase Name and Description	More than four in five households (HHs) are able to meet essential food and non-food needs without engaging in atypical, unsustainable strategies to access food and income, including any reliance on humanitarian assistance	Even with any humanitarian assistance at least one in five HHs in the area have the following or worse: Minimally adequate food consumption but are unable to afford some essential non food expenditures without engaging in irreversible coping strategies.	Even with any humanitarian assistance at least one in five HHs in the area have the following or worse: Food consumption gaps with high or above usual acute malnutrition **OR** Are marginally able to meet minimum food needs only with accelerated depletion of livelihood assets that will lead to food consumption gaps.	Even with any humanitarian assistance at least one in five HHs in the area have the following or worse: Large food consumption gaps resulting in very high acute malnutrition and excess mortality **OR** Extreme loss of livelihood assets that will lead to food consumption gaps in the short term.	Even with any humanitarian assistance at least one in five HHs in the area have an extreme lack of food and other basic needs where starvation, death, and destitution are evident. (Evidence for all three criteria of food consumption, wasting, and CDR is required to classify Famine.)
Priority Response Objectives	Action required to Build Resilience and for Disaster Risk Reduction	Action required for Disaster Risk Reduction and to Protect Livelihoods	Urgent Action Required to: → Protect livelihoods, reduce food consumption gaps, and reduce acute malnutrition	Save lives and livelihoods	Prevent widespread mortality and total collapse of livelihoods

Source: http://www.fews.net/IPC

2.6. DEVELOPING A COMPOSITE INDEX:

The number of indices to measure the intensity, duration, and spatial extent of drought. It is useful to also refer to these scientific indices for monitoring drought situations at the National and State levels.

Figure No.3: Composite Index.



Source: modified from India drought manual2016, 2020.

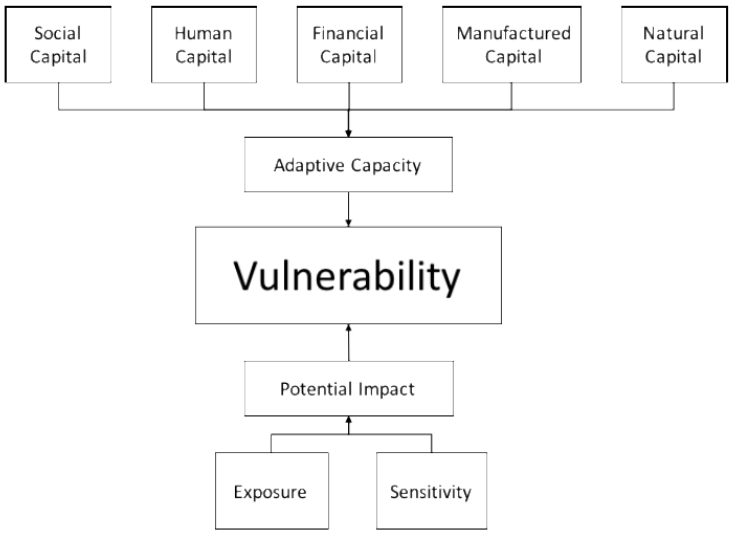
2.7. DROUGHT VULNERABILITY:

The climate change adaptation and mitigation scientific literature abounds with vulnerability frameworks. A popular formula for calculating vulnerability is:

Vulnerability (V) = Exposure (E) + Sensitivity (S) – Adaptive Capacity (AC).

A wide range of elements, such as social, economic, physical, environmental, and institutional ones, should be considered when assessing vulnerability. Drought-related factors like intensity, anticipated frequency under climate change, anticipated frequency (based on prior drought events), and spatial extent are typically employed for assessing exposure. For determining sensitivity, it is necessary to include variables that identify the system of interest (for instance, agriculture), such as reliance on water resources, level of land degradation, population density, and diversification of revenue sources. Calculating adaptability capability requires variables that describe the five capitals (natural, social, human, financial, and manufactured). Potential data sources are also provided as a starting point for locating essential data.

Figure no.4: The conceptual framework showing the multiple dimensions to be included for assessing vulnerability to drought. Modified from Gbetibouo et al. (2010)



Source: Modified from Gbetibouo et al. (2010)

3. BUT HOW IS THAT TECHNICALLY ACHIEVED?

3.1. ATMOSPHERIC MODELLING**:** For Estimating Precipitation, Temperature And Radiation.

3.2. HYDROLOGICAL MODELLING: For Estimating Stream Flow ,Soil Moisture And Evapotranspiration as well reservoir in-and outflow ,lake levels, and sediments

3.3. ECOSYSTEM MODELLING: for estimating crop yield, vegetation state and water usage.

3.4. REMOTE SENSING APPROACHES: For monitoring of crucial water management variables

4. CONSEQUENCES:

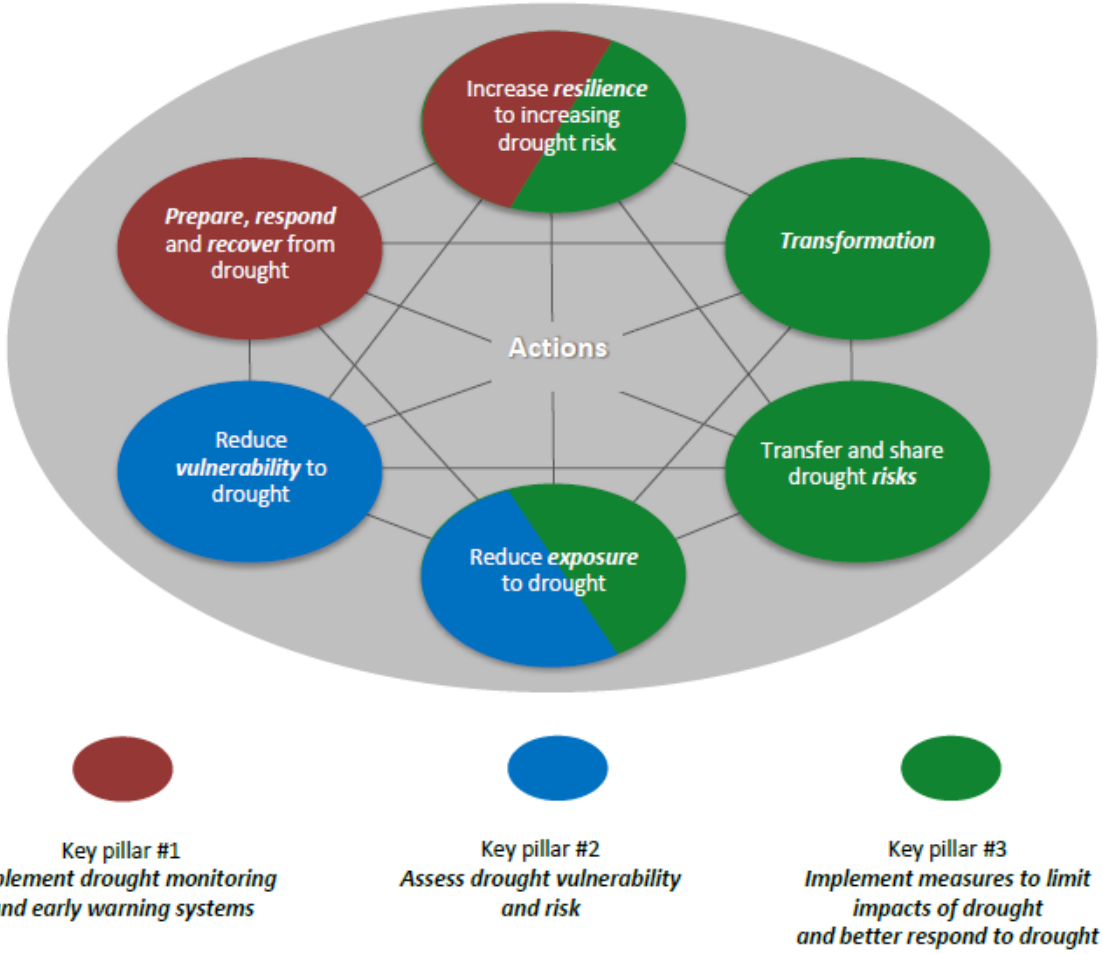
Drought periods can have serious effects on the environment, agriculture, health, the economy, and society. Depending on the level of sensitivity, the effect changes. For example Due to the lack of alternative food sources, subsistence farmers are more inclined to relocate during times of drought. Famine is more likely to occur in locations where the majority of the population relies on as a main food supply.

5. RECOMMENDATION:

The state administration chose the policy of building numerous rainwater collecting facilities under various government programmes in order to collect an increasing amount of rainwater and replenish groundwater in order to address the water problems in the Bundelkhand region.

5.1. INCREASE RESILIENCE TO DROUGHT RISK

Figure5. The DRAMP Framework for Drought Resilience, Adaptation, and Management. The DRAMP Framework goals are coloured to illustrate how well they fit with each of the "3 key pillars" of reducing drought risk. The '3 important pillars' are implemented through the actual steps outlined in these Technical Guidelines.



5.2. DROUGHT MONITORING AND EARLY WARNING SYSTEMS:

The objectives behind an effective monitoring and early warning system are to:

1) At the State, district, and sub-district levels, provide accurate and timely information on rainfall, crop sown area, soil moisture data (where possible), stream flow, groundwater, lake and reservoir storage, and storage in lakes and reservoirs at the appropriate geographical scale.

2) Identify drought conditions as soon as possible so that District Agriculture Contingency Plans and the Crisis Management Plan can be put into effect.

5.2.1. KEY VARIABLES FOR MONITORING DROUGHT

State Governments monitor drought by obtaining information from various sources on key variables of drought which include:

1. Meteorological Data: Rainfall and other parameters like Temperature, Wind speed and Relative Humidity (subject to availability)

2. Weather forecast - Short, medium, extended range
3. Soil Moisture (subject to availability)
4. Sown Area / Crop Health / Stress
5. Satellite based Vegetation Index
6. Stream Flow - Discharge
7. Groundwater Levels
8. Reservoir and Lake Storage / Level
9. Impacts – distress sale and migration of cattle, human migration, fodder availability, drinking water, animal health, employment opportunities in agriculture sector.

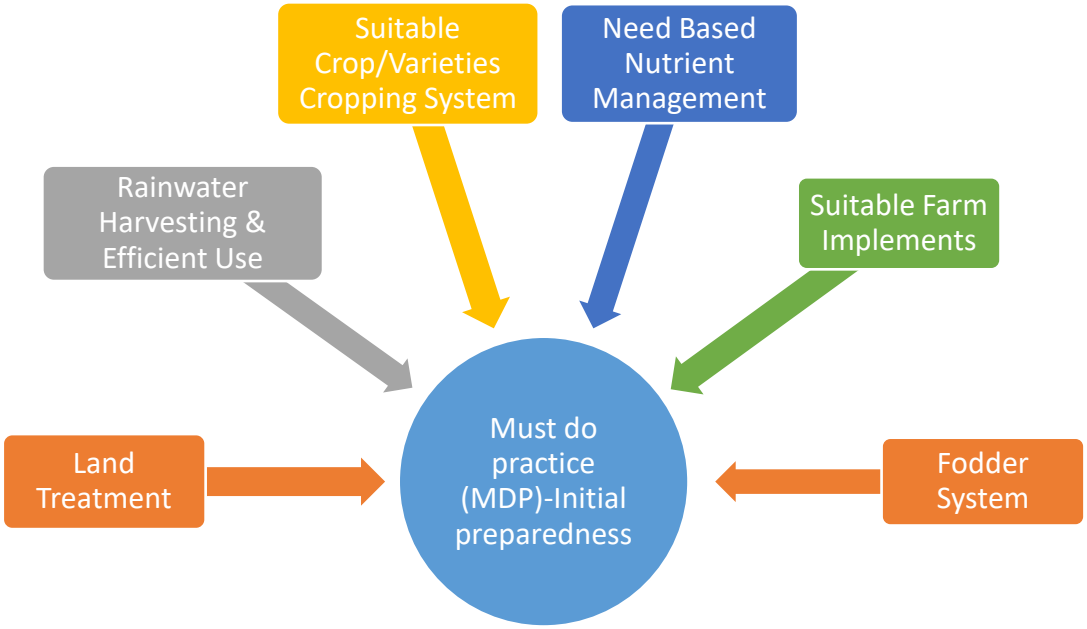
5.3. CRISIS MANAGEMENT PLAN:

The Ministry of Agriculture and Farmers Welfare prepares a Crisis Management Plan for drought (CMP) before the commencement of each Kharif season.

5.3.1. **CONTINGENCY CROP PLANNING:**

Table 11: Crop Contingency Plan

Crops Affected due to Inadequate Rains	Alternate Crops
Paddy	Gram, pulses, oilseeds, and fodder
Maize	Pulses and oilseeds
Cotton	Soyabean and pulses
Sugarcane	Pulses, fodder



5.4. Diversifying and modernising agriculture while managing the land and the water sustainably.

5.5. WATERSHED MANAGEMENT: A watershed, also known as a drainage basin or catchment area, is an independent drainage unit for surface water runoff that drains or "sheds" water into a particular body of water. One watershed is separated from another by a natural boundary known as the water divide or the ridge line.

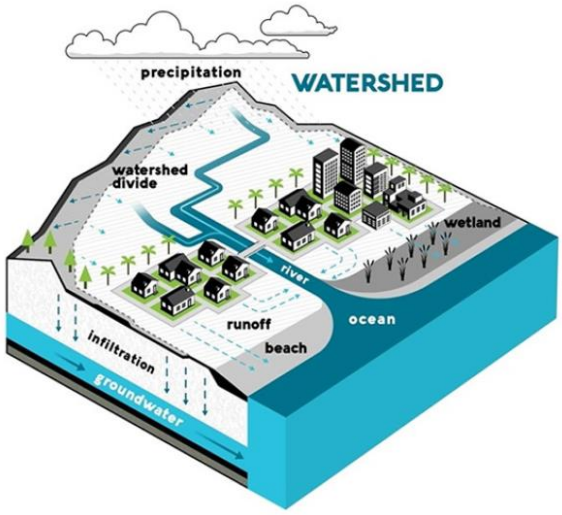


Figure Source: Drishti IAS Coaching Centre

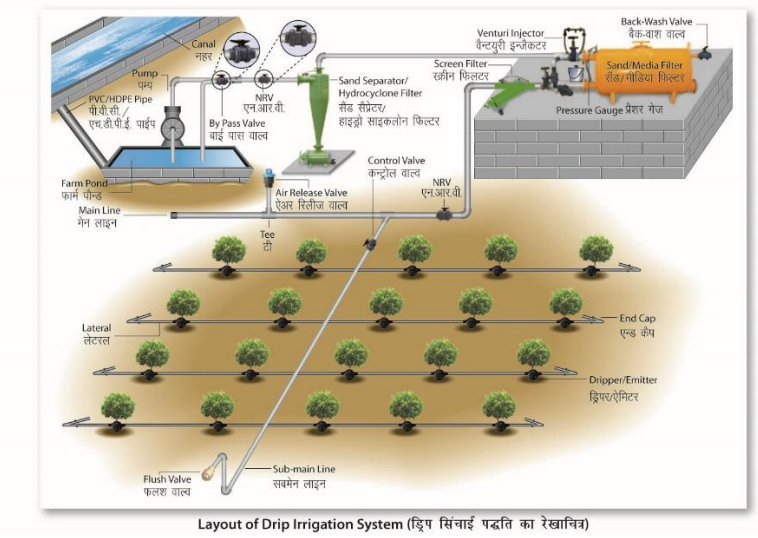
5.6. WATER RESOURCE MANAGEMENT

- Provision of Water
- Reservoir Management
- Repairs and Augmentation of Existing Water Supply Schemes
- Special Measures and Schemes for Areas with Drinking Water Scarcity
- Construction of Temporary Piped Water Supply
- Construction of Bore-wells
- Supply of Water through Tankers and Bullock Carts

5.7. RELIEF THROUGH TAX WAIVER & CONCESSION

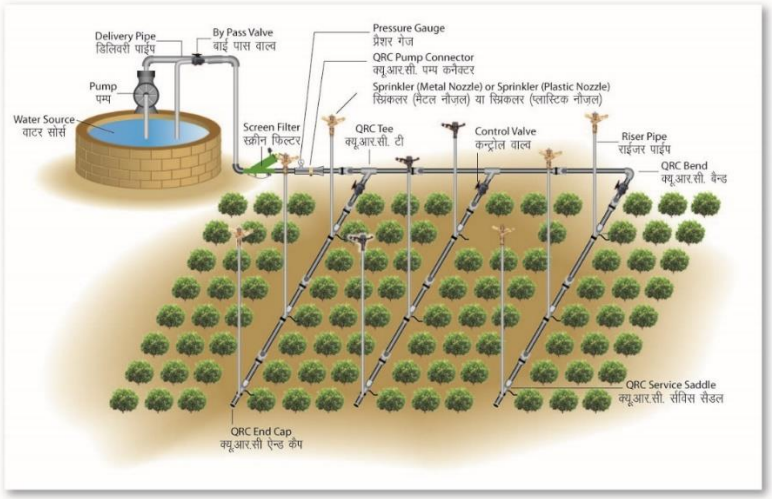
5.8. WATER SAVING TECHNOLOGIES:

5.8.1. Drip irrigation :



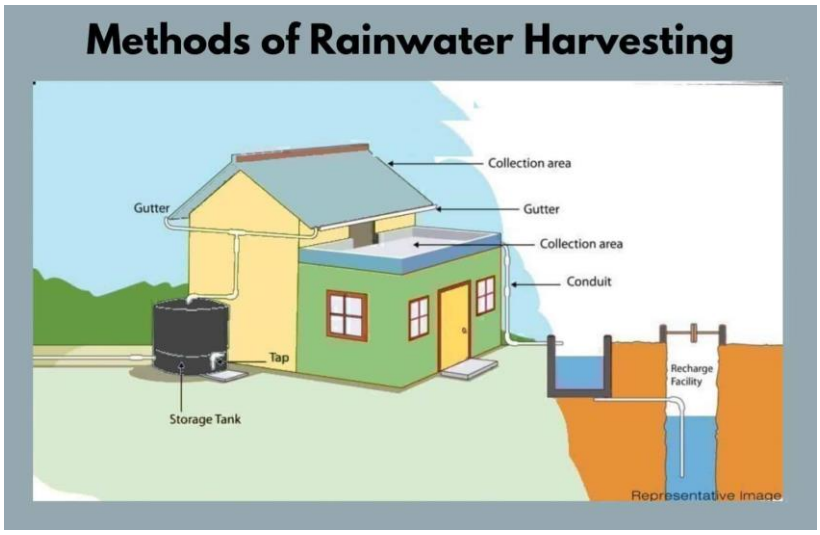
Layout of Drip Irrigation System (ड्रिप सिंचाई पद्धति का रेखाचित्र)

5.8.2. SPRINKLER IRRIGATION SYSTEM:



Layout of Sprinkler Irrigation System (छिड़काव सिंचाई प्रणाली का रेखाचित्र)

5.9. RAINWATER HARVESTING: Rainwater collection and storage from roofs or other suitable catchments.



5.10. ARTIFICIAL RECHARGE OF GROUND WATER

- Contour Bunding
- Contour Trenching
- Contour Cultivation
- Bench Terracing
- Graded Bunding
- Gully plugging
- Check Dams / Nalla Bunding Construction
- Gabion Structure
- Stream Bank Protection
- Farm Ponds
- Percolation Tanks (PT) / Spreading Basin

5.11. TRADITIONAL WATER HARVESTING AND CONSERVATION

- Dug Well Recharge
- Village Pond / Tank
- Tankas / Kunds / Kundis
- Vav / Vavdi / Baoli / Bavadi / Jhalara
- Hill Slope Collection
- Spring Water Harvesting
- Rainwater harvesting in Urban Areas
- Rooftop
- Paved and unpaved areas
- Waterbodies
- Storm water drains

5.12. Recycled water: formerly used wastewater that has undergone treatment and purification.
5.13. Use of water outside prohibited: limiting the use of sprinkler hoses or buckets for water-intensive home care jobs like filling pools or watering outside plants.
5.14. Land use: A thoroughly thought-out crop rotation can reduce erosion and enable farmers to plant less water-dependent crops in years with less rainfall.
5.15. Cloud sprite: a deliberate attempt to change the weather in order to bring on rain.
5.16. Natural forest regeneration
5.17. Crop insurance
5.18. Injection well
5.19. Community participation
5.20. Educating and dissemination of knowledge.
5.21. online interaction and availability of real time drought related information
5.22. soil & moisture conservation programs

6. ACKNOWLEDGEMENT:

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