Kurukshetra Summary November 2017

More Crop Per Drop: Efficient Irrigation Water Use

- Globally only 0.4% of total water on earth is at our disposal. 14% of world population shares 53% of total water resources, while 86% of world population (including China, India) shares 47% of global water resources
- India's share of world's water resources is only 4% although it contributes 17% of world population.

An estimate shows that by 2050, the water demand is likely to be about 73% in irrigation sector, followed by industry and domestic sectors. Also, there are spatial and temporal variations of water availability and per capita availability of water resources are declining. Hence, we need to focus on irrigation to increase water use efficiency.

- Status of irrigation development shows that the assessed irrigation potential is about 140 mha while actual realized irrigated area is far less.
- In addition there is low productivity per unit use of water. For example, irrigation water withdrawal for rice production is 3.48 BCM/yr/mha while the same for Myanmar is at 1.90.
- Agriculture sector, although consuming about 80% of India's water resources, suffers from low water use efficiency (38%).
- The irrigated area, in gross terms, is about 80 million hectare, the largest amount of irrigated agriculture in the world. Ground water contributes to meeting major irrigation water needs.
- The conventional irrigation water use, such as through canal and flood irrigation, has efficiency varying from 55 to 66% while the improved micro irrigation technology has efficiency above 90%.
- A huge amount of water loss in canal and flood irrigation occurs due to evaporation, percolation and seepage.
- In a well-designed surface irrigation system, the water application efficiency is at least 60% while in sprinkler irrigation system, it is about 75%. Low water application efficiency is due to, irregular land surface, wrong irrigation methods, steep slope of land surface etc.

Steps for Water Conservation:

- Limited supply of water resources, threat from climate change effects, contamination of water sources are few factors which are further reducing the water availability. Hence, there is an urgent need to conserve water
- Some of the steps that could be adopted for water conservation in irrigation are:
    - Proper and timely maintenance
    - Adopting 'drip and sprinkler' systems for crop irrigation where such systems are suitable
    - Revision of cropping pattern in the event of change in water availability
    - Promoting multiple uses of water
    - Introducing night irrigation practice to minimize evaporation loss

- Conjunctive use of surface and ground water, especially in areas where there is threat to water logging
- Conservation of monsoon flows in rivers, much of which go as waste water into the sea

Worldwide initiatives:

- The World Water Council (2000) envisions that about 50% of increased agricultural demand by 2025 should be met by increasing productivity of water.
- The National Water Mission of GoI has set a target of increasing water use efficiency by 20% as part of National Action Plan on Climate Change.
- GoI also launched PMKSY (Pradhan MantriKrishiSinchaiYojana) with an aim to improve farm water use efficiency to reduce wastage of water, enhance the adoption precision irrigation as well as enhance recharge of ground water acquifers and sustainable water conservation practices.

Examples of Best Practices:

- In India, Jain Irrigation System Ltd. is engaged in working in 'drip and sprinkler' irrigation since 1990s. Their experiment in rice production with drip irrigation has shown many economic benefits such as 40% enhancement of rice yield, up to 70% water saving.
- In addition, there are health improvement of farmland through reduction of skin, respiratory and mosquito bite diseases. Further, there is reduction of environmental pollution through no or low methane emission, global warming mitigation etc.

Conclusion:

- Efficient water use in agricultural sector is a challenging task in Indian context as stakeholders are many, which makes collaboration difficult.
- There is need to have an integrated solution for irrigation system such as introducing micro irrigation systems, application of IT, use of sensor based water conveyance and application to fields, introducing solar pumping techniques and adopting other water conservation interventions.
- Zero tillage technology preserves moisture in the soil and use of laser levelling technology has potential to save irrigation water. There are good practices in India on the subject which should be scaled up.

Pradhan MantriKrishiSinchayeeYojana

- Since independence, we have been able to bring only about 45% of cultivated lands of India under assured irrigation. Data show that per ha productivity of all crops taken together was 1.6 times higher under largely rainfed conditions during biennium 2011-12.
- Indian agriculture is using too much land and too much water rather inefficiently Yield levels of most crops in India are lower than the world average due to lower level or poor adoption of improved technology.
- With availability of irrigation, it is possible to enhance the cropping intensity known as 'vertical intensification'. Presently, 76% of agricultural land in the country remains unused for half of the productive period due to lack of access to meet the crop water requirement.

- Once assured irrigation is available, diversification of high value crops has the potential to raise the farmers' income. The past green revolution technologies are input intensive and have not helped the entire agriscape of India.
- Additionally, average size of operational holding is declining with 67% as marginal farmers, there is growing disparity between agricultural and non-agricultural incomes, rural youth has rising aspirations, and there are inadequate institutional arrangements to mitigate risks and crop loss due to droughts, floods, heat/cold waves and other natural disasters.
- Hence, there is urgent need to increase the farmers' income and one way to do so is to increase the irrigation coverage and efficiency.
- Estimates show that gross irrigated area needs to be increased from present level of 92.6 Mha to 110.4 Mha in 2022 – an increase of 2.5 Mha per annum.

Pradhan MantriKrishiSinchayiYoana (PMKSY):

- The present Indian irrigation is besieged with several problems including a widening gap between irrigation potential created and irrigation potential utilized, high dependence on groundwater irrigation leading to over-exploitation of ground water resources and declining water tables in large parts, poor development of water resources and rural electrification and seasonal flooding in eastern region, low water use efficiency/water productivity in agriculture and all other sectors, weak regulation and half hearted implementation of water policies and non-convergence of several water resources related schemes.
- Hence, an ambitious scheme of 'Pradhan MantriKrishiSinchayeeYojana' was developed with the twin objectives of "HarKhetkoPani – providing irrigation to each farm" and "Per drop more crop – improving water productivity".
- PMKSY Components – Accelerated Irrigation Benefit Program; HarKhetKoPani; Per Drop More Crop; Watershed development
- Approach of the PMKSY is:
    - Faster completion of ongoing major and medium irrigation projects including National projects under AIBP.
    - Effective management of runoff water and improved soil and water conservation activities based on watershed basis.
    - Creation of new water sources through minor irrigation schemes, repair, restoration and renovation of water bodies, and additional rain water harvesting structures under HarKhetkoPani.
    - Efficient water conveyance and precision water application devices like drips, sprinklers, rain-guns in the farm to achieve 'Per drop more crop'.
- Focus of the program is to provide end-to-end solution to irrigation supply chain through development of the water resources, creation of an efficient distribution network and improve farm level management and water-use efficiency.
- In spite of the good intentions and reasonable allocation of funds by the central government and its disbursement through NABARD, the program has made little headway due to number of factors such as:
    - Lukewarm interest at the district and state level
    - Insufficient capacity at the district to develop an innovative and cost-effective District Irrigation Plan which really addresses the issues of the district

- Lack of synergy and convergence between different line development departments
- Aspirations of the district/state in fund allocation are much higher than the actual funds available under the scheme.

Irrigation Systems In India

- There are various types of systems of irrigation practices in different part of India. Irrigation is carried on through wells, canals, perennial canal and multipurpose river valley projects.
- India's irrigation is mostly groundwater well based. At 39 million hectares (67% of its total irrigation), India has the world's largest groundwater well equipped irrigation system (China with 19 mha is second, USA with 17 mha is third)..
- However, even when full potential of available resources are developed, irrigation facilities can be extended to 115 million ha, of which 80 mha from surface water and 35 mha from ground water.

Need for irrigation:

- India is a big country and stands next to China. So irrigation facilities are needed to grow more food to feed our teaming millions.
- The distribution in rainfall is uneven and uncertain which either causes famines or drought
- Different water requirements of different crops can only be met through irrigation facilities.
- India, being a tropical country, the temperature is high and evaporation more reapid, so, artificial irrigation is necessary for ample supply of water and also to prevent water scarcity in long dry winter season.

Sources of Irrigation in India:

- According to Agricultural census 2010-11, India's total area under irrigation is 64.7 million hectares. Of this, maximum 45% is shared by tube wells followed by Canals (26%), wells (19%) and others (7%).

Types of Irrigation Systems:

1. Tank Water Irrigation System –
    - Prevalent in the uneven and relatively rocky plateau of Peninsular India. E.g. – Deccan Plateau, Andhra Pradesh, Karnataka, Tamil Nadu, Eastern Madhya Pradesh, Chhattisgarh, Orissa and Maharashtra.
    - About 8% of total irrigated area is irrigated by tanks.
    - Most of the tanks are natural and do not involve heavy cost of construction. Since it is constructed on rocky bed, it has longer life span.
    - In many tanks, fishing is also carried on. This supplements both the food resources and income of the farmer.
    - Drawbacks – Covers a large area of cultivable land; Evaporation of water is rapid; Do not ensure perennial supply of water; Lifting of water from tanks and carrying it to the fields is a strenuous and costly exercise.
2. Well Water Irrigation System –

- More widespread in plains, coasts and some regions of peninsular India.
- Less costly and more flexible as water can be drawn whenever needed and evaporation loss is minimized and no fear of over irrigation
- Well irrigation accounts for more than 60% of net irrigated area in the country against 29.2% of canal and only 4.6% of tank irrigation.
- U.P has the largest area under well irrigation which accounts for 28% of the well irrigated area of India. This is followed by Rajasthan (10%), Punjab (8.65%), Madhya Pradesh (8%), Gujarat (7.3%), Bihar, Andhra Pradesh and TN.

- Well are of two types:
  - Open wells – These are shallow and irrigate a small area because water available is limited and the level of water goes down during the arid season.
  - Tube wells – These are deep, more suitable and have the capacity to draw a large volume of water A deep tube well worked by electricity, can irrigate a much larger area (about 400 hectares) than a surface well (1/2 hectares).
  - In Rajasthan and Maharashtra, artesian wells are now supplying water to agricultural lands. In artesian wells, water level remains at a high-level because of the natural flow of water due to high pressure.

3. Inundation/Canal Irrigation system:
   - These are the main source of irrigation in India as it covers near about 42% of total irrigated land. The net area under canal irrigation is about 15.8 million hectares.
   - Punjab and Haryana have become the first granaries of country due to these canals which include Western Yamuna Canal, Sirhind Canal, Upper Bari Doab Canal &Bliakra Canal
   - The important canal of U.P are upper and lower Ganga canal, Agra and Sharda Canal. Rajasthan has become third granary due to Rajasthan canal project.
   - In Tamil Nadu, most important are the Buckingham canal and the Periyar canal.
4. Perennial Canals Irrigation System:
   - It gets 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 bodies
   - So this system of irrigation ensures supply of water in all seasons. Tamil Nadu, Andhra Pradesh and Karnataka have adopted this system. Punjab and UP also use this system of irrigation.
   - In many places, rain water harvesting systems are installed and water is stored in large artificial reservoirs.
5. Multipurpose River Valley Projects:
   - These projects are helping in irrigation and growth of agriculture.

Major Irrigation Projects in India

Table 1: Major Irrigation Projects in India

Name of the project	River	Beneficiary states
Bhakra Nangal Project	Satluj	Punjab, HP, Haryana & Rajasthan
Damodar Valley project	Damodar	Bihar & West Bengal
Hirakund Dam	Mahanadi	Orissa
Thungbhdra Project	Thungbhadra	AP & Karnataka
Nagarjuna Sagar Project	Krishna	AP
Kosi Project	Kosi	Bihar
Farakka Project	Ganga Bhagirathi	West Bengal
Gandak project	Gandak	Bihar, UP & Nepal
Beas Project	Beas	Rajasthan & Punjab
Rajasthan Canal	Satluj	Rajasthan, Punjab & Haryana
Chambal Project	Chambal	Madhya Pradesh & Rajasthan
Ukai Project	Tapti	Gujarat
Tawa Project	Narmada	Madhya Pradesh
Sri Ram Sagar Project	Godavari	Andhra Pradesh
Malaprabha Project	Malprabha	Karnataka
Mahi Project	Mahi	Gujarat
Mahanandi	Mahanadi	Orissa
Indukki Project	Periyar	Kerala
Koyna Project	Koyna	Maharastra
Upper Krishna Project	Krishna	Karnataka
Ram ganga project	Ram ganga	Uttar Pradesh
Tehri dam	Bhilan ganga & Bhagirath	Uttar Pradesh
Narmada Sagar	Narmada	MP, Rajasthan, Gujarat & Maharastra
Massan ore (Canada) Dam	Mayurakashi	West Bengal

Watershed Development In India

- Rainfed areas of India are almost entirely single cropped areas with scanty of rainfall, prone to frequent droughts, soil erosion, characterized by fragile pasture lands necessitating large scale cattle migration, deleting water tables, low employment opportunities and chronic poverty levels..
- Hence, to address such challenges in these areas watershed development and soil conservation programs were formulated.

Watershed Development Initiatives in the 1990s:

- From the WARASA guidelines in 1990-91 to the 2015 NEERANCHAL guidelines, integrated watershed management program has remained a flagship program for govt. in its effort for drought moderation.
- The GoI held the view that the best way to reclaim watersheds was through an integrated management model given the inter-linkages between the diverse dimensions – the natural resources, humans and cattle all of which were inter-twined. Lack of

comprehensiveness and integrated management of watershed management activities led to severe soil erosion and environmental problems.

DPAP and DDP:

- Dr. C. H. Hanumantha Rao chaired a technical committee on Drought Prone Areas Program (DPAP) and the Desert Development Program (DDP). It said that despite the fact that DPAP and DDP has been in operation for almost 2 decades, it was observed that the programs had not created substantial impact.
- The success stories at RalegaonSidhi and Adgaon in Maharashtra ,Kabbalnala and Mittemari in Karnataka, habua in M.P presented a case that drought can be beaten with concerted efforts for development on watershed basis and active participation of local farmers.
- The committee recommended that greater attention be given to people's own strategies and their own indigenous technologies including the locally preferred plans so as to incorporate them in programs to mitigate the rigors of drought.
- It reiterated that harmonious management development and utilization of land, water and vegetation resources on watershed basis should be implemented with total participation of beneficiaries.

NWDPRA:

- The National Watershed Development Program for Rainfed Areas (NWDPRA) recognized that sustainability was possible only through people's participation and implementation should be through participatory model.
- It further recognized that capacity building was needed for all stakeholders. The role of women was seen as crucial from planning to implementation.
- The Objectives of NWDPRA were:
    - Conservation, development and sustainable management of watersheds
    - Enhancement of agricultural productivity and production
    - Restoration of ecological balance in the degraded and fragile rainfed ecosystems by greening the areas
    - Reduction in regional disparity between irrigated and rainfed areas
    - Creation of sustainable employment opportunities
- Guiding principles of NWDPRA – conservation of natural resources, integrated development of natural and social resources, in-situ moisture conservation, sustainable farming systems, adoption of ridge to valley approach, due emphasis on mobilization of communities at village level, empowerment of village communities

IWDP:

- From 1990-99, the World Bank Financed India's Integrated Watershed Development Program (IWDP). The project objectives were to introduce improved and sustainable land management practices in selected watersheds through the promotion of cost effective and replicable conservation technologies.

HARIYALI:

- With the emergence of the Panchayti Raj Institutions, the watershed development teams at village level got merged with Gram Panchayats.

- This resulted in watershed development programs at each level being administered by people who had many other responsibilities.
- The Parthasarathy Committee report recommended a National Authority for Sustainable Development of Rainfed Areas, to be set up as a quasi-independent authority to manage watershed programs.

NEERANCHAL:

- In 2015, GoI approved the World Bank assisted project Neeranchal. The scheme was designed to bring about institutional changes in watershed and rainfed agricultural management practices in India.
- It aimed to build systems that ensure watershed programs and rainfed irrigation management practices are better focused and more coordinated.
- It aims to devise strategies for the sustainability of improved watershed management practices in program areas, even after the withdrawal of project support.
- It promoted a watershed plus approach, support improved equity, livelihoods, and incomes through forward linkages on a platform of inclusiveness and local participation.
- It supported both the conservation and production outcomes including the availability of water in rainfed areas, catering to the needs of small and marginal farmers as well as the asset-less, including women.
- The challenges remained in enhanced participation of communities, building stronger capacities and systems to plan, implement, monitor and post-project sustainability of local institutions and assets.
- These challenges were to be addressed during the implementation phase under Neeranchal.

NRAA:

- The National Rainfed Area Authority (NRAA) was constituted as an attached office of the Dept. of Agriculture in 2006. The authority serves as an advisory body for policy and program formulation and monitoring of schemes and programs to resolve the agrarian challenges across the vast rainfed system of the country besides promoting sustainable practices for steady growth of agricultural sector and farmer's welfare.

Conclusion:

- The government has provided adequate resources and manpower for effective implementation. In successful implementation of Neeranchal program lies the future of millions of rainfed farmers of India.

Floods And Droughts In India: Causes and Solutoin

- Floods and drought, both are a result of hydrologic extreme.

Floods:

- A rainfall takes place somewhere in the upstream catchment, and consequent high flow in the river may spill out in to the habitation areas somewhere downstream. This is 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 the city/village. This is called drainage congestion (Mumbai in July 2005).
- In India, 33.5 mha of area is flood prone, and out of this, on an average, some 7.5 mhais affected by floods every year.

Causes of floods:

- A very heavy rainfall in the upstream
- Natural Lake Burst as the water storage builds up due to landslide-dam blocking the path of water bursts and the accumulated water flows out in short time.
- Breach of Embankments
- Dam Break

Managing Floods:

- Approach to flood management is a combination of protection from floods of less severity, reducing the damage by flood forecasting and disaster relief in case of floods of larger severity.
- Flood management options are typically divided in two types, structural – i.e. comprising some construction of embankments, and flood control reservoirs; and non-structural, comprising flood forecasting, flood plain zoning and disaster relief.
- A flood control reservoir stores the incoming flood water, and releases it slowly after the flood is over. Most famous examples being Hirakud dam on Mahanadi, and a series of dams in Damodar Valley.

Drainage Congestion:

- Innundation in cities is usually due to inability to drain out rain water fast enough. Construction of buildings impedes the flow of water over land; solid waste may choke the storm water drains, which are in any case not adequate, and in coastal cities, the problem is compounded if a heavy rainfall coincides with high tide (E.g. – Mumbai on 29 August 2017).

Droughts:

- Drought is a phenomenon that extends over a long duration. Droughts are divided in three types:
    - Meteorological drought is when the rainfall is deficient.
    - Hydrological drought is when there is inadequate water in the rivers/aquifers
    - Agricultural drought is when there is inadequate water supply to crops and the crops starts wilting.
- About 153 mha area of country is drought prone.

Inter Basin Transfer (IBWT):

- By an ingenious design of canals, and at times by pumping, it is possible to take water from a surplus basin to a deficit basin. Such water transfer is called inter basin transfer of water.

- In year 2000, the National Water development Agency (NWDA) made public the "National Perspective Plan for Inter Basin Water Transfer", (NPP) popularly known as river linking plan.

Benefits of NPP:

- Irrigation to an additional area of 35 mHA; Generate 34,000 MW of hydro power
- Provide drinking water to a large number of villages and towns
- Drought mitigation in many flood affected states
- Flood control in Ganga, Brahmaputra, Mahanadi and Godavari basins
- Facilitate inland navigation; development of fisheries
- Infrastructure development; Infrastructure Development; Employment generation
- Improve aquatic environment by improving EFR, during lean season.

The main objective of the IBWT is to reduce regional imbalance in water availability. Many such schemes are already existing. The most notable are, Beas – Sutlej link, IGNP Canal which brings Sutlej water to Rajasthan, SardarSarovar main canal that takes Narmada water to Saurashtra, PeriyarVaigai link etc.

MICRO-IRRIGATION AND APPROACHES FOR IMPROVING WATER USE EFFICIENCY IN AGRICULTURE

- As per United Nations Food and Agriculture Organization (UNFAO, 2011). Irrigation and livestock segments use 91 percent of water withdrawal in India. About a third of the water withdrawal comes from groundwater.
- Groundwater level is depleting very fast due to its use in irrigation along with rural and urban water supplies.
- Presently, about 54 percent of India suffers from water stress. As recharging most of this withdrawn groundwater takes a long time and the ground water exploited from the greater depth cannot be recharged by rainfall, there is an urgent need of sustainable and judicious use of water resources.
- The tropical climate of India leads to a high evapo-transpiration and prevalent uneven distribution of rainfall across regions, necessitates increasing the area under irrigation.
- Most common method of irrigation under Indian agriculture is surface irrigation, but its water use efficiency is low.
- The irrigation methods having greater irrigation efficiency are different methods of micro-irrigation like drip and sprinkle irrigation. Drip irrigation system irrigates the root zone of the crop, not the whole surface.
- In sprinkler irrigation, water is distributed through a system of pipes, is sprayed on the crops and falls like smaller water drops.

Water Use Efficiency (%) Under Different Irrigation Systems:

	Surface irrigation	Sprinkler Irrigation	Drip Irrigation
Conveyance efficiency (%)	50-70	NA	NA
Application Efficiency (%)	40-70	60-80	90
Surface Moisture evaporation (%)	30-40	30-40	20-25
Overall Efficiency (%)	30-35	50-70	80-90

Micro irrigation: way to' more crop per drop'

- Micro irrigation helps in reduction of input consumption and increase the productivity of the crop by various means. Judicious use of water in micro irrigation system helps to improve the water use efficiency by saving water and brings down the overall irrigation cost by saving water, electricity and labour.
- In micro irrigation systems, the evaporation, runoff and deep percolation losses are reduced. Water is also saved as limited quantity of water is applied at root zones or selected places which actually need water and thus, small water sources can also be used for micro irrigation. As a result of reduction in input costs, farmers have more choice to introduce new crops on their farms.
- Use of micro irrigation techniques help in improving power use efficiency by 30-50 percent as lower power and fewer hours are involved in irrigation.
- Judicious use of fertilizer and direct fertilizer application to the root through fertigation can improve fertilizer consumption efficiency by 20-30 percent, these two commodities, a lot of electricity and fertilizer can be saved along with the subsidy amount provided to the farmers for this purpose amounting to thousands of crores.
- As water is applied in a controlled manner at the targeted places, the soil moisture levels remains at optimal levels increase the crop productivity, helps in increasing the income of the farmers. Though, the farmer has to pay the installation cost at first, the benefits to the farmer is really promising and sustainable.

Current status and growth in India:

- India now has close to 8 million hectares out of 140 million hectare of total area under cultivation through micro-irrigation, i.e. about 5.5 percent average penetration at the all India level, much less than developed countries and even China.
- Majority of the area covered under micro irrigation systems comes under sprinkler irrigation with 56.4 percent, while 43.6 percent comes under drip irrigation.

Some of the Government efforts via various micro-irrigation focus schemes/projects are as follows:

- National mission on Micro-irrigation: NMMI (2010-2014):-under this programme, the area under micro irrigation is almost doubled.
- National mission for sustainable agriculture NMSA (2014-15): under the head 'on farm water management' component of NMSA, micro irrigation issues is addressed. It emphasizes on enhancing water use efficiency by promoting efficient on farm water management technologies and equipments.
- Pradhan mantrikrishisinchayiyojna (2015-2019)

Approaches for enhancing water use efficiency in agriculture:

- Supplemental irrigation combined with on farm water harvesting practices such as mulching or increasing bund height, reduces susceptibility to drought and helps farmers to get the most out of the scarce resources.
- Following are various means of enhancing use-efficiency and productivity of water in agricultural production system:

1) Avoid over irrigation, 2) Select crops and cropping system based on available water supplies, 3) Mixed cropping system, 4) Irrigation scheduling based on evapotranspiration, soil content or soil water tension, 5) Use full irrigation at critical growth stages and deficit irrigation at rest of the stages, 6) Practice conservation tillage- to conserve soil water, conservation tillage practices like minimum tillage, no till, and strip till are much useful. Under these practices, tillage operation is reduced and crop residue from the previous crop is at least partially retained on the soil surface, 7) Carefully manage surface irrigation.

- To improve water infiltration in tight soils, polyacrylamide or straw mulch should be use for increasing water holding capacity of the soil. For crops that are less sensitive to moisture stress, use alternate-row irrigation, irrigate one side of a bed on one irrigation and then the other row or side.
- Another strategy is to irrigate only compacted rows; since water infiltrates wheel traffic rows more slowly than soft rows, water is less likely to move below the root zone.

Present challenges and their solution:

Micro irrigation has penetrated only 5.5 percent owing to various reasons, these are:

- Finance: micro irrigation demands an initial investment which is not in the reach of every Indian farmer as most of them belong to small and marginal category.
- Stable schemes guidelines and their implementation: it has been observed that schemes are only effective for 5 months of the year and not available to the farmers during the peak demand months due to their uncertainty in guidelines for implementation.
- Use of information technology and dedicated team for process management.
- Focusing strategy for water intensive crops.
- Other practical approaches: the public water bodies should be managed by local bodies for their maintenance and usage.

Conclusion:

Need based irrigation, particularly micro irrigation is a must for enhancing sustainable food production in this era of water scarcity to meet the national aim of providing food and nutritional security to all.

HARVESTING RAINWATER FOR AGRICULTURAL NEEDS

- Rainfed agriculture in India is practised in about 57 percent of an estimated 140.3 mha net cultivated area and India ranks first among the rainfed agricultural countries of the world in terms of both extent and value of produce.
- The importance of rainfed agriculture is obvious from the fact that 55 percent of rice, 91 percent coarse grains, 90 percent pulses, 85 percent oilseeds and 65 percent cotton are grown in rainfed areas.

Characteristics and issues with Indian rainfedagriculture:

- Rainfed areas in India are highly diverse: it is practised under a wide variety of soil type, agro climatic and rainfall conditions and is mainly concentrated in five states- Rajasthan, Madhya Pradesh, Maharashtra, Andhra Pradesh and Karnataka.

- The annual rainfall varies between 400 to 1000 mm which is unevenly distributed, highly uncertain and erratic. As a result of low and erratic rainfall, fall in food production is often noticed.
- The rainfed agriculture in India is mainly characterised by frequent droughts, soil degradation, low soil organic contents, multi nutrient deficiencies, low external inputs, low investment capacity of farmers and poor market linkages.
- Long term data for India indicates that rainfed areas experience 3-4 droughts per decade of moderate to severe intensity. Also, long dry spells during monsoon season cause severe water stress and result in partial or complete loss of the crops.
- The land degradation in rainfed areas that mainly include soil erosion by wind and water, loss of soil humus, depletion of soil nutrients, deterioration and reduction of vegetation cover and loss of biodiversity also affects the producing capacity of the land adversely.
- Use of external production inputs e.g. balanced nutrients, supplemental irrigation, good quality seeds and pesticides are lower in rainfed than in irrigated crops.
- Small and marginal farmers who account for major operational holdings in rainfed agriculture need credit for both consumption and investment, but the credits to these farmers from the formal institutions are low and the dependence on money lenders is high.
- The rainfed agriculture in India is precarious and faced with a number of issues including low cropping intensity (single crop system involving a long fellow period during non monsoon period), low productivity and poor returns over cost of cultivation, poor adoption of modern technology, uncertainty in output, high incidence of rural poverty, lack of institutional credit, inadequate public investment and increasing number of suicides among farmers.
- The rainfed agriculture is also more vulnerable to climate change implications than the irrigated agriculture due to its poor capacity to cope with extreme water and weather shocks.

Rainwater harvesting (RWH) for upgrading rainfed agriculture:

- The yield of food grains in the rainfed regions varies from 1-2 t/ha compared to attainable yields of more than 4 t/ha. Water has primarily been an issue in rainfed agriculture. Therefore, harvesting of surplus runoff, its storage and reuse for supplemental irrigation and the efficient in-situ conservation of rainwater can be potential strategy to achieve the desired level of yield in these areas.

Methods of RWH:

- In situ water harvesting: It refers to collection of rainwater 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.
- External water harvesting: - it includes all those techniques which induce collection and storage of rainfall and/ or runoff for its beneficial use e.g. for raising agricultural and horticulture crops or for domestic and livestock consumption.
- Traditional methods-
    - Village ponds and tanks;
    - Tankas/kunds/kundis are underground structures of various shapes and sizes to collect rainwater for drinking purpose in the desert and arid areas of Rajasthan.

- Khadin, a runoff farming and groundwater recharging system is popular in deep Thar desert of Rajasthan having annual rainfall as low as 150-350 mm.
- Vav/baoli/bavadi/jhalara are traditional wells in Rajasthan and northeast India.
- Hill slope collection system is common in hilly areas with good rainfall e.g. in Uttrakhand, Himachal Pradesh, Meghalaya and Arunachal Pradesh.

Contemporary methods:

- Check dams and nallabunding ; Farm ponds
- Percolation tanks impound rainwater and have a waste weir to dispose of surplus flow in excess of the storage capacity of the tanks.
- Sub surface barriers, constructed below river bed on impervious subsurface strata, are most suitable artificial structure for promoting ground water recharge in arid and semi-arid regions

Government initiatives in promoting RWH and their effectiveness:

- A major national initiative in India in which RWH is a significant component is the watershed development programme (WPD) taken up under different schemes of the Government of India (GOI) and the state governments.

Way forward:

- Rainfed agriculture requires same level of concreted water governance and management priorities as given to the irrigated agriculture during the past six decades.
- Concentrated efforts are also required for building up constitutional capacities, policy frameworks, knowledge generation and public finance for RWH in rainfed agriculture. Since substantial funding is required for the creation of RWHS, it calls for public support.
- Awareness on RWH and water conservation should be created among the masses through education, mass media, regulation. Incentives and disincentives.

FLOOD AND DROUGHTS: WATER FOR IRRIGATION AND POPULATION NEEDS OF INDIA

- The average annual rainfall of the world in 840 mm, whereas in India, it is 1150 mm. But the fact is that some parts of the country (i.e., South and West) are facing water scarcity (drought) and some other parts (North and East) are getting floods.
- The per capita availability of rain (water) in different basins of the country is having vast variations.

Water Availability

- The average availability of water in India is about 200 m^3 per person per year. The minimum water requirement is about 1700 m^3 / person as fixed by U.N. agencies and World Bank. If the availability of water is 1000 $m^{3,}$ it is considered as a water scarcity state.
- Though the water available is 650 m^3/ per person per year in Tamil Nadu, there is no need for any anxiety, since water availability in Israel is only 450 m^3/ per person per year but they are managing it very well.

- We can use the latest technology in water management like drip and sprinkler irrigation on a large scale to save water and reclaiming sewage and effluent water and use it for irrigation.
- Since sufficient land, water and technology are available in the country, it is possible to find out the solutions. The solutions are:
  a. The useable water estimated (69 mHm) seems to be very low/not correct; it should be reassessed/updated accurately.
  b. Water harvesting
  c. Water management
  d. Waste water reclamation (sewage and effluent water) and utilization for irrigation as done in Israel.
  e. Introducing large scale drip and sprinkler irrigation as estimated by the expert committee.
  f. Interlinking of rivers in the country.

Salient points to be considered to solve the problems:

- There are about 45,000 large dams in the world of which 46 per cent is in China, 14 percent is in USA, only 9 per cent in India.
- Our environmentalists are against the construction of dams (Reservoirs) to store the flood water going as waste giving some reasons.
- China's project to divert waters of southern river (Yantze) to the arid north (Yellow river) is nearing completion. There is another plan to hand to divert out Brahmaputra's water to Northern China, which will affect India's water resources.
- Supreme Court asked centre to set up a high-level task force to work out the modalities of interlinking of rivers in India within 10 year.
- In another judgment of the Supreme Court (27.02.2012) directed the centre to implement interlinking of rivers in a time bound manner.

Conclusion:

If we want to bring agriculture of the country in the top of the world, the farmers should get water to irrigate about 150–160 MHA for which interlinking of rivers is a must. If we find solutions to avoid drought and flood which is not impossible, India will become a developed country easily and early.

SUSTAINABLE AGRICULTURE: ALIGNING CROPPING PATTERN WITH THE AVAILABILITY OF WATER

- Indian agriculture is facing with an array of problems such as water scarcity, reduction in cultivable land/capita, high cost of crop inputs, lack of marketing network and avenues for value addition of farm produce and fluctuating market prices.
- Thus, sustainable agricultural production system is the key of improve yield potential and eco-efficiency.
- Sustainable agriculture is the wave of farming according to the location-specific ecosystem and study of relationship between organisms and their environment.
- Such system rely upon crop rotations, crop residues, animal manures, legumes, green manures, cultivation, and mineral bearing rocks to maintain soil fertility and productivity. There are following ways to sustain agricultural productivity:
  - Soil management
  - Efficient water resources management

    - Crop management includes right time of sowing, cultivation of suitable crops and varieties in rotation, intercropping, mixed-cropping.
- Sustainable water management in agriculture aims to match water availability and water needs in quantity and quality, in space and time, at reasonable cost and with acceptable environmental impact. Under water demand management most attention has been given to irrigation scheduling (when to irrigate and how much water to apply) giving minor role to irrigation methods (how to apply the water in the field).
- However, both irrigation scheduling and the irrigation method are inter-related. It forms the sole means for optimizing agricultural production and for conserving water and it the key to improving performance and sustainability of the irrigation system.
- The conventional crops and cropping patterns prevailing in most of the dryland areas do not take care various aspect related to soil moisture.
- Therefore produce just satisfactory yield levels in normal and above normal rainfall years whereas,in abnormal or moisture stress situations lead to crop failures or very poor yield resulting unstable economic condition of dryland farmers.
- Therefore, selection of crops/varieties and cropping system and their management should aim at most efficient use of water over wide range of rainfall situations.
- Although the cropping systems would depend, upon the agro-climatic factors, it is certainly profitable to adopt double cropping, intercropping and mixed cropping since these systems help to increase land use efficiency.
- Intercropping helps to enrich soil fertility, retain soil moisture, reduce the incident of weeds, pests and diseases, make fodder available throughout the year and to obtain additional money.

Major cropping Patterns of India:

- The major change in cropping pattern that has been observed in India is a substantial area shift from cereals to non-cereals.
- The fact that large areas remains under food grains shows that land productivity has not increased at par with technological possibilities. Despite significant changes in cropping pattern, the shift towards high valued commercial crops has been very small.
- Rice-based cropping systems may include lowland and upland crops.

The following rice based cropping systems are practiced in India:

Rice-Wheat:

- Most prevalent in Uttar Pradesh, Punjab, Haryana, Bihar, West Bengal and Madhya Pradesh states.
- 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, build up of *Phalaris minor,* low input use efficiency in north western plains, low use of fertilizer in eastern and central India. Appropriate varietal combination, shortage of labour during optimum period for transplanting paddy, crop residue management etc.

Rice-Rice**:**

- Rice-rice is the popular cropping patterns in irrigated lands in humid and coastal ecosystem of Asom, West Bengal, Odisha, Tamil Nadu, Andhra Pradesh, Karnataka and

Kerala and spreading over an area of 6.0 million hectares. The major issues in sustaining.

- Deterioration in soil physical conditions, micronutrient deficiency, poor efficiency of nitrogen use, imbalance in use of nutrients, non-availability of appropriate trannsplanter to mitigate labor shortage during critical period of transplanting build up of obnoxious weeds such as *Echinochlocrusgallli* and non-availability of suitable control measures.

Rice-Oilseeds/Pulses**:**

- Mainly mustard, linseed, groundnuts, lentil, lathyrus and pea are grown during winter season rice fallow belt of eastern and southern in India.
- Adoption of appropriate high yielding rice and oilseeds/pulses varieties, adequately supported by improved production technology, ensures desired productivity of the system.
- Factors limiting productivity of this cropping system in the region are like physical factors (droughts and erratic distribution of rainfall, small area under assured irrigation, high percolation and resulting in heavy nitrogen losses in red sandy and loam soils),
- Input related factors (delayed and prolonged transplanting, low coverage under high yielding varieties (HYVs), little attention to timely weed control, inadequate supply of quality seed and little attention to disease/pest control), social factors (low literacy, large proportion of marginal and tribal farmers, practices of animal grazing on agricultural lands and low risk bearing capacity of farmers of the region.

Pearlmillet-Based Cropping System**:**

- Pearlmillet is more drought-resistant crop than several other cereal crops and is generally preferred in low-rainfall areas and light soils. The area under the pearlmillet crop in India is about 12.4 m ha and Rajasthan (4.6 m ha) shares about the 2/3 of the total area.
- Considering the cropping patterns, pearlmillet is grown during *kharif* along with pulses, groundnut, oilseeds cotton, tobacco and *kharif* sorghum as sole as well as mixed and intercrop followed by wheat, chickpea and mustard during *rabi* season.
- The following issues are important for sustainability of system over mining of nutrients depleting soil fertility, imbalance in fertilizer use, decreasing response to nutrients, lowering roundwater table and build up of diseases/pests and weeds.

Maize-Wheat**:**

- Maize is the principal crop of *kharif* season in northern hills of the country but plains of northern states like Utter Pradesh, Rajasthan, Madhya Pradesh and Bihar also have sizeable acreage under this crop.
- As most of the area in maize-wheat system is in rainfed conditions when uncertainty of rainfall is a major limitation. Farmers in general, tend to grow low yielding traditional varieties. The major concerns of maize-wheat system are erratic rainfall, weed infestation and multiple nutrient deficiencies.

Sugarcane-Wheat**:**

- Uttar Pradesh, Punjab, Harayana and Bihar account for 68% of the total area under sugarcane. Sugarcane-ratoon-wheat is the most important crop sequence.
- The other states where the system covers considerable area under sugarcane-wheat are Madhya Pradesh and Rajasthan. Problems in sugarcane-wheat system are late

planting of sugarcane as well as wheat and imbalance, inadequate use of nutrients, poor nitrogen use efficiency in sugarce, low productivity of ratoon due to poor sprouting, buld up of Trianthemapartulacastrum and Cyprus rotundus in sugarcane and stubble of sugarcane pose tillage problem for succeeding wheat crop and need to be managed properly.

- The emerging deficiencies of P, K,S and micro-nutrients are limiting system productivity directly and through interactions with other nutrients.

Cotton-Wheat

- Cotton is widely grown in alluvial soils of Punjab, Haryana, Rajasthan and Western Utter Pradesh and black cotton coils of Andra Pradesh, Tamil Nadu and Karnataka. With the availability of short-duration varieties of cotton, cotton-wheat cropping system has become dominant in North.
- 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 ball worm and white fly and consequently, poor nitrogen use efficiency in cotton results in low productivity of the system and appropriate technology for intercropping in widely spaced cotton is needed to be developed.

Legume-based Cropping Systems**:**

- Legume crops generally include pulses and oilseeds and known for their compatibility and suitability in different cropping patterns.
- The popular cropping systems are pigeonpea/soybean-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 to yield barriers, 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.

Conclusion:

- The agricultural technology needs to move production oriented towards profit oriented sustainable farming.
- The Promotion of efficient water harnessing technologies accordingly selection of crops and cropping systems can, not only change the trajectory of water resource conservation and utilization, but also enable poor farmers to enhance productivity of crops.

WOMEN'S ROLE AND RIGHTS IN WATER CONSERVATION & IRRIGATION

- The latest census figures list less than 35% women formally as primary workers in the agricultural sector, in contrasts to 81% men. However, there participation in policy making is trivial.
- The primary reason for their low involvement in decision making is because of the fact that they are usually not listed as primary earners and owners of land assets within their families.

- So their role is highly confined in getting loans, participating in market panchayats, assessing and deciding the crop patterns and in liasing with the govt. administrators vis-à-vis their male counterparts.
- According to official statistics, in the rural areas, 59% men work in agriculture, but the figures are 75% for women.
- Women have an important role to play in promoting a new attitude towards the use of water resources, based not only on technical knowledge, but also on cultural and ethical values.
- The importance of women for water and water for women was formally recognized in Dublin conference. It claimed for full involvement of women in the planning and implementation of all scheme and initiatives for drinking water and sanitation.
- Rio declaration of 1992 declared that the 'women have a crucial role to play in environmental administration and sustainable development. The holistic involvement is essential to achieve the goal of sustainable development.
- In India. Over the years, we have witnessed that water resource policies and programs have proven detrimental to women's water rights and consequently, to the sustainable management and use of water.
- Interventions such as traditional irrigation fail to take into consideration the existing imbalance between men and women's ownership rights, division of labour and incomes.
- By raising the value of land, irrigation brings about social change which usually favors men.

Way Forward:

- To begin with, ensuring women's right to use and control of land and irrigation water is a primary requirement. There is a direct correlation between independent land and irrigation rights for women and a higher productivity of land and labor.
- Thus, land allocation under irrigation schemes should be to individual farmers rather than to households which will, in effect, help millions of women engaged in farming.
- Given that women's incomes are considerably lower than men's and that the capital requirements to invest in irrigated crops can be quite high, access to credit systems should be made available to women irrigators.
- We need to improve women's skill in water resources management with their active participation.

Water in Indian Constitution

- Water is a matter included in Entry 17 of List II i.e. State List. This entry is subject to the provision of Entry 56 of List-I i.e. Union List.
- Entry 56 of List I of 7th Schedule provides that "Regulation and development of inter-state rivers and river valleys to the extent to which such regulation and development under the control of Union is declared by Parliament by law to be expedient in the public interest".
- Article 262
    - Parliament may by law provide for the adjudication of any dispute or complaint with respect to the use, distribution or control of the waters of, or in, any inter State river or river valley
    - Notwithstanding anything in this Constitution, Parliament may by law provide that neither the Supreme Court nor any other court shall exercise jurisdiction in respect of any such dispute or complaint as is referred to in clause (1)

Jal KrantiAbhiyan:

- It was celebrated during year 2015-16 to consolidate water conservation and management

Objectives:

- Strengthening grass root involvement of all stakeholders
- Encouraging the adoption/utilization of traditional knowledge in water resource conservation and management
- Enhancing livelihood security through water security in rural areas.

Components:

- Jal Gram Yojana – Two villages in every district (preferably being a part of dark block or facing acute water scarcity) are being selected as Jal Grams. An integrated water security plan for water conservation, water management and allied activities are prepared.
- Development of Model Command Area
- Mass Awareness Programme
- Other Activities – Under this component, States are being encouraged to adopt State Water Policy in line with National Water Policy, 2012. They are also being encouraged to set up their State Water Resources Council and State Water Regulatory Authority.

JALBHARATHI: People's Movement in Water Conservation

- A movement had been initiated in southern state of Karnataka in the name of 'Jalabharathi' about eight years back.
- The prime motto of the movement was to educate the people on importance of water conservation and judicial use of water, by adopting various water conservation techniques mainly rainwater harvesting.

National Hydrology Project:

- The main objective of the project is to improve the extent, quality, and accessibility of water resources information, decision support system for floods and basin level resource assessment and to strengthen the capacity of targeted water resources professionals and management institutions in India.

National Water Mission:

- The main objective is "conservation of water, minimizing wastage and ensuring its more equitable distribution across and within States through integrated water resources development and management.

Goals of this mission:

- Comprehensive water database in public domain and assessment of impact of climate change on water resources
- Promotion of citizen and state action for water conservation, augmentation and preservation
- Focused attention to vulnerable areas including over-exploited areas

- Increasing water efficiency by 20%
- Promoting basin level integrated water resources management.