GIST OF KURUKSHETRA

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Irrigation & Water Conservation

Shankar IAS Academy™
Door No 18, New Plot No 259 /109,
AL Block, 4th Avenue, Shanthi Colony,
Annanagar, Chennai - 600040.
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1. CONSERVING WATER: THE TRADITIONAL WAY

What is the need to conserve water?

- In India, a warming climate is drying up lakes and rivers, while rapid urbanisation and water pollution are putting enormous pressure on the quantity and quality of surface and ground water.

- The country’s fragile agricultural system still depends primarily on rainfall and a bad monsoon season can wreak havoc on the national economy.

- Statistics reveal that the per capita availability of water in India has fallen from 6,042 cubic metre in 1947 to about 1,545 cubic metre in 2011.

- History tells us that both floods and droughts were regular occurrence in ancient India.

- Perhaps this is why every region in the country has its own traditional water harvesting techniques that reflect the geographical peculiarities and cultural uniqueness of the regions.

- The basic concept underlying all these techniques is that rain should be harvested whenever and wherever it falls.

- Archaeological evidence shows that the practice of water conservation is deep rooted in the science of ancient India.

- The settlement of Dholavira, laid out on a slope between two storm water channels, is a great example of water engineering.

- Chola King Karikala built the Grand Anicut or Kallanai across the river Cauvery to divert water for irrigation (it is still functional) while King Bhoja of Bhopal built the largest artificial lake in India.

Why the Government is interested in reviving the traditional water conservation systems?

- With rainfall patterns changing almost every year, the Indian government has started looking at means to revive the traditional systems of water harvesting in the country.

- Given that these methods are simple and eco-friendly for the most part, they are not just highly effective for the people who rely on them but they are also good for the environment.

List out some of the traditional water conservation systems?

- **Jhalara**: Jhalaras are typically rectangular-shaped stepwells that have tiered steps on three or four sides. These stepwells collect the subterranean seepage
of an upstream reservoir or a lake. The city of Jodhpur has eight jhalaras, the oldest being the Mahamandir Jhalara that dates back to 1660 AD.

- **Talab /Bandhi**: Talabs are reservoirs that store water for household consumption and drinking purposes. They may be natural, such as the pokhariyan ponds at Tikamgarh in the Bundelkhand region or man made, such as the lakes of Udaipur.

- **Bawari**: Bawaris are unique stepwells that were once a part of the ancient networks of water storage in the cities of Rajasthan. To minimise water loss through evaporation, a series of layered steps were built around the reservoirs to narrow and deepen the wells.

- **Taanka**: A Taanka is a cylindrical paved underground pit into which rainwater from rooftops, courtyards or artificially prepared catchments flows. Once completely filled, the water stored in a taanka can last throughout the dry season and is sufficient for a family of 5-6 members.

- **Ahar Pynes**: Ahar Pynes are traditional floodwater harvesting systems indigenous to South Bihar. Pynes are artificial rivulets led off from rivers to collect water in the ahars for irrigation in the dry months.

- **Johads**: Constructed in an area with naturally high elevation on three sides, a storage pit is made by excavating the area, and excavated soil is used to create a wall on the fourth side. This prevents structural damage to the water pits that are also called madakas in Karnataka and pemghara in Odisha.

- **Panam Keni**: The Kuruma tribe (a native tribe of Wayanad) uses a special type of well, called the panam keni, to store water. Wooden cylinders are made by soaking the stems of toddy palms in water for a long time so that the core rots away until only the hard outer layer remains and then it is used to store the water.

- **Khadin**: The main feature of a khadin, also called dhora, is a long earthen embankment that is built across the hill slopes of gravelly uplands. Sluices and spillways allow the excess water to drain off and the water-saturated land is then used for crop production.

- **Kund**: A kund is a saucer-shaped catchment area that gently slope towards the central circular underground well. Its main purpose is to harvest rainwater for drinking. Traditionally, these well-pits were covered in disinfectant lime and ash, though many modern kunds have been constructed simply with cement.

- **Baoli**: These beautiful stepwells typically have beautiful arches, carved motifs and sometimes, rooms on their sides. Stepwells used exclusively for agriculture had drainage systems that channelled water into the fields.
- **Nadi**: Found near Jodhpur in Rajasthan, nadis are village ponds that store rainwater collected from adjoining natural catchment areas. The location of a nadi has a strong bearing on its storage capacity and hence the site of a nadi is chosen after careful deliberation of its catchment and runoff characteristics.

- **Bhandara Phad**: Phad, a community-managed irrigation system, probably came into existence a few centuries ago. The Phad system is operated on three rivers in the Tapi basin – Panjhra, Mosam and Aram – in the Dhule and Nasik districts of Maharashtra.

- **Zing**: Zings, found in Ladakh, are small tanks that collect melting glacier water. A network of guiding channels brings water from the glacier to the tank. A trickle in the morning, the melting waters of the glacier turn into a flowing stream by the afternoon. The water, collected by evening, is used in the fields on the following day.

- **Kuhls**: Kuhls are surface water channels found in the mountainous regions of Himachal Pradesh. The channels carry glacial waters from rivers and streams into the fields.

- **Zabo**: Practised in Nagaland, Zabo is also known as the Ruza system. Rainwater that falls on forested hilltops is collected by channels that deposit the run-off water in pond-like structures created on the terraced hillsides.

- **Bamboo Drip Irrigation**: Bamboo Drip irrigation System is an ingenious system of efficient water management that has been practised for over two centuries in northeast India. The tribal farmers of the region have developed a system for irrigation in which water from perennial springs is diverted to the terrace fields using varying sizes and shapes of bamboo pipes.

- **Jackwells**: The Shompen tribe of the Great Nicobar Islands lives in a region of rugged topography that they make full use of to harvest water. In this system, the low-lying region of the island is covered with jackwells (pits encircled by bunds made from logs of hard wood).

- **Ramtek Model**: The Ramtek model has been named after the water harvesting structures in the town of Ramtek in Maharashtra. In this system, tanks connected by underground and surface canals form a chain that extends from the foothills to the plains.

- **Pat System**: The Pat system, in which the peculiarities of the terrain are used to divert water from hill streams into irrigation channels, was developed in the Bhitada village in Jhabua district of Madhya Pradesh. Diversion bunds are made across a stream near the village by piling up stones and then lining them with teak leaves and mud to make them leak-proof.
• **Eri**: The Eri (tank) system of Tamil Nadu is one of the oldest water management systems in India. Still widely used in the state, eris act as flood-control systems, prevent soil erosion and wastage of runoff during periods of heavy rainfall, and also recharge the groundwater. Eris can either be a system eri, which is fed by channels that divert river water, or a non-system eri, that is fed solely by rain.

2. MORE CROP PER DROP: EFFICIENT IRRIGATION WATER USE

*What is the need for efficiency in irrigation?*

- Water resources are limited and they are vital for economic development, crucial for food security, national security and energy security.

- As per the recent study the water demand is likely to increase about 73 percent in irrigation sector, followed by industrial and domestic sectors.

- There are spatial and temporal variations of water availability. For example, 75 percent of the rainfall in India occurs in 4 months with higher precipitation in North east region and lowest in Rajasthan.

- India's per capita availability of fresh water is low when compared to countries like Brazil, Australia, USA, UK, Bangladesh and China.

- There is increasing trend of lower low productivity per unit use of water raising concern in context of India's growing population.

- Irrigation is the major input cost amounting to about 70 percent of total input cost. Increasing water use efficiency leads to reduction in input cost and leads to better savings.

- More than 70 percent of the people either directly or indirectly dependent on agriculture and monsoon plays an important role in the economy.

- The conventional irrigation water use, such as through canal and flood irrigation has an efficiency of about 55 to 60 percent but the efficient technologies like micro irrigation techniques has an efficiency of about 90 percent.

*What are the various types of irrigation efficiency?*

- **Water conveyance efficiency** takes into account the conveyance and transit loss, and is determined as the ratio of water delivered to farm or irrigated plot over the water supplied or diverted from river or reservoir.

- **Water application efficiency** focuses on the attention of suitability of the method of application of water to the crops, and is measured by the ratio of quantity of water delivered to the field.

- **Water use efficiency** is the ratio of water consumptively used to the quantity of water delivered.
• **Water storage efficiency** is the ratio of water stored in the root zone during irrigation and the water needed in the root zone prior to irrigation.

• **Water distribution efficiency** evaluates the degree to which the water is uniformly distributed throughout the root zone.

**What are the steps required for water conservation?**

• Rehabilitation and restoration of damaged and silted canal system to enable it to carry designated discharge.

• Conjunctive usage of surface and ground water, especially in areas where there is a threat to water logging.

• Adopting micro irrigation systems like drip and sprinkler mechanisms for irrigation wherever possible.

• Revision of cropping pattern in the event of change in water availability.

• Constitution of water user associations and transfer of management to them as mentioned in the National Water Policy.

• Introducing night irrigation practices to reduce the evaporation losses.

• Proper and timely system maintenance.

• Assuring timely and optimum irrigation for minimising water loss and water logging.

• Conservation of monsoon flows in rivers, mush of which go as waste to the sea.

• Construction of check dams, barriers, ponds and lakes will enhance the conservation of water resources.

• Rainwater harvesting must be promoted by following TamilNadu model as it increases the level of ground water.

**3. PRADHAN MANTRI KRISHI SINCHAYEE YOJANA TOWARDS DOUBLING FARMERS’ INCOME**

**What is Pradhan Mantri Krishi Sinchayee Yojana?**

• The major objective of the PMKSY is to achieve convergence of investments in irrigation at the field level, expand cultivable area under assured irrigation (Har Khet ko pani), improve on-farm water use efficiency to reduce wastage of water, enhance the adoption of precision-irrigation and other water saving technologies (More crop per drop), enhance recharge of aquifers and introduce sustainable water conservation practices by exploring the feasibility of reusing treated municipal based water for peri-urban agriculture and attract greater private investment in precision irrigation system.

• The scheme also aims at bringing concerned Ministries/Departments/Agencies/Research and Financial Institutions engaged in creation/use/recycling/potential recycling
of water, brought under a common platform, so that a comprehensive and holistic view of the entire "water cycle" is taken into account and proper water budgeting is done for all sectors namely, household, agriculture and industries.

- The programme architecture of PMKSY aims at a 'decentralized State level planning and execution' structure, in order to allow States to draw up a District Irrigation Plan (DIP) and a State Irrigation Plan (SIP).

- DIP will have holistic developmental perspective of the district outlining medium to long term developmental plans integrating three components namely, water sources, distribution network and water use application of the district to be prepared at two levels - the block and the district.

- The programme will be supervised and monitored at the national level by an Inter-Ministerial National Steering Committee (NSC) under the Chairmanship of the Prime Minister with Union Ministers of all concerned Ministries.

- At the state level the scheme is to be administered by a State Level Sanctioning Committee (SLSC) to be Chaired by the Chief Secretary of the respective States. The committee will have all authority to sanction the project and also monitor the progress of the scheme.

- It will have an outlay of Rs. 50,000 crore over a period of five years (2015-16 to 2019-20). The allocation for the current financial year is Rs. 5300 crore.

- It is expected that PMKSY will provide convergence to existing schemes of water management, thus bringing efficiency to the use of water.

**What are the interventions needed for successful implementation of PMKSY and doubling farmers' income?**

- Support for development of groundwater and lift irrigation schemes should be given. Targeted support to irrigation deprived farm households to construct wells/tube wells.

- Affordable assured power for peak season irrigation - emulate the policies from Madhya Pradesh and Gujarat.

- Support to Solar power irrigators must be given especially in the non grid areas with shallow water tables.

- Support has to be given to micro irrigation to promote speedy installation of drips and sprinklers especially in the water stressed areas and areas underlain with poor quality groundwater.
Supporting conversion to underground piped conveyance network to reduce water losses and delivering uniform supplies.

Conjunctive management of tanks and groundwater systems through regular desilting of tanks, reducing encroachments, buried supply channel etc emulate Mission kakatiya of Telangana.

Encourage groundwater harvesting and recharge, recharge shafts, recharge tube wells, infiltration wells, and percolation tanks to tame seasonal floods.

Peri urban waste water irrigation must be promoted for farm forestry, fodder, vegetable and floriculture cultivation.

Watershed treatment through inclusion of communities for asset development, ownership and long term maintenance.

Ensure community participation and social inclusion in all programs with special emphasis on women and girl child who are traditionally responsible for domestic water provisioning.

In hilly areas like Uttarkhand, Himachal Pradesh and North east states, special emphasis must be given on rejuvenation of springs like Dhara vikas program of Sikkim Government.

4. Irrigation Systems in India

What is meant by irrigation?

Irrigation is a technique of supplying water to dry land as a supplementation of rain water. It is mainly aimed for farming.

What are the needs for irrigation?

India is a big country and stands next to China in terms of population and so irrigation facilities are needed to grow more food to feed our teeming millions.

The distribution in rainfall is uneven and uncertain which either causes famines or drought. By means of irrigation we can check both.

Different water requirements of different crops can only be met through irrigation facilities.

India, being tropical country, the temperature is high and evaporation more rapid, so, artificial irrigation is necessary for ample supply of water and also to prevent water scarcity in the long dry winter season.

What are the types of irrigation?

Depending upon the availability of surface or ground water, topography, soil and rivers various types of irrigation practiced in India are as follows:

Tank water irrigation system: It is prevalent in the uneven and relatively rocky plateau of Peninsular India.

Tanks are common sight in states like Tamil Nadu, Karnataka, Deccan Plateau, Eastern Madhya Pradesh and Andhra Pradesh.

Most of the tanks are natural and do not involve heavy cost for construction. Even an individual farmer can have his own tank.
• In many tanks, fishing is also carried out. This supplements both the food resources and income of the farmer.

• It has some demerits like covering large area of cultivable lands and large scale evaporation in shallow tanks.

• **Well water irrigation system:** It is more prevalent in plains, coasts and some parts of peninsular India.

• It is less costly and more flexible as water can be drawn whenever needed and evaporation loss is minimised and no fear of over irrigation.

• **a) Open wells:** Open wells are shallow and irrigate a small area because water available is limited and the level of water goes down in the arid season.

• **b) Tube wells:** Tube wells are deep, more suitable and have the capacity to draw a huge volume of water. Such type of well always has water irrespective of time.

• **Inundation/canal irrigation system:**
  It plays an important role in the Indian irrigation system as 42 percent of total irrigation is done by canals.

• They supply the water only when there is flood in the rivers, and therefore, are of no use during the dry season when water is required the most.

• These canal type irrigation is found in U.P, Punjab, Haryana and many other Indian states.

• **Perennial Canals irrigation System:**
  These canals get the supply of water either from the river directly or through the reservoirs of the river projects.

• In order to supply water throughout the year, reservoirs are constructed for storing water across the water bodies, referred as Dams.

• In many places, rain water harvesting systems are installed and water is stored in large reservoirs to be used for agricultural purposes.

• This system is greatly adopted in Tamil Nadu, Andhra Pradesh and Karnataka.

• **Multipurpose River Valley Projects:**
  In recent times, multipurpose river valley projects are helping in irrigation and growth of agriculture.

5. **Watershed Development in India**

• **What are the initiatives of Government post 1991 for the watershed development?**

• Hanumanth Rao committee recommended the revamp of Drought Prone areas program and Desert area program.

• Based on the recommendations of the committee many schemes were reformulated and launched with new impetus to propel the watershed development in India
• **National Watershed Development Project for Rainfed Areas (NWDPRA):**

  - The scheme of National Watershed Development Project for Rainfed Areas (NWDPRA) was launched in 1990-91 in 25 States and 2 Union Territories based on twin concepts of integrated watershed management and sustainable farming systems.

  - During IX Plan, the scheme was extended to 3 newly formed States of Uttaranchal, Jharkahand and Chhattisgarh. The scheme of NWDPRA has been subsumed under the Scheme for Macro Management of Agriculture (MMA) from 2000-2001.

  - At present, this scheme is being implemented as a programme of Centrally Sponsored Scheme of Macro Management of Agriculture in 28 States and 2 UTs. Funds are released to the States based on Approved Annual Work Plan.

  - The Scheme is presently being implemented on the basis of Common Guidelines for Watershed Development Projects issued by National Rainfed Area Authority (NRAA).

  - Financing pattern of NWDPRA programme is applicable as per the financing pattern of MMA i.e. 90:10 of Central & State Government. For North Eastern States it is 100% grant.

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**Integrated Wastelands Development Project (IWDP) Scheme:**

  - The scheme provides for the development of an entire micro watershed in an holistic manner rather than piecemeal treatment in sporadic patches. The thrust of the scheme continues to be on development of wastelands.

  - The basic objective of this scheme is an integrated wastelands development based on village/micro watershed plans.

  - These plans are prepared after taking into consideration the land capability, site condition and local needs of the people.

  - The scheme also aims at rural employment besides enhancing the contents of people's participation in the wastelands development programmes at all stages, which is ensured by providing modalities for equitable and sustainable sharing of benefits and usufructs arising from such projects.

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**Hariyali:**

  - This scheme has been initiated by the Ministry of Rural Development for empowering the village community through Panchayati Raj Institutions (PRIs) to undertake the area development programmes on watershed basis with financial and technical support from the Government.

  - Under this initiative, all the on-going area development programmes, such as Integrated Wasteland Development
Programmes (IWDP), Drought Prone Areas Programme (DPAP) and Desert Development Programme (DDP) are to be implemented through the PRIs.

**National Rainfed Area Authority (NRAA):**

- The Government has set up National Rainfed Area Authority (NRAA), an expert body to provide the much-needed knowledge inputs regarding systematic up-gradation and management of country’s dry land and rainfed agriculture.

- The Authority’s mandate is wider than mere water conservation and covers all aspects of sustainable and holistic development of rainfed areas, including appropriate farming and livelihood system approaches.

- Issues pertaining to landless and marginal farmers, who constitute the large majority of inhabitants of rainfed areas, are to be addressed by the Authority.

**Neeranchal:**

- The programme will lead to reducing surface runoff of rainwater, increasing recharge of ground water and better availability of water in rainfed areas resulting in incremental rainfed agriculture productivity, enhanced milk yield and increased cropping intensity through better convergence related programmes in project areas.

- Neeranchal is designed to further strengthen and provide technical assistance to the Watershed Component of PMKSY, in particular and all components of PMKSY, in general, to enhance its delivery capacity.

- Neeranchal will support the Watershed component of PMKSY (erstwhile IWMP) which was implemented by the Department of Land Resources (DoLR) in 28 States.

- The Neeranchal project was approved by the cabinet in October, 2015 with a total budget outlay of Rs.2142 crore with the Government share of Rs.1071 crore and the rest 50% by the World Bank.

### 6. HARVESTING RAINWATER FOR AGRICULTURAL NEEDS

**What is the importance of rain water harvesting?**

- Rainfed agriculture in India is practiced in about 57 percent of an estimated 140.3 Mha net cultivated area.

- It contributes 40 percent of food grains and supports 40 percent of population, 80 percent of horticulture and 60 percent of livestock.

- The rainfed agriculture in India is characterised by frequent droughts, soil degradation, low soil organic content, multi nutrient deficiencies, low external inputs, low investment capacity of farmers and poor market linkages.

- The land degradation in rainfed areas that mainly includes soil erosion by water, loss of humus, depletion of soil nutrients,
deterioration and reduction of vegetation cover and loss of biodiversity also affects the production capacity of the land adversely.

- The rainfed agriculture is more vulnerable to climate change implications than the irrigated agriculture due to its poor capacity to cope with extreme water and weather shocks.

- Prolonged dry spells during flowering, pollination and seed formation stages of a crop is detrimental to the yield.

- The use of harvested rainwater can be used for life saving irrigation for one or two seasons and at the same time it will aid in the increase of average yield.

**What are the traditional methods of RWH?**

- **In - situ water harvesting:** It refers to the collection of where it falls for use on the same surface.

- The methods mainly include contour bunding, field bunding, ridge and furrowing, contour trenching and contour cultivation.

- These in - situ measures are very effective in building up the soil moisture levels to sustain the vegetation growth during dry spells and also contribute to ground water recharge.

- **External water harvesting:** It includes all those techniques which induce collection and storage of rainfall and runoff for its beneficial usage.

- These methods are also considered very useful for groundwater recharge both when there is deficit in rainfall and during flash floods.

**What are the methods of rainwater harvesting?**

- **Village ponds/tanks** are the most commonly used methods to collect and store rain water. Pond is constructed based on the relief and topography. pond water is generally available for 2 months to a year after the rains, depending upon the catchment characteristics and the amount and intensity of rainfall.

- **Tankas/kunds/kundis** are underground structures of various shapes and sizes to collect rainwater for drinking purposes in the desert and arid regions of Rajasthan. These are built both for individuals and for the community usage.

- **Khaddin**, a runoff farming and groundwater recharging system is a popular deep Thar desert of Rajasthan having annual rainfall of as low as 150 - 330 mm. This system is based on the principle of harvesting rainwater on farmland and subsequent use of this water saturated land for crop production.

- **Vav/baoli/bavadi/jhalara** are traditional wells have steps on all sides. They were setup by the nobility in cities to provide water supply to the community.
• Hill slope collection system consists of lined channels across hill slopes to intercept rainwater. These channels convey water to agricultural fields or to fill small fish ponds.

What are the contemporary methods of RWH?

• Check dams and nalla building consist of an embankment across small streams and long gullies with a waste weir in a suitable place. The impounding also facilitates percolation of water into deeper soil and makes it possible to bring under cultivation and land under the bed of nallas.

• Farm ponds are useful in storing water for supplemental/life saving irrigation. The pond location should be near where the water is to be used, e.g. for irrigation, it should be above the irrigated fields.

• Percolation tanks impound rainwater and have a waste weir to dispose of the surplus flow in excess of the storage capacity of the tanks. These tanks are used entirely for the recharging of the aquifers through percolation.

• Sub surface barriers, constructed below river bed on impervious subsurface strata, are the most suitable artificial structure for promoting groundwater recharge in arid and semi arid regions.

7. FLOODS AND DROUGHTS IN INDIA: CAUSES AND SOLUTIONS

What are floods?

• The term flood is commonly used to describe any inundation of water. But there are two distinct mechanism to cause such inundation.

• A rainfall takes place somewhere in the upstream catchment, and consequent high flow in the river may spill out in the habitation areas somewhere downstream. This is called flood.

• The other mechanism is, a high rainfall may take place locally, and the rainwater may fail to drain out fast enough, and accumulate in city or village. This is called drainage congestion.

• The inundation that takes place every year in Assam and U.P is flood, but the inundation took place in Mumbai and Chennai were drainage congestion.

What are the causes of Floods?

• A very heavy rainfall in the upstream catchment causes a very large river flow. The width of the river through the city downstream is not adequate to carry that flow, and the water spills over, beyond the usual banks.

• Natural lake burst. A landslide takes place in the river and acts like a dam. Water accumulates behind it, creating a lake. As the water storage builds up, the landslide dam blocking the path of the
water bursts, and the accumulated water flows out in a short time, causing the flood.

- **Breach of Embankments.** Embankments are constructed along both banks of river to protect human habitation. If the embankment breaches, the river flow enters the habitation.

- **Dam Break.** This is very rare, but a man made dam may burst releasing a large quantity of water and causing the flood.

**How to manage floods?**

- Flood management options are typically divided into two types, structural - comprising some construction of embankments, and flood control reservoirs and non structural - flood forecasting, flood plain zoning and disaster relief.

- Embankments must be constructed along the banks of the rivers to contain the flow of the river and prevent it from spilling in to the areas of the human activity.

- Flood control reservoirs like Hirakud dam and series of dams in Damodar valley must be built to contain floods and store the excess water and to release the water when the situation normalise.

- Flood forecasting doesn't prevent floods as such, but it will prevent the loss of life, and to some extent the loss of property.

- Flood plain zoning refers to restricting the activities in flood plains, depending on the assessment. This is done to reduce the loss of human life and economic resources.

- If a flood does occur, relief operations are needed to rescue marooned people and provide them with shelter, food and water, and medical help.

- Proper solid waste management and promotion of storm water drains in the urban areas may prevent the inundation caused by the drainage congestion.

**What are droughts?**

- Like floods, droughts are also hydrologic extreme. But drought neither have a clearly defined beginning, nor a clearly defined end.

- Drought is a phenomenon that extends over a long duration. Droughts are divided into three types:

  - **Meteorological drought** is defined on the basis of the degree of dryness, in comparison to a normal or average amount, and the duration of the dry period.

  - **Agricultural drought** links various characteristics of meteorological drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil-water deficits, reduced groundwater or reservoir levels, and so on.

  - **Hydrological drought** refers to a persistently low discharge and/or volume
of water in streams and reservoirs, lasting months or years. Hydrological drought is a natural phenomenon, but it may be exacerbated by human activities.

**What are the necessary interventions needed to mitigate the drought?**

- Borrowing of money by the community in the drought-prone areas is mostly from private money lenders at higher rates of interest. Thus, provision of micro-credit facilities is an important intervention.

- Human actions like unabated sand mining in the rivers and rivulets lead to unprecedented depletion of ground water levels, further compounding the plight of drought-hit population. So, heavy and stricter law enforcement must be put in place.

- Agriculture universities and NGOs have brought out documentation on best practices in drought-coping mechanisms and the same needs to be inventoried at district, mandal and village levels, validated and replicated.

- Migration during drought is mainly of the younger segment of the population leaving behind aged and children. Social security needs of such population need to be addressed as part of drought mitigation measures.

- Additional supplementing of nutrition especially to vulnerable sections of population like children, women, old aged and sick need to be augmented.

- Drought-related health risks should be properly assessed to ensure preventive and curative measures.

- Drought causes scarcity in food market, leading to spiralling prices of food commodities. Reduced incomes and increasing prices mean conditions of starvation and semi-starvation. Such conditions are not as visible as melancholic signs of starvation but certainly debilitating. Thus, it is essential to improve the food supplies through public distribution system in the areas affected by drought.

- The government’s drought management strategy should include measures to support the affected population in effectively coping up with the adversities caused by drought. For instance, the government departments should support the efforts of farmers in diversification of crops through input provisioning and extension services.

**Sustainable Agriculture:**

**Aligning cropping pattern with the availability of water**

**What is meant by sustainable agriculture?**

- Sustainable agriculture is the way of farming according to the location specific ecosystem and study of relationships between organisms and their environment.
• Such systems must be resource conserving, socially supportive, commercially competitive and environmentally sound.

• These systems generally avoid the usage of synthetically compounded fertilizers, pesticides, growth regulators, and livestock feed additives, instead relying upon crop rotations, crop residues, animal manures, off farm organic wastes, and mineral bearing rocks to maintain soil fertility and productivity.

**Why cropping pattern must be changed for sustainable production?**

• As both natural resource soil and water are the limiting resources for the crops and these are also indiscriminately used based on the crops.

• As there is a change in climatic patterns and monsoon is being erratic the necessary intervention should be made in cropping pattern to sustain food and economic security.

**What are the major cropping patterns of India?**

• **Rice-Wheat**: Rice-Wheat system is the most widely adopted cropping system in the country and has become mainstay of cereal production.

• The states of Uttar Pradesh, Punjab, Haryana, Bihar, West Bengal and Madhya Pradesh are now the heart land of rice-wheat cropping system with an estimated area of 11 million hectares.

• Important issues emerging as a threat to the sustainability of rice-wheat system are over mining of nutrients from soil, disturbed soil aggregates due to puddling in rice, decreasing response to nutrients, declining ground water table, build up of diseases/pests & *phalaris minor*, low input use efficiency in north western plains, low use of fertilizer in eastern and central india, lack of appropriate varietal combination.

• **Rice-Rice**: Rice-rice is the popular cropping system in irrigated lands in humid and coastal ecosystems of Orissa, Tamil Nadu, Andhra Pradesh, Karnataka and Kerala and it is spread over an area of six million hectares.

• The major issues in sustaining productivity of rice-rice system are deterioration in soil physical conditions, micronutrient deficiency, poor efficiency of nitrogen use, imbalance in use of nutrients, non-availability of appropriate transplanter to mitigate labour shortage during critical period of transplanting, build up of obnoxious weeds such as *echinochloa crusgalli* and non-availability of suitable control measures.

• **Rice-Mustard**: From a view point of food security and national economy, rice-rapeseed/mustard may be considered as an important cropping system.
• In this cropping system, the yield of Rice is satisfactory in all ecosystems, however, wide variations in yield of mustard were recorded from one ecosystem to another.

• Nevertheless, adoption of appropriate high yielding rice and mustard varieties, adequately supported by improved production technology, ensures desired productivity of the system.

• **Maize-Wheat**: Among maize-wheat growing areas, maize is the principal crop of Kharif season in northern hills of the country but plains of northern states like Uttar Pradesh, Rajasthan, Madhya Pradesh and Bihar also have sizeable acreage under this crop.

• Poor maize-wheat yield has been reported from Andhra Pradesh, Assam, Gujarat, Madhya Pradesh, Maharashtra, Rajasthan, Tripura, Eastern Uttar Pradesh and Tamil Nadu.

• There are number of reasons for poor yield but the most significant are sowing time, poor plant population, poor weed management, poor use of organic and inorganic fertilizers.

• **Sugarcane-Wheat**: Sugarcane is grown in north India (Uttar Pradesh, Punjab, Haryana and Bihar), which account for 68 per cent of the total area under sugarcane, sugarcane-ratoon-wheat is the most important crop sequence.

• The system is also gaining importance in Jorhat, Sibsagar and Sonitpur districts of Assam; Ahmedanagar and Kolhapur district of Maharashtra and Belgaum district of Karnataka. The other states where the system covers considerable area under sugarcane-wheat are Haryana, Punjab, Madhya Pradesh and Rajasthan.

• Problems in sugarcane-wheat system are late planting of sugarcane as well as wheat, imbalance and inadequate use of nutrients, poor nitrogen use efficiency in sugarcane, low productivity of ratoon due to poor sprouting of winter harvested sugarcane in north India, build up of *trianthema partulacastrum* and *cyprus rotundus* in sugarcane, stubble of sugarcane pose tillage problem for succeeding crops and need to be managed properly.

• **Cotton-Wheat**: Cotton is widely grown in alluvial soils of north India (Punjab, Haryana, Rajasthan and Western Uttar Pradesh) and black cotton soils of central India (Andhra Pradesh, Tamil Nadu and Karnataka).

• With the availability of short duration varieties of cotton, cotton-wheat cropping system has become dominant in North. About 70-80 per cent area of cotton is covered under this system.

• In Central region also, wherever irrigation is available, cotton-wheat is practiced.
The major issues of concern in cotton-wheat cropping system are delayed planting of succeeding wheat after harvest of cotton, stubbles of cotton create problem of tillage operations and poor tilth for wheat, susceptibility of high yielding varieties of cotton to boll worm and white fly and consequently high cost on their control leading to unsustainability, poor nitrogen use efficiency in cotton results in low productivity of the system, appropriate technology for intercropping in widely spaced cotton is needed to be developed.

**LEGUME BASED CROPPING SYSTEMS** : Legume crops (pulses and oilseeds) are popular for their suitability in different cropping systems.

Recent advances in the development of large number of varieties of pulse and oilseed crops, varying largely for maturity duration, have made it possible to include them in irrigated crop sequences.

The popular cropping systems are pigeon pea-wheat in Madhya Pradesh and groundnut wheat in Gujarat, Maharashtra and Madhya Pradesh and groundnut-sorghum in Andhra Pradesh and Karnataka.

The major issues in legume based cropping systems are no technological breakthrough has been achieved so far in respect of yield barriers, particularly in legumes, susceptibility of the pulses to aberrant weather conditions especially water logging and adverse soils making them highly unstable in performance, high susceptibility to diseases and pests, low harvest index, flower drop, indeterminate growth habit and very poor response to fertilizers and water in most of the grain legumes.